TENNESSEE VALLEY AUTHORITY

CONNECTED COMMUNITIES

Synthetic Resiliency Modeling on Extended Power Outages

Pilot Project Case Study

Contents

LOCATION

Nashville, TN

PROJECT COSTS

$160,000
Total Funding

$80,000
TVA Connected Communities

$80,000
Pilot Team Match

FOCUS AREAS

Enhanced Community Resiliency

Project Summary

RUNWITHIT Synthetics (RWI) applied synthetic modeling to forecast the human impacts of a widespread power outage to help the city of Nashville with future planning.

TOPICS

- ✓ Community Resource Planning
- ✓ Event Response

TECHNOLOGY

- ✓ Synthetic Modeling Software

KEY PARTNERS

- Synthetic Modeling Software Company
- Local Power Company
- City Sustainability Officials
- Nonprofit Research Institution
- Project Advisor

Challenge and Solution

Challenge

Nashville has experienced various extreme weather events over the last decade, including heat waves, flooding and tornadoes, which produce electrical outages across the city. These events cause damage to the city and interrupt the lives of residents. With the increasing likelihood of outages from extreme weather events and other factors, such as cybersecurity attacks, there is an emphasis on studying and modeling ways Nashville can be more resilient in the face of these events.

Solution

RUNWITHIT Synthetics (RWI) applied synthetic modeling to forecast the human impacts of a widespread power outage to help the city of Nashville with future grid and resilience planning. This included studying distributed energy resource (DER) adoption across the city and how these resources impact residents' experiences with severe events that lead to widespread power loss.

Focus Areas Supported

Enhanced Community Resiliency

Synthetic modeling generates precise and complete data on household behaviors and grid performance, allowing stakeholders to identify vulnerabilities and anticipate needs without relying on real personal data.

By visualizing these scenarios, decision-makers can develop targeted strategies for load-shedding, restoration of power, as well as infrastructure improvements and emergency response and resilience support. This proactive approach ensures that resources are allocated effectively, community support systems are robust and the impacts on vulnerable populations are minimized. Ultimately, synthetic modeling enables communities to prepare comprehensively, reducing the adverse effects of power outages and enhancing overall resilience, particularly on those most vulnerable and affected.

> **“We’re facing pressures from extreme climate events, and we have all of these technologies emerging like heat pumps, solar panels, people buying EVs and getting household batteries. There’s a lot of new factors in play that are really driven by humans. So, how do we create that sense of urgency and help people be prepared?**
>
> **DEAN BITTNER** | chief technology officer and cofounder, RWI

Goals, Approach and Results

Project Goals

The Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI) collaborated with Nashville Electric Service (NES) and the city of Nashville to model an extended power outage in Nashville and the potential benefits of placement and adoption of distributed energy resources (DER) across the city.

By using a citywide outage, those with and without DER at their homes or businesses can be compared, as everyone experiences the outage at the same time but is not impacted equally. The software used in this exercise simulated and measured the impacts of the first 24 hours, the first 72 hours, and a full week of an outage, with a focus on environmental justice factors like economic disadvantage and medical vulnerability.

OUTAGE SCENARIOS

First 24 hours

First 72 hours

1 Week

> **What we do is kind of like SimCity except for real. We create these scenarios, and we simulate them in the computer and we look at them on an interface that's very much like a computer game, but it's a very serious topic, with real implications for people. In this case a weeklong power outage in Nashville.**
>
> **DEAN BITTNER** | chief technology officer and cofounder, RWI

Goals, Approach and Results

Project Approach

At the outset of the project, a collaborative effort was initiated to address an anticipated cold snap in Nashville, with city officials and grid specialists concerned about managing demand. Recognizing the high risk of a widespread power outage due to an expected cold snap, key stakeholders including RUNWITHIT Synthetics (RWI), the chief resilience officer for Nashville, NES and TVA were brought together.

The goal of the project, made possible through the TVA Connected Communities funding opportunity, was to develop strategies that could positively impact communities by preparing them in advance of adverse weather events.

The city focused on its responsibility to provide resources and resilient support for the population during outages of varying durations. TVA's role was to support local power companies like NES and ensure community stability during crises. NES was particularly concerned with preventing outages and managing load shedding in ways that minimized the impact on marginalized communities.

Thinking of future planning and applications, these stakeholders aimed to craft messages and strategies that could be taken back to their communities to foster better preparation and resilience.

Using advanced synthetic modeling, RWI used detailed data about Nashville's population and power grid to simulate how outages could potentially impact neighborhoods across the city. This data allowed a precise understanding of resident behaviors, emergency response timelines and acute needs during extreme weather conditions.

