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Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

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CONTENTS

Overview

With an ever-increasing frequency, businesses and communities face emergencies such as extreme weather-related events. According to the National Oceanic and Atmospheric Administration (NOAA), the U.S. sustained 246 weather and climate disasters that generated overall damage costs of $1 billion or more since 1980 (as of January 2019). The cumulative cost of these events has exceeded $1.6 trillion. Over the past three years, the annual average number of billion-dollar disasters has been more than double the long-term average. The number and cost of disasters are increasing due to a combination of increased exposure, vulnerability, and the fact the climate change is increasing the frequency of some types of extreme weather. Since 1980, over 13,000 deaths have been attributed to these weather-related disasters.

When these disasters affect densely-populated cities, damage, disruption, and recovery costs are magnified. City leaders have to find new ways to plan, design, build and manage their cities under more challenging conditions. The responsibilities of cities to safeguard the well-being of their citizens takes center stage. Resilience strategies that drive enhanced preparedness and faster recovery become critical.

Keys to achieving digitalization, decentralization and decarbonization

Technology can contribute as an important enabler of city resilience. New technology trends such as digitalization enable both decarbonization and decentralization, important pillars for keeping city operational processes efficient and city residents healthier. In the case of decarbonization, best practices in the areas of energy generation, distribution and consumption help reduce CO_2 emissions. In fact, energy accounts for two-thirds of total greenhouse gas emissions and 80% of CO_2 emissions. Any effort to mitigate climate change must include improvements in both energy efficiency and accelerated deployments of renewable energy. Global political commitments and significant cost decreases in renewable energy (PV/wind) are helping to fuel the CO_2 reduction momentum.

Decentralization, the second pillar that contributes to improved city resilience, implies the shift from centralized power plants to the generation, storage and distribution of energy closer to where it's used. Microgrids are an example of how distributed energy can help support key aspects of city infrastructure services. Microgrids are characterized by controllable loads, energy storage, digitized controls and (most often) renewable energy generation sources.

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Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

A microgrid can operate both in parallel with the traditional grid or in self-sufficient islanded mode. Microgrids can keep the lights on during a large storm by islanding from the main grid and can assist in faster recovery of the main grid using coordinated restart processes.

Today, resilient cities need to be prepared for anything. Extreme weather, cyberattacks, even temporary fluctuations in the grid, can range from a temporary setback to a life-threatening event. By collaborating to build an energy solution that meets the unique needs of every city, resilience and operational continuity can be assured, generating energy cost savings and lowering carbon footprint.

City investments in digitalization drives cost reductions and enhances overall grid stability. Digitalization gathers critical grid performance data through low-cost devices that communicate and integrate throughout the transmission and distribution path. The result is real-time grid operational information, both technical and economic, which can enable the shifting grid energy consumption to lower tariff (or demand) hours by supplying loads with stored energy during higher cost peak hours. More stability to the grid is accomplished when distributed resources such as solar arrays are merged to the grid, bringing decentralized energy options for coping with natural disasters.

Innovations such as microgrids, bi-directional grid management and flexible financing options now make it possible for cities to reduce cost, improve reliability and achieve resilience.

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Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

Resilience measures take root across the nation

Numbers of cities across the US are pursuing initiatives that strengthen resilience in multiple ways. Below are several current examples:

PITTSBURGH, PA – Partner collaboration and energy access for all, viewed as critical success factors

Pittsburgh's planning initiative, p4 (People, Place, Planet, and Performance), launched in 2015, provides a framework for unified action across the city to achieve a just and sustainable future with the shared goal of a "world class city that benefits all." Collaborating with key players such as utilities, city energy stakeholders, building owners, technology vendors, and nearby universities has served as the recipe for success.

Pittsburgh's strategies are derived from working with communities and putting forward projects that can both reduce emissions, build resilience and develop communities. The city faces a number of challenges including air quality, aging buildings, and some antiquated physical infrastructure systems.

History show that economic divides and neglected populations lower overall city resilience. In Pittsburgh, municipal energy plans are attempting to deliver on promises to vulnerable citizens. This serves as an important first step for raising overall prosperity levels. Higher resulting tax revenues then contribute to overall citizen safety and well-being. When poor air quality, for example, is addressed through renewable energy in the poorest sections of town, overall health improves and healthcare costs are controlled. As power plans support better public transportation, economic opportunities increase. Raising up energy equity for all develops city economies and leads to a more resilient city infrastructure.

The Pittsburgh community plan centers on supporting existing residents while increasing job opportunities and protecting the environment. A focus has been placed on those neighborhoods that have yet to share in the growth and recovery experienced by downtown and other areas. These are areas that suffer from problems of air quality, reliable energy access, as well as safety. These neighborhoods present an opportunity to develop an environmentally resilient community based on equitable land use, job growth for residents and reliable transportation and infrastructure systems.

Pittsburgh's resilience investments are currently addressing several important areas:

Buildings

Citizens are subjected to higher insurance premiums and higher building operating costs due to the lack of compliance with leading standards and improved efficiency. The content of modern building codes includes updated technology and standards that allow buildings to be more energy efficiency, cost-effective, and resilient.

Energy

It has been shown that up to 60 percent of the energy that moves along aging gas and electric lines can be lost during transmission. The City of Pittsburgh, in partnership with the Department of Energy, the National Energy Technology Lab, Duquesne Light, and the University of

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Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

Pittsburgh Center for Energy, is currently developing a 21st century energy infrastructure plan to address these issues. The plan calls for the expansion and optimization of district scale energy systems, such as microgrids, thermal loops, combined heat and power systems and other innovative technologies.

Electric vehicle charging infrastructures

Pittsburgh neighborhoods typically lack driveways and garages, making home charging prohibitive for many city residents. In such an environment, neighborhood charging stations can ensure access to localized charging infrastructure, and can operate with off-grid solar generation and battery backup, providing a resilient hub for residents to gather and charge devices or vehicles in times of grid failure. The charging stations can also serve other two-way communication purposes, such the distribution of weather advisories or similar information in times of emergency.

City Performance Tool offers assessment and implementation benefits for resilience

Siemens corporation acts as one of the technology advisors and partners of Pittsburgh, and has made available an advanced simulation tool (called the City Performance Tool). This tool helps city officials to better define planning and decision-making scenarios as they pertain to city infrastructure modernization. The tool uses the same standards to accurately compare projects that may come from varying sectors of the city and impact different communities. This means that city leaders can better understand which projects can generate the most overall impact or the most impact per dollar spent.

Siemens uses this tool to assess concepts and technologies already identified by the city in order to help prioritize projects. Siemens also uses this tool to illustrate the impact of some technologies that city and community leaders may not have considered. The City of Pittsburgh has used the City Performance Tool to assess the potential impact of its Climate Action Plan and its projects specifically targeted at the some of the poorer neighborhoods.

Analysis using the tool starts with more than 350 data inputs from the city's transport, energy and buildings sectors, including more general characteristics such as population and growth. Other parameters being measured include the supply mix of electricity generation, transport modalities, and travel patterns, building energy use, and the city's CO_2 footprint. The model estimates the future impact of more than 70 technologies including renewable energies, gas turbines, LED lighting, and mass transit and EV technologies. The outputs of the model are measured in CO_2e emissions, nitrogen oxides (NOx), particulate matter, gross full-time equivalents (FTE), and capital and operating expenses.

The tool utilizes risk and cost modeling to advise cities on how they can achieve their environmental targets while providing an indication on how each infrastructure-related decision will influence job creation and the infrastructure sector growth. It also measures the impact of a city's strategic plan and evaluates buildings, transport and energy technologies comparing traditional methods with state-of-the-art implementations. Each city can customize how the tool is used depending upon the particular city's planning and infrastructure requirements.

Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

BROOKLYN, NY – Convergence of blockchain and microgrid technologies establishes community power network

Brooklyn is the most populous borough of New York City, with over 2.6 million residents. Neighborhoods are vibrant with many tightly knit, long-established communities. Dense in both businesses and residential buildings, energy availability is required on a 24-hour basis, 365 days a year. As traditional power grids are more stressed by the booming Brooklyn population, residents are seeking to improve the reliability of their energy access.

The Brooklyn Microgrid project is a recent initiative where neighbors are both consuming and producing their own electricity with a distributed energy system that uses a blockchain enabled transactive energy platform. The Microgrid combines photovoltaic and battery storage units to act as an energy source should a citywide power outage occur.

Hybrid approach enables predictable energy access

The supporting technology merges benefits of both private blockchain (a distributed ledger which allows invited users to manage power transactions without making the data public) and microgrids. The microgrid aims to strengthen the local grid and reduce disruption, leaving the local neighborhood unaffected, when incidents occur tens or even hundreds of miles away. During catastrophic weather events like hurricane Sandy, if the rest of the city loses power, community members continue to have power access. Since the community still uses the local utility networks, the power architecture is viewed as a hybrid local grid (as opposed to an island microgrid which operates in completely independent manner).

The microgrid serves as the nucleus for an energy future consisting of networks of energy cells. Blockchain also supports this process, by making it much easier to conduct energy trading within the energy cells. Siemens software allows the transfer of energy between the producers and consumers of the energy by providing real time analysis of supply and demand across the system.

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Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

LOS ANGELES – Examining resilience issues related to fire and power availability threats

In 2015, the City of Los Angeles published its first-ever Sustainable City Plan providing a comprehensive and actionable vision for protecting the environment, growing the economy and improving equity for every citizen. In LA, sustainability and resilience go hand-in-hand and plans are in place to better prepare for the stresses and shocks of climate change and related weather and fire endangerment threats.

