Siemens Corporation
300 New Jersey Avenue, NW
Washington DC 20001

Siemens contributors to this report include:

Dr. Noorie Rajvanshi, Corporate Technology
Dennis Rodriguez, Head of External Affairs - Western US

For more information about Siemens work in the major metropolitan areas of California and about this report, please contact:

Dennis Rodriguez
Head of External Affairs - Western US
Siemens Corporation
(e) dennis.rodriguez@siemens.com

Printed in the United States

SIEMENS
Ingenuity for life

Technology Pathways to a Resilient Los Angeles

http://www.usa.siemens.com/cities

Siemens Corporation | **Technology Pathways to a Resilient Los Angeles**

About the Report

Siemens Corporation is a U.S. subsidiary of Siemens AG, a global powerhouse focusing on the areas of power generation and distribution, intelligent infrastructure for buildings and distributed energy systems, and automation and digitalization in the process and manufacturing industries. Through the separately managed company Siemens Mobility, a leading supplier of smart mobility solutions for rail and road transport, Siemens is shaping the world market for passenger and freight services. Due to its majority stakes in the publicly listed companies Siemens Healthineers AG and Siemens Gamesa Renewable Energy, Siemens is also a world-leading supplier of medical technology and digital healthcare services as well as environmentally friendly solutions for onshore and offshore wind power generation. For more than 160 years, the company has innovated and invented technologies to support American industry spanning manufacturing, energy, healthcare and infrastructure.
In fiscal 2018, Siemens USA reported revenue of $23.7 billion, including $5.0 billion in exports, and employs approximately 50,000 people throughout all 50 states and Puerto Rico.

Today resilient cities need
to be prepared for anything.
Extreme weather, cyber attacks,
even temporary fluctuations
in the grid can range
from a temporary setback
to a life-threatening event.

Siemens Corporation | **Technology Pathways to a Resilient Los Angeles**

Contents

Executive Summary

It is becoming apparent through daily events that the time to invest in resilience is now. Resilience is the ability of cities and its private citizens, organizations or systems to prepare for, respond, recover from and thrive in the face of hazards. The goal is to ensure the continuity and advancement of economic prosperity, business success, environmental quality and human well-being, despite external threats. Being resilient is the only way for cities to remain economically competitive and attractive for business growth in this globalized world.

This report builds on our previous work from city performance tool (CyPT) that analyzed and compared the performance of 19 technologies and their impact on GHG reductions, air quality, costs, and job creation. The top-performing technologies in the area of GHG reductions were identified and included electric heat pumps, electric cars, technologies that reduced time between trains on Metro trains, and rooftop PV panels. Based on the analysis the City of Los Angeles greenhouse gas reduction targets for 2035 and 2050 are achievable. Success will require transitioning to 100% generation of renewable electricity and to 45% of passenger travel by transit and active transport in addition to the 19 technologies. Statistics gathered during the analysis also points to the use of distributed energy to help mitigate some of LA's challenges. Resulting emissions reductions would be accompanied by a 72% improvement in air quality and almost two million local jobs.

In this report we examine how technologies can enhance resilience of critical urban infrastructure for Los Angeles by strengthening emergency preparedness, and by reinventing urban mobility and utilities. Three strategies stand out that would be essential for creating a resilient city:

• **Modernization of city infrastructure** that leverages better data, more transparency and better predictability through connectivity of energy and transportation infrastructure. Modernizing the grid has emerged as a high priority for ensuring a resilient electric future. The implementation of innovative software capable of understanding when, where, and why electricity is being used, helps to cut down on waste. Energy stakeholders are also capable of performing predictive analytics for more efficient grid maintenance.

Our recent City Performance Tool (CyPT) analysis for LA shows that electrification of 100% of car and bus fleet would require installation of 196,000 EV chargers for cars and 500 EV charges for buses by 2050. Although LADWP experiences very few electricity outages today inserting new consumers like electric vehicles in the future could strain the performance of the grid. Utilizing spaces designated for fixed EV charging stations as microgrids running on solar energy, allow EVs to be charged without having to tie into the grid. Additionally, these stations have an advantage of being scattered throughout the city in emergency situations, such as blackouts, which will improve the overall resilience of cities and their residents.

