Research question: How can treating homes as community infrastructure—through coordinated programs in retrofit, repair, and workforce development—create sustainable pathways for economic resilience, intergenerational equity, and climate adaptation in rural and underserved Oregon communities? Focus areas: Aging housing stock and vulnerability to climate impacts. Aging homeowners and the "age-in-place" retrofit economy. Workforce development and credentialing in energy, housing, and resilience services. Economic mobility and intergenerational equity for younger workers entering retrofit and home service fields. Community-based delivery models: CBOs, cooperatives, and public–private partnerships. Funding and policy levers: state/federal housing and energy resilience programs, local economic development incentives. Environmental and social outcomes: emission reduction, job creation, safety, affordability, and long-term sustainability. Goal: Identify frameworks, case studies, and empirical evidence showing how housing infrastructure repair and energy transition efforts can double as workforce development and economic revitalization strategies, particularly in rural and disadvantaged regions.

Integrated home retrofit and workforce development programs in rural and underserved Oregon communities create sustainable pathways by generating local jobs, serving aging homeowners while training younger workers, and achieving 15-40% energy savings that support economic resilience, intergenerational equity, and climate adaptation.

Abstract

Treating homes as community infrastructure—by integrating retrofit, repair, and workforce development—has yielded measurable benefits across economic, social, and environmental domains. In diverse settings that include rural and underserved regions (with several examples from Oregon), programs implemented through community-based organizations, public–private partnerships, and coalitions report the following outcomes:

1. Economic resilience. Several initiatives link home retrofits with workforce training to generate local job creation (e.g., one model documented 85 jobs and $5.9 million in cost savings) and stimulate broader economic stability.
2. Intergenerational equity and age-in-place. Models that combine home modifications with formal apprenticeships or credentialing serve older homeowners by improving accessibility and safety, while simultaneously creating pathways for younger, marginalized workers.
3. Climate adaptation. Weatherization and efficiency upgrades consistently produce energy savings ranging from 15% to 40% alongside reductions in greenhouse gas emissions, thereby contributing to improved community resilience.

These studies emphasize that aligning retrofit investments with workforce development and community partnerships transforms aging housing stock into a strategic asset, supporting economic mobility, social cohesion, and climate adaptation in rural and disadvantaged communities.

Paper search

We performed a semantic search using the query "Research question: How can treating homes as community infrastructure—through coordinated programs in retrofit, repair, and workforce development—create sustainable pathways for economic resilience, intergenerational equity, and climate adaptation in rural and underserved Oregon communities?

Focus areas:

Aging housing stock and vulnerability to climate impacts.

Aging homeowners and the "age-in-place" retrofit economy.

Workforce development and credentialing in energy, housing, and resilience services.

Economic mobility and intergenerational equity for younger workers entering retrofit and home service fields.

Community-based delivery models: CBOs, cooperatives, and public–private partnerships.

Funding and policy levers: state/federal housing and energy resilience programs, local economic development incentives.

Environmental and social outcomes: emission reduction, job creation, safety, affordability, and long-term sustainability.

Goal: Identify frameworks, case studies, and empirical evidence showing how housing infrastructure repair and energy transition efforts can double as workforce development and economic revitalization strategies, particularly in rural and disadvantaged regions." across over 138 million academic papers from the Elicit search engine, which includes all of Semantic Scholar and OpenAlex.

We retrieved the 500 papers most relevant to the query.

Screening

We screened in sources that met these criteria:

- **Integrated Housing-Workforce Intervention**: Does the study examine a program or intervention that integrates both housing infrastructure improvement (retrofit, repair, or energy efficiency) AND workforce development components (job training, credentialing, or skills development)?
- **Target Population**: Does the study focus on rural, underserved, or disadvantaged communities (geographically rural, economically disadvantaged, or facing structural barriers to accessing housing and workforce services)?
- **Existing Housing Focus**: Does the study focus on improvement of existing housing stock (renovation, retrofit, repair) rather than primarily on new construction or large-scale development projects?
- **Community-Based Delivery Model**: Does the study examine interventions delivered through community-based organizations, cooperatives, public-private partnerships, or other coordinated community infrastructure approaches (rather than solely individual market-based services)?

- **Relevant Outcome Measures**: Does the study report on at least one outcome related to economic mobility, job creation, intergenerational equity, climate adaptation, energy efficiency, housing affordability, or community resilience?
- **Empirical Evidence with Implementation**: Is this an empirical study (quantitative, qualitative, mixed-methods, case study, program evaluation, systematic review, or meta-analysis) that provides evidence-based findings about actual program implementation and outcomes (rather than opinion pieces, editorials, or purely theoretical policy analyses)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Program Model**:

  Extract how the program treats homes as 'community infrastructure' including:

- Overall program structure and theory of change
- How retrofit/repair and workforce development are coordinated or integrated
- What makes this a community-level rather than individual household approach
- Scale of operation (number of homes, geographic scope)
- Program duration and phases
- Key innovations or distinguishing features

- **Community Context**:

  Extract characteristics of the target communities including:

- Geographic location and rural/urban classification
- Socioeconomic indicators (income, poverty rates, demographics)
- Housing stock characteristics (age, condition, energy performance)
- Climate vulnerabilities and adaptation needs
- Existing workforce and economic base
- Community assets and challenges
- Any measures of 'underserved' status

- **Delivery Approach**:

  Extract details about program delivery including:

- Lead organizations and their roles (CBOs, cooperatives, government, utilities, etc.)
- Partnership structures and governance models
- Funding sources and financing mechanisms
- Service delivery model (direct service, contractor network, cooperative, etc.)
- Community engagement and participation methods
- Quality assurance and oversight processes

- **Workforce Development**:

  Extract workforce development components including:

- Types of training programs (pre-apprenticeship, apprenticeship, certification, etc.)
- Skills and trades covered (energy efficiency, weatherization, repair, etc.)
- Target populations for training (age groups, existing workers, unemployed, etc.)
- Credentialing and career pathway structures
- Integration with actual housing work/job placement
- Partnerships with educational institutions or unions
- Evidence of career advancement or wage improvements

- **Economic Outcomes**:

  Extract evidence of economic impacts including:

- Jobs created (number, types, wage levels, permanence)
- Economic mobility outcomes for workers
- Local economic development effects
- Cost savings for homeowners (energy, maintenance, health)
- Cost-effectiveness or return on investment measures
- Economic resilience indicators
- Intergenerational wealth building or asset preservation

- **Social Outcomes**:

  Extract social and equity outcomes including:

- Intergenerational equity impacts (young worker opportunities, elder supports)
- Community cohesion or social capital effects
- Health and safety improvements
- Housing affordability and stability outcomes
- Age-in-place or displacement prevention results
- Accessibility improvements for disabled/elderly residents
- Cultural preservation or community identity impacts

- **Climate Outcomes**:

  Extract climate and environmental outcomes including:

- Energy savings achieved (quantity, percentage reduction)
- Greenhouse gas emission reductions
- Climate adaptation measures implemented
- Resilience improvements (weatherization, disaster preparedness)
- Indoor air quality or environmental health benefits
- Renewable energy installations or grid impacts
- Long-term sustainability measures

- **Success Factors**:

  Extract factors that enabled success including:

- Key policy levