Community Resilience Planning and Clean Energy Initiatives: A Review of City-Led Efforts for Energy Efficiency and Renewable Energy

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Executive Summary

KEY TAKEAWAYS

- Climate change is the primary driver of clean energy initiatives in community resilience planning.
- While most city resilience plans include at least one energy efficiency initiative, only about a quarter of them include a larger, comprehensive set of initiatives.
- Cities with comprehensive energy efficiency initiatives also tend to have comprehensive renewable energy initiatives.
- Cities without robust sets of energy efficiency and renewable energy can emulate and adapt the clean energy initiatives included in the resilience plans of leading cities.

BACKGROUND

Cities are global hubs of economic activity and energy consumption, accounting for 66% of energy use and 70% of CO_2 emissions.[1] All of them rely on the uninterrupted flow of energy to function properly. However climate change is presenting them with an unprecedented array of risks, challenges, and disruptions. In response, cities are actively planning to improve energy efficiency and promote renewable energy to make their neighborhoods more resilient in the face of climate change as well as other shocks and stresses.

RESILIENCE AND THE ROLE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Both energy efficiency and renewable energy reduce risks and enhance community resilience. Efficiency lessens vulnerability to hazards like extreme weather by strengthening grid reliability. It also builds community capacity to cope with stresses by providing public health, safety, quality of life, and equity benefits. Increasing the use of renewable energy is a core strategy to reduce greenhouse gas (GHG) emissions and mitigate the impacts of climate change. Renewable energy also helps achieve other city resilience objectives like restoring power quickly after outages.

THIS STUDY

To assess the extent and quality of clean energy initiatives within community resilience plans, we reviewed and rated 66 plans selected from the international program, 100 Resilient Cities. Based on this review, we identified the energy efficiency and renewable energy initiatives that cities are commonly including in their plans. We also identify and discuss opportunities that cities have missed to improve their energy efficiency and increase their reliance on renewable energy.

[1] C40 Cities, "Why Cities? Ending Climate Change Begins in the City," 2012. www.c40.org/ending-climate-change-begins-in-the-city.

REVIEW OF RESILIENCE PLANS

A key finding is that climate change is the primary driver of clean energy initiatives in community resilience planning, surpassing in importance the other shocks and stresses identified in the plans we reviewed.

Although cities are using energy efficiency and renewable energy in their climate-change mitigation and resilience planning, the extent, targets, and quality of policies and initiatives vary. We developed a rating scheme to assess the 66 plans included in our study, yielding these results:

- 15 cities have plans rated as Exemplary or Substantial for energy efficiency (4 Exemplary and 11 Substantial), and 13 cities have plans rated as Exemplary or Substantial for renewable energy (4 Exemplary and 9 Substantial)
- 39 cities have Adequate ratings for energy efficiency, 32 for renewable energy
- 12 cities have Lacking ratings for energy efficiency, 21 for renewable energy

Most of the resilience plans (60 out of 66) include at least one energy efficiency initiative for either buildings or transportation. Forty-two out of 66 cities include at least one initiative to increase renewable energy generation. Few cities, however, include a large, comprehensive set of energy efficiency and renewable energy initiatives. Almost four out of five resilience plans are rated as Lacking or Adequate for energy efficiency and renewable energy. Therefore most cities' resilience plans incorporate either few clean energy initiatives or none at all. This suggests that they are prioritizing other types of initiatives instead.

ENERGY EFFICIENCY INITIATIVES

Several cities stand out for the energy efficiency provisions included in their resilience plans. These exemplars illustrate the opportunities available to other cities to improve their efficiency. Among these cities' robust efficiency initiatives, the most common are:

- Encouraging sustainable modes of transportation
- Promoting transit-oriented development and transit efficiency strategies
- Increasing the number of private electric vehicles (EVs)
- Setting benchmarking, energy audit, and retrofit requirements for buildings
- Requiring fuel switching and/or electrification in buildings
- Developing microgrids
- Establishing municipal building and fleet efficiency policies

Honolulu exemplifies how a city can take a comprehensive approach to energy efficiency within its resilience plan. The city's current initiatives include a benchmarking ordinance for commercial buildings, a residential energy use disclosure ordinance, incentives to increase private uptake of EVs, and expansion of its EV charging network.

RENEWABLE ENERGY INITIATIVES

Among the plans we studied, a common robust initiative is to set the goal of generating 100% renewable energy. Other common robust renewable energy initiatives include:

- Increasing local wind energy generation
- Increasing the penetration of solar-plus-storage systems
- Constructing waste-to-energy facilities
- Municipal renewable energy installation and/or purchasing

Los Angeles, for example, is taking a comprehensive approach to reaching its renewable energy goals. The city plans to leverage its municipal utility to replace 70% of its existing electricity generation with renewables within 15 years to achieve a long-term goal of 100% renewable energy. Los Angeles is also planning a solar-plus-storage pilot for municipal buildings, with the goal of eventually rolling out the project to vulnerable neighborhoods.

ENERGY EQUITY AND AFFORDABILITY

Energy equity, defined as reducing energy burdens and improving energy affordability, is an objective in the resilience plans of a few cities including Athens, Chicago, and New York. Poorer and disadvantaged communities in urban areas face disproportionate exposure to the shocks and stresses of climate change. However only 8 out of 66 cities in our study actively address energy inequity in their plans (including transportation inequity). Twelve cities have largely passive initiatives in their plans, and 47 out of 66 do not consider energy or transportation equity at all.

RECOMMENDATIONS

We encourage cities to assess energy efficiency and renewable energy opportunities and take action to strengthen their community resilience plans. The leading cities highlighted in this report provide models for initiatives that can advance energy efficiency and renewable energy as part of resilience planning and preparation, thus providing models that other cities can emulate. Energy efficiency and renewable energy are critical tools in the face of climate change. By establishing and implementing robust clean energy initiatives, cities can become more resilient to disruptions in energy supplies and changes in energy use, regardless of the cause.

Introduction

Local governments are increasingly focused on disaster preparedness, climate adaptation, and community resilience. A growing number of threats, from aging infrastructure to the multiple impacts of climate change, can stress physical and social systems. Resilience has become a key concern in this context. The international initiative known as 100 Resilient Cities defines resilience as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience" (100 Resilient Cities 2019, FAQ). Shocks are generally single catastrophic events, like storms or floods. Stresses are influences that put daily or recurring pressure on communities, such as unhealthy water supplies, frequent electric power outages, or other disruptions.

Many cities around the world have recognized the need to develop plans to prepare for stresses and catastrophes. Their objectives are to reduce damage to critical infrastructure, minimize disruptions, and shorten the duration of negative impacts. Communities have rapidly increased their resilience planning over the past several years in the wake of numerous natural disasters. One example is Hurricane Maria in 2017, which caused at least $90 billion in damages and may have claimed over 4,500 lives (NOAA 2019a, 2019b; Kishore et al. 2018). Concerns about long-term stressors, especially climate change, are also key drivers of community resilience planning.

Resilience planning covers a broad spectrum of issues and infrastructure vital to communities, including energy systems, and resilience plans often speak to a broad set of priorities and concerns of local governments. In this report, we examine the extent to which communities have incorporated energy efficiency and renewable energy into their resilience planning.

In ACEEE's earlier work on resilience, we discussed ways in which energy efficiency can increase the resilience of energy systems and the communities they serve (Ribeiro et al. 2015). Our previous review identified resilience-related benefits of efficiency measures, discussed ways to incorporate efficiency into resilience planning, and presented case studies showing how local governments and utilities can leverage energy efficiency to increase the resilience of their communities. In 2015, most cities were only beginning to grapple with the concept of community resilience and its implications for local governance. While our research indicated that energy efficiency was a clear pathway toward making communities and their residents stronger, safer, and more resilient, the extent to which municipalities had incorporated efficiency into their nascent resilience initiatives remained unclear.

Since ACEEE completed its initial research on energy efficiency and resilience, a number of initiatives around the world, particularly 100 Resilient Cities, have worked to establish community resilience planning as a local government practice.[1] An increasing number of

[1] 100 Resilient Cities was an international initiative of the Rockefeller Foundation "dedicated to helping cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st Century." This initiative provided funding to support the development of resilience plans for

localities have offices or staff dedicated to resilience planning and/or have incorporated resilience planning efforts into their sustainability activities. Given this increased activity and the availability of a large number of city resilience plans, we built on our earlier research and analyzed whether cities have begun to pursue clean energy as a resilience strategy.

RESILIENCE BENEFITS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Community clean energy strategies typically include policies, actions, and initiatives focused on two main goals: (1) reduce energy use through increased energy efficiency and (2) increase the use of renewable energy sources like solar and wind. Increased use of renewable, distributed energy resources, in combination with other types of distributed resources such as energy storage, microgrids, and combined heat-and-power systems, can also support community resilience.

Energy efficiency can be a core strategy to reduce risks and enhance community resilience. First, it can reduce vulnerability to hazards, including extreme weather and climate change. Second, it can increase a community's capacity to cope with stresses by providing benefits to public health, safety, equity, and quality of life. One clear benefit of energy efficiency that it can help homes remain livable during power outages and other service disruptions (York, Baatz, and Ribeiro 2016; Leigh et al. 2014), a benefit that DOE (2019a) calls "increased passive survivability." This advantage is particularly important for vulnerable demographic groups that are sensitive to temperature changes, such as the sick and elderly (Ribeiro et al. 2015). This is not merely an issue of comfort: the inability of buildings to maintain internal temperatures during power outages can have life-and-death consequences. When Hurricane Sandy hit the United States' eastern coast, 50 people, or almost one-third of US fatalities attributed to the storm, died of complications related to power outages, including hypothermia (C2ES 2018).

Energy efficiency is also an important strategy to support grid reliability and resilience (Relf et al. 2018). Decreasing building energy use through citywide energy efficiency improvements can reduce the risk of grid failure when extreme events cause demand to exceed system capacity; building owners can also be protected from the price spikes that are often driven by such events (DOE 2019a).

Table 1 shows the many resilience benefits that can result from energy efficiency.

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participating cities and created a network of cities selected from over 1,000 applications. The 100 Resilient Cities organization concluded its work on July 31, 2019. See www.100resilientcities.org/about-us/.

Table 1. Resilience benefits of energy efficiency

Benefit type	Energy efficiency outcome	Resilience benefit
Emergency response and recovery	Reduced electric demand	Increased reliability during periods of stress on electric systems and increased ability to respond to system emergencies
	Backup power supply from combined heat and power (CHP) and microgrids	Ability to maintain energy supply during emergency or disruption
	Efficient buildings that maintain temperatures	Residents can shelter in place as long as buildings' structural integrity is maintained.
	Multiple modes of transportation and efficient vehicles	Provides several travel options that can be used during evacuations and disruptions
Socioeconomic	Local economic resources may remain in the community	Stronger local economy that is less susceptible to hazards and disruptions
	Reduced exposure to energy price volatility	Economy is better positioned to manage energy price increases, and households and businesses are better able to plan for the future
	Reduced spending on energy	Ability to spend income on other needs, increasing disposable income (especially important for low-income families)
Public health	Improved indoor air quality and emission of fewer local pollutants	Fewer public health stresses and illnesses
Climate mitigation and adaptation	Reduced greenhouse gas emissions from power sector	Mitigation of climate change
	Cost-effective efficiency investments	More leeway to maximize investment in resilient redundancy measures, including adaptation measures

Source: Ribeiro et al. 2015

As shown in table 1, energy efficiency can be a multifaceted strategy to support community resilience. It can help communities endure and recover from energy supply disruptions that occur, for example, during storms and floods; thus, natural disasters are typically leading targets of resilience planning. Energy efficiency can also address longer-term objectives, such as reducing carbon emissions to mitigate climate change.

Renewable energy with storage can provide communities with an additional layer of resilience. Replacing fossil fuel–intensive electricity generation with utility-scale renewable energy can mitigate climate change by reducing greenhouse gas (GHG) emissions at the source. Decentralized renewable energy assets such as solar can be placed at or near the point of consumption and, if the system is islanded, can operate during times of grid disruption or failure.[2] Decentralized renewable energy systems with storage also avoid the

[2] *Islanded* means capable of operating independently from the grid.

concerns associated with traditional diesel generators, such as fuel resupply, shortages, and hazardous emissions.

Research Objectives and Methodology

RESEARCH QUESTIONS

Our primary research objective is to examine how energy efficiency and renewable energy have been incorporated into select cities' plans in the years since we first examined these aspects of community resilience planning (Ribeiro et al. 2015). While our earlier work identified and discussed the benefits of energy efficiency and its potential role in community resilience planning, few resilience plans at that time included efficiency as a resilience strategy. Since then, the number of resilience plans available for review has increased substantially, providing an opportunity to examine whether and how such plans are including provisions for increasing energy efficiency and the use of renewable energy.

We address the following research questions:

- What clean energy policies, programs, or actions are local governments including in their resilience plans?
- To what extent are energy efficiency and renewable energy being used to achieve resilience objectives?
- What shocks and stresses do these strategies aim to mitigate?
- Which cities include the most extensive sets of energy efficiency and renewable energy actions in their resilience plans?
- Are cities addressing energy equity and affordability in their resilience plans? If so, how?
- What major opportunities have cities missed to strengthen community resilience through energy efficiency?

DATA SOURCES

We reviewed and analyzed a large set of community resilience plans from cities around the world. Our primary data source is a set of 66 resilience plans publicly available through 100 Resilient Cities. These plans are available in English, were released before July 1, 2019, and generally follow a template established by 100 Resilient Cities. Key categories of the template are broad goal areas and specific actions. Goal areas are the objectives targeted in resilience plans, such as environmental sustainability, good governance, and safer communities. An action generally establishes a policy or program to achieve an objective. Actions also can include establishing performance metrics to track progress. The 100 Resilient Cities initiative used established criteria and guidelines to select participating cities from a pool of over 1,000 applicants. The selected cities received technical support in developing their resilience plans.

We also reviewed community resilience plans from five cities not included in 100 Resilient Cities: St. Paul, Minnesota; Alameda, California; Hong Kong, China; Shimla; India; and Malmo, Sweden. This extra step allowed us to compare a small number of plans developed independently from the 100 Resilient Cities initiative. Our main criteria for selecting this small set were availability and geographic/economic diversity, as we aimed to mirror the diversity of the large set obtained from 100 Resilient Cities. The goal of comparing the small and large sets of cities was to identify any differences in the inclusion and recognition of the resilience benefits of energy efficiency. Such differences might suggest that 100 Resilient Cities, in helping its participants create resilience plans, actually biased those plans toward certain clean energy actions. Our review of these five additional cities is presented in Appendix B.

METHODOLOGY

We reviewed and rated resilience plans by identifying, classifying, and tallying the energy efficiency and renewable energy initiatives they contained. We then applied an overall rating to each plan.

We first classified each energy efficiency and renewable energy initiative based on its relative strength and comprehensiveness, assigning them one of three classifications that reflected our own qualitative assessments: (1) robust, (2) comprehensive, and (3) general. Initiatives vary widely: some are relatively small, simple actions, such as a campaign to promote energy-efficient lightbulbs, whereas others are large, complex programs that require building benchmarking and provide incentives and technical assistance for comprehensive building retrofits to improve energy efficiency. We also identified which shocks and/or stresses the initiative targeted.

To rate overall resilience plans, we compiled the total number of energy efficiency and renewable energy initiatives within each classification (robust, comprehensive, general). City plans could earn one of four ratings based on the total number of initiatives and their associated classifications:

- *Exemplary.* Aims to enhance resilience through a large number of robust, comprehensive, and/or general initiatives in the city's buildings, transportation, and/or renewable energy sectors
- *Substantial.* Aims to enhance resilience through a mix of robust, comprehensive, and general initiatives in the city's buildings, transportation, and/or renewable energy sectors
- *Adequate.* Aims to enhance resilience through a mix of comprehensive and general initiatives and very few robust initiatives in the city's buildings, transportation, and/or renewable energy sectors; or relates an existing clean energy, climate action, or other relevant plan to its resilience strategy
- *Lacking.* Includes few general initiatives overall or no initiatives that aim to enhance city resilience through the buildings, transportation, and/or renewable energy sectors

Appendix D presents the details of these ratings, which signify the value that cities place on energy efficiency and renewable energy. Cities that earned an Exemplary or Substantial rating often made energy efficiency and renewable energy initiatives central components of their resilience plans. Those that earned an Adequate or Lacking rating did not place a high value on energy efficiency and renewable energy resources in their resilience plans.

Figure 1 illustrates the steps of our approach.

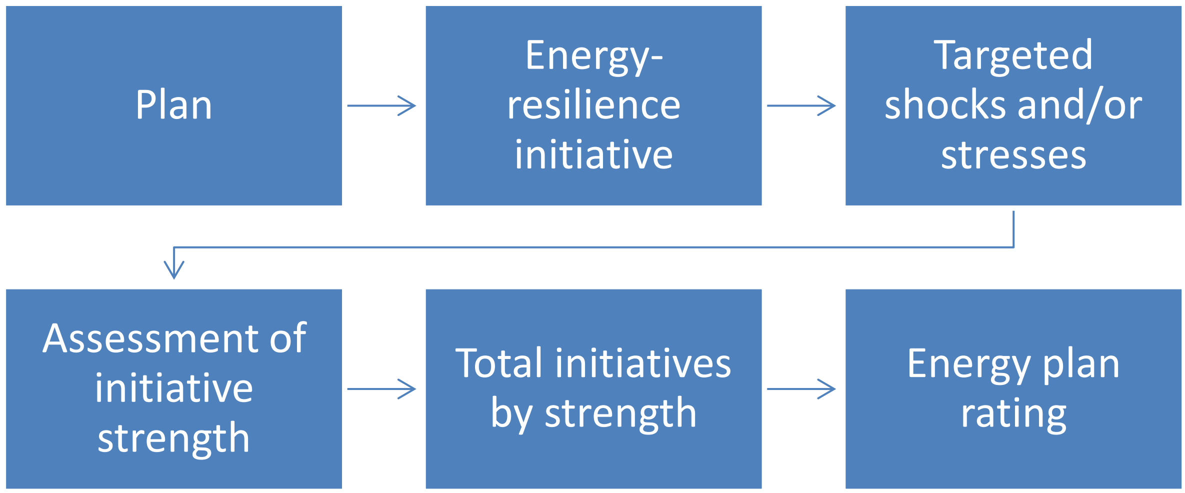

Figure 1. Methodology

DATA LIMITATIONS

Perhaps the most significant limitation of the data is that plans may identify and describe intended or recommended actions, but not actions actually taken and implemented. For example, although we might rate a plan as Exemplary for energy efficiency, this does not necessarily mean that the plan has resulted in exemplary actions.

A related limitation is that our ratings are specific to energy efficiency and renewable energy within community resilience planning. The rating system we developed applies to the breadth and goals of a city's clean energy initiatives strictly within the context of community resilience planning; our system does not rate a city's overall energy efficiency planning, which can be entirely separate. We do not fully assess each city's energy policy landscape. For example, Boston's plan earned an Adequate rating for containing few energy efficiency and renewable energy initiatives. However the city has consistently proven itself to be a national leader in the field of clean energy policy and planning (Ribeiro et al. 2019). Similar instances may occur throughout our set of cities. In these cases, a city's clean energy policy landscape may be primarily driven by a framework other than resilience.

Overall Findings

Applying our rating scheme yielded the results shown in figure 2.

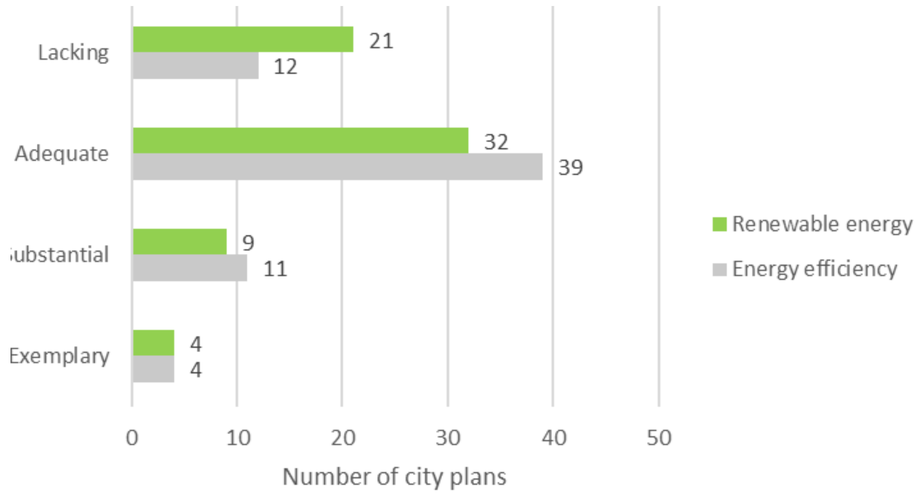

Figure 2. Summary of ratings

A key observation from figure 2 is that the majority of resilience plans are rated as Adequate or Lacking. Thus, most cities are incorporating only a few clean energy initiatives—or none at all—into their resilience plans. This suggests that many communities are prioritizing other types of initiatives and can do more to incorporate energy efficiency and renewable energy into their resilience planning.

Fewer cities fall into the Substantial or Exemplary categories. Fifteen city plans are rated as either Substantial or Exemplary for energy efficiency; 13 are rated as either Substantial or Exemplary for renewable energy.

A similar number of cities earned ratings within these categories for both energy efficiency and renewable energy planning. Six cities are leaders in incorporating clean energy objectives—both energy efficiency and renewable energy—into their resilience planning, earning at least a Substantial rating for both. Sixteen cities earned a Substantial or Exemplary rating for either energy efficiency or renewable energy, but not for both.

We find that many of these cities are embarking on innovative policies to improve their efficiency in the building and transportation sectors, as well as increase their renewable energy generation. Further examination and analysis of these policies can be found in the following sections, but here we highlight a few examples, all of which target climate change:

- Honolulu has proposed an ordinance that would require commercial building owners to benchmark buildings and perform subsequent energy-saving actions.
- The Santiago Metropolitan Area has proposed building 400 kilometers of new trails that will increase cycling and walking trips and lower transportation-related energy use and GHG emissions.

- Los Angeles plans on replacing 70% of the city's electricity generation with clean energy through its municipal utility by 2030.

Cities that earned top ratings for renewable energy and energy efficiency are concentrated in notably different geographical areas: all the cities that earned Exemplary ratings for renewable energy planning were in the United States, while the four cities that earned Exemplary ratings for energy efficiency planning were dispersed all over the world, with two in the United States, one in Argentina, and one in Greece, as shown in table 2 below.

Table 2. Exemplary city plans by resource

Energy efficiency	Renewable energy
Athens	Chicago
Buenos Aires	Honolulu
Honolulu	Los Angeles
New York	New York

A closer analysis shows that 8 of the 13 plans that earned Exemplary and Substantial ratings for renewable energy originate in the United States, while just 6 US cities are included in the top 15 plans for energy efficiency. Omitting American cities from both counts reveals the global nature of energy efficiency and its resilience value: 5 of the top 13 plans for renewable energy originate in Asia (3 plans) and South America (2 plans), whereas 9 of the top 15 plans for energy efficiency are based in South America, Europe, Africa, and Oceania.[3]

Figures 3 and 4 display the overall ratings of each city reviewed in our analysis and illustrate the ratings achieved for energy efficiency, renewable energy, and energy equity planning.