• **Digital twin for resilience planning** using data and simulation tools to project potential outcomes in the wake of disasters and can help city officials identify gaps as well as generate scenarios for investments;

• **Strengthening urban energy systems** through hybrid grids that combine mini/micro grids and energy storage and can operate in "island" mode (generating power independently in the event of a grid power outage) could restore power to critical infrastructure in as short a time as possible. Utilities can better manage peak demands with technologies such as distribution management technologies, distributed power generation, virtual power plants, and microgrids. Energy storage equipment (e.g. batteries or electric vehicles) can provide additional power for times of abnormal peak demand or shortages in supply, to help in maintaining energy supply to consumers. Combined with a microgrid, battery storage creates a hybrid power grid that can stand-alone in the absence for a central grid.

Cities cannot do this alone. Partnerships between local governments and technology companies can leverage data to improve city services, through these partnerships, cities can also avail of advances in big data and communication applications that can help cities optimize infrastructure and start to dramatically improve how it performs. Cities also need partnerships with private companies and financial institutions to support innovative funding mechanisms that drive resilient outcomes.

Siemens Corporation | **Technology Pathways to a Resilient Los Angeles**

Introduction

Around the world, local and federal governments as well as business and private citizens are facing the challenge of dealing with increasingly frequent threats to their infrastructure. These threats might be weather related, e.g. large storms, floods, earthquakes, wildfires; technological, e.g. failures due to aging infrastructures or material defects; or human caused, such as accidents or physical/cyber-attacks. Whatever the reason for these events, cities across the globe have a challenging task to plan and be prepared for these threats that in most cases are extremely difficult to predict.

What is Resilience?

Resilience is the ability of a system to survive and thrive in the face of a complex, uncertain and ever-changing future. It is a way of thinking about both short-term cycles and long term trends: minimizing disruptions in the face of shocks and stresses, recovering rapidly when they do occur, and adapting steadily to become better able to thrive as conditions continue to change. The concept of resilience extends beyond the physical or built world for most of the cities. As an example, for the city of Los Angeles resiliency means modernization of infrastructure but it also means preparing Angelenos through education and financial empowerment. For this publication, we will focus on the infrastructure view of resiliency planning and discuss the role of technology in creating resilient and sustainable communities.

As a global leader in intelligent infrastructure, Siemens has been a part of resiliency discussion not only through its products and technologies but also through partnerships with organizations like C40 and 100RC. In 2013, leadership at C40 and Siemens signed a memorandum of understanding to partner to combine Siemens' technical expertise with C40's robust network of cities. Since then the two organizations have worked on several projects and co-authored numerous publications including the most recent report *New Perspectives on Climate Finance for Cities*[i] that provides insights on potential financing options for climate change projects in cities, including details of the lead times, steps required, and lessons learned from cities around the world. Similarly, the cooperation between 100ResilientCities, a Rockefeller Foundation initiative and Siemens began in 2016 when Siemens joined the platform of partners to offer expertise and thought leadership on resilience. With help of this partnership the two organizations have worked together in topics like urban eMobility, convening workshops in New York City and Pittsburgh that brought wide range of stakeholders together to discuss the future of eMobility in the city and what the city, its citizens and utilities need to do.

Resilience and Sustainability

Sustainability and resilience are complimentary and overlapping concepts. Cities are using long-term sustainability planning to represent the end goal they are pursuing to secure a good quality of life for all people, today and in the future, through strong and prosperous communities, a vibrant and resource efficient economy, and stewardship of both local and global environmental assets.

Resilience planning helps broaden the goals set by a city's long-term climate action plan and embraces the turbulence of daily life. Resilience is about learning to live with the spectrum of risks that exist at the interface between people, the economy and the environment, and maintaining an acceptable stability or equilibrium in spite of continuously changing circumstances. Resilience also addresses the interdependencies between systems and minimizes unforeseen 'gaps' in risk management.

In the case of Los Angeles, the 2019 update to Sustainable City pLAn[ii] aka LA's Green New Deal incorporates policies that increase resilience through climate adaptation, infrastructure modernization, and economic security and acknowledges that sustainability and resilience would need to work hand in hand for protecting the most vulnerable Angelenos from climate change shocks and stressors.

