TVA TENNESSEE VALLEY AUTHORITY

Alerting Elders to Air Quality Health Risks

Pilot Project Case Study

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Knoxville, TN

$982,075
Spend to Date

$746,138
TVA Connected Communities

$235,937
Pilot Team Match

Energy and Environmental Justice

Project Summary

To improve the health and wellness of under-resourced elders, Three[3], Inc. implemented strategies to improve resiliency to indoor and outdoor environmental health risks.

TOPICS

✓ Indoor Environmental Monitoring
✓ Smart Home Devices
✓ Wi-Fi Connectivity

TECHNOLOGY

✓ Open-Source Software
✓ Environmental Sensors
✓ Wi-Fi Hotspots
✓ Smart Devices

KEY PARTNERS

- Research Firm
- Social Purpose Organization
- University Partner
- Local Power Company
- Project Advisor

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Challenge and Solution

Challenge

As humans age, we become more susceptible to negative health outcomes from poor air quality. Both indoor and outdoor air quality can present health challenges for older people and impact their day-to-day activities. Un-weatherized homes in under-resourced communities are frequently kept at unsafe temperatures and exposed to indoor hazards, requiring more frequent medical treatments for residents. Historically under-resourced communities of color, especially elders, in the Knoxville area may be more impacted or susceptible to negative air quality concerns.

Solution

To improve the health and wellness of under-resourced elders, Three[3], Inc., a 501(c)(3) non-profit research organization located in Knoxville, Tennessee, and partners collaborated to develop the Elders Alerts System for Imminent Environmental Risks (EASIER) system, an open-source software tool and technology ecosystem that improves the elderly's resiliency to indoor and outdoor environmental health risks.

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Focus Areas Supported
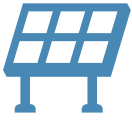
Energy and Environmental Justice

By monitoring indoor environmental conditions, targeted interventions can be implemented to improve air quality and health outcomes. Additionally, indoor environmental monitoring enhances energy efficiency by identifying areas needing upgrades, such as inefficient heating, ventilation and air conditioning (HVAC) systems, and ensuring that weatherization programs do not compromise the environmental quality of residents' homes. This data-driven approach can also provide key insights that guide policymakers in equitable resource allocation and inform policy development to address the root causes of poor indoor environments. Community education and participatory research initiatives empower underserved residents to make informed decisions about their health and environment and provide communities with the information they need to advocate for better living conditions.

> " Being in so many homes and conducting so many surveys, we have found that weatherizing homes produces health benefits, but also the indoor environment can be quite challenging, for elders in particular. From the start, the EASIER system was conceived to put sensors in to measure various key environmental variables and conditions to alert elders that there are issues in their homes.
>
> **BRUCE TONN** | president, Three[3]

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Goals, Approach and Results

Project Goals

The goal of this pilot project was to enroll 50 households across the Knoxville area in locations that are deemed to be environmental justice locations per the Environmental Protection Agency (EPA) environmental justice tool, EJScreen. The pilot project aimed to improve the resilience of elders to indoor and outdoor air quality risks through the development of EASIER. To start, indoor environmental quality (IEQ) monitoring sensors were installed in homes to measure temperature, humidity, particulate matter and other indoor conditions. Air quality monitors were also placed outside in participating neighborhoods. This data were then combined with weather conditions and weather forecast data to trigger alerts to elders and designated members of their networks in the case of extreme events. This communication protocol is important as it alerts family and friends of participating elders to potential dangers.

PILOT PROJECT GOAL

A functioning EASIER that is deployed in homes of elders will demonstrably reduce indoor and outdoor environmental health risks.

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Goals, Approach and Results

Project Approach

The ideation for the project began three years ago with Three[3] leading the way, as the team already held extensive research experience in estimating the health benefits of weatherizing low-income homes, including the non-energy impact assessment for TVA's Home Uplift project. This previous research revealed that weatherizing homes both improves health and highlights challenges in the indoor environment, particularly for the elderly.