[3] The absence of Asia from this count suggests that on that continent, the resilience value of renewable energy may be much higher than that of energy efficiency.

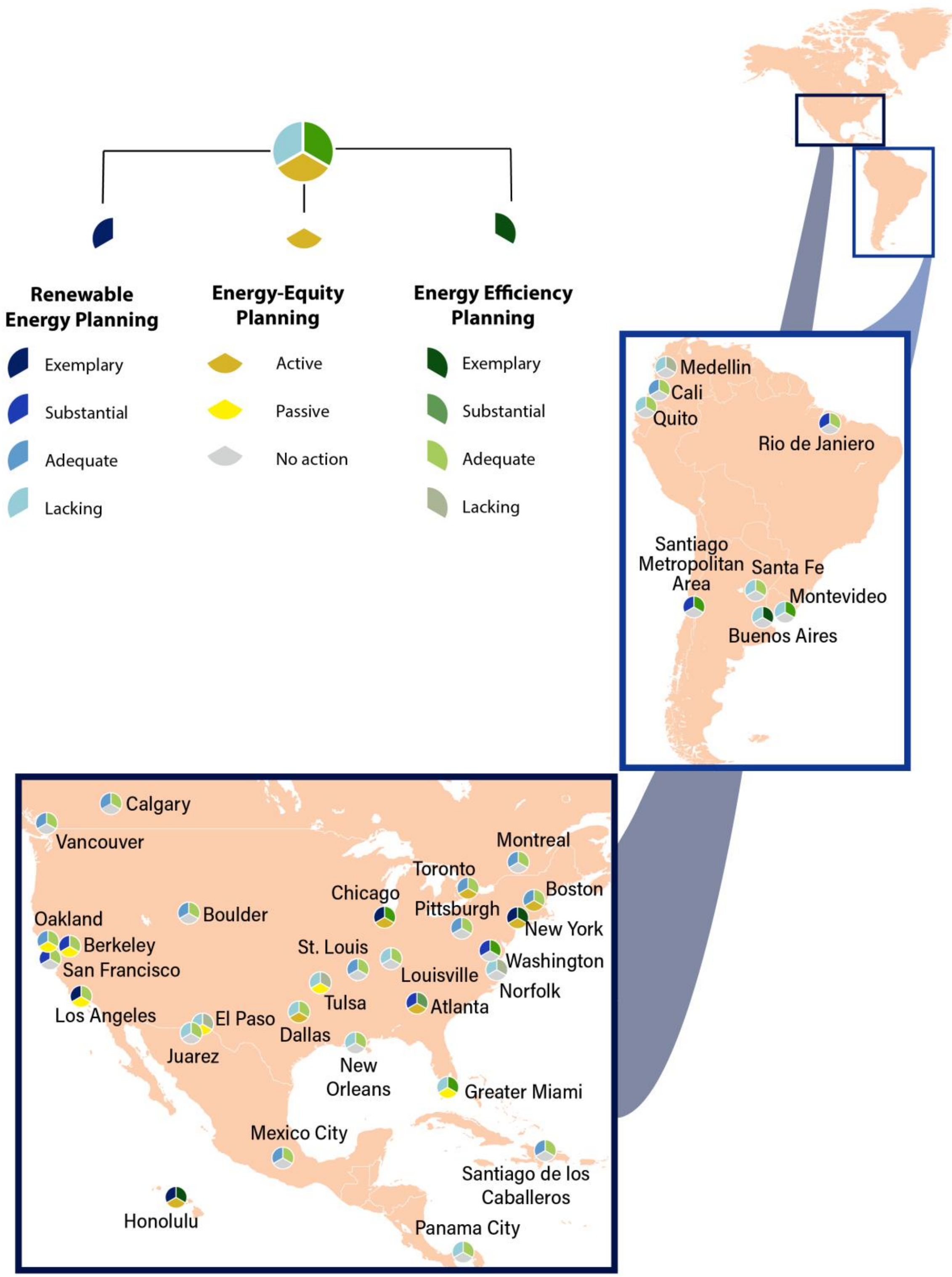

Figure 3. Cities in North and South America

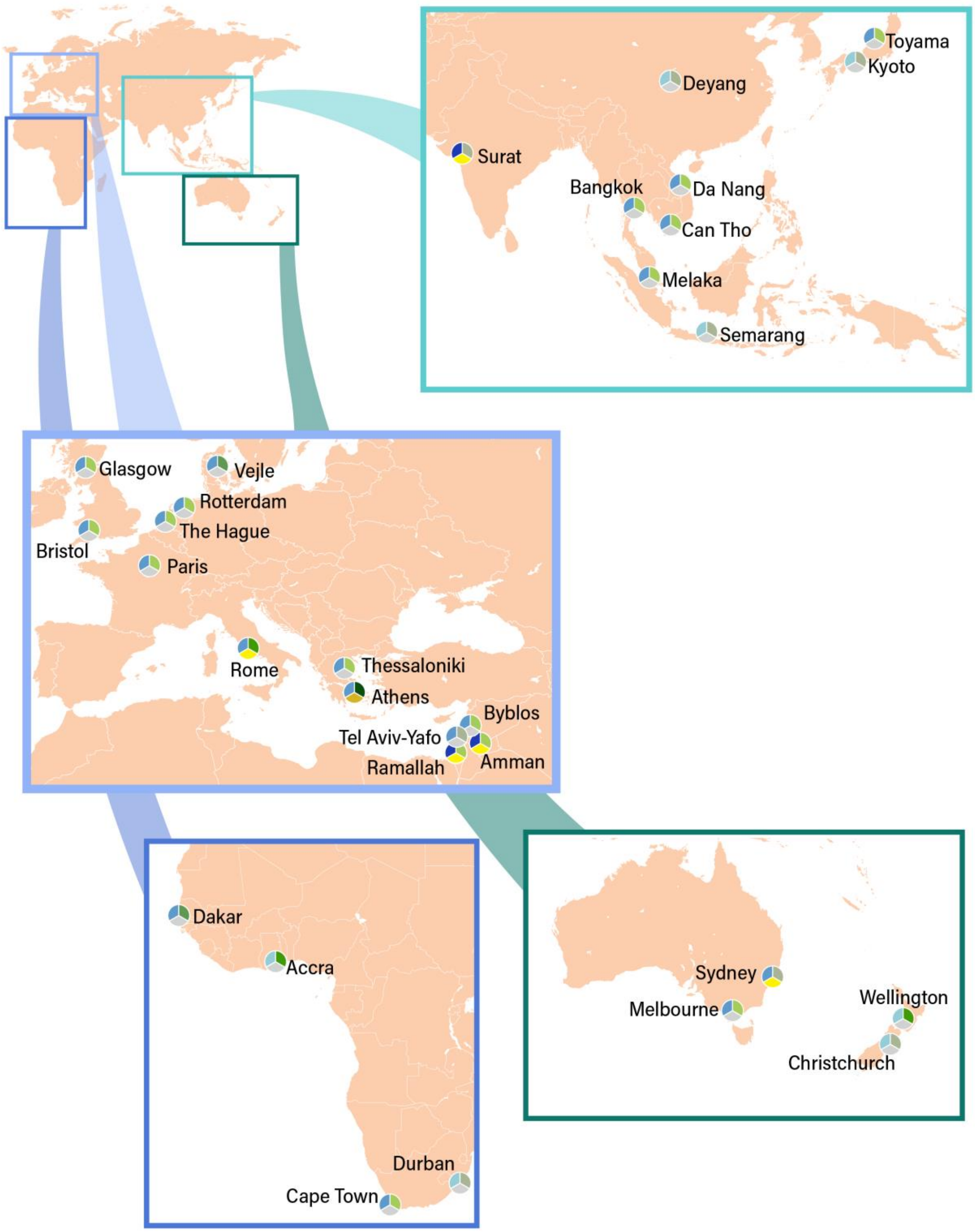

Figure 4. Cites in Europe, Asia, Africa, and Oceania

Plans that earned Substantial and Exemplary ratings for energy efficiency initiatives are found worldwide. This global distribution may reflect an observation recently emphasized by the Intergovernmental Panel on Climate Change (IPCC): actions that reduce both energy demand and emissions can bolster sustainable development by reducing poverty, providing jobs and opportunities, sparking innovation, and creating sustainable cities, among other advantages (IPCC 2018).

SHOCKS AND STRESSES

Cities overwhelmingly view climate change as the primary stress to be addressed by the clean energy initiatives in their resilience plans. In the plans we reviewed, we identified 158 clean energy initiatives that seek to broadly mitigate the effects of climate change or reduce GHG emissions. These initiatives focus on aging infrastructure and infrastructure failure, extreme weather, energy insecurity, poor air quality, environmental degradation, power outages, and extreme heat. As shown in figure 5, climate change–mitigating initiatives nearly outnumber all other top shocks and stresses combined.

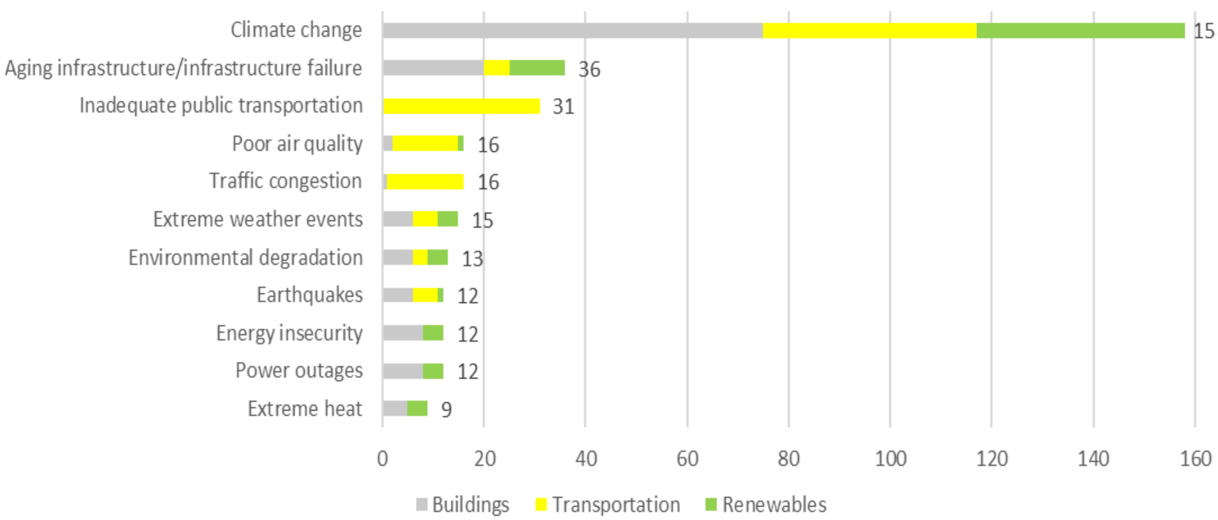

Figure 5. Initiatives by shocks/stresses mitigated

Cities targeted various sectors to mitigate particular shocks and stresses. For example, plans were most likely to consider improving transportation efficiency the best way to combat poor urban air quality, followed by improving building energy efficiency and increasing renewable energy. Improvements to building stock and replacing older fossil-fuel generation resources with renewables are most often cited as ways to address aging infrastructure and infrastructure failure. Initiatives intended to mitigate climate change spanned all sectors, which aligns with the global consensus on effective climate-change mitigation and reflects the dominant focus on climate change among the cities in our sample (IPCC 2018).