Sustainability and Resilience Leadership in Los Angeles

Los Angeles is fast becoming one of the most sustainable cities in the world under the leadership of LA Mayor Eric Garcetti and through his Office of Sustainability, led by the city's Chief Sustainability Officer, Lauren Faber. In LA, sustainability and resilience go hand-in-hand. Through its sustainability and resilience plans the city is providing comprehensive and actionable vision for protecting the environment, growing the economy, improving the equity of Angelenos, all while making their infrastructure safe, strong, and prepared for the stresses and shocks of climate change and other threats.

Earlier this year, Mayor Garcetti launched an update to the city's first-ever Sustainable City pLAn and set bold targets leading the nation in renewable energy and moving to zero emissions transportation. Various agencies and departments across the city are working towards supporting these targets through initiatives in energy, buildings and mobility.

The city has made great strides in becoming a leader in clean and renewable energy. By choosing not to rebuild three coastal natural-gas power plants[iii] that currently provide 38% of LA's electricity, the city is already making progress towards it's 100% renewable goal. At the request of the Mayor, the Los Angeles Department of Water and Power (LADWP) has launched the LA100 study to determine the technical and economic feasibility of 100% renewables energy in the city[iv] and this effort is also validated by external research that quantitatively shows that path to 100% renewable by 2030 can even save money for ratepayers[v].

As one of the largest markets in United States for electric vehicles, LA is investing in its eMobility. From the Los Angeles Department of Transportation's (LADOT) plans to convert its entire bus fleet to electric buses by 2030[vi] to LADWP's popular electric vehicle (EV) charger rebate program for consumers,[vii] the city is proving itself a leader in clean, efficient transportation.

Creating Resilient Cities

As a member of 100RC, Los Angeles is one of 74 cities with a comprehensive resilience plan. The "Resilient Los Angeles" strategy released in 2018 proposed 96 actions around 15 targeted goals. That said, the overarching goals of the Resilient Los Angeles plan are multi-faceted and include; strengthening the city's infrastructure, protecting the city's economy, making the city's institutions more inclusive, and creating safer neighborhoods in Los Angeles. Under the guidance of Mayor Eric Garcetti and through the leadership of the city's Chief Resilience Officer, Aaron Gross, Los Angeles has approached resilience from the perspective of it being a core value that serves as a guidepost across the spectrum of the city's portfolio.

Siemens is contributing to LA's resilience efforts through though leadership as well as technologies. Through publications like "A Blueprint for a 21st Century Los Angeles Infrastructure" and of a City Performance Tool Report.[viii] Siemens analyzed and compared the performance of 19 technologies and their impact on GHG reductions, air quality, costs, and job creation. The top-performing technologies in the area of GHG reductions were identified and included electric heat pumps, electric cars, technologies that reduced time between trains on Metro trains, and rooftop PV panels. Based on an analysis using Siemens City Performance Tool, the City of Los Angeles greenhouse gas reduction targets for 2035 and 2050 are achievable. Success will require transitioning to 100% generation of renewable electricity and to 45% of passenger travel by transit and active transport. Half of the heating consumed by buildings in LA would have to be generated by electric heat pumps instead of natural gas furnaces. Average headway (or the time between trains) on Metrorail lines would have to drop from 11 minutes today to just 4 minutes by 2050. Finally, nine new Metrorail lines would have to be constructed and, in conjunction, ridership on all rail would have to increase compared to today. Statistics gathered through the use of the Siemens City Planning also points to the use of distributed energy to help mitigate some of LA's challenges. Resulting emissions reductions would be accompanied by a 72% improvement in air quality and almost two million local jobs.

Resilient buildings, transportation and energy systems are building blocks of resilient communities. A truly resilient city needs to be prepared to respond to both climate stresses, e.g. rising temperatures, shifts in precipitation patterns, and climate shocks, e.g., storm events, disruptions from cold snaps or heat waves.

"The focus of this report is on how emerging technology can enhance city resilience by strengthening emergency preparedness, and by reinventing urban mobility and utilities. Cities cannot do this alone."

Partnerships between local governments and technology companies can leverage data to improve city services, through these partnerships, cities can also avail of advances in big data and communication applications that can help cities optimize infrastructure and start to dramatically improve how it performs.