Influenced and inspired by existing community relationships from previous work, the Three[3] team had a robust local network of support, which facilitated the formation of a well-rounded advisory committee, setting the stage for a successful project team that met community needs.

Three[3] initially proposed a similar project to another agency two years prior, but the project proposal had limitations due to the team composition and progress was paused. When the TVA Connected Communities funding opportunity arose, the team was reformed and strengthened with additional technology experts and professionals from social work and geography, creating a robust team of University of Tennessee (UT) professors, graduate students and support staff. A revised project proposal was developed to include a more specific scope and an expanded team, bringing on Socially Equal Energy Efficient Development (SEEED) to ensure equitable impact to residents.

Speaking to the Connected Communities focus areas, this initiative began with a strong foundation in the Energy & Environmental Justice framework ensuring it addressed the specific needs of limited-income and elderly populations. The system was designed to use sensors to measure key environmental variables such as temperature, humidity and indoor air quality. In certain conditions, it would alert residents to potential issues. By piloting a project aimed at developing a system to help residents, especially elders, monitor the environmental quality of their homes, underserved community members would be better able to make home upgrades and lifestyle changes that support better overall health.

The project started with a focus group involving elders and caregivers from the community to ensure the product would meet their needs and expectations. Participants were shown the system components and engaged in discussions about aging in place and their specific concerns. This initial engagement provided valuable insights and helped shape the recruitment strategy for the project.

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Goals, Approach and Results

Project Approach (CONTINUED)

The UT team network built out the fully functional EASIER system, while SEEED focused on recruiting elders and obtaining their feedback. The system's development was a collaborative effort with the community, ensuring it was respectful of elders and inclusive of diverse perspectives. Feedback was continuously gathered through user experience testing, focus groups and in-home demonstrations, allowing for iterative improvements based on real-world use and community input.

As is common with pilot projects of this nature, the project team ran into technology installation challenges that required troubleshooting. The project team also experienced stagnation when it came to recruiting enough community members to participate and provide useful, comprehensive feedback, which was critical for developing a viable final product. When recruitment stalled, the Three[3] team led creative engagement strategies and campaigns to attract more community members, ensuring a diverse range of feedback. Recruitment milestones were ultimately met, but there remained a constant need for more participants to provide feedback and test new methods throughout the project lifecycle.

The rollout of the app and community engagement campaigns were successful, with clear goals met within the project timeline. Elders who participated became highly engaged, providing detailed feedback and suggestions for improvement. Some community members became particularly enthusiastic, contributing significantly to the project's development.

> " One of the elders had never used a smart device before, so I wanted to start simple with her. We started with looking up recipes since she likes to cook. Now she uses her tablet not only for EASIER, but to look up recipes, so she's started using her smart device. Then we went to other homes where the elder had hooked his smart watch and his phone to the indoor air quality monitor so he could monitor his house even without using the tablet, so we had all levels of users.

LAURA HUMPHREY | project manager, Three[3]

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Goals, Approach and Results

Project Approach (CONTINUED)

The project concluded with a waiting list of residents eager to participate, indicating strong community interest and support. The collaborative approach, continuous feedback and flexible strategies ensured the project's success and set a foundation for future initiatives.

> " We got feedback that not only were participants looking at the app, but they were looking at the sensor every day, and it helped them understand their indoor environment.
>
> **BRUCE TONN** | president, Three[3]

CONNECTED COMMUNITIES IN ACTION

> " The week of our first install, we knew how valuable the system would be in the homes. It was December going into January, and Knoxville was hit with this major ice storm and rolling blackouts. We had only gotten installed in two homes at that time, but it was clear that we couldn't do this fast enough. We needed to have this system in their homes and ready to send an alert that week. But we weren't there yet, of course. The system wasn't ready to send alerts, but we felt a responsibility to check in on our elders. We were able to monitor the few systems and see if a home was getting too cold. If the house looked like it was too cold, I called and checked in on them.
>
> A few of those elders recruited their friends because they saw that the project was going to be valuable, and so did we. We call this Connected Communities, and we were connecting the elders to their social network, but it ended up that we were very connected with them, as well.
>
> **LAURA HUMPHREY** | project manager, Three[3]

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Goals, Approach and Results

Project Results

At the close of the pilot project lifecycle, there was a waitlist for residents wishing to participate in the program.

