New Programs at the Intersection of Health and Energy Efficiency: Can We Quantify the Impacts?

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ABSTRACT

Low-income weatherization programs provide a wide array of benefits, yet most are evaluated primarily on energy savings. Non-energy impacts (NEI), such as health improvements, reduced safety hazards, and enhanced housing stability, often go unmeasured despite their real-world importance, particularly for vulnerable households. This paper presents an evaluation framework developed for Delaware's Energy Resilient and Healthy Homes (ERHH) Initiative, a pilot effort designed to align energy efficiency upgrades with healthcare and housing improvements. The pilot formed partnerships between the healthcare and energy efficiency sectors in a collaborative, integrated care program combining elements of pre-weatherization, weatherization, and assessments by healthcare professionals.

The ERHH Initiative's evaluation framework integrates household-level health and energy assessments with program-wide data protocols, emphasizing early evaluation planning, minimal participant burden, and standardized tools. It captures metrics on social determinants of health (SDOH), energy efficiency, energy burden, indoor air quality, and well-being among other factors, supporting both qualitative and quantitative analyses.

Although full implementation was halted when the new administrator decided to focus on programs with greater direct energy savings, the framework offers a model for how integrated programs can generate timely, actionable insights. For example, data collected through home assessments could have identified respiratory risks that might aggravate asthma or issues delaying weatherization, allowing for targeted remediation and better coordination across sectors.

The design supports a rigorous, holistic framework, sympathetic to systematic NEI evaluation. Supporting future replication by public health and energy organizations alike, it provides a pathway to measure and maximize full impacts of energy and health investments.

Introduction

The relationship between housing quality and health outcomes is increasingly recognized within both the energy and healthcare sectors. Substandard housing conditions, such as mold, inadequate ventilation, and inefficient or malfunctioning heating and cooling systems, can compromise indoor air quality and thermal comfort, contributing to chronic illnesses like asthma and cardiovascular disease, as well as acute safety risks. These health burdens are disproportionately concentrated in low-income and/or vulnerable households that often face compounding challenges, including high energy costs and limited access to remediation services. (Swope 2019 and 2023)

High energy use in such homes is frequently the result of outdated appliances, poor insulation, air leakage, and insufficient system maintenance. This drives up household energy burdens and contributes to economic instability, which in turn limits a family's ability to invest in health, housing, or energy upgrades. Weatherization programs (including Weatherization Assistance Programs (WAP)) are a

proven strategy for reducing energy consumption and lowering utility bills. Still, many households are excluded from these services due to structural issues, such as roof damage, electrical hazards, or mold, that disqualify them from standard program eligibility. A new report (ACEEE 2025) notes one in five WAP-audited homes is deferred because of needed repairs, and of those, 40% go unaddressed. These conditions, if not addressed, could result in no weatherization services, or ineffective weatherization, or unsafe conditions. Because households have been excluded or deferred from weatherization, there is increased interest in pre-weatherization or weatherization-readiness programs, which typically address home conditions that would cause the home to be ineligible for weatherization programs. (NASCSP)

While deep retrofit programs and high-performance housing initiatives offer long-term solutions, they often focus on new construction or homes in relatively good condition. (GHA; US DOE; Energize Delaware 2022) These types of programs have an implicit tie-in to health benefits. Still, they do not provide robust household assessments and remediation that integrate energy efficiency and health-improving treatment in occupied homes.

On the health side, community-based programs have made strides in reducing environmental health risks through education, minor home repairs, and targeted disease management. (Jacobs 2011; Alidoust 2023) However, these initiatives are typically siloed, funded through public health or philanthropic channels, and lack integration with (and staff often lack knowledge of) energy efficiency programs. This separation limits their scale, sustainability, and potential for holistic impact.

An integrative care approach partnering energy efficiency and healthcare is on the rise, with a philosophy similar to the Energy Resilient and Healthy Homes Initiative (ERHH Initiative) discussed in this paper, including for example, the Residential Retrofits for Energy Equity (R2E2) partnership between ACEEE and others, DOE weatherization-plus-health voluntary partnerships between WAP grantees and healthy homes service providers (NCHH), energy-plus-health program approaches (VEIC), various studies measuring NEI of the TVA Home Uplift Initiative (Three[3]) and research at the intersection of housing and health conducted by the Johns Hopkins University, Bloomberg School of Public Health . (Pollack; Shi 2017).

The ERHH Initiative and other integrated care approaches underscore the need to integrate healthcare and energy efficiency funding to address structural inequities like inadequate housing, high energy costs, and limited access to care. While energy efficiency upgrades can yield measurable health benefits, traditional funding streams remain siloed, and the healthcare system lacks mechanisms to recognize or sustain these gains. Braiding funds across sectors is a strategic imperative. These programs are unlikely to pass a limited TRC test, so robust evaluation of the full range of benefits may help justify increased funding for these initiatives.

Drivers, Vision, and a New Program Approach

The Delaware Sustainable Energy Utilities' (DESEU) Energy Resilient and Healthy Homes (ERHH) Initiative was a pilot project designed to foster partnerships between the healthcare and energy efficiency sectors, to align energy efficiency upgrades with health and safety improvements through a coordinated, data-driven approach. The ERHH Initiative united individuals from both sectors who acknowledge the necessity of coordinating and discussing energy efficiency alongside related factors that impact people's health in their homes. This multifaceted approach simultaneously addressed health, housing, and energy through policy procedures and funding. The ERHH Initiative included elements of pre-weatherization and weatherization programs, with the added layer of coordinating with the health care community. Health and energy assessments were to be conducted by trained technicians and community health workers, scheduled at three points: pre-treatment, post-treatment, and at the program's conclusion.

By bridging gaps across sectors, ERHH provides a pathway for addressing energy, health, and housing inequities simultaneously. Few programs embed robust evaluation frameworks, including home assessment and data collection tools, where data enables quantifying both energy and non-energy

impacts at the household level. Fewer still systematically integrate data across agencies to capture the full scope of benefits—economic, environmental, and health-related—that these interventions can deliver within the program and across the community.

Energy Resilience: Through the ERHH Initiative, households receive an initial energy assessment in which technicians identify and recommend potential weatherization and energy efficiency improvements, and assess any necessary health, safety, and pre-weatherization repairs needed.

Healthy Homes: Health assessments are crucial to the ERHH Initiative. Every participating home was to receive a health assessment by a healthcare professional. In addition, it was expected that some participants would be recommended to the program by health care partners (local hospitals and doctor's offices). While a participant's initial health complaint may focus on one item (e.g., asthma), the health assessments are holistic and comprehensive. Assessments at the client's home help implementers and health partners identify issues (e.g., mold, mildew, pests) and take corrective actions to improve household health. Remediation may include education, coordination with the energy efficiency team, and/or home repairs. Although the ERHH pilot program was not designed as a typical health research study, data collected at the household level still provide valuable information and metrics.

Social Determinants of Health: The social determinants of health (SDOH) refer to the conditions that people experience from birth to old age, which are influenced by the distribution of resources. One SDOH domain is access to healthcare and quality of health. Another includes economic stability, food security, housing, and access to energy. Health is affected by neighborhood, built environment, community, workplace conditions, and incarceration. Throughout the project, the ERHH Initiative collects data on SDOH from the population and program participants, including employment status, housing stability, social cohesion, school attendance, and perceptions of health discrimination. (CDC 2025; CHR&R 2025)

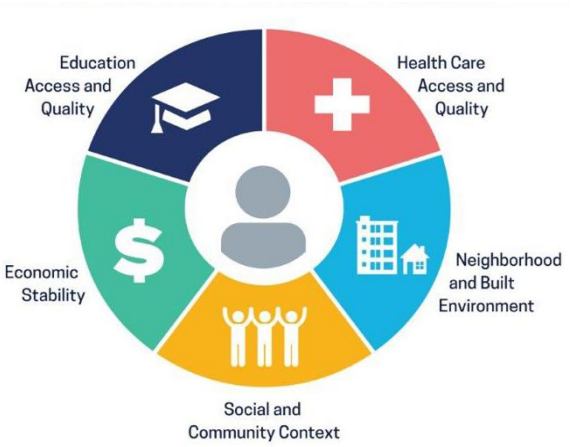

Figure 1. Social Determinants of Health

Evaluation Framework

Evaluations are most effective when embedded early in program design, especially for pilot programs, where they support formative learning, refine delivery, and promote cross-sector coordination. Early technical assistance helps administrators and implementers identify key metrics, build usable data systems, engage stakeholders, and make real-time adjustments to improve outcomes and accountability. (Scott 2022) The ERHH evaluation team developed an evaluation framework early in the Initiative, engaging all administrators and implementers as it was developed. The evaluation framework was set up to measure NEI based on a theory of change and actual interventions, and served four primary objectives.

First, it aimed to evaluate the overall program by quantifying non-energy impacts (NEIs) using clearly defined performance indicators. The theory of change identified the data elements needed to determine whether program activities lead to meaningful outcomes, particularly across health, housing, and energy domains. These metrics would allow for tracking program evolution, informing continuous improvement, and supporting comparisons to past studies and national benchmarks. (See "Theory of Change" and "Key Performance Indicators and Metrics Measuring Success.")