Resilient Urban Energy

Energy is the basis of life in urban environments and it is also the first part of daily life of a citizen that is affected in after a big event like storm or earthquake. Hence it is no surprise that most of the resilience strategies revolve around building an "unbreakable" energy generation, transmission and distribution system. The recent bankruptcy filings by Pacific Gas and Electric (PG&E) is clear indication that utilities and ISOs cannot make light of large events like wildfires that are becoming more frequent with changing climate.
Modernizing the grid has emerged as a high priority for ensuring a resilient electric future. The implementation of innovative software capable of understanding when, where, and why electricity is being used, helps to cut down on waste. Such solutions also provide transparency to consumers about pricing. Energy stakeholders are also capable of performing predictive analytics for more efficient grid maintenance. Distribution management technologies, distributed power generation, virtual power plants, and microgrids are just four possible technology solutions to better manage peak demands, while providing reliable energy.

Although LADWP experiences very few electricity outages today, incorporating renewables at utility scale, from distributed sources, and inserting new consumers like electric vehicles in the future could strain the performance of the grid. By planning now for a modernized grid, LA can ensure a more resilient and reliable grid at the same time avoiding future reliance on fossil fuel-based back up generation. This section speaks to some of the technologies and strategies that can help create a truly resilient urban energy system in LA.

Micro - and mini-grids

A microgrid is a scaled down version of the centralized power system that generates, distributes, and regulates the flow of electricity. It can operate either grid-connected or islanded and if required, switch between both operating modes. This improves resilience because it provides uninterrupted power and balance volatile generation with demand. Minigrids are electrical islands. They are often considered "off-grid" as they don't require a connection to a central grid. These are ideal solutions if resiliency is the key consideration. Minigrids are distinguished from microgrids in that they can only operate autonomously or can be connected to a localized distribution network and do not require connection to the central grid. More commonly these minigrids could be operated using diesel generators but for resilience and sustainability considerations, distributed energy resources such as solar or wind would be more appropriate choices.

In addition to improving resiliency, both these solutions have several co-benefits including ability to reduce costs through intelligent power management, improving reliability and ensuring a steady flow of cleaner and higher quality power for its residents and businesses, enabling higher renewable integration and thereby reducing emissions.

A recent example of resiliency planning at work is the Siemens' microgrid at Blue Lake Rancheria.[ix] Three years ago, long before PG&E's Public Safety Power Shutoff program, this century-old Native American reservation in northern California decided to invest in micro-grids. This micro-grid runs on a 500 kW solar PV system and 950 kWh battery storage system that can be operated either connected with the PG&E grid or independently (islanding mode). The micro-grid has impressive economic and environmental benefits – saving the tribe over $200,000 annual energy costs and reducing 150 tons of CO_2 per year. In addition, the Rancheria is already reaping the benefits of their investments through improved power resiliency. In the first week of October, while much of the Humboldt county was scrambling to respond for the PG&E power outage, Blue Lake Rancheria was able to hold their own and able to provide people with essential services, such as water, food and communication. Amidst the power outage, Rancheria was one of a handful of places in the county where residents were able to buy gas.[x]

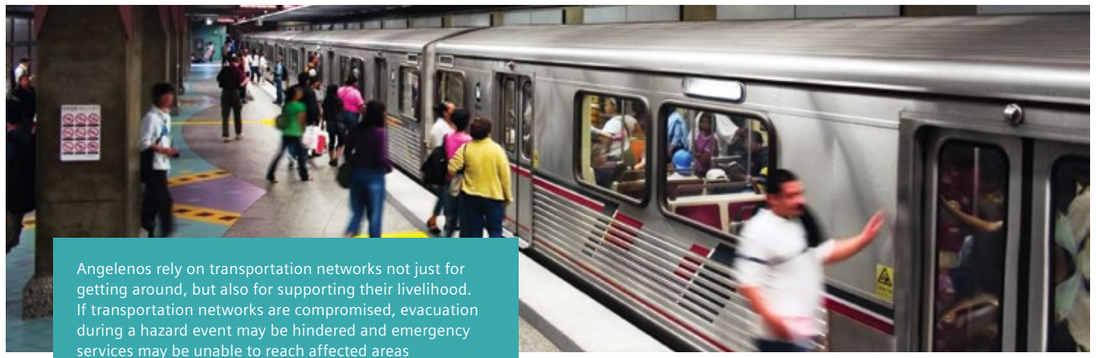
Energy Storage

Energy storage equipment (e.g. batteries or electric vehicles) can provide additional power for times of abnormal peak demand or shortages in supply, to help in maintaining energy supply to consumers. Combined with a microgrid, battery storage creates a hybrid power grid that can stand-alone in the absence for a central grid. Over past two decades, Lithium-ion (Li-ion) battery technology has advanced significantly both from a technical and cost perspective. The economic viability of storage coupled with expert view that energy storage is the natural complement to the renewable resource's inherent variability will help facilitate additional renewable penetration into the grid.