There also are several cities that use energy efficiency to address shocks and stresses other than those listed in figure 2 above. For example, Rio de Janeiro, Santiago de los Caballeros, and the Santiago Metropolitan Area all cited streetlamp LED retrofits as a strategy to reduce crime and violence in addition to reducing energy use and GHG emissions, thus illustrating the multifaceted benefits of energy efficiency for resilience planning.

In the following sections, we outline the most prominent and robust energy-resilience initiatives that cities are pursuing in their plans. We highlight specific examples and describe the stated resilience benefits of each initiative in the context of particular drivers.

Energy Efficiency Initiatives

Energy efficiency actions appear more frequently in city resilience plans than do actions focused on renewable energy. However our review shows that only a small number of plans include a robust set of initiatives designed to improve energy efficiency and to increase supplies of renewable energy. We rated 15 out of 66 plans as Exemplary or Substantial for their energy efficiency initiatives, and the rest as Adequate or Lacking. Therefore most cities are incorporating only a very small number of clean energy initiatives—or none at all—into their resilience plans. This suggests that while cities may recognize the benefits of energy efficiency, it is not a high priority among the many areas commonly addressed in community resilience plans. There are many ways to address energy efficiency and renewable energy within communities. In this section we highlight a handful of prominent energy efficiency initiatives that appear in several plans.

The most common robust energy efficiency initiatives included are:

- Encouraging sustainable modes of transportation
- Promoting transit-oriented development and transit efficiency strategies
- Increasing the number of private electric vehicles (EVs)
- Setting benchmarking, energy audit, and retrofit requirements for buildings
- Requiring fuel switching and/or electrification in buildings
- Developing microgrids
- Establishing municipal building and fleet efficiency policies

Table 3 outlines and summarizes these energy efficiency initiatives; it identifies cities that are leaders in making energy efficiency part of their resilience plans, as well as the shocks and stresses that the above initiatives are intended to mitigate.

Table 3. Prominent energy efficiency initiatives in resilience plans

Energy efficiency initiative	Leading cities	Shocks and stresses mitigated	Resilience benefits
Multimodal transportation	Buenos Aires, Greater Miami, Honolulu, Louisville, Melaka, Mexico City, New York, Rome, Santiago	Climate change, aging infrastructure/infrastructure failure, poor air quality, environmental degradation	• Reduces transportation-related energy use and GHG emissions • Provides alternative modes of transport in disaster situations • Frees up petroleum fuel supplies
Transit-oriented development and transit efficiency	Buenos Aires, Mexico City, Thessaloniki	Climate change, aging infrastructure/infrastructure failure, poor air quality	• Reduces transportation-related energy use and GHG emissions • Maintains property values • Protects residents from changes in fuel prices
Private EV uptake	Honolulu	Climate change, poor air quality, extreme weather events, earthquakes	• Reduces transportation-related energy use and GHG emissions • Can use battery to provide backup power in the event of grid failure
Building benchmarking, audits, and retrofits	Atlanta, Chicago, Dakar, Greater Miami, Honolulu, New York, Saint Paul*	Climate change, aging infrastructure/infrastructure failure, extreme heat, power outages	• Reduces building energy use and GHG emissions • Maintains internal temperatures in the event of grid failure • Hardens buildings against extreme events
Building fuel switching and electrification	New York, Alameda*	Climate change, aging infrastructure/infrastructure failure, poor air quality, extreme weather events	• Reduces building energy use and GHG emissions
Microgrids	Berkeley, Oakland	Climate change, aging infrastructure/infrastructure failure, extreme weather events, extreme heat, environmental degradation	• Islands itself in the event of grid failure and continues to deliver electricity • Reduces energy costs
Municipal energy efficiency strategies	Athens, Chicago, Dakar, Greater Miami, Honolulu, Rome, Vejle, Washington, DC	Climate change, aging infrastructure/infrastructure failure, extreme heat, power outages	• Reduces municipal energy use and GHG emissions • Allows policies and programs to be tested before citywide implementation

*City not included in the 100 Resilient Cities network

We now expand upon the resilience value of each energy efficiency initiative and detail how these initiatives are being pursued in select model cities.

MULTIMODAL TRANSPORTATION

Among city resilience strategies, the most detailed and prominent initiatives are plans to build well-connected cities with multiple modes of easily accessible transportation. These strategies are found worldwide: at least one city on all continents except Africa includes robust multimodal transportation initiatives in its resilience planning. Urban multimodal transportation systems are an effective climate-change mitigation strategy because they reduce city energy use and GHG emissions. Increasing bicycling to account for 11% of urban commuting can reduce long-term city energy use and associated GHG emissions by as much as 7% each worldwide (Mason, Fulton, and McDonald 2015). Multimodal transportation systems can also provide alternative modes of transit within a city in the event that one mode is disrupted. Multimodal transportation systems may also free up petroleum supplies when energy resources need to be diverted to critical vehicles and facilities (Ribeiro et al. 2015).

The resilience plans of Mexico City and the Santiago Metropolitan Area are examples of strategic multimodal transportation planning. For example, both plans include provisions to encourage bicycling. Mexico City also includes initiatives to develop pedestrian-only and car-free zones within the city, expand the EcoBici bikeshare program, create dedicated bike lanes, and develop a complete streets policy (Mexico City 2016).[4] Similarly, the Santiago Metropolitan Area is using its plan to encourage walking and bicycling trips. Specific initiatives include developing complete streets for both vehicles and bicycles, creating a 400-kilometer multipurpose trail for pedestrians and bicyclists in rural areas, installing short- and long-term parking spaces for bicycles, and launching road coexistence campaigns (Santiago de Chile 2017).

In addition to taking concrete steps to encourage bicycling, several cities are also investing in their transit systems. Melaka's strategy proposes creating new bus terminals, upgrading existing ones, and requiring bus operators to transition to zero- and low-carbon fleets to improve transit efficiency (Melaka 2019). To increase transit mode share, Greater Miami plans to create "mobility hubs" that will provide first- and last-mile solutions to help commuters reach current and new bus and rail stations. These solutions include increasing walking and bicycling infrastructure to reach the hubs, supporting carsharing and micro-transit, and installing infrastructure at the stations that supports electric and zero-emission transportation options (Greater Miami and the Beaches 2019). Several other cities also plan to increase their resilience by improving efficiencies in their transit services. The next section discusses how pairing transit efficiency investments with transit-oriented housing policies can enhance resilience.

[4] Focusing on street connectivity, complete streets policies aim to give pedestrians, bicyclists, motorists, and public transportation users easy and safe access to roads.

TRANSIT-ORIENTED DEVELOPMENT AND TRANSIT EFFICIENCY

Transit-oriented development (TOD) is a planning and development method that prioritizes mixed-use neighborhoods, walkability, and density near public transit (DOT 2019). Coupling TOD and strategic transit efficiency investments, such as expanded bus and rail lines, is a prominent climate-mitigation policy because—by reducing dependency on personal vehicle use—it can reduce transportation-related energy use and emissions citywide (EPA 2011). Further, TOD may improve economic resilience because it can safeguard households against changes in the price of fuel and maintain property values (Ribeiro et al. 2015). A small number of city resilience plans incorporate TOD and transit efficiency approaches at different stages of implementation. Thessaloniki, for example, proposes studying TOD by mapping land uses within 400 meters of metro stations and developing pedestrian zones (Thessaloniki 2017). More advanced city efforts include joint TOD and transit efficiency initiatives. For example, Buenos Aires plans on reforming its urban code to encourage mixed-use development while also building 16 kilometers of new subway tunnels that will link the city's existing 800-kilometer subway system (Buenos Aires 2018).

EV UPTAKE

The benefits of EVs as a climate mitigation and emissions-reduction strategy depend on which energy resources are used to generate the electricity that charges the vehicle. Consequently, the effectiveness of using EVs in this capacity can vary from city to city.[5] When promoting EVs, it is essential to consider how the added electricity load will be managed in order to maximize the emissions-reduction potential (Khan and Vaidyanathan 2018). The primary barrier to increasing EV use is the need to create a citywide charging network (Melton 2016).

Honolulu's resilience plan exemplifies a comprehensive approach to building a citywide charging network. Proposed actions include:

- Installing 30 Level 2 chargers at 15 municipal buildings
- Installing additional chargers in locations that complement the transit system and contribute to the development of a "carbon-free corridor"
- Updating the city's building code to ensure residential properties and parking lots are EV-ready
- Drafting an EV Readiness Plan to guide policies that will expedite EV charging projects, identify charging locations to optimize use, and incorporate additional EV provisions in the city's building code (Honolulu 2019).

Chicago's resilience plan seeks to electrify and retrofit commercial trucks and buses. Through the Drive Clean Chicago initiative, the city plans to leverage $20 million in federal

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[5] Cities served by grids with a higher concentration of fossil-fuel generation sources may see less value in EV integration because charging the vehicles may exacerbate carbon emissions. However the resilience value of EV integration increases as cities work to decarbonize their electric grids. In fact, EVs can enable a smoother and accelerated transition to decarbonization because charging the vehicles when electric demand is low and renewable energy output is at its peak can help avoid curtailment (Khan and Vaidyanathan 2018).

funding to put 500 low- and zero-emissions commercial vehicles on its streets (Chicago 2019).

Last, Wellington's resilience plan proposes to build out a citywide EV charging network to shield the city from vulnerabilities in its fuel supply chain, particularly in the aftermath of an earthquake (Wellington 2017). Wellington's strategy highlights the full potential of using EVs as a resilience initiative, beyond simply reducing GHG emissions. In 2011, the Tohoku earthquake and tsunami in Japan exposed the consequences of relying on vehicles that used traditional fuels. In the aftermath of the disaster, EVs were used to bring food and medical relief to communities affected by the earthquake and tsunami (Belson 2011). In disaster areas, restoring electricity often takes priority over replenishing petroleum fuel supplies. Thus, EVs will likely have access to energy sooner than petroleum-fueled vehicles.

BUILDING BENCHMARKING, AUDITS, AND RETROFITS

Improving the energy efficiency of buildings can support grid reliability and enable people to remain in their dwellings during outages or other disruptions to energy supplies. Reducing energy consumption in the built environment is also a leading strategy for reducing GHG emissions.

Policies that require energy-consumption benchmarking aim to increase energy efficiency investments in buildings, as tracking a building's energy performance over time can alert owners and managers to potential inefficiencies. In turn, benchmarking can spark energy-saving actions and enable building owners to measure and track improvements. Cities that require benchmarking have seen a cumulative energy savings of 3–8% in their building stock over a two- to four-year period (Mims et al. 2017).

Building retrofits can not only increase the overall energy efficiency of a building and its resistance to extreme events but also harden buildings against extreme weather and other shocks, such as earthquakes (Phillips 2017). However, while several city plans mention the importance of taking actions that both harden buildings and improve their energy efficiency, no plan proposes such a mandate.

Honolulu's plan includes proposals to benchmark commercial buildings and single-family homes; it also proposes requiring energy-saving actions. Under the city's proposed Energy Benchmarking and Retro-commissioning Ordinance, commercial buildings will have to benchmark energy usage, adhere to a set retro-commissioning schedule, and meet phased energy intensity reduction targets. The ordinance will also require noncompliant buildings to undergo retrofits. In addition, the city intends to adopt a residential energy disclosure policy. If passed, the Residential Energy Conservation Ordinance will require owners and landlords to provide energy information to buyers and renters (Honolulu 2019). The latter ordinance does not require owners to take energy-saving actions, but making residential energy use visible can drive consumer demand for more energy-efficient properties, and this transparency can result in energy-saving upgrades (ACEEE 2018).