The program had consistent participant retention, having only two participants leave the program (i.e., a participant moved out of the pilot service area, and a participant fell ill and experienced circumstances that resulted in program withdrawal).

MEASURABLE OUTCOMES

30
appropriate alerts

that the EASIER alert system provides to users and networks

48
qualifying homes

enrolled with the EASIER alert system

41
individuals and organizations

connected to the EASIER alert system and their direct users

Key Partners

- **Energy Home Basics**
  - **Bruce Glanville**, founder and home energy specialist
- **Knoxville Utilities Board**
- **Nexus Insight Advisors – Bannockburn, Illinois**
- **Slipstream, Madison, Wisconsin**
- **Social Equal Energy Efficiency Development (SEEED)**
  - **Kiska Johnson**, engagement specialist
  - **Stan Johnson**, president
- **Tennessee Valley Authority**
  - **Lisa Akins**, senior program manager
  - **Georgia Caruthers**, senior project lead
- **Three³, Inc.**
  - **Laura Humphrey**, project manager
  - **Erin Rose**, vice president
  - **Bruce Tonn**, president
- **University of Nebraska Medical Center**
  - **Kristina Kintziger**, professor of public health
- **University of Tennessee, Knoxville**
  - **Suzie Allard**, professor of communication
  - **Bryce Bible**, graduate student
  - **Kelsey Ellis**, professor of geography
  - **Jennifer First**, professor of social work
  - **Logan Montuori**, graduate student
  - **Xiaopeng Zhao**, professor of biomedical engineering

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Lessons Learned

1 Be Consistent and Creative With Recruiting

Recruitment faced a temporary slowdown, but the team successfully navigated this by re-engaging through community outreach. They targeted senior centers, churches, neighborhood watch meetings and community centers. These efforts helped establish trust with the elders, essential for successful recruitment. To overcome stagnation, it's crucial to build relationships within the community. By showing genuine interest and understanding their concerns, elders were more willing to participate. Eventually, these efforts led to a waiting list, highlighting the importance of persistent and creative engagement strategies. Other communities can adopt similar tactics, ensuring continuous presence and interaction in community hotspots to build trust and foster participation.

2 Incentivize Participants

It's essential to value and reward participants adequately. Offering tangible incentives, such as keeping the equipment post-project and financial compensation for feedback, motivated participation and retention. Immediate feedback was provided for any concerns, ensuring their issues were addressed promptly. Participants felt valued and integral to the project, knowing their input led to real changes, such as modifying system features based on their suggestions. Regular communication, addressing concerns and tangible rewards can significantly enhance participation and retention rates.

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Lessons Learned

3

Conduct App User Testing and Focus Groups

Gathering feedback early in the process has been essential in making the app as useful as possible. User testing allowed the team to adjust thresholds that trigger an excess of unnecessary pollutant alerts. Be sure to allow time to train residents on using apps. Consider the population and their potential limitations to ensure apps are usable — for example, font size, usability/complexity and language is also important for optimal and equitable access.

Feedback Mechanisms

- Pre-deployment focus groups to evaluate the app components and provide feedback to improve the design and functionality
- In-person engagement through home visits to troubleshoot issues and gather feedback
- Data and information collection through the app

> " As researchers in the academic environment, this is a very unique project because of its transformative nature. In normal research projects, we just focus on the algorithm. In this project, we have the balance between the technical development and the user and have taken a user-centered, human-centered approach. We're doing constant engagement and feedback, collecting information and evaluation from the users, which helps improve the design and make the app more user-friendly. The connection to the community and collaboration with the community were crucial factors for the success of the project.