Energy storage solutions offer resilience through enhanced flexibility and fast response resource to effectively manage variability in generation and load. It also provides emission free backup power, which improves local air quality.

Resilient Transportation

Mobility is the name of the game in Los Angeles. With nations 5th most congested streets and over 2.5 million cars on the road, Angelenos rely on transportation networks not just for getting around, but also for supporting their livelihood. If transportation networks are compromised, evacuation during a hazard event may be hindered and emergency services may be unable to reach affected areas. After the event, the delivery of food, fuel and other goods will be affected due to disruption in logistics. All of these things affect the health and safety of citizens and their ability to return quickly to their normal patterns of life and work. Diverse and flexible transportation network provides citizens a range of travel options and enhance resilience after an event.



Angelenos rely on transportation networks not just for getting around, but also for supporting their livelihood. If transportation networks are compromised, evacuation during a hazard event may be hindered and emergency services may be unable to reach affected areas

Investing in e-mobility continues to be a top priority for LA, and in response the city is rapidly building up its EV fleets, electric buses and charging infrastructure as part of a broader effort to reduce greenhouse gas emissions. This section speaks to two technologies that can improve the resiliency of transportation networks

E-charging (Electric Vehicle Charging) Infrastructure

Our recent City Performance Tool (CyPT) analysis for LA shows that electrification of 100% of car and bus fleet would require installation of 196,000 EV chargers for cars and 500 EV charges for buses by 2050. These numbers although in-line with LA's most recent update to the sustainability pLAn,[vi] would likely put a strain on the grid, but if managed in a smart way, could become a solution for resilient infrastructure.

Utilizing spaces designated for fixed EV charging stations as microgrids running on solar energy, allow EVs to be charged without having to tie into the grid. Additionally, these stations have an advantage of being scattered throughout the city in emergency situations, such as blackouts, which will improve the overall resilience of cities and their residents. With help of these technology advancements, these charging stations provide the required infrastructure for low emission transport, supporting CO_2 emissions reduction programs and air quality improvement initiatives within LA. In addition, investing in EV charging infrastructure would help futureproof the city while anticipating tomorrow's electromobility challenges and building capacity and flexibility within urban infrastructure projects today. When not in islanding mode, these charging infrastructures could also serve as a source of electricity to the central grid.

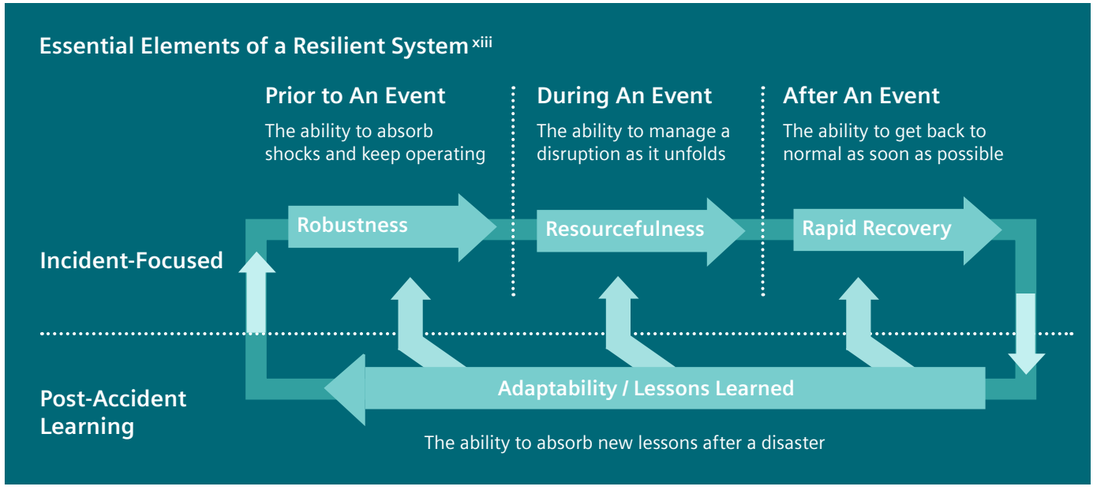
V2X (Vehicle-to-everything)