Benchmarking efforts in Honolulu and other US cities benefit from access to several state and federal resources such as EPA's ENERGY STAR® Portfolio Manager. Funding for energy efficiency retrofits may be a barrier for many other cities.

In countries that are just beginning to pursue energy efficiency, cities are first tackling low-hanging fruit. Dakar's resilience strategy illustrates how cities in developing countries can make minor improvements to existing systems to leverage significant energy savings and improve electric reliability by reducing power demand. Dakar's resilience initiatives include retrofitting commercial buildings with self-regulating thermostats for air-conditioning units, which will result in energy savings of 28% over four years against 2013 levels. The city also plans to replace incandescent light bulbs (which make up 70% of lighting in commercial buildings) with LEDs, achieving energy savings equal to 11 times the city's lighting consumption in 2013 by 2030 (Dakar 2016).

BUILDING FUEL SWITCHING AND ELECTRIFICATION

Fuel switching, a strategy to reduce GHG emissions, is the process of converting existing building heating equipment so that it can use less carbon-intensive fuel sources. For example, propane or heating oil boilers and furnaces can be retrofitted to use natural gas. Electrification is another fuel switching strategy; its popularity is growing rapidly as communities work to reduce carbon emissions from transportation and buildings. In buildings, the primary target for electrification is replacing fossil-fuel boilers and furnaces with electric heat pumps.

New York's resilience plan is an example of how cities can use both voluntary and mandatory measures to facilitate a transition to more efficient, less carbon-intensive fuel sources in buildings. Under New York's strategy, #4 heating oil will be banned citywide by 2030. To facilitate this phaseout, the city has proposed to incentivize fuel switching through the Retrofit Accelerator Program. Reducing carbon emissions also reduces other harmful emissions, which improves public health, particularly in low-income areas of the city that have poor air quality (New York 2015). Alameda's plan, though not associated with the 100 Resilient Cities network, takes fuel switching a step further: the city will require all new buildings to use all-electric heating equipment. The city will also require existing buildings undergoing substantial redevelopment to convert their heating systems from gas to electric (Alameda 2019).

MICROGRIDS

Microgrids can be valuable resources for community resilience, particularly if they can operate independently (island) from the main grid during times of grid stress or failure. When considering the inclusion of microgrids in their plans, cities need to assess their resilience objectives and needs in order to choose the optimal design and model. Some microgrids are designed to increase the cost effectiveness of electricity delivery from the grid; others are designed to supply power during grid outages (DOE 2019b). Microgrid designs should also include diverse resources to ensure a consistent power supply. A diverse portfolio of energy resources such as solar, storage, diesel generators, and combined heat and power can prevent microgrids from excessive reliance on a single resource and ensure continued operation should a disaster constrain resource supply (Bakke 2016). For example, microgrids that only incorporate diesel generators have a less than 90% probability of surviving an outage that lasts more than two days and almost no chance of surviving an outage of three days or more because of uncertainties surrounding fuel resupply. However microgrids that incorporate solar, storage, and diesel maintain a 90% survivability rate for about 3.5 days, which falls to 50% after 4.5 days (Anderson et al. 2017). Therefore several resilience strategies incorporate a cross-cutting approach to microgrid design and resource integration.

The importance of improving the energy efficiency of buildings within a microgrid should not be overlooked. When these buildings perform at or near maximum efficiency, less generation is needed to power them (Ribeiro et al. 2015), thus freeing additional capital that cities can use to incorporate more buildings into the microgrid or to simply reduce total project costs.

Berkeley's resilience plan proposes the development of a series of solar-plus-storage microgrids that connect both public and private critical facilities (Berkeley 2016). Oakland's resilience plan takes a comprehensive approach to microgrid design by addressing both supply and demand. In its EcoBlock pilot project, Oakland is creating a solar-powered microgrid that encompasses an entire city block. This project also includes deep energy retrofits in 30 low-income residential buildings on the block and the use of smart controls and on-site storage (Oakland 2016). Oakland's efforts are projected to run the EcoBlock on near net-zero energy and to reduce emissions by 85% (Salem 2018).

Another advantage of microgrids is their ability to continue delivering electricity during extreme weather events. In 2017, microgrids in the Houston area provided electricity to grocery stores and gas stations during Hurricane Harvey. One of these stores ultimately served as a makeshift operations center for National Guardsmen, a search-and-rescue team, and other government agencies (Microgrid Knowledge Editors 2018).

MUNICIPAL ENERGY EFFICIENCY STRATEGIES

Across all resilience plans, initiatives to improve the energy efficiency of municipal building and fleet operations are among the most prevalent. Local government initiatives seeking to reduce the energy use of buildings and increase the percentage of efficient vehicles and EVs in the municipal fleet are a pillar of sustainability, GHG emissions reduction, and climate-change mitigation (Ribeiro et al. 2019).

Greater Miami's resilience plan takes this lead-by-example approach in its proposed Building Efficiency 305 program, under which local governments in the Greater Miami area will benchmark and improve building energy performance before the program expands to the commercial and residential sectors (Greater Miami and the Beaches 2019). Rome's plan addresses municipal fleet efficiency and electrification. That city is taking actions to procure more zero-emissions vehicles by 2025, at which point it will begin purchasing EVs exclusively (Rome 2018). Another municipal transportation initiative is the development of charging station networks. By increasing the number of EVs in the municipal fleet and expanding EV charging infrastructure, municipal governments can gradually encourage private EV uptake (Khan and Vaidyanathan 2018). In the United States, local governments are the second-largest owner of EV charging stations (AFDC 2019)

Renewable Energy Initiatives

While energy efficiency is the most prevalent energy resilience strategy, renewable energy can also play a vital role in achieving city resilience objectives and climate-change mitigation outcomes. The success of a resilience initiative often depends on how effective and innovative a city is at pairing energy efficiency and renewable energy (DOE 2019a).

Increasing renewable energy supplies is a common objective in the plans we evaluated; 42 out of 66 cities include at least one initiative to increase renewable energy generation. As with energy efficiency, however, only a small number—13 out of 66—have sets of initiatives that we rate as Substantial or Exemplary. This section examines prominent renewable energy and storage initiatives that cities have included in their resilience plans.

One common initiative is setting a goal to generate 100% of a city's energy from renewable sources. Other common renewable energy initiatives include:

- Increasing local wind energy generation
- Increasing the penetration of solar-plus-storage systems
- Constructing waste-to-energy facilities
- Installing or purchasing municipal renewable energy

Table 4 summarizes the resilience value of these initiatives.

Table 4. Prominent renewable energy initiatives in resilience strategies

Renewable energy initiatives	Leading cities	Shocks and stresses mitigated	Resilience benefits
Renewable energy generation	Atlanta, Chicago, Honolulu, Los Angeles, Malmö,* Washington, DC	Climate change, aging infrastructure/infrastructure failure, extreme heat, environmental degradation, power outages, fires	• Decarbonizes the electric grid
Wind energy generation	New York	Climate change	• Decarbonizes the electric grid
Solar plus storage	Berkeley, Honolulu, San Francisco	Climate change, aging infrastructure/infrastructure failure, extreme weather events, extreme heat, earthquakes	• Provides backup power to buildings in the event of grid failure • Produces local renewable energy year-round • Reduces building GHG emissions
Biogas	New York, Ramallah, Santiago	Climate change, aging infrastructure/infrastructure failure, environmental degradation, power outages	• Serves as a joint waste management and sustainable energy strategy • Can provide energy-insecure cities with locally generated energy

Renewable energy initiatives	Leading cities	Shocks and stresses mitigated	Resilience benefits
Municipal renewable energy strategies	Amman, Chicago, Honolulu, Los Angeles, Melbourne, New York, Ramallah, Rio de Janeiro	Climate change, aging infrastructure/infrastructure failure, extreme heat, environmental degradation, power outages, fires	• Decarbonizes the electric grid • Can provide energy-insecure cities with locally generated energy

*City not included in the 100 Resilient Cities network

LOCAL RENEWABLE ENERGY GENERATION

Initiatives to increase local renewable energy generation and consumption take several forms, one of which is the setting of a renewable or clean energy goal or mandate. This type of initiative, which appears in several resilience plans, requires city energy suppliers to achieve a certain percentage of renewable or clean energy by a set year. Renewable energy goals most commonly entail increasing the share of wind, solar, hydroelectric, and/or geothermal energy. Clean energy goals may be broader, including not only renewable energy resources but also other zero- and low-carbon energy resources such as nuclear or biomass.

Renewable energy goals and mandates seek to reduce carbon emissions from buildings and industry by changing the source of the electricity that powers these sectors. Setting such goals is a significant climate mitigation strategy. The Intergovernmental Panel on Climate Change states that renewables must supply 70% to 85% of electricity by 2050 if global temperature increases are to stay within 1.5°C (2.7°F) (IPCC 2018). To support reaching this target, several cities have adopted renewable energy goals that require or encourage energy suppliers to use 100% renewable energy. For example, Los Angeles has adopted a mandate to use 100% renewable energy by 2050, and the city's resilience plan states the intention to replace 70% of existing power with renewable energy resources in the next 15 years.

Los Angeles has its own municipal utility, which gives the city direct authority over energy resource decisions (Los Angeles 2018). Cities like Atlanta, which have 100% renewable energy goals but are served by investor-owned utilities, do not have direct authority over the mix of energy sources they use. Rather they must work to create the necessary regulatory and market environment to reach their clean energy objectives. Cities without their own municipal utilities do have some options, including mandating energy efficiency requirements in buildings, offering incentives and financing options for renewable energy, and entering into energy performance contracts with their investor-owned utilities (Atlanta 2017).

LOCAL WIND ENERGY GENERATION

Very few plans included initiatives to increase wind energy production. One exception is New York's plan, which includes early-stage provisions to increase the share of wind energy in the city's power mix by changing market entry rules, reducing financial risk, identifying port assembly sites, assessing interconnection points, and updating zoning rules to streamline wind installation (New York 2015). New York's plan suggests that cities must start by reforming local codes and barriers; only after that can wind energy begin to gain traction in a city. Wind energy can also provide resilience value as a distributed resource capable of withstanding some weather events and islanding itself if need be. Wind generation may falter during extreme weather events like as tornadoes and hurricanes, but it is capable of performing at its highest capacity during more moderate weather events (DOE 2018). This was the case in the United Kingdom in 2018 when a severe cold snap resulted in record wind output (Wentworth 2018).

SOLAR PLUS STORAGE

Installing solar-plus-storage systems is a strategic way to ensure that a building or series of buildings maintain power in the event of a power outage. Solar-plus-storage systems have a 90% chance of surviving a power outage of about 3.5 days when paired with diesel generators (Anderson et al. 2017). An important consideration when siting such systems is to prioritize (1) buildings that can serve as community shelters and (2) critical facilities such as police departments, fire stations, and healthcare facilities. For example, Hurricane Maria caused almost the entire island of Puerto Rico to lose power. In the hurricane's wake, solar plus storage continued to generate electricity at San Juan's VA Hospital, but the lack of power at other healthcare facilities, such as dialysis centers, led to an unnecessary loss of lives (DOE 2018; Hernandez, Schmidt, and Achenbach 2018). Finally, prioritizing critical facilities that are in underserved areas can ensure that the most vulnerable members of a community are not unduly burdened when seeking shelter or resources.

