SYNTHETIC ENVIRONMENTS FOR RESILIENCE PLANNING

Incubatenergy Labs 2020 Pilot Project Report

Startup

RUNWITHIT Synthetics

Hosts

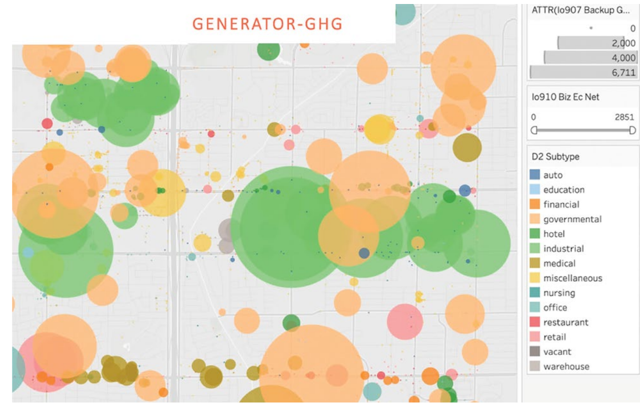
EPRI and Salt River Project (SRP)

Technology Solution

Resilience is a necessary part of modernizing grid infrastructure to prepare for and mitigate hazards of all types. Among the most daunting challenges utilities face are predicting and dealing with natural disasters, especially high-impact, low-frequency (HILF) scenarios that can affect not only utility systems but also other critical infrastructures and can have cascading impacts on customers and society. Simulating potential impacts and possible resilience measures is extremely difficult given the immense physical systems involved, the complex interdependencies, and human dynamics across many dimensions.

The RUNWITHIT (RWI) pilot project involved proof-of-concept testing of modeling tools based on artificial intelligence (AI) for simulating a dual-disaster scenario from a utility perspective, exploring impacts, and testing pre-emptive countermeasures. RWI creates single synthetic environments (SSE) as digital living models of cities, including entities such as geospatially accurate utility infrastructure, other infrastructure and community services, residents and businesses, and different types of technologies. These SSEs interact to support sophisticated scenario modeling and analysis through a hyper-localized virtual laboratory and visualization tool drawing on data and intelligence from diverse sources. Inflections such as new technologies, policies, and procedures can be trialed, optimized, and validated.

Challenge: Customer and Community Resilience



Screenshot mapping hyper-localized, time-based GHG emissions from backup generators during the outage based on energy consumption patterns and generator types for area businesses

Project Overview

Working in collaboration with SRP and EPRI, RWI set out to demonstrate an SSE application in utility resilience, creating the dual-disaster scenario of a power outage within the utility's service area during the time of COVID-19. Proof-of-concept goals were to simulate how dual events can stress critical infrastructures and create health and safety risks, as well as demonstrate the use of AI-based modeling and visualization in diagnosing and mitigating vulnerabilities.