V2X is part of the growing IoT services that means connected-vehicle-to-everything, where everything includes other vehicles or infrastructure. Originally this term was limited to communications services but with increased uptake of electric vehicles this definition has expanded to flow of energy. Under the communication technologies umbrellas vehicles can communicate to other vehicles or to infrastructure which enables more efficient traffic control, a significant reduction in accident numbers and an even greater cut in emissions than possible up to now. Better communication improves road safety and reduces accident numbers, it can also optimize the flow of traffic, minimizing congestion and stop-and-go traffic. In future v2x infrastructure can help support automated and autonomous driving.

Experts believe that EVs have the potential to help balance loads and improve the resiliency of our nation's electricity infrastructure. Batteries in EVs could be used as additional, distributed, small-scale storage by drawing and storing surplus electricity from the grid at times when renewables are producing excessive energy and feeding it back into the grid during peak demand hours or when the grid is offline, for example after a large storm. This technology, called V2G or vehicle-to-grid, brings EVs online as a mobile energy storage unit and requires a bi-directional flow of power between the grid and the vehicle to enable provision of advanced grid services. This bi-directional characteristic of EV batteries could also be used to discharge electricity from EVs to buildings directly, called vehicle-to-building or v2b. This can provide back-up and emergency services to homes and businesses.

Resilience Challenges

The definition of resilience divides the concept in three timescales – prior to an event, during an event and after an event. A truly resilient system would not only enable rapid recovery but also have capabilities to anticipate such events through advanced planning and manage disruptions as they occur. Most of attention as well as resources are dedicated to the preparations in the short-term before large weather events like hurricane or for rapid recovery immediately following these events. Yet, investments in long-term measures to ensure a resilient infrastructure for cities are few.



Although Los Angeles is already leading the way globally in the sustainability and resilience efforts, there is still quite a lot of work that could be done to make the city truly resilient:

- **Modernization of city infrastructure.**
A digital city doesn't simply mean connected city, it also means an intelligent city that leverages better data, more transparency and better predictability through connectivity of energy and transportation infrastructure. LA has been consistently top-ranked as the digital city of the year[xiv] in recognition of its initiatives like LA open data and clean streets initiatives and in an excelled position to leveraging this information to plan for resilience.

- **Digital twin for resilience planning.**
Digital twin is not a new concept but with connected infrastructure it is becoming exceedingly cost-effective planning approach for cities. Creating a digital replica of LA's most vulnerable infrastructure and leveraging today's data and simulation tools to project potential outcomes in wake of disasters can help city officials identify gaps as well as generate scenarios that would provide highest benefit for investments.

- **Strengthening urban energy systems.**
Through distributed energy resources, cities can create a hybrid grid that combines mini/micro grids and energy storage. After a large weather event, when central grids fail and require months of efforts to bring power back online, operating these hybrid power systems in islanding mode could restore power to critical infrastructure within days.

Who Pays for Climate Resilience?

Reducing energy impacts through large energy efficiency efforts and deep building retrofits, distributed energy resources like rooftop solar and storage solutions are some the strategies that communities will need to implement to become resilient. But when thinking about implementing measures that will make a city's infrastructure stronger, there's always the question about who will pay for it. However, it is also important to consider that there are very large costs associated with doing nothing. According to the World Bank, by 2030, without significant investment into making cities more resilient, natural disasters may cost cities worldwide $314 billion each year.[xv]