San Francisco's Solar + Storage for Resiliency Project is an example of how solar-plus-storage systems can be used to increase community resilience. This project, now concluded, aimed to create a citywide network of buildings powered by solar-plus-storage energy systems. The project considered financial and technical feasibility, identified critical power needs, and studied how to size the system for maximum benefit (San Francisco 2016).

Another important consideration when designing solar-plus-storage systems is to strengthen them against extreme events. For example, a flexible racking device can allow solar systems to withstand hurricane-force winds, as occurred at San Juan's VA Hospital, where the system operated at capacity during Hurricane Maria. Shielding battery systems from water damage and flooding is also critical to ensure that systems stay operational during extreme events (DOE 2018).

BIOGAS

Biogas, a type of waste-to-energy resource, is often used as a low-carbon alternative to fossil-fuel energy resources, particularly in critical facilities like wastewater treatment plants (DOE 2018). Waste-to-energy plants are known for their ability to provide both electric and thermal energy (i.e., combined heat and power) during operation, and during disasters, they can be just as reliable as their natural gas–powered counterparts (Chittum 2012). Moreover, waste-to-energy plants can provide benefits year-round. Ramallah, for example, has proposed a waste-to-energy plant to address energy insecurity, as the city imports all its electricity from foreign neighbors (Ramallah 2017). Because waste-to-energy has the advantage of serving as both a waste management system and a source of sustainable energy, several cities, particularly in developing countries, include this type of initiative in their resilience plans.

MUNICIPAL RENEWABLE ENERGY STRATEGIES

Like municipal energy efficiency strategies, municipal renewable energy strategies were also among the initiatives most commonly included in city resilience plans, with solar energy being the chief resource pursued. Cities we reviewed planned to install onsite resources, purchase renewable energy through contracts with their utility, or conduct pilot projects on municipal buildings before citywide implementation. For example, Ramallah and Amman, two energy-insecure and -dependent cities, planned to install solar energy on municipal buildings (Ramallah 2017; Amman 2017). These installations would provide the cities with an independent energy source able to power additional privately owned buildings if connected to the grid. Melbourne plans to partner with nearby local governments and anchor institutions to enter into group purchasing contracts for utility-scale generation (Melbourne 2016). Los Angeles and Rio de Janeiro are planning solar energy pilot projects on municipal buildings before expanding the programs citywide (Los Angeles 2018; Rio de Janeiro 2015).

Energy Equity and Affordability

Energy equity—reducing energy burdens and improving energy affordability—is an objective in the resilience plans of a number of cities, including Athens, Chicago, and New York. Poor and disadvantaged communities in urban areas face disproportional exposure to the shocks and stresses of climate change, and actions and strategies that incorporate social justice and equity into the planning process are integral—not peripheral—to limiting global temperature rise to 1.5°C (2.7°F) (Hoerner and Robinson 2008; IPCC 2018).

Not only do marginalized communities face increased exposure to the abovementioned risks, they also grapple with higher energy costs in what is known as a cost burden (Drehobl and Ross 2016). Compounding these disadvantages, marginalized communities can also face higher transportation costs (Vaidyanathan 2016). Generally, alleviating energy and/or transportation cost burdens is the main goal of the energy- and transportation-equity initiatives in city resilience plans, but these are not the only types of burdens cities seek to alleviate. For example, New York City's efforts to phase out certain types of heating oil is driven in part by the fact that many buildings using more-polluting oils are in low-income communities.

When assessing energy equity provisions within resilience strategies, we classified cities as Active, Passive, or Does not consider. We also considered transportation-equity provisions to be in the same category as energy equity. Active energy equity considerations satisfy two criteria:

- The city has collected specific data pertaining to energy and/or transportation inequity.
- The city has identified specific goals and/or initiatives it will pursue to remedy energy and/or transportation inequity.

Cities classified as Passive only satisfy one of the above, and those classified as Does not consider satisfy none.

Our findings indicate that only 8 out of 66 cities actively address energy- and/or transportation inequity in their plans, and only 11 cities passively address the issue. Notably, 47 out of 66 cities do not consider energy- and/or transportation equity at all.[6] The full set of city classifications can be found in Appendix E.

LEADING CITIES

Table 5 summarizes energy equity initiatives from selected cities as examples of ways to address affordability and energy burdens.

Table 5. Leading cities with energy or transportation equity considerations

Leading cities	Sector	Data collected	Energy equity resilience initiatives
Athens	Energy	% of households without insulation; % of households using heating oil	• Establish an energy poverty observatory • Launch an energy-saving awareness campaign • Create building renovation passports
Honolulu	Transportation	Cost of transportation relative to national average	• Launch a vehicle buyback program aimed at low- and middle-income (LMI) households • Provide rebates and incentives to participating LMI households • Raise the fuel tax to fund the program
Toronto	Transportation	% commuter mode and duration by race and sex	• Create a mobility action plan to expand sustainable modes of transport in underserved communities • Identify additional routes to increase the efficiency of public transit to underserved communities

Identifying data related to energy equity is important for understanding the extent of historic trends and for planning remedial actions. Data can help local governments identify marginalized demographic groups and neighborhoods and uncover additional environmental, social, and economic inequities (Park 2014). Collecting data is the first step in planning an energy initiative that seeks to effectively combat energy inequity. Below we describe energy equity initiatives included in resilience planning in Athens, Honolulu, and Toronto.

Athens

Athens' resilience plan includes a section specifically dedicated to remedying energy burdens. According to the city, 25% of Athenians are unable to warm their homes in the winter due to costs. The city has identified two main energy burdens: the percentage of

[6] This is not to say that city resilience plans do not consider equity at all. We are singularly focused on equitable planning within the context of energy and transportation.

households living without insulation and the percentage of households using heating oil. Athens proposes three solutions. First, the city will establish an observatory that will study energy inequities within the city and offer solutions. Next, the city will embark on a campaign to promote energy savings within buildings. Last, the city will use energy audits to create "building renovation passports" for individual buildings. These "passports" will establish step-by-step energy efficiency roadmaps for audited buildings over a 15- to 20-year time horizon (Athens 2017).

Honolulu

Honolulu residents face transportation costs 34% higher than the United States' average. To address this disparity, the city proposes to establish a buyback program for high-emission and inefficient personal vehicles to lower transportation costs. The primary targets of the program will be low- and middle-income households. The city will provide participating households with public transportation incentives or rebates to be used toward the purchase of an EV. Although EVs are sometimes considered an expensive climate-mitigating strategy, Honolulu's unique plan views EVs as a strategy to address both energy and economic inequities. Honolulu proposes raising its fuel tax to fund this program, predicting that a tax increase of 5 cents per gallon could put 2,250 clean vehicles on the road every year (Honolulu 2019).

Toronto

Having identified Black Torontonians as the demographic most likely to face longer commute times, the city's transportation-equity initiatives aim to reduce commute lengths in underserved communities. Although lowering the energy intensity of its transportation sector is not Toronto's primary goal, the proposed mobility action plan will strengthen walking, biking, and transit infrastructure, and so it will increase the energy efficiency of the transportation sector as an added benefit (Toronto 2019).

Missed Opportunities

Many of the community resilience plans that we reviewed did not include certain initiatives that could increase energy efficiency and renewable energy supplies. Cities that miss out on these opportunities may lose potential resilience benefits and increase the risks to energy systems and infrastructure. Below we discuss the key missed opportunities revealed in our review.

CITY–UTILITY PARTNERSHIPS

Energy utilities can be valuable partners for cities by helping them deliver clean energy programs. Cities can work with the utilities serving their communities to promote energy efficiency among households, businesses, and industries, including initiatives for energy equity. They can also establish renewable energy standards that increase the share of energy derived from clean sources, and they can even develop their own renewable energy resources that serve their communities directly.

Cities with municipal utilities are especially well aligned to work toward common clean energy goals because the city government oversees utility administration and operations. Cities can also partner with investor-owned utilities (IOUs). For example, Minneapolis has established a strong partnership with Xcel Energy, the IOU that serves the city. The partnership aims to increase energy efficiency and renewable energy supplies and impacts.

We found a few other resilience plans that incorporated city–utility partnerships. New York, for example, includes initiatives to work with its electric and natural gas utilities to harden infrastructure, protect against climate risks, and implement storm resiliency measures such as fixing leak-prone pipes and gas mains. New York is also working with National Grid, its natural gas utility, to build a waste-to-energy plant capable of converting 8% of the city's food waste into renewable biogas (New York 2015). Wellington also partners with its utility to build redundancy and flexibility into the electrical grid through more distributed and decentralized energy generation (Wellington 2017).

It is important to note that the 100 Resilient Cities strategy template may have inadvertently deterred cities from providing details on the exact role of utilities in their resilience plans. Many cities listed their utilities as "partners" for each action and may have deemed this sufficient and omitted additional information.

Hardening and Efficiency Policies for Existing Buildings

Retrofit policies that require owners to both harden and improve the energy efficiency of buildings are uncommon. However resilience strategies do present several avenues that may be used to pursue this dual approach. Honolulu, for example, proposes a program that will finance hurricane-resistant retrofits in homes built before 1995, but the program does not include energy efficiency provisions like retrofitting buildings to meet or exceed current energy codes (Honolulu 2019). Wellington's resilience plan acknowledges the potential benefits of joint hardening and energy efficiency retrofits. The city proposes to study when seismic hardening improvements can be linked to energy efficiency improvements to a home's ventilation, insulation, and windows. However the city falls short of proposing a mandatory policy or program (Wellington 2017).

San Francisco may provide the best example of a joint hardening and energy efficiency program; the city highlights several examples of buildings that underwent seismic hardening and energy efficiency retrofits. However the city does not suggest adopting a mandatory policy that would require building owners to both harden and improve the energy efficiency of their buildings.

Retrofitting buildings to exceed codes is a robust climate and disaster mitigation policy. Research suggests that investing in buildings to meet or exceed certain provisions of the 2015 International Building Code and International Residential Code can be cost effective, prevent injury and disaster-induced mental health conditions, and save lives. These investments can spur job creation, adding an additional layer of economic resilience (Multihazard Mitigation Council 2018). Further, actions targeting the building envelope can enhance both efficiency and resilience. For example, installing impact-resistant windows and shutters can achieve energy cost-savings of 29% (HUD 2017). Initiatives that target energy efficiency and hardening improvements also contribute to long-term economic resilience for building owners, as the energy efficiency retrofit can generate savings over time and the hardening retrofit can help owners avoid economically disastrous rebuilding costs.

EVS AS A CLIMATE-RESPONSIVE RESOURCE

Many plans include initiatives to integrate EVs into both municipal and private fleets. The chief justification for these plans is that EVs will reduce GHG emissions and energy use, as well as improve local air quality and public health. While the value of EVs as a climate mitigation resource is evident in city resilience strategies, not much is said on the value of EVs as emergency response resources, particularly in the context of vehicle-to-building and vehicle-to-grid applications.[7]

Vehicle-to-building (V2B) allows vehicle owners to power a building from an EV's charged battery. A partially charged battery can supply electricity to a building for up to a few hours, while additional benefits depend on whether the vehicle can move out of the impact zone to recharge. V2B can enhance resilience by reducing peak demand and providing demand response (Khan and Vaidyanathan 2018), thus protecting cities from stresses such as power outages and safeguarding against shocks by supplying energy when extreme events knock out the power grid. Municipalities can take the lead on V2B integration by identifying a handful of buildings that provide the most value in disaster situations. Cities should target critical buildings like police departments, fire stations, and healthcare facilities when prioritizing V2B project sites.

Vehicle-to-grid (V2G) uses come with a unique set of resilience values and can serve as a complement to V2B applications. While both uses provide energy reserves, V2G applications can help maintain the local distribution grid by providing frequency regulations and voltage control in times of grid disruption. V2G can also help grid operators avoid renewable energy curtailment by satisfying demand during peak solar or wind output (EAC 2018).