Second, at the household level, the framework supports tailoring remediation plans to leverage health and energy assessment data. To avoid burdening participants and agencies, evaluators modified existing intake and assessment tools rather than creating wholly new tools, adding targeted questions about conditions like mold, pests, and well-being. These data also fed into the overall program evaluation.

Third, the framework standardized data elements and procedures across implementing agencies. This ensured consistency and enabled both household- and program-level analyses. Tracking was integrated into existing agency systems, attending to confidentiality, retrieval, and compatibility.

Fourth, the framework guided technical assistance throughout the planning phase. Evaluators collaborated with administrators, agencies, and healthcare partners to clarify participation pathways, align data collection responsibilities, and promote shared learning. The goal was to support adaptability while maintaining rigor across sectors.

Although the program funding ended before full implementation, the framework was designed to generate actionable feedback during delivery. For example, had the ERHH Initiative moved forward, aggregated data could have been used to identify homes with respiratory risk factors—such as mold exposure—before upgrades began. Implementers could then coordinate with health providers to address hazards and re-sequence interventions, ensuring safety and efficiency. This illustrates how the framework was intended to bridge frontline observations with strategic decisions, supporting real-time adaptation.

Theory of Change and Conceptual Model

A theory of change illustrates the goals, outcomes, and long-term impacts of a specific intervention. As shown in Figure 2 (GHHI 2011), the ERHH Initiative's comprehensive housing interventions were designed to produce both energy and non-energy outputs, such as health, safety, and financial stability, and ultimately influence broader social determinants of health. The conceptual model helped the evaluation team and program partners clarify intended impacts, define necessary data elements, and align implementation efforts toward shared goals. By starting with the desired outcomes in mind, the model served as a roadmap for data collection. It guided the customization of existing instruments and ensured that all critical data could be captured, stored, and retrieved efficiently.

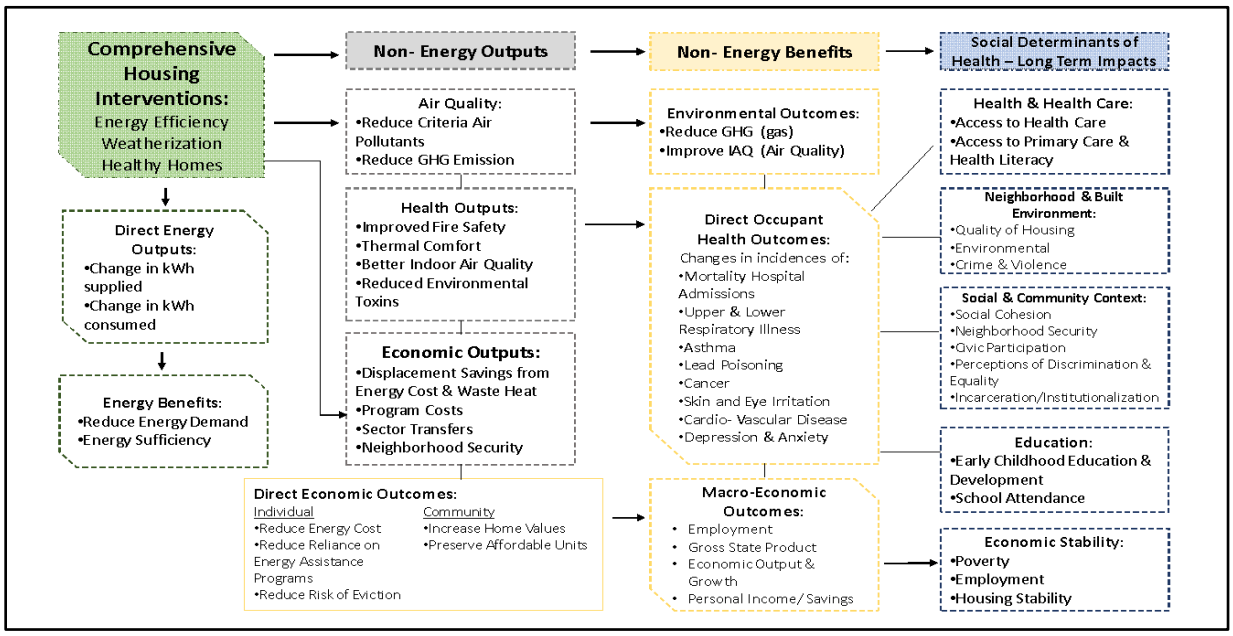

Figure 2. Theory of Change, Conceptual Model, and Linkages to Non-energy Impacts (GHHI 2011)

For example, data collected on non-energy outputs like indoor air quality improvements or the removal of respiratory hazards, can be used to calculate non-energy impacts like fewer asthma incidents, reduced medical visits, improved thermal comfort, or decreased school absenteeism. These outputs also tied to broader changes in housing stability and financial resilience. Collecting follow-up and contextual data supported long-term analysis of social determinants of health and enabled a fuller understanding of the program's potential to affect household and community well-being.