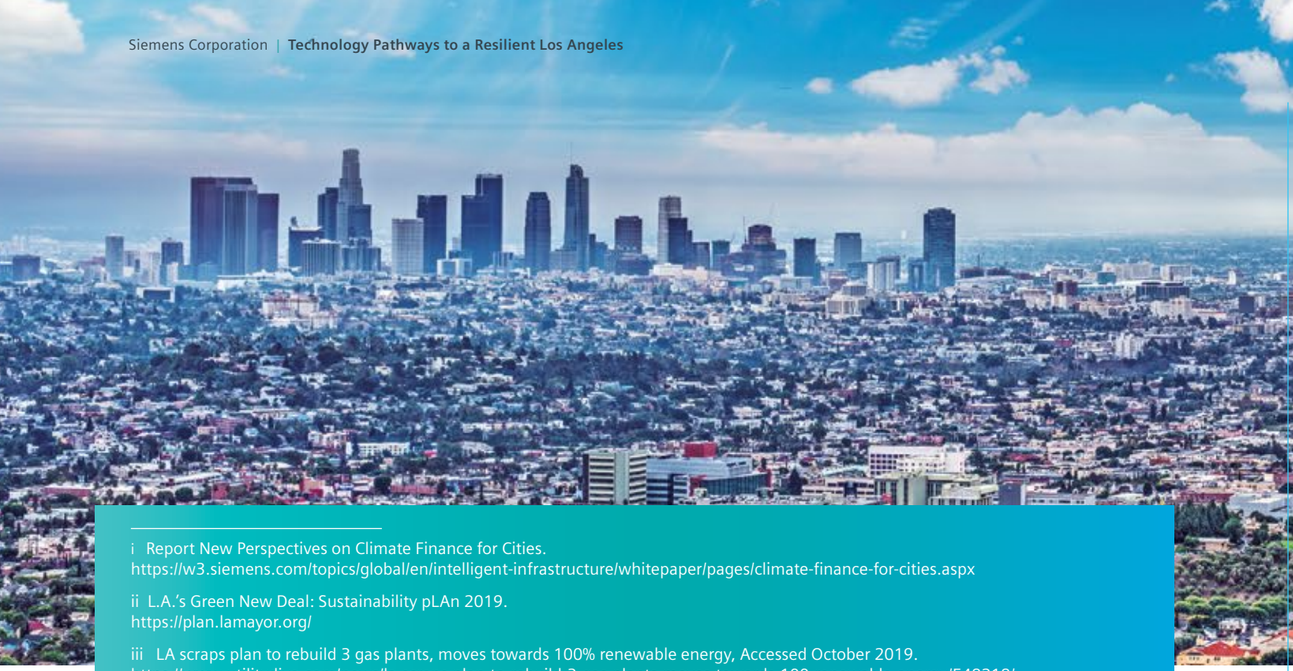
Most recent example from PG&E's Public Safety Power Shutoff program shows that even preventative measures to reduce the wildfire risks come with a price tag. Analysis from Michael Wara, director of Stanford University's Climate and Energy Policy Program, estimates that the PG&E outages had a $1.8 billion economic impact on the outage region. Investments in long-term strategies such as creating islands or micro-grids that can operate independent of the central grid and eliminate the need for transmission lines that are a fire hazard or upgrading the current transmission lines to be fire-resistant are critical to avoid these short-term fixes.

Urban climate finance has become an intense talking point around the world. In the US, several cities are planning and implementing climate-resilience strategies. A recently published playbook highlights examples on how 8 US cities are paying for climate resilience.[xvi] Some of these strategies are discussed here and could be adopted in LA:

- **Generating local revenues.**
Issuing general obligation bonds backed by property tax revenues is a mechanism cities like Miami are pursuing with an assurance that as soon as the new bond was repaid, the property taxes would not increase. Local governments are also considering allowing electric utilities like PG&E to make their ratepayers cover costs for investments in cleaner energy as well as resiliency measures. Post-Hurricane Sandy, New York City engaged in two energy-utility rate cases, first the 2013 Con Edison rate case resulted in that utility investing $1 billion in flood risk mitigation for electric, gas, and steam facilities and other assets and the second 2016 National Grid rate case produced about $250 million annually to help modernize pipeline infrastructure and customer information technology systems.

- **Embed resilience standards in infrastructure projects.**
Using the power of regulations, cities are ensuring that the future capital spent on public infrastructure will strengthen climate resilience. As an example, in 2014, San Francisco issued instructions to all city departments to incorporate sea level rise as a factor in capital planning. Another example from Boston, where the new Smart Utility Standards, requires analysis of the feasibility of installing microgrids for energy resilience for any developments in excess of 100,000 square feet.

