

HUD Green & Healthy Homes Technical Studies Program

ENVIRONMENTAL HEALTH WATCH

***Remote Monitoring of Home Air Quality for Comparison of  
Energy Star and Deep Energy Retrofits***

**I. Abstract**

**Project Partners:**

Environmental Health Watch (APPLICANT)

Swetland Center for Environmental Health, School of Medicine, Case Western Reserve University

Intwine Connect

Cleveland Housing Network

Affordable Comfort, Inc

**Overview:** This technical study focuses on two aspects of green and healthy housing: 1) comparison of two green renovation standards in terms of cost, energy use, environmental quality and health outcomes; 2) feasibility of a new remote monitoring technology to evaluate environmental quality for research purposes.

**Need for ratcheting-up energy-efficiency in low-income housing renovation:** Current green practice in low income single family renovation includes retrofitting to Enterprise Green Communities and Energy Star standards, and less commonly, to LEED standards. While this represents significant progress towards healthier, more energy-efficient housing, the current green strategies alone will not get the housing sector as a whole to the substantial reductions in energy use needed to adequately address climate change and housing affordability. We need a range of aggressive strategies to ratchet-up home energy performance to reduce the carbon footprint of our older housing stock, improve health, and reduce utility costs.

An approach to high performance energy retrofits known as **Deep Energy Reduction** (DER) has significant potential for use in affordable housing. Deep Energy Reductions provide 75-90% reductions in overall energy use, resulting in dramatic utility bill savings. DER can result in heating and cooling loads that are 30-50% lower than those of similar Energy Star homes.

**Goal:** To compare two affordable green housing retrofit strategies – Energy Star and Deep Energy Reduction - with regards to energy use, affordability, environmental quality and occupant health while implementing cutting-edge remote sensing technologies for environmental and energy measurements.

**Objective 1:** Compare Energy Star and Deep Energy renovations of low-income housing with respect to their impacts on energy use, affordability, environmental quality, and occupant health.

- **Hypothesis 1:** Homes with Deep Energy renovations will *have a lower heating/cooling load* compared to homes with Energy Star renovations.
- **Hypothesis 2:** Homes with Deep Energy renovations will *have similar or improved indoor environmental quality* compared to homes with Energy Star renovations.
- **Hypothesis 3:** Occupants in newly renovated Deep Energy homes or Green Star homes will *exhibit similar improvements in health and quality of life measures* compared to their previous, (non-renovated) homes.
- **Hypothesis 4:** Deep Energy Reductions will have *lower overall costs* – construction, financing and operating – over the life-cycle of the house, as compared to Energy Star.

**Objective 2:** Determine the feasibility and acceptability of the remote monitoring system being developed with Intwine Connect to measure indoor air quality and energy use for research purposes.

- **Hypothesis 1:** Remote monitoring will be a *consistent, reliable and effective method* to evaluate environmental quality.
- **Hypothesis 2:** Remote monitoring will be a *more accurate method* to describe low-level concentrations and time-varying patterns of environmental quality parameters compared to standard techniques.
- **Hypothesis 3:** Remote monitoring technologies will *increase opportunities* for occupants to gain access to and learn about the environmental quality in their own homes.

**Design:** Twelve vacant homes will be renovated by the Cleveland Housing Network to Enterprise Green Community standards. Half of the homes will be renovated to meet Energy Star standards and half will be renovated to meet Deep Energy Reduction standards. Building tightness, energy use, and selected environmental quality measures will be taken at pre- and post-renovation data collection visits. During the last stage of renovation the remote sensing systems developed by Intwine Connect will be installed in each home. Following renovation, low-income families will lease (with an option to purchase in 15 years) and move into the homes. At this time we will educate residents about the study, enroll them, and collect basic baseline health information.

Over the course of the next year we will make four home visits, once per season, during which we will assess energy use, utility costs, environmental quality (using standard methods), and occupant-reported health outcomes. At the visits, trained EHW inspectors and Swetland Center personnel will collect the environmental data, interview occupants, and respond to participant questions or concerns. The remote sensing technology will take measurements continuously during occupation. We will evaluate the difference between renovation types by comparing cost, energy, environmental and health data, and we will evaluate remote monitoring feasibility by summarizing performance data and comparing environmental monitoring results with standard measurement techniques (i.e. portable meters and passive monitors employed during the quarterly inspections).

**Statistical power and analysis:** Our sample size calculations for environmental outcomes verify that this study has sufficient power to detect a meaningful difference in contaminant concentration between renovation types. With repeated measures, the number of measurements per house increases the analytical power and decreases the number of houses needed. This study will be able to detect a 10% or lower change in most of the indoor air quality parameters to be measured with standard methods; given that we will have more repeated measures for energy use, cost, and remote monitoring data, those analyses will be able to detect even smaller differences between Energy Star and Deep Energy Reduction. These calculations only use the four measurements taken while the homes are occupied, but we will potentially also be able to use pre- and post- renovation measurements in the analysis, which would serve to lower the amount of change we would be able to detect. Additionally, our regression analyses will also take into account potential other factors that might explain a difference in environmental quality.