XIAOPENG ZHAO | professor of biomedical engineering, UT

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Lessons Learned

4 **Streamline and Consolidate Data**

Managing a large database poses a challenge for any project team, especially with varied and undocumented issues that arise in pilots. The EASIER system initially generated too many alerts due to poor indoor air quality, necessitating a reevaluation of the alert rules. Adjusting these rules proved challenging and highlighted the complexity of managing real-time data, but the development team was able to bank excessive alerts to clean up the user experience for participating residents. To address similar challenges, consider establishing clear, adaptable alert criteria and be prepared for iterative refinements. Regularly reviewing and adjusting the data rules based on user feedback and actual conditions can help manage the volume and relevance of alerts effectively.

> " I was initially worried that the system wasn't going to generate any alerts, and the exact opposite happened. There were many more alerts because the indoor air quality conditions were way past the thresholds that appear in the literature. To deal with the issue, we needed to go back and rethink the alert rules themselves. It turned out to be a challenging intellectual exercise that I don't know if we've actually solved at this project, but that's going to be a focus on future projects.

BRUCE TONN | president, Three[3]

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Lessons Learned

5   ## Consider the Technology Limitations Early

The team found that it is important to make sure the data limit of any internet delivery technology is enough to meet the data requirements of the technology and users. Hotspots with a 100 MB data limit proved insufficient, causing power issues and data gaps. The team had to work closely with service providers to find feasible solutions, emphasizing the need for reliable connectivity, especially in limited-income homes. Upgrading to more reliable routers and increasing data limits solved these problems, and the project team expertly negotiated lower rates to mitigate the additional expense. For future projects, assessing and addressing technological limitations early is vital. Communities should ensure adequate data capacity and reliable internet service to support project requirements.

> **It goes back to that Energy & Environmental Justice framework, this need for connectivity in limited-income housing. Entertainment and comfort for people who are in their homes a lot is important, so if we're looking towards future projects or recommendations, it would be connectivity. Direct funding support for connectivity in homes is going to be a major need for future projects that develop things with AI, electronics and connectivity.**

LAURA HUMPHREY | project manager, Three[3]

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Lessons Learned

6 Research Versus Reality

The unexpected number of alerts led to additional system testing, which yielded surprises for the project team. Sensor testing in real-world conditions revealed surprising discrepancies from literature-based expectations. To further understand the misalignment, the development team tested the indoor air quality in some UT buildings, finding that they exceeded safety thresholds, prompting questions about the accuracy of existing data and the real-life implications of these findings. As the development team demonstrated in this project, researchers should be prepared for unexpected results and be willing to adapt their understanding based on real-world data. Continuous testing and validation in various environments can provide a more accurate picture and improve the relevance and effectiveness of interventions.

> This project revealed some philosophical questions from the research perspective. We're trying to balance what's possible, with what's safe, with do we even know exactly if these are acute issues or long-term issues. It really revealed a lot about the world that we live in. It was surprising, to say the least.
>
> **BRYCE BIBLE** | graduate student, UT

7 Incorporate Community Equity and Partnerships

The project's success relied heavily on intentional partnerships and a focus on community equity. Existing relationships from previous community work provided a strong foundation, and the advisory committee included diverse stakeholders, ensuring the project addressed the needs of the community comprehensively. Additionally, making the system open-source and aligning partner contracts to benefit the community were crucial decisions. Other communities should prioritize building strong, equitable partnerships and consider potential intellectual property, budgeting and capacity challenges early. Engaging local organizations and ensuring the project's benefits extend to the broader community can enhance viability, scalability and impact.

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Looking Ahead

As the pilot project ends, the project team is working to transition participants to sustainable internet service agreements, ensuring residents can continue to benefit from the EASIER system and associated connected technology.

NEXT STEPS

The project team plans to pursue funding through other agencies and organizations to continue the development and implementation of the open-source EASIER system for future use at scale. If funding allows, the University of Michigan presented the project team with an opportunity to collaborate on a weatherization and health project, working closely with community-based organizations to install the EASIER system in elderly, low-income housing in urban Detroit.

Future improvements being considered include health impact reports for residents to provide healthcare professionals and home energy management system integration and upgrades. Through these upgrades, the project team aims to scale EASIER into a viable, open-source software tool that supports home energy efficiency and the holistic health of residents everywhere.

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