- **Through public-private partnerships.**
Cities can leverage public-private partnerships (P3) in two distinct ways: firstly, by leveraging real estate development opportunities that invest in both public infrastructure and private development, cities may negotiate resilience requirements as part of permitting process for example in Hoboken's Resiliency park.[xvii] Secondly, cities can also tap into P3 for creating new innovation investment mechanisms such as green bonds and climate funds.



i Report New Perspectives on Climate Finance for Cities.
https://w3.siemens.com/topics/global/en/intelligent-infrastructure/whitepaper/pages/climate-finance-for-cities.aspx

ii L.A.'s Green New Deal: Sustainability pLAn 2019.
https://plan.lamayor.org/

iii LA scraps plan to rebuild 3 gas plants, moves towards 100% renewable energy, Accessed October 2019.
https://www.utilitydive.com/news/la-scraps-plan-to-rebuild-3-gas-plants-moves-towards-100-renewable-energy/548218/

iv LADWP 100% Renewable Energy Study, Accessed October 2019.
https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-power/a-p-cleanenergyfuture/a-p-renewableenergystudy?_adf.ctrl-state=13d5qta1s8_4&_afrLoop=1322292373631205

v Clean Energy for Los Angeles, Accessed October 2019.
https://www.foodandwaterwatch.org/sites/default/files/clean_energy_for_los_angeles_-_final_clean_1.pdf

vi L.A. City Approves Full LADOT Transit Electrification by 2030. Accessed October 2019.
https://la.streetsblog.org/2017/11/09/l-a-city-approves-full-ladot-transit-electrification-by-2030/

vii Los Angeles Department of Water and Power, Accessed October 2019.
https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric?_adf.ctrl-state=16js547us2_47&_afLoop=1327153781313187

viii Climate LA: Technology Pathways for LA to Achieve 80x50 in Buildings and Transportation.
https://w3.siemens.com/topics/global/en/intelligent-infrastructure/cypt-reports/pages/la-technology-pathways.aspx

ix Blue Lake Rancheria Native American Reservation Microgrid Goes Live. Accessed October 2019.
https://news.usa.siemens.biz/press-release/energy-management/blue-lake-rancheria-native-american-reservation-microgrid-goes-live

x Blue Lake Rancheria becomes a hub of services during outage, Accessed October 2019.
https://www.times-standard.com/2019/10/11/blue-lake-rancheria-becomes-a-hub-of-services-during-outage/

xi Connecting Electric Vehicles to the Grid for Greater Infrastructure Resilience, Accessed October 2019.
https://www.nrel.gov/news/program/2017/connecting-electric-vehicles-to-the-grid-for-greater-infrastructure-resilience.html

xii Enhancing Grid Resilience with Integrated Storage from Electric Vehicles. Accessed October 2019.
https://www.energy.gov/sites/prod/files/2018/06/f53/EAC_Enhancing%20Grid%20Resilience%20with%20Integrated%20Storage%20from%20EVs%20%28June%202018%29.pdf

xiii Reproduced from Resilience of the U.S. Electricity System A Multi-Hazard Perspective, 2016. Accessed August 2019.
https://www.energy.gov/sites/prod/files/2017/01/f34/Resilience%20of%20the%20U.S.%20Electricity%20System%20A%20Multi-Hazard%20Perspective.pdf

xiv Los Angeles Named America's #1 Digital City for Third Year in a Row, Accessed October 2019.
https://www.lacity.org/blog/los-angeles-named-america-s-1-digital-city-for-third-year-row

xv World Bank Group. 2016. Investing in Urban Resilience: Protecting and Promoting Development in a Changing World. Washington, DC.
https://openknowledge.worldbank.org/handle/10986/25219

xvi Playbook 1.0: How Cities Are Paying for Climate Resilience.
https://static1.squarespace.com/static/5736713fb654f9749a4f13d8/t/5d275d9135b62f0001df44b5/1562860947122/Playbook+1.0+How+Cities+Are+Paying+for+Climate+Resilience+July+2019.pdf

xvii Hoboken Resiliency Park.
https://www.njfuture.org/smart-growth-101/smart-growth-awards/2018-smart-growth-award-winners/700-jackson/

Siemens Corporation | **Technology Pathways to a Resilient Los Angeles**