Evaluation Processes

As initiatives like the ERHH Initiative evolve, the ability to tell the stories and measure impacts across sectors and over time is essential for replication, policy advancement, and sustainable funding. This participatory-oriented evaluation approach and mindset were designed to integrate thoughtful inquiry and action. To clarify, evaluating the ERHH Initiative employed a multipronged approach. As the evaluation team balanced independence, neutrality, and minimized bias, it also sought to engage all those involved in the early stages, who clearly had an eye on the future and wanted to help the underserved through this care-integrated initiative. On the one hand, the evaluation team worked openly with the agencies, providing guidance and technical assistance. On the other hand, evaluators focused on impacts, ensuring that all necessary data elements could be gathered to tell this rich story and quantify metrics related to energy and non-energy impacts, including health and social determinants of health (SDOH). Also, because this type of program is unlikely to pass a limited TRC test, robust evaluation of the full range of benefits may help justify increased funding for these initiatives.

What sets this evaluation framework apart is its intentional integration of social determinants of health, energy efficiency, and qualitative insights into a unified structure. Rather than treating energy efficiency, health, and housing factors independently, the ERHH Initiative's evaluation approach operationalizes their interdependence by introducing rigorous metrics and methods that can also adapt to accommodate local variation while enabling comparisons across sites and over time. In this way, the framework is designed as a living document, robust yet flexible.

SDOH indicators are essential in this framework because they reflect underlying structural and environmental factors that influence both energy outcomes and health outcomes. Tracking these SDOH indicators ensures the framework reflects real-world complexity, avoids reductionist energy metrics, and aligns with broader health equity goals. For example:

- **Employment status** affects a household's energy burden and capacity to invest in home upgrades. Employment also serves as a proxy for economic stability, which impacts health and housing security. (Van Der Noordt 2014)
- **Housing stability and quality** are directly related to both energy efficiency (for example, the ability to stay in a home and potentially retrofit it) and health (for example, exposure to mold or extreme temperatures). These factors often disqualify homes for treatment in traditional weatherization programs, which means these factors are critical to track in the ERHH Initiative where they can be included in remediation plans and activities. (Chen 2022)
- **Social cohesion** provides insight into community resilience and program uptake. Stronger neighborhood networks may enhance household stability, participation, feedback loops, and program sustainability. (Chuang 2013)
- **School attendance** serves as a proxy for child health and family stability. Missed school days are often linked to substandard housing and related health issues. (Allison 2019)
- **Perceptions of discrimination** capture the lived experiences of program participants and the inclusivity of program design and implementation. These perceptions impact engagement and trust, both of which are essential for effective delivery. (Pascoe 2009)

To strengthen the ability to apply results more broadly and build on existing research, we selected metrics that align with those used in national evaluations, such as the U.S. Department of Energy's Weatherization Assistance Program (WAP). We also cross-walked data collection instruments and selected survey questions with major public health surveillance systems, including the National Health Interview Survey and the CDC's Behavioral Risk Factor Surveillance System (BRFSS), particularly in relation to asthma and housing-related health impacts. Participant surveys included validated measures like Cantril's Ladder to assess overall life satisfaction and perceived well-being. This method is a simple but powerful proxy for changes in quality of life throughout an intervention period. (Cantril) Taken together, these enable future comparisons and support broader claims about program effectiveness, contributing to the field's growing understanding of how integrated interventions can yield measurable improvements in health, housing quality, and energy resilience. (Tonn 2014a; Tonn 2014b; Tonn 2015; DHSS 2017; GHHI 2018; NCHH 2009; VEIC 2019).

The evaluation framework bridges a gap between public health and energy evaluation communities, setting a precedent for shared accountability, data interoperability, and equity-focused measurement strategies. Just as there are standard SDOH measurement protocols, asthma checklists, and energy audit tools, (CDC, CDC 2018; Energize Delaware HEC^2; PhenX 2025) the ERHH Initiative's data collection and evaluation protocol can become a standardized protocol for integrated care programs.

Key Performance Indicators and Metrics Measuring Success

The DESEU ERHH Initiative key performance indicators and measurement metrics narrate the story of funding sources and participation pathways, measure progress and success, inform reports to the community and funders, and support analyses of SDOH indicators for data inferences. While the specific data collection instruments (intake forms, checklists, surveys, etc.) and equations are not included in this paper (space constraints) the following tables illustrate the foundations of the evaluation framework and summarize the process used in developing the evaluation framework. This approach is replicable in any number of programs interested in measuring NEI. The following tables contain a high level of detail, reflecting the heart of the ERHH evaluation framework. We recognize that some readers may prefer to focus on categories and overall structure, while others, like program administrators, evaluators, and practitioners, will benefit from specifics. By including this detail, we provide both a conceptual roadmap for understanding the framework and a practical reference for those implementing or adapting it.