> **"Regarding restoration priorities, some of the grid technicians were saying they've been up the pole a few times resetting a breaker, looking into the backyard of people having a get-together because they have a generator, fridge, freezer and barbeque. Then, they wonder, 'am I in the best place?'**
>
> **DEAN BITTNER** | chief technology officer and cofounder, RWI

Goals, Approach and Results

Project Approach (CONTINUED)

The synthetic model simulated real-life scenarios where residents used various heating methods and the grid's response was closely monitored.

By simulating the first 24 hours, the first 72 hours and an entire week of power outage, the project highlighted the varying impacts of power outages on different community segments, particularly economically disadvantaged populations.

Once modeling was complete, EPRI supported the project with data processing and analytics, helping synthesize the findings.

RWI used Holodeck software to provide a visual and human story of these simulations, making it easier for stakeholders to grasp the implications. It examined how load shedding could be managed to minimize adverse effects on vulnerable groups and how resilience support could be provisioned effectively.

The simulations revealed areas of the grid under capacity and gaps in community support infrastructure, particularly in newer developments like Antioch.

WHAT IS SYNTHETIC MODELING?

RWI is able to synthesize populations and infrastructure from public sources like census data, municipal open-source data and even satellite imagery, which is a key enabler for this project. The RWI synthetic populations are accurate in geography and demographics without a concern for privacy, as the RWI technology uses multiple public sources to simulate real-life individuals and households without assigning real identities.

By consulting multiple sources, the approach ensures the inclusion of individuals and attributes that are missed by more traditional sources (e.g., census data) due to limitations in sampling and under-reporting. This includes those who are economically disadvantaged, at risk, vulnerable, houseless or undocumented; in many cases, these individuals are uniquely visible in synthetic populations and are most vulnerable when the power goes out.

The RWI models played out the what-if needs, sentiments, responses and impacts on the population in the lead-up to the power outage and the hours, days and weeks following the loss of power due to extreme cold. The scenarios were modeled based on best-available research and data from published and open sources, including utility and academic sources.

Goals, Approach and Results

Project Approach (CONTINUED)

The project also underscored the human need that emerges during such crises, emphasizing the importance of understanding and preparing for the diverse impacts on different community segments.

The insights gained from this project informed stakeholders about the necessary preparations and highlighted the importance of socially just load-shedding systems and processes. The city began discussions with the Department of Energy focused on integrating social justice measures into future grid planning and management.

Ultimately, the project aimed to equip stakeholders with the knowledge and tools to better prepare for and manage the impacts of extreme weather events on the power grid and the community. RWI produced a series of video assets to provide an understandable, visual representation, ensuring audiences could form a deeper connection to the human aspects of these scenarios.

While not as extreme as the scenario modeled, Nashville experienced a cold snap in December 2023 which validated many of the project's findings as NES implemented their load-shedding plan, and compared actual with synthetic, which was an outcome of this project.

> **"Playing out the simulation lets you connect to this situation in a very human way, and it's in the way that you might experience it, if it were to happen. You're seeing the synthetic people go about their lives in trying circumstances, and you realize we're all so human. There's this low-income family, single parent, five kids, and you look at the circumstances and know we have to help them. It's that kind of opportunity to practice and gain some understanding so when the real experience comes, we'll be much more prepared for how things will unfold.**
>
> **DEAN BITTNER** | chief technology officer and cofounder, RWI

Goals, Approach and Results

Project Results

Through their modeling work, RWI investigated the impacts of an outage across Nashville during the first 24 hours, the first 72 hours and a full week. The team created a series of videos that explain the methodology used in the modeling scenarios and the various impacts felt by different personas created for this project, helping different stakeholder groups communicate findings from the study in a dynamic, compelling way. This project output allows other community groups to look at resilience planning in new, more localized ways and provides a lot of digestible information related to resiliency in under five minutes.

Check out these videos to learn more about resiliency modeling and the potential impacts of an outage on Nashville.

HOW NASHVILLE HAS BENEFITTED

Key stakeholders worked together to bolster resilience support in underserved Nashville neighborhoods, addressing the identified needs. This real-world application underscored the importance of preparation and the value of the synthetic modeling approach in understanding and mitigating the impacts of power outages on marginalized communities.

During the December 2023 cold snap in Nashville, many of the human activities and grid responses modeled in this project began occurring. In response, NES activated their load-shedding plan designed during this project for the first time, successfully mitigating many of the negative impacts extreme cold can have on residents, businesses and power supply across the city.