A number of Initiatives have been launched across the Los Angeles area to help strengthen overall resilience:

Transportation

Integration of e-vehicles has emerged as a top priority. The Los Angeles Department of Transportation (LADOT) has plans to convert its entire bus fleet to electric buses (eBuses) by 2030. The Los Angeles Department of Water and Power (LADWP), the municipally owned and water electric utility, operates a popular electric vehicle (EV) charger rebate program for consumers, called "Charge Up L.A.!" The City itself has the most publicly available EV chargers of any U.S. city.

Renewable energy

In the LA area, micro-generation strategies like residential rooftop solar panels, which use the grid as a backup, are now less costly and easier to deploy. Benefits include decreased energy loss by avoiding long-distance electricity

transfer and increased resilience by having multiple electricity sources.

Grid modernization

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.

Fire control

The Los Angeles plan also calls for resilience to withstand the energy onslaught of hot and dry days, and the related rolling black outs and wildfire threats. Some wildfires were started by aging electrical equipment, and, as a result, some utilities plan to cut power to

CONTENTS

areas that are under threat from nearby fires. A possible backup plan to help address such a scenario is to make power available through a community microgrid for those people in high risk areas.

Technology comparisons reveal most effective solutions

Siemens is contributing to these efforts through the publication of a City Performance Tool Report. 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.

For municipalities to build up resilience to natural disasters, a two-pronged approach is needed.

Resulting emissions reductions would be accompanied by a 72% improvement in air quality and almost two million local jobs.

THOUSAND OAKS, CA – Biogas waste used to power local water works operations

In hot, dry places water systems are even more vital to the well-being of citizens. Many municipalities spend as much as 35% of their budgets on the energy needed to run water and wastewater plants.

The city of Thousand Oaks strengthened its resilience planning by implementing a biogas fueled microgrid that powers its wastewater treatment plant.

The configuration offers 100% on-site renewable generation which, in effect, turns the wastewater treatment plant into a strategic energy resource. The cogeneration plant supplies about 85% of the treatment facility's power. A separate on-site, 584 kWh solar farm comprised of 2,783 motorized panels delivers the balance of the energy required. This green energy effort saves the city about $300,000 per year operating the 14 million gallon per day plant.

The plant takes waste from the wastewater treatment process and funnels it into an anaerobic digester, where it decomposes and eventually produces methane. This methane gas is burned in a Siemens internal combustion engine, producing much of the electricity and heat that the wastewater plant needs for its day-to-day operations.

As an added benefit, the plant operates at such efficiency that it has started processing waste from businesses in the region. The "tipping fees" charged for these services amount to an additional $400,000 per year.

The Siemens engine is purpose-built for these types of applications and continues to run for long periods of time despite the very demanding and difficult environment. Having an engine that's able to run on a continuous basis affords Thousand Oaks the ability to keep costs low without having to purchase more expensive power from a utility.

PUERTO RICO – Where disaster planning and rapid recovery are now on top of the investment agenda

For municipalities to build up resilience to natural disasters, a two-pronged approach is needed. First, disaster preparedness strategies must be planned. When disaster strikes, damage to assets and threats to the citizenship can then be minimized. Second, recovery from the damage inflicted by the natural disaster must be quick an effective. The island of Puerto Rico and its municipalities have suffered the effects of two major hurricanes in rapid succession. Lessons learned from both have given birth to new resilience-related innovations.

Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

The benefits of quick natural disaster recovery

When Hurricane Maria struck in 2017, Puerto Rico's entire electrical grid collapsed, leaving nearly all of its 3.4 million residents without power.

The island's Olein Oil Refinery, however, was prepared for such an eventuality. Just months before Maria, Olein was producing enough reliable, low-cost energy to power 100% of its operations—using the local power grid only as a backup source. Olein had built a Combined Heat and Power (CHP) plant for the purpose of lowering energy costs. The plant captures heat from its generators and converts it into chilled water using a hot-water-driven vapor absorption chiller. This approach cut Olein's energy costs in half.

The Siemens gas engines that powered the plant run on propane. Therefore, they are able to be operated without power capacity derating, loss of efficiency or damage to the equipment. Propane happens to be the most available fuel in Puerto Rico, and the plant did not collapse after the hurricane. The fuel supplier, filled the propane tank one day before the hurricane and then four days later.

The use of distributed renewable generation coupled with the ability to store energy helps strengthen the resilience of both San Juan and the rest of the island.

After the hurricane passed through, much of the island was without power for over eight months and 10,000 businesses on the island remained closed. During that same time period, as a result of their resilient power system, Olein retained all of its employees and hired an additional 20 people from the surrounding area.