In developing the evaluation framework, evaluators researched existing approaches to quantify each metric and to build upon and compare our results to existing research, [1,2] documented requisite inputs, and cross-walked all existing data collection tools against mandatory data, added questions to existing tools to minimize data burden.[3] The evaluability assessment ensured instruments collected all data elements required to measure change in each metric.

Table 1 concentrates on demographics and program-level data. Table 2 summarizes categories of key outcomes and metrics selected for evaluation. Some metrics may fall into more than one category. For example, improved indoor air quality is a measure of health outcomes and environmental outcomes. The base analysis can be the same, with results presented from multiple perspectives. All evaluated metrics require documenting the results of baseline (pre-treatment) assessments (including home

[1] For example, ORNL/TM-2014/345, Health and Household-Related Benefits Attributable to the Weatherization Assistance Program provides survey questions, equations, present value monetized benefits. (Tonn 2014a)

[2] For example, GHHI discusses a blueprint for improving asthma outcomes: Healthy Homes and Asthma. Dec 2019.

[3] For example, we added IAQ and other questions to the assessment tool used for the Energize Delaware Home Energy Checkups and Counseling, (HEC^2) (Energize Delaware HEC^2)

conditions and baseline health-related metrics) and subsequent recommendations, remediation plans, activities, and treatments for both energy efficiency and healthcare. Treatment can include tangible physical equipment and repairs, education, and behavioral changes.

In Tables 1 and 2, metrics are evaluated and reported as financial impacts, summary statistics, anecdotal, qualitative, and contextual data, as labeled and described in the note in Table 1.

Table 1. Key Performance Indicators and Measurement Metrics – Demographics and Program Levels

Indicators	Metrics
Participation	• Potentially eligible homes (#) • Homes not served and reason for screening out (#,%) • Eligible households served (#,%) • Participants at various income levels (%SMI, %AMI, %FPL)* • Demographic breakdown, geographic breakdown (rural and urban, census tract) (#,%) • Households that receive referrals and ultimately return for service (#,%)
Program Resources	• Total funding leveraged for energy efficiency, health and safety, renewable energy, and green jobs (funding and costs by source and purpose) • Amount of investment financed (housing tax credits, on-bill programs, grants, etc.) value added to the project
Housing Type and Ownership	• Participation by housing type (#,%) • Ownership – renter, owner (#,%)
Low and Moderate Income (LMI) Parity	• Savings across LMI and market rate programs (% total savings) • Penetration rate by income band (%SMI, %AMI, %FPL)* statewide, census tract
* Area Median Income (AMI), State Median Income (SMI), and Federal Poverty Level (FPL) $: Quantify as a monetary, financial impact #: Quantify with summary statistics, such as the number of cases, unit energy savings (kWh or BTU), changes in emissions reported in ppm, or tons, or percentage change in baseline level, etc. A: Anecdotal or qualitative data collected from surveys and interviews which support case studies, secondary research, and the process evaluation overall, adding to the contextual SDOH discussion C: Contextual data	

Table 2. Energy Resilient and Healthy Homes Key Performance Indicators and Measurement Metrics

Category	Evaluated Metrics	Contextual
Energy Outcomes	Annual electricity savings(kWh, MWh) per home ($,#) Annual fuel savings (MCF, MMBtu) per home ($,#) Peak demand savings per home (#) Specific measures/treatments ($,#)	Local, state, national norms for LMI weatherization programs
Environmental Outcomes	Outdoor air pollutants (on society) ($) Indoor Air Quality (IAQ) (#) Greenhouse gas (GHG) emissions ($,#)	Importance of impacts on climate change
Economic Indicators Promoting Workforce Development	Direct employment - jobs created (# by job type, e.g., clean energy jobs and agency) attributable to program, hours of labor (FTE,$,#,A,C) Indirect economic impact ($) LMI residents added to workforce (#,A) Increase in pay (#,$,%), sustainable long term placement (#,%)	American Community Survey data
Economic Indicators Easing Energy Burden	Change in energy burden (% reduction in % of income paid for energy bills) (#,$,A) Reliance on energy assistance programs ($,#) Changes in ability to pay for food, medicine, energy ($,#,A) Eviction rate (#)	Poverty rates Census data American Community Survey data