The success of both V2B and V2G is directly linked to a city's EV charging network. Vehicles and chargers capable of bidirectional energy flows are necessary to make the process technically feasible. Unfortunately, the availability of these chargers is currently the exception and not the rule (Khan and Vaidyanathan 2018). Local governments can take the lead by creating pilot projects that realize the full resilience value of EVs.

Recommendations

Cities are major contributors to global GHG emissions. In response, communities around the world are recognizing the benefits of energy efficiency and renewable energy in addressing climate change, as evidenced in their resilience plans. By taking actions to increase energy efficiency and renewable energy, cities can reduce their GHG emissions. In doing so, they can also strengthen community resilience against the potential impacts associated with a warmer climate, such as increases in the number and severity of damaging weather events.

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[7] A few resilience plans recognize the potential of EVs as emergency energy resources but stop short of proposing vehicle-to-building and/or -grid policies or programs.

The majority of community resilience plans we reviewed include a mix of energy efficiency and renewable energy initiatives. This is a positive sign that cities are working to increase community resilience and address climate change. However only a small number of community resilience plans have robust sets of energy efficiency and renewable energy initiatives, indicating that there are many missed opportunities and much room for improvement.

To strengthen energy efficiency and renewable energy initiatives within community resilience plans, we recommend the following:

- Cities without robust initiatives in their plans can examine and emulate those cities that have a comprehensive set of initiatives for increasing energy efficiency and renewable energy in their communities.
- Cities can learn from their more experienced counterparts and adapt initiatives that the latter have included in their plans. Fortunately, there are many edifying examples. It also is important to monitor and review the results of these experiences to determine which initiatives are most effective, particularly because of the newness of these efforts.
- Cities can consider opportunities not included in the resilience plans that we reviewed. These opportunities include city–utility partnerships, hardening and efficiency policies for existing buildings, and EV use as a climate-responsive resource.

We encourage cities to expand and strengthen their clean energy initiatives within their resilience plans to increase the impact and effectiveness of the latter. By taking appropriate actions, cities can be leaders and play a major role in meeting global targets for reducing harmful GHG emissions, thereby lessening the impacts of climate change.

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Appendix A. Lessons and Applications for Taiwan

The shocks of greatest concern for Taiwanese cities are heat waves, typhoons, earthquakes, and climate change. High-heat events can stress the electricity supply due to high power demand. Improving the thermal envelopes of buildings and increasing the efficiency of air-conditioning equipment and lighting systems (especially commercial) can greatly reduce summertime electricity demand during these heat events. Well-insulated buildings and the use of various passive cooling systems and technologies can also make residential buildings livable during the electric system outages that occur during hot weather. The cities in table A1 can serve as guides for Taiwan's resilience planning efforts.

Table A1. Model cities for Taiwan

Model city	Threat type	Threat	Resilience initiative
Honolulu	Shock	Typhoons	Create a typhoon-retrofit program to protect existing buildings and incorporate provisions that improve both resilience and energy efficiency
	Stress	Climate change	Use renewable energy to power 100% of island-wide energy demand
	Stress	Extreme heat	Launch a benchmarking program for private buildings to encourage energy efficiency and reduce electricity demand
Wellington	Shock	Earthquake	Transition municipal and private fleets to EVs to safeguard against petroleum fuel supply shortages
Dakar	Stress	Power outages	Retrofit existing buildings to reduce energy demand
Hong Kong	N/A	N/A	Install information and communications technology within grid infrastructure to protect against disruptions
	N/A	N/A	Expand transit-oriented development strategies and set transit ridership goals

To limit the effects of climate change, Taiwan can follow Honolulu's lead and set the goal of using renewable energy to meet 100% of demand. Wellington's EV efforts also seek to limit petroleum supply vulnerabilities and can therefore serve a model for Taiwan. These two initiatives can also safeguard Taiwan against disruptions in fuel supply that may result from earthquakes.

Pursuing the above initiatives may also limit Taiwan's exposure to another critical stress: energy insecurity. Taiwan imports 98% of its energy and relies heavily on oil, coal, and natural gas to meet its energy needs (EIA 2016). This dependency leaves Taiwan extremely vulnerable to fuel supply disruptions and shortages. Reducing dependence on imports and establishing a domestic supply of energy can help Taiwan bolster resilience on multiple fronts.

Because Taiwan experiences typhoons, it may be useful to apply lessons from Honolulu's proposed hurricane retrofit program. Implementing retrofit requirements that improve energy efficiency can give participating buildings an additional layer of resilience.

Hong Kong can serve as a guide for Taiwan because the two regions face similar challenges. Hong Kong aims to incorporate information and communication technologies into its transmission and distribution grid to optimize system performance and safeguard against any attacks or disruptions to the energy system. Further, Hong Kong plans to incorporate energy-efficient design into its buildings, as well as to harden coastal buildings by raising them above current levels, installing flood gates, and moving electric and mechanical facilities to the upper floors of buildings to shield them from flooding. Finally, citing its existing rail-oriented development plans in its resilience strategy, Hong Kong is expanding its rail system to 300 kilometers so that 75% of the population and 85% of employment opportunities will be near railways, allowing Hong Kong to retain its impressive public transit ridership levels of 90% (Hong Kong 2016).

Taiwan's remote mountain villages face a significant barrier to resilience planning: landslides. No plan directly uses energy initiatives to respond to this threat, which can devastate infrastructure and result in near total capital losses. If landslides are common in a particular area, governments and institutions can be reluctant to reinvest given the associated risk. Because their isolation can prevent a speedy recovery, these villages can often go weeks without power in the event the local transmission and distribution grid fails or is damaged. Thus, vehicle-to-building (V2B) applications may be useful in enhancing the resilience of remote villages. In the context of emergency response, the island government can identify buildings in vulnerable areas and equip them with the necessary infrastructure to support bidirectional energy flow. Vehicles can then be used as critical sources of onsite energy to support rebuilding and recovery efforts in villages; they can also be used to transport residents out of the village in the event an early warning system predicts that a landslide is about to occur. V2B also minimizes capital losses because the island government only needs to equip a few buildings with V2B capability. A solar-powered EV charging station will also ensure that vehicles have a renewable source of energy. However siting the station appropriately to minimize its exposure to landslides is paramount to the efficacy of this approach. We thus recommend further research into the resilience value of V2B applications against landslides.

Appendix B. Resilience Plans outside the 100 Resilient Cities Network

Resilience plans not associated with the 100 Resilient Cities network were difficult to find. When searching for plans, we aimed to emulate the global geographic diversity achieved by the 100 Resilient Cities initiative, but ultimately we did not find any resilience plans from South America or Africa with English translations. That said, the findings of the plans we did obtain were consistent with those of the 100 Resilient Cities plans in the context of energy efficiency, but the majority earned Substantial ratings for renewable energy. We used the same rating system as described in Appendix D to determine how these cities would perform if they were included in the 100 Resilient Cities initiative. Table B1 outlines the ratings each city achieved.

Table B1. Resilience plans of cities outside 100 Resilient Cities

City	Country	Energy efficiency	Renewable energy	Equity
Alameda	United States	Substantial	Substantial	Does not consider
Hong Kong	China	Substantial	Adequate	Does not consider
Malmö	Sweden	Lacking	Substantial	Does not consider
Saint Paul	United States	Exemplary	Substantial	Active
Shimla	India	Lacking	Lacking	Does not consider

We find that the 100 Resilient Cities network does not appear to bias cities in a certain direction with regard to energy planning, as the initiatives in the outside plans were similar to those in 100 Resilient Cities. For example, Saint Paul's Climate Action & Resilience Draft Plan included several proposals that echo those of Honolulu's resilience plan. The city included initiatives such as mandatory benchmarking, voluntary retrofit programs, robust private EV uptake programs, and increases in biking infrastructure. Saint Paul also had comprehensive approaches to remedying energy inequity (Saint Paul 2019). Further, Alameda's plan achieved a Substantial rating, as it followed the trend of other American cities by declaring that its municipal electric utility will deliver 100% clean energy by 2020 (Alameda 2019). Further, the percentage of plans within 100 Resilient Cities that do not consider equity is about 70%, while that percentage among outside cities is 80%. A larger sample size may have yielded results closer to the 70% of 100 Resilient Cities.

Appendix C. Resilience Plan Initiatives

An initial step of our review was a macroanalysis to determine the kinds of energy efficiency and renewable energy initiatives cities were including in their resilience plans; Table C1 outlines those macro-level initiatives. We use this list as a guide and reference for our review of the plans included in our research. It is not necessarily a definitive list of all possible resilient energy initiatives included in available community resilience plans.

Table C1. Initiatives in city resilience plans

Sector	Initiative
Building efficiency	Update building codes
	Establish a green building certification program
	Promote net-zero buildings
	Offer incentives for energy efficiency upgrades
	Establish benchmarking, auditing, and retrofitting requirements
	Conduct lighting retrofits
	Create voluntary energy efficiency challenges and/or programs
	Promote or require fuel switching in buildings or district energy systems
Grid reform	Pursue the creation of microgrids or smart grids
	Bolster grid resilience generally and/or add redundancy
	Offer demand response programs
	Seek energy efficiency market reform
Public-facing energy efficiency strategies	Promote workforce development and/or energy entrepreneurship
	Conduct public awareness campaigns on energy efficiency
	Draft a sector-specific energy efficiency plan
Transportation efficiency	Encourage private EV uptake
	Promote multimodal transportation
	Require transit-oriented development and boost transit efficiency
Municipal approaches to energy efficiency	Improve municipal building efficiency
	Procure low-emitting and EVs for municipal fleets
Renewable energy	Establish renewable energy goals or support utility-scale renewable energy generation
	Promote and install locally-owned solar energy generation
	Install local wind energy generation
	Pursue and construct small hydroelectric energy generation
	Construct waste-to-energy facilities
	Deploy solar-plus-storage or storage systems
	Seek renewable energy market reform

Sector	Initiative
Public-facing and community-based renewable energy strategies	Draft a resource- and/or community-specific plan that aims to increase local renewable energy generation
	Conduct public awareness campaigns on renewable energy
	Create renewable energy cooperatives and enroll city residents
Municipal approaches to renewable energy	Install renewable energy on municipal buildings and/or properties
	Enter into a renewable energy group purchasing contract

Appendix D. Initiative and Plan Ratings

We developed a qualitative rating scheme to characterize the relative strength of each energy initiative a city included in its resilience strategy: robust, comprehensive, and general. We classify robust initiatives according to these criteria:

- Initiative has a clear objective
- Several supporting actions are detailed and listed
- Initiative is mandatory and applies citywide
- Initiative has clear energy resilience value or implications

A comprehensive initiative satisfies three out of the above four criteria, and a general initiative only satisfies one or two of the four.

Furthermore, 100 Resilient Cities is a global initiative encompassing cities with energy policy landscapes at various stages of development that often seek to mitigate an array of city-specific challenges. For example, cities in developing countries may not have access to the same resources as those in developed countries, so cities in developing countries may have earned higher ratings for initiatives that may seem standard or routine in developed countries. For example, Dakar's plan included an initiative to install thermostats in commercial buildings. Though this may be the standard is many other countries, the city defined the initiative as a key method of lowering energy use and shielding the city from chronic power outages. Thus, in some cases, we accounted for these considerations when rating energy initiatives.

To identify city plans that placed a high value on energy efficiency and renewable energy, we compiled the number of robust, comprehensive, and general energy efficiency and renewable energy initiatives for all cities and developed unique quantitative rating systems for both energy efficiency and renewable energy.