Goals, Approach and Results

Key Partners

- **City of Nashville**
  - **Kendra May Abkowitz**, chief sustainability and resilience officer
- **Electric Power Research Institute (EPRI)**
  - **Jared Green**, technical leader, Distribution Operations and Planning
  - **Incubatenergy Labs Team**
- **Nashville Electric Service (NES)**
  - **Daniel Hanks**, engineering supervisor, Distribution Planning
  - **Tony Richman**, manager, Energy Services Engineering
- **RUNWITHIT Synthetics (RWI)**
  - **Sama Ahmed**, product manager
  - **Dean Bittner**, chief technology officer and cofounder
  - **Myrna Bittner**, chief technology officer and cofounder
  - **Anne Haas**, chief of U.S. operations
  - **Katelyn Petersen**, client executive
  - **Quentin Randall**, client executive
- **Tennessee Valley Authority (TVA)**
  - **Lisa Akins**, senior program manager
  - **Georgia Caruthers**, senior project lead
  - **Steven Coley**, manager
  - **Samuel Delay**, former senior project manager

> “A lot of places have smaller cooperatives or community-oriented utilities. It can help them understand their infrastructure in a sophisticated way and determine how much help are they going to need for a resilient response.
>
> **DEAN BITTNER** | chief technology officer and cofounder, RWI

Lessons Learned

1 Customers are Key

As we collectively prepare for the future of energy, power providers and distributors must explore innovative solutions that engage all people. Reinforcing the power grid to handle current demand projections will require extensive investment at all levels of the energy industry, but there are ways to potentially lessen the burden. Traditionally, end-use customers have been passive recipients of power, but they will need to become active participants, understanding the need for and taking part in voluntary load-reduction activities during times of need.

> **"There's many that anticipate we could at least get 35% reduction out of telling folks that we need to collectively reduce our load. Think about provisioning a grid that has access to an additional 35% in these times of extreme load. So, maybe there's a social solution, an effective way to encourage voluntary reduction so that we don't have to build out that infrastructure to handle the extreme scale of these quite rare events.**
>
> **DEAN BITTNER** | CTO and cofounder, RWI

2 Understand Stakeholder Perspectives and Priorities

Change is inherently challenging, but engaging stakeholders in ways that meet them where they are can ensure alignment and foster a change mindset. To encourage people to prepare and support each other during times of need, project teams must understand their stakeholders' current position and capabilities. It's crucial to start from their present context and guide them gradually, recognizing resource constraints and individual capacities. In this project, the team collaborated closely with community partners who then communicated the project's shared vision to their communities. This approach highlights the importance of tailoring engagement strategies to the audience's readiness and perspectives. Despite the unpredictability of responses, the fundamental desire to help and support one another remains a constant and powerful motivator.

Lessons Learned

3

Eliminate Silos

Convergence is increasingly crucial as breaking down silos within project teams and stakeholder groups inspires creative solutions to collective problems. While individual entities—like distributors, generators and municipal resilience teams—are highly capable within their domains, the real power emerges when these groups collaborate and coordinate their responses. Often, issues in one silo can be resolved by actions taken in another, but the lack of awareness and communication hinders this potential. Bringing people together in a shared environment allows them to share perspectives, understand each other's roles and challenges and discover how actions in one area can significantly benefit another. This collaborative approach not only enhances problem-solving but also fosters innovative solutions that might otherwise remain unexplored.

> **"The real power comes from those folks working together to coordinate a response. It was inspiring to see how just putting people together was so instrumental in finding some very profound solutions.**

DEAN BITTNER | chief technology officer and cofounder, RWI

Looking Ahead

As demonstrated in the December 2023 cold snap, Nashville will continue to refine event responses and utilize findings to plan city resources and power grid upgrades to ensure the resiliency of the city and surrounding communities.

While RWI's modeling focused on Nashville's unique profile and needs, communities across the region can apply findings and activities to ideate plans to support their residents, businesses and the grid during times of extreme weather events.

While applications of the RWI approach to resilience can make a crucial difference for communities when they most need it, RWI is also progressing applications in grid resource planning that address the intersection of grid and community by incorporating place-based indicators like environmental justice and workforce to help plan a clean, resilient and equitable grid that is prepared for the future.

RWI is also preparing a resilience and DER tabletop exercise where community members, strategists, utilities and stakeholders can interact dynamically with a power outage scenario to practice and prepare for when the power might go out for extended periods.

> **"The project had a focus on what impacts an outage has on economically disadvantaged populations. The same outage affects everybody, but not everybody the same way. If someone loses power and loses everything in their fridge, and they can replace it, that's a different impact than somebody who can't afford to replace the food or medicine that they have in their fridge.**
>
> **DEAN BITTNER** | chief technology officer and cofounder, RWI

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