Category	Evaluated Metrics	Contextual
	Property/home values /home affordability rates ($)	
Health Indicators Creating Healthy and Safe Homes	Fire safety (working smoke detectors in home) ($,#,A) Number of fires due to faulty wiring (#,$,A) Thermal comfort (home warm or cool enough) ($,#,A) Well-being (#,A) Access to healthcare (#, A) Number of trips for healthcare by reason (#,$,A) Specific conditions related to environment (asthma, lead, skin irritation, cardiovascular disease, mental health) ($,#,A,C) Changes in IAQ, GHG and emissions associated with participants (#,%,$,A,C) Treatment to improve IAQ ($,#,A,C) Treatment to reduce fire hazards ($,#,A,C) Treatment to improve thermal comfort ($,#,A,C) Health and safety issues abated (# homes, % issues abated ($,A,C) Visits to emergency room (ER) or primary care physician (PCP) for environmentally driven illness, cost of visits (#,$,A,C) Perceptions of household changes in health and safety, changes in program-related health and healthcare costs (e.g., visits to ER or PCP (#,$,A), incidence of environmental health issues (#,$,A))	Mortality, Hospital Admissions Centers for Medicaid Services, population data Other secondary research data (e.g., ORNL studies)
Social Determinants of Health	Current employment status (#,C) Housing (stability, quality) (#,A,C) Social cohesion (A,C) Perceptions of discrimination (#,A,C) School attendance, missed days, reason (#,A,C) Work attendance, missed days, reason (#,A,C)	Neighborhood Security) Incarceration, Institutionalization Early Childhood Education & Development Healthy People 2030/ACS School attendance

Tables 3 and 4 provide examples illustrating one health indicator—asthma—within the evaluation framework. Table 3 documents the indoor contaminants and housing conditions that affect indoor air quality (IAQ) and asthma, along with the corresponding repair and weatherization treatments, references, and anticipated SDOH outcomes. Table 4 condenses this information into the evaluated metric, the evaluation method, and the data requirements.

Table 3. Example: One Health Indicator – IAQ and Asthma—Contaminants and Treatments

Indoor Contaminants	Repair and Weatherization Treatment	
Unvented combustion appliances (e.g., kerosene space heaters)	Removal of all unvented combustion space heaters	Air sealing, insulation
Poor ventilation of combustion gases	Repair/replace unvented heat pumps, vented gas heating, or enclosed wood burners, coal or biomass stoves, unvented open-flamed cookers	HVAC system repair, maintenance, replacement
Poor ventilation of combustion gases	Increase the volume of indoor to outdoor air exchanged	Mechanical and window ventilation
Lower levels of surface and ambient mold	Remove moldy objects from home	Ground vapor barrier, dryer venting, repair leaking roof

Table 4. Example: One Health Indicator – IAQ and Asthma—Methods and Data Required

IAQ Metrics	Methods and Data Required
Homes receiving treatment that could improve IAQ (#) Treatment by type per asthma checklist (#) Treatment by type per weatherization records (#) Cost per treatment to monetize benefits ($)	Recommend using the Asthma Checklist (CDC 2018) and the HEC^2 (Energize Delaware HEC^2) assessment tools with modifications, pre and post. Surveys, observations, interviews about home health environments and improvements. Participant perceptions about IAQ, pre/post survey. Health assessment survey and observed IAQ conditions pre and post treatment. IAQ test data if collected by agency.

Data Collection

Administrators, the evaluation team, and implementing agencies collaborated to develop standardized intake and assessment tools that ensured consistent data collection across all participating homes. Each administrator began with their own forms, so it took considerable effort to integrate evaluation questions into existing forms and to ensure essential data were collected to support efficient analyses. These standardized instruments were designed to align with the evaluation framework, minimize participant burden, and support both household- and program-level tracking. While agencies used different platforms (e.g., spreadsheets or databases), data formats were aligned with evaluation requirements. Multi-perspective assessments—home energy, home health, and personal health--conducted at pre-treatment, post-treatment, and at the program's conclusion, (combined with surveys and qualitative interviews) provide longitudinal data needed to measure changes over time. To be clear, the evaluation team was working with a data-rich program. Implementers already planned to collect data such as that needed to verify income. They were already planning detailed energy audits, post-installation inspections, and collecting utility bills. They were planning to conduct health assessments and regular reporting. The evaluation plans leveraged all these data and made structural and detailed adjustments.

Table 5 summarizes the key tools used for data collection, including eligibility screeners, referral documentation, assessment forms, utility data tracking, and participant surveys. Intake and assessment tools also documented participation pathways (participants could enter the program through several pathways, e.g., referrals from health care professionals, community assistance agencies, or direct outreach), tracked outcomes, and facilitated data sharing while maintaining privacy protections.