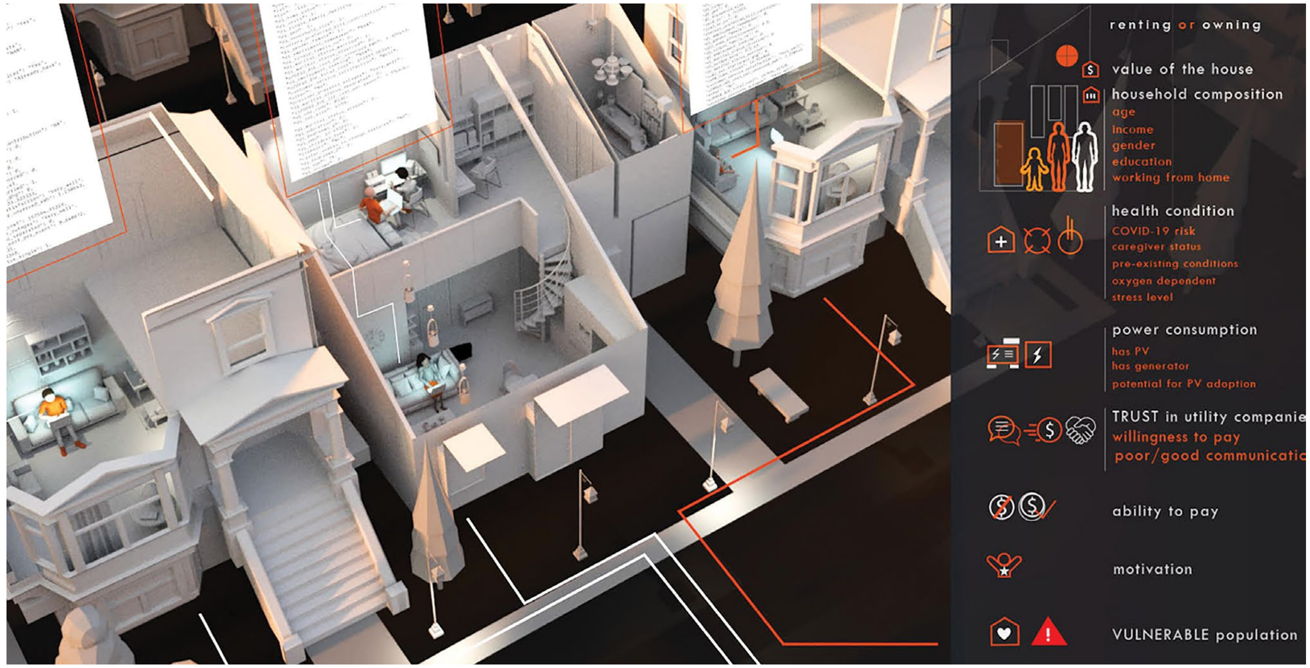
SRP directed RWI to focus on a 15.6-square-mile area in metro Phoenix/Tempe to simulate a 7-hour outage, starting on a typically sweltering July afternoon, during the pandemic with shelter-in-place guidelines. This outage affected 18,249 homes and over 2,000 businesses. RWI's goal was to bring this area to life, synthetically generating entities for grid assets, COVID-19 consumption curves, and economic conditions, as well as customers' psychographics, health, economics, demographics, and access to backup power. Emergency response and medical access in the community also were represented. These entities —and their behavior before and during the outage— were synthesized from more than 200 interconnected models.

Because consequences for end-use consumers are the focus of utility resilience efforts, RWI concentrated modeling around key aspects of SRP's commercial and residential customer base. The models incorporated businesses, their existing backup and auxiliary power capacity, and their plans around outage response, power sources, and greenhouse gas emissions (GHG) during outages.

To synthesize the residential population in the area in great detail, model inputs included census data, property and taxation data from Maricopa County, health data from Arizona Department of Health Services, and additional sources. Also incorporated were forward-looking energy plans, customer segmentation data from the Smart Energy Consumer Collaborative's "Wave 7" Report, and survey data characterizing how willingness to pay depends on the type and length of outages and is contingent on household characteristics.

Results & Learnings

Modeling and simulation of this portion of SRP's service territory under the dual-disaster scenario produced billions of data points from various outage scenarios reflecting differing levels of communications effectiveness, increases in the availability of backup power generation, and COVID-19 infection rates. Pilot project work highlighted key aspects of RWI's approach and generated a number of important insights.



Screenshot capturing human impacts of the outage based on interconnected household demographics and psychographics, including willingness to pay, health risk, and consumption patterns

Incorporation of research, domain expertise, and data. The RWI approach to synthetics decomposes complexity and scope into manageable models that capture the contributions of individuals and teams in building out the virtual laboratory. These models combine to form the SSE, a collaborative energizer and a focal point for those who provide research and expertise.

Synthetic grid asset modeling. RWI uses public data sources as well as power system engineering expertise to generate grid assets and locations in the SSE. The capability to synthesize the grid removes roadblocks to integrated analysis and experimentation that are introduced by regulatory and internal controls, as well as alleviates concerns of data breaches.

Hyper-localized customer insight. Through the layering of research and public data from disparate local and national sources, RWI quickly synthesized an accurate representation of SRP's customers and their activities, status, and plans.