For energy efficiency, we established the Exemplary, Substantial, Adequate, and Lacking thresholds by first finding the total number of initiatives at the 95th, 70th, 50th, and 10th percentiles, respectively. These percentiles were natural cutoff points in the data. We then found the median number of actions by strength using the total number of initiatives. For renewable energy, we followed an identical process, but the natural cutoff points were located at the 95th, 90th, 80th, and 40th percentiles. These percentiles were not used as definitive criteria but rather were used as reference points when devising the rating system.

Tables D1 and D2 outline the criteria for each rating based on the number and type of initiatives. To better capture and rate plans with fewer total initiatives but a higher concentration of robust and comprehensive initiatives, we determined that city plans must satisfy at least two out of three criteria to earn the accompanying rating below.

Table D1. Energy efficiency rating system

Rating	Robust initiatives	Comprehensive initiatives	General initiatives
Exemplary	≥ 2	≥ 5	≥ 4
Substantial	≥ 1	≥ 2	≥ 3
Adequate	≥ 0	≥ 1	≥ 2
Lacking	= 0	= 0	≥ 0

Table D2. Renewable energy rating system

Rating	Robust initiatives	Comprehensive initiatives	General initiatives
Exemplary	≥ 1	≥ 2	> 2
Substantial	= 1	≥ 1	≥ 1
Adequate	= 0	= 1	> 1
Lacking	= 0	= 0	≥ 0

While the renewable energy rating system proved effective, we found the energy efficiency rating system less so, as cities with a greater number of general initiatives were achieving higher ratings than warranted. To correct for this, we developed an alternative, more stringent rating system for cities whose total number of general initiatives was greater than the sum of their robust and comprehensive initiatives (table D3). Like the above rating systems, we based this one on natural cutoff points in the data. Cities had to satisfy at least two out of the three criteria.

Table D3. Energy efficiency rating system for cities with a preponderance of general initiatives

Rating	Robust initiatives	Comprehensive initiatives	General initiatives
Exemplary	≥ 2	≥ 5	≥ 5
Substantial	≥ 1	≥ 4	≥ 3
Adequate	≥ 1	≥ 1	≥ 2
Lacking	= 0	= 0	≥ 0

Tables D4 and D5 list the ratings for energy efficiency and renewable energy, respectively. Further, if a city related an existing climate or environmental action, clean energy, sustainable transportation, resilience, or sustainability plan to their resilience plan, we gave it an Adequate rating.

Table D4. Ratings for energy efficiency

City	Robust initiatives	Comprehensive initiatives	General initiatives	Total	Energy efficiency rating
Athens	0	7	4	11	Exemplary
Buenos Aires	2	4	5	11	Exemplary
Honolulu	3	5	1	9	Exemplary
New York	4	8	4	16	Exemplary
Accra	0	3	3	6	Substantial
Atlanta	1	4	2	7	Substantial
Chicago	1	6	3	10	Substantial
Dakar	1	2	1	4	Substantial
Greater Miami	2	2	3	7	Substantial
Montevideo	1	2	1	4	Substantial
Rome	1	6	1	8	Substantial
Santiago Metro	1	1	7	9	Substantial
Vejle	0	4	3	7	Substantial
Washington, DC	1	4	2	7	Substantial
Wellington	0	3	3	6	Substantial
Amman	0	2	5	7	Adequate
Bangkok	0	1	2	3	Adequate
Berkeley	1	1	1	3	Adequate
Boston	1	0	2	3	Adequate*
Boulder	0	1	1	2	Adequate
Bristol	0	0	2	2	Adequate**
Byblos	0	2	2	4	Adequate
Calgary	0	0	2	2	Adequate**
Cali	0	2	0	2	Adequate
Can Tho	0	0	1	1	Adequate**
Cape Town	0	1	0	1	Adequate
Da Nang	0	0	1	1	Adequate**
Dallas	0	1	2	3	Adequate
Glasgow	0	0	0	0	Adequate**
Juarez	0	1	1	2	Adequate
Los Angeles	0	1	5	6	Adequate
Louisville	1	0	0	1	Adequate*
Melaka	1	1	0	2	Adequate
Melbourne	0	2	0	2	Adequate

City	Robust initiatives	Comprehensive initiatives	General initiatives	Total	Energy efficiency rating
Mexico City	2	0	2	4	Adequate*
Montreal	0	0	2	2	Adequate**
New Orleans	0	2	3	5	Adequate
Oakland	0	2	1	3	Adequate
Panama City	0	1	2	3	Adequate
Paris	0	2	3	5	Adequate
Pittsburgh	0	2	6	8	Adequate
Quito	0	1	1	2	Adequate
Ramallah	0	1	1	2	Adequate
Rio de Janeiro	0	2	1	3	Adequate
Rotterdam	0	2	1	3	Adequate
San Francisco	0	1	5	6	Adequate
Santa Fe	0	1	1	2	Adequate
Santiago de los Caballeros	0	2	0	2	Adequate
St. Louis	0	0	1	1	Adequate**
The Hague	0	0	0	0	Adequate**
Thessaloniki	1	1	3	5	Adequate
Toronto	1	1	0	2	Adequate
Toyama	0	1	1	2	Adequate
Vancouver	0	0	1	1	Adequate**
Christchurch	0	0	1	1	Lacking
Deyang	0	0	0	0	Lacking
Durban	0	0	0	0	Lacking
El Paso	0	0	3	3	Lacking
Kyoto	0	0	2	2	Lacking
Medellin	0	0	0	0	Lacking
Norfolk	0	0	0	0	Lacking
Semarang	0	0	4	4	Lacking
Surat	0	0	3	3	Lacking
Sydney	0	0	1	1	Lacking
Tel Aviv-Yafo	0	0	2	2	Lacking
Tulsa	0	0	3	3	Lacking

*Cities with at least one robust initiative automatically earn an Adequate designation. **Cities that relate a relevant outside plan to their resilience strategy automatically earn an Adequate designation.

Table D5. Ratings for renewable energy

City	Robust initiatives	Comprehensive initiatives	General initiatives	Total	Rating
Chicago	1	2	0	3	Exemplary
Honolulu	2	2	1	5	Exemplary
Los Angeles	1	2	0	3	Exemplary
New York	1	3	1	5	Exemplary
Amman	0	1	1	2	Substantial
Atlanta	1	1	0	2	Substantial
Berkeley	1	0	2	3	Substantial
Ramallah	0	2	1	3	Substantial
Rio de Janeiro	0	1	1	2	Substantial
San Francisco	1	1	0	2	Substantial
Santiago Metropolitan Area	0	3	1	4	Substantial
Surat	0	1	1	2	Substantial
Washington	1	0	1	2	Substantial
Athens	0	0	1	1	Adequate*
Bangkok	0	0	2	2	Adequate
Boston	0	0	0	0	Adequate*
Boulder	0	0	2	2	Adequate
Bristol	0	0	0	0	Adequate*
Byblos	0	1	0	1	Adequate
Calgary	0	0	1	1	Adequate*
Cali	0	0	0	0	Adequate*
Can Tho	0	0	1	1	Adequate*
Cape Town	0	0	1	1	Adequate*
Da Nang	0	0	1	1	Adequate*
Dakar	0	0	0	0	Adequate*
Glasgow	0	0	0	0	Adequate*
Melaka	0	0	0	0	Adequate*
Melbourne	0	1	0	1	Adequate
Mexico City	0	0	0	0	Adequate*
Montreal	0	0	0	0	Adequate*
Oakland	0	0	2	2	Adequate
Paris	0	1	0	1	Adequate
Pittsburgh	0	0	1	1	Adequate*
Rome	0	1	0	1	Adequate

City	Robust initiatives	Comprehensive initiatives	General initiatives	Total	Rating
Rotterdam	0	0	2	2	Adequate
Santiago de los Caballeros	0	0	0	0	Adequate*
St. Louis	0	0	0	0	Adequate*
Sydney	0	1	0	1	Adequate
Tel Aviv-Yafo	0	0	2	2	Adequate
The Hague	0	0	0	0	Adequate*
Thessaloniki	0	0	1	1	Adequate*
Toronto	0	0	0	0	Adequate*
Toyama	0	0	2	2	Adequate
Vancouver	0	0	0	0	Adequate*
Vejle	0	0	0	0	Adequate*
Accra	0	0	1	1	Lacking
Buenos Aires	0	0	1	1	Lacking
Christchurch	0	0	0	0	Lacking
Dallas	0	0	1	1	Lacking
Deyang	0	0	0	0	Lacking
Durban	0	0	0	0	Lacking
El Paso	0	0	1	1	Lacking
Greater Miami	0	0	1	1	Lacking
Juarez	0	0	0	0	Lacking
Kyoto	0	0	1	1	Lacking
Louisville	0	0	1	1	Lacking
Medellin	0	0	0	0	Lacking
Montevideo	0	0	1	1	Lacking
New Orleans	0	0	1	1	Lacking
Norfolk	0	0	0	0	Lacking
Panama City	0	0	1	1	Lacking
Quito	0	0	0	0	Lacking
Santa Fe	0	0	0	0	Lacking
Semarang	0	0	1	1	Lacking
Tulsa	0	0	0	0	Lacking
Wellington	0	0	0	0	Lacking

*Cities that relate a relevant outside plan to their resilience strategy automatically earn an Adequate designation.

Appendix E. Equity Ratings

Table E1 lists the city equity ratings. We measured equity only in relation to energy and transportation planning, so equity considerations in other sectors are not reflected here.

Table E1. Ratings for equitable energy and transportation planning

City	Collected energy equity data	Identified goals and/or actions	Rating
Athens	•	•	Active
Atlanta	•	•	Active
Boston	•	•	Active
Chicago	•	•	Active
Dallas	•	•	Active
Honolulu	•	•	Active
New York	•	•	Active
Toronto	•	•	Active
Amman	•		Passive
Berkeley		•	Passive
El Paso	•		Passive
Greater Miami		•	Passive
Los Angeles		•	Passive
Oakland		•	Passive
Ramallah		•	Passive
Rome		•	Passive
Surat		•	Passive
Sydney		•	Passive
Tulsa	•		Passive
Accra			Does not consider
Bangkok			Does not consider
Boulder			Does not consider
Bristol			Does not consider
Buenos Aires			Does not consider
Byblos			Does not consider
Calgary			Does not consider
Cali			Does not consider
Can Tho			Does not consider
Cape Town			Does not consider
Christchurch			Does not consider

City	Collected energy equity data	Identified goals and/or actions	Rating
Da Nang			Does not consider
Dakar			Does not consider
Deyang			Does not consider
Durban			Does not consider
Glasgow			Does not consider
Juarez			Does not consider
Kyoto			Does not consider
Louisville			Does not consider
Medellin			Does not consider
Melaka			Does not consider
Melbourne			Does not consider
Mexico City			Does not consider
Montevideo			Does not consider
Montreal			Does not consider
New Orleans			Does not consider
Norfolk			Does not consider
Panama City			Does not consider
Paris			Does not consider
Pittsburgh			Does not consider
Quito			Does not consider
Rio de Janeiro			Does not consider
Rotterdam			Does not consider
San Francisco			Does not consider
Santa Fe			Does not consider
Santiago de los Caballeros			Does not consider
Santiago Metropolitan Area			Does not consider
Semarang			Does not consider
St. Louis			Does not consider
Tel Aviv-Yafo			Does not consider
The Hague			Does not consider
Thessaloniki			Does not consider
Toyama			Does not consider
Vancouver			Does not consider

City	Collected energy equity data	Identified goals and/or actions	Rating
Vejle			Does not consider
Washington			Does not consider