Table 5. Data Collection Forms and Tools

Tool or Form	Description
Procedures and policies manual	Describes policies and procedures, e.g., participant eligibility, referral, application and intake, selection criteria, communications between coordinating agencies, outreach plans. Identifies participation pathways (documenting multiple entry points into the program). Details of which agency is responsible for collecting data, recording, data transfer.
Eligibility screening tools	Eligibility criteria used to select participants from all potential participants, e.g., income, geographic location, services.
Referrals	All referrals made to assist clients in accessing services and other resources, outcomes.
Health assessments and related	General health and SDOH metrics, i.e., well-being, healthcare access, home environment. Documented work orders and completed interventions. Multipoint assessments track changes over time attributable to the Initiative.
Energy assessments and documentation	Documents housing conditions and could include a (modified) Healthy Homes Assessment and energy audit, recording baseline conditions, HVAC and water heating systems, recommended improvements. Scope of work outlines repairs, remediation (e.g., mold, pests), and/or weatherization, and estimated costs. Post-treatment inspection documents completed work updated housing conditions, costs by funding source and use.

Tool or Form	Description
Energy bills and usage data	Fuel bills and usage data for 12 months prior to treatment and one to two years after treatment. All fuels: electricity, natural gas, and delivered fuels (oil, propane, coal, wood, etc. Document on-site generated electricity system.
Surveys and qualitative interviews	Periodic surveys and qualitative interviews: pre- and post-treatment, interim surveys collecting qualitative and quantitative data from multiple perspectives. Questions, frequency, and precise timing for each fielding determined with implementers and partners.

All programs, especially pilots, evolve over time, and in this pilot, treatment is unique to the home and its conditions. It's important to assess the process in real time and over time, identify and address barriers (for example, challenging applications or agency coordination), examine effects immediately post-treatment, and investigate the longer term impacts, especially those that take time to manifest (for example, the number of asthma events and related trips to the doctor). Most importantly, the combined qualitative and quantitative data tell the story of the impacts, experiences of householders and providers, and offer guidance as the Initiative unfolds, so that barriers can be addressed and successes built upon.

A Few Lessons Learned From Early Collaborations

The design of the evaluation framework, developed in collaboration with administrators, implementing agencies, and health care partners, generated several lessons and highlighted barriers worth noting. Because funding ended before full implementation, these lessons reflect insights from framework design and early collaboration with agencies rather than field results.

Lessons and Barriers

- **Shared Outcomes Matter.** When agencies from different sectors agree on core outcomes, e.g., reduced emergency visits or improved housing stability, it is easier to justify shared funding.
- **Data Silos.** Privacy laws (for example, HIPAA) and incompatible data systems make it difficult to share information across sectors. The evaluation and implementation teams were discussing options to anonymize and share personal health assessment data at the time the Initiative closed.
- **Data Burden**. Data burden, e.g., multiple surveys or adding to existing data collection instruments, can overwhelm participating agencies. The extensive standardization and collaboration put a burden on the agencies in an effort to reduce the burden on participants.
- **Misaligned Timelines.** Utility and public health reporting cycles differ, complicating coordination.
- **Administrative Burden.** Managing two (or more) funding streams often increases compliance requirements and documentation needs.

Recommendations

- Develop **MOUs and data-sharing agreements** at the start of program design. Ensure all implementing agencies understand program goals, why data are needed, and how it will be used.
- Use **integrated case management platforms** that respect privacy while allowing for shared indicators. Consider methods to anonymize personal identifying information to facilitate data sharing and evaluation. Discuss data analysis methods and goals as the integrated data collection and management systems are developed and implemented.
- Identify all **data elements required**, conduct an **evaluability assessment**, and work with agencies to build on their **existing data collection forms and procedures**. Do not reinvent their processes. Ensure that each question ties directly to an outcome that needs to be measured. Take the time to review all existing forms--intake, surveys, and other data collection activities--to integrate new data elements, minimizing additional interactions. Explain how each data element will be used so

that the participating agencies understand why they are collecting the data. While this places an added burden on program and evaluation staff, it reduces the burden on agencies and participants.
- Consider **intermediary organizations** that can manage funds and reporting across sectors.
- Advocate for **policy change** to allow Medicaid or public health funding to support environmental interventions with proven health co-benefits. Health considerations should inform energy policy.

Implications for Broader Adoption

The ERHH Initiative's evaluation framework offers a replicable model for embedding social determinants of health into energy and housing program evaluations. Its key contribution lies in uniting energy efficiency, healthcare, and housing systems through shared metrics, coordinated data infrastructure, and adaptable tools. Even though the ERHH Initiative was halted before full implementation, the framework remains valuable as a blueprint for how cross-sector programs can be evaluated in real time and used to guide planning, course corrections, and strategic investment.