"Trust in utility" modeling. RWI's psychographic and human behavior model measures trust shifts and outcomes under different outage conditions. The data from these models furnish valuable insight into long-term customer engagement and allow comparison among targeted inflections, such as improving communications and education on community resilience. Maintaining and improving trust form a critical part of resilience planning.

Equitable and inclusive planning and response. RWI's monitoring of the status of individuals in SSE scenarios furnishes unique perspectives. In this case, locating vulnerable populations and exploring the particulars of their experiences provided opportunities to assess the impact of specific programs and resilience measures.

Informed priorities. SSEs often deliver unanticipated value. With COVID-19, residents face new and unique vulnerabilities to their health and safety, exacerbated by outage conditions. By quantifying multiple risk and stress factors, RWI was able to generate a repair priority heat map based on human impacts and outcomes to assist utility planners in weighing tradeoffs and making complicated decisions.

Bringing research to life. Survey-based research on consumer segmentation and sentiment is conducted inside the SSE. Via machine learning, RWI administered surveys to the entire synthetic population—in one case, administering surveys every 15 minutes during the lengthy outage to gauge as-it-happens changes in trust and willingness to pay for various interventions. U.S. Department of Energy calculations around economic losses were also run to keep a dynamic tally of outage impacts. Perspectives on customer sentiments and impacts, interleaved with other data and maps, can enhance and validate findings.

Informing strategic planning and program development. The SSE improved understanding of current installations of backup generators and plotted their GHG emissions during the outage. Additionally, businesses and residences mostly likely to next adopt backup supply were projected, along with resultant GHG emissions. These findings can support decisions regarding incentive programs, investments, and opportunities to engage with businesses and residential customers.

Implications & Next Steps

This pilot demonstrated use of advanced computer simulation techniques, coupled with powerful visualizations, for creating a realistic synthetic environment of a utility service area and its customers to support analysis of diverse future scenarios for utility risk assessment and strategic planning. The SSE created by RWI in conjunction with SRP and EPRI exists as an extensible modeling tool suitable for deeper investigation of the case studied—simulating an extended peak-summer outage during the pandemic to understand resilience-related vulnerabilities, interdependencies, perspectives, interventions, and outcomes—and for other applications.

RWI is engaged in multiple sectors including defense, energy, mobility, health, policy, and environmental resource management. This cross-sector activity informs SSE projects in areas such as disaster planning, technology validation and penetration, and security. For example, RWI and university researchers have created an SSE that models consumer adoption of technologies such as solar, electric vehicles, and battery storage. Users can visualize and explore human factors and other drivers influencing adoption, where and when various consumers might decide to deploy, and where and which grid assets might be impacted.

Based on this pilot, RWI plans to evaluate the sharing of customer assets like these for improving resilience, shaving peaks, and meeting additional electric utility needs. Adding microgrids, other infrastructures and utilities, disaster and weather layers, and the like promise further insights and broader opportunities. Active participation by consumers is an essential element in modernizing grids and decarbonizing energy systems. Utilities interested in exploring the use of SSEs for combining deep engineering understanding with human dimensions to plot favorable paths forward are encouraged to reach out to the participants in this pilot project.

TESTIMONIAL: RWI Synthetics

Our experience with EPRI was key in helping RWI understand the ways that our technology and techniques can help navigate challenges and opportunities in building energy futures.

Myrna Bittner

TESTIMONIAL: SRP

RWI's synthetic intelligence is a powerful tool to analyze the complex interactions between utility assets, community infrastructure, and human behavior during multiple simultaneous disasters. In fact, it is the only practical method I've seen.

Gary Rector

Resources

Myrna Bittner, RWI Synthetics
Chief Executive Officer and Co-Founder
myrna@runwithitsynthetics.com

Gary Rector, SRP
Data Scientist
gary.rector@srpnet.com

Omar Siddiqui, EPRI
Senior Program Manager, Electrification & Customer Solutions
osiddiqui@epri.com

Resources

Erik Steeb, Incubatenergy® Lead
esteeb@epri.com; 650.680.6530

Anne Haas, Incubatenergy® Challenge Lead
ahaas@epri.com; 704.608.6314

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA • 800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com