A new planning approach based on a resilient design

After Maria, Puerto Rico was presented with a rare opportunity to redesign its power system top to bottom and to place an emphasis on resilience. Island stakeholders opted for is a series of mini-grids. The mini-grids will be able to operate independently if required, but they can share power with each other should a big storm incapacitate one or several of them.

Mini-grids offer a different energy management design that systematically improves resilience by separating the existing grid into pockets of critical loads served by distributed resources that can operate in both grid-connected and island modes. They are distinguished from microgrids in that they utilize existing distribution infrastructure, and can be sized much larger than typical microgrids, for example, encompassing the San Juan region. The proposed 10 mini-grids will cover most of the island and can each withstand or recover very quickly from a catastrophic weather event.

Through reduced dependence on centralized thermal resources, risks of catastrophe are significantly reduced. The use of distributed renewable generation coupled with the ability to store energy helps strengthen the resilience of both San Juan and the rest of the island.

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Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

New global innovations that further enhance city resilience

Across the globe, cities are adapting to new ways for handling their unique resilience challenges and many are introducing a new generation of digitalized technologies:

Mobile Resilience Power Transformers

In parts of New York City, mobile resilience power transformers can be replaced within days rather than the weeks it takes to replace traditional transformers. Siemens is providing Con Edison, the utility that powers New York City and local areas, with compact, light and environment-friendly transformers. The mobile resilience transformers allow Con Edison to respond to events in which multiple transformers are impacted and normal spares or system redundancy may not be able to address the issues.

Digital twins

A digital twin is a virtual model that analyzes the gathered city infrastructure performance data and then uses it to run simulations and benchmark performance, allowing city administrators to pinpoint where resilience investments should be made. By pairing both virtual and physical worlds (the twins), analysis of data and monitoring of systems can actively avert problems before they occur, preventing system breakdowns and developing new efficiency opportunities.

In the future, digital twins could simulate an entire city and predict what would happen as a result of a certain intensity of storm, factoring in wind and snow/rain levels for instance. Helsinki, Finland for example, uses some virtual models that interpret past weather data to predict more accurately potential new storm effects, and to plan accordingly.

In Portugal, such models are used to predict river water levels and which adjoining areas are likely to flood first when a storm occurs. Their model integrates GIS maps and takes into account geographical elevations and potential flood paths. Such tools are effective in helping cities to strengthen their resilience.

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SIEMENS
Ingenuity for life

Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

Predictive air quality / monitoring

In Germany, certain cities are developing the capability to predict air quality 5 days in advance and to simulate what actions can be taken. Artificial Intelligence (AI) programs recommend strategies to help air pollution index numbers remain below potentially harmful levels.

Predictive maintenance

Modern Internet of Things (IoT) technologies can now predict failures in electro-mechanical systems before they occur. In the case of city transit systems, like subways, software can help determine the optimal time or targeted time to perform maintenance before unanticipated downtime strikes. When the flexibility to shut down subway lines is limited (e.g., during rush hour) predictive maintenance helps systems to remain robust and redundant.

EV charging infrastructures

Both fixed and portable EV charging stations, some which can be solar powered, allow EVs to be charged without having to tie into the grid. Additionally, these stations can be deployed throughout the city in emergency situations, such as blackouts, which will improve the overall resilience of cities and their residents.

Across the Country, Municipalities Look to Distributed Energy to Boost Resilience

CONTENTS

Conclusion

The flexible integration of decentralized energy and energy storage devices presents opportunities to increase the resilience of energy supply while at the same time improving efficiency and adopting cleaner sources of power.

Making urban electricity systems more resilient and sustainable calls for a shift towards distributed, automated and remotely controlled energy systems. Microgrid infrastructures, whereby small, independent electricity or heat grids distribute locally generated energy to nearby customers, can ensure a constant power supply even if the main power grid is under stress. In the event of a major catastrophe at a centralized plant or in the transmission network, microgrids could channel energy to critical services, such as hospitals and other emergency services.

Siemens enables cities to boost their resilience by bringing international know-how directly to city managers. Our task is to help urban areas become more resilient to the physical, social, and economic challenges that are a growing part of the 21st century. We work with public organizations as well as private companies in helping cities, their people, communities and institutions respond to the stresses and acute shocks caused by rapid urbanization, globalization, and climate change. For us, resilience is not only about surviving—it is also about thriving, regardless of the challenge.

Siemens expertise is integrating hardware and software to improve quality of life, capacity, and efficiency in metropolitan areas. Siemens has established the Center of Competence Cities (CoC Cities) to specifically address the needs of urban planners and to enter into a structured dialogue and base-lining assessment with urban decision-makers. To learn more visit **https://new.siemens.com/us/en/company/topic-areas/intelligent-infrastructurehtml#Resilience**

Making urban electricity systems more resilient and sustainable calls for a shift towards distributed, automated and remotely controlled energy systems.

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