A central takeaway from this work is that evaluation should be embedded from the outset, not treated as an afterthought—so that it can shape design decisions and help identify barriers before they undermine outcomes. Social and health impacts should be considered core program goals, especially for interventions serving vulnerable populations, and not treated as ancillary benefits. The framework also illustrates how standardized, but flexible data protocols can promote cross-sector collaboration while reducing duplication and administrative burden.

The framework is particularly applicable to pre-weatherization programs that address structural barriers to upgrades, to integrated care pilots operating in underserved communities, and to public agencies aiming to quantify the full return on investment from housing retrofits. Programs that already collect health or housing data can adapt this framework by aligning intake and assessment tools with SDOH and energy-related indicators, embedding evaluation into operational workflows, and creating feedback loops that support mid-course correction and continuous improvement.

For the broader field, this framework extends traditional evaluation practice by operationalizing the interdependence of energy efficiency, health, and housing stability. It aligns with national data systems such as the CDC's Behavioral Risk Factor Surveillance System (BRFSS) and the National Health Interview Survey (NHIS), and it has the potential to scale into larger public health and informatics initiatives. Parallel to growing interest in measuring the non-energy impacts of energy interventions, there is a surge of attention among medical researchers, institutions, and funders on understanding how housing-related SDOH influence health outcomes. Several large-scale studies on respiratory and cardiovascular disease already incorporate housing quality into their instruments. However, these tools typically omit detailed energy data, and research cohorts rarely include information about weatherization or pre-weatherization treatments. Given the rich, underutilized energy data collected by utilities and weatherization programs, this disconnect represents a significant missed opportunity.

In the future, large medical datasets such as the NIH's All of Us Program, Vanderbilt University's BioVU Biobank, and Mount Sinai's BioMe Biobank and Million Health Discoveries Program, could adopt similar frameworks to incorporate energy data through partnerships with utilities and housing agencies. Linking medical and energy datasets in this way would fill a major gap in SDOH research and could catalyze advances in precision public health.

Targeting Resources and Interventions

Databases and mapping tools developed in the last few years are useful tools to help target resources and interventions in ways that capture the complex relationship between housing quality and population health. For example:

The Hopkins Housing and Health Collaborative works with communities, policymakers, and practitioners to explore the lifelong connection between housing and health and well-being. The Collaborative developed the Housing Quality Metric tool that identifies poor quality housing by the census level, predicting the "…likelihood that a US census tract contains a large share of poor-quality housing units across three domains: physical inadequacy, housing cost burden, and poor neighborhood perception." (Garrison 2025)

Under President Biden, the White House Council on Environmental Quality launched **Executive Order 14008**, including the Climate and Economic Justice Screening Tool (CEJST) designed to identify marginalized or overburdened communities. (White House 2022) A central component of the order was the Justice40 Initiative, created "…to ensure that federal agencies deliver 40 percent of the overall benefits of climate, clean energy, affordable and sustainable housing, clean water, and other investments to disadvantaged communities." Although the Trump Administration rescinded Order 14008, the CEJST remains a useful tool. (Harvard Law 2025)

Data maps generated using the **Census Reporter** identify, for example, demographics, economics, families, housing, and social conditions by census tract. (ACS 2023)

The National Center for Healthy Housing (NCHH) and the American Public Health Association (APHA) developed the **National Healthy Housing Standard** and **NCHH Code Comparison Tool** to connect housing and public health sectors as an evidence-based reference. NCHH drew from environmental public health, safety, building science, engineering, and indoor environmental quality. (NCHH 2012; ATSDR 2024)

Quantifying Impacts of Integrated Programs at the Intersection of Energy and Health

The ERHH Initiative and its evaluation framework offer a replicable model for embedding social determinants of health into energy and housing program evaluations. NEI are at the heart of integrated care models and an important measurable outcome. With thoughtful and early evaluation planning and data gathering emphasizing minimal participant burden and standardized tools, many metrics can be measured directly, illustrated in Tables 1 and 2. Metrics capture SDOH, energy efficiency, energy burden, indoor air quality, and well-being among others. Evaluated in real time and over time, these metrics can be reported as financial impacts, summary statistics, and as qualitative and contextual data for the individual, at the program level, and benchmarked against results of other studies.

Ultimately, while the ERHH Initiative was halted before full implementation, the evaluation framework demonstrates that these impacts can, in fact, be quantified through standardized metrics, integrated data systems, and cross-sector collaboration. By embedding evaluation at the outset, aligning energy and health indicators, and minimizing participant burden, the framework provides a practical model for measuring both energy and non-energy outcomes. In doing so, it answers the central question of this paper: programs operating at the intersection of health and energy efficiency can quantify their impacts, and in ways that inform replication, policy advancement, and long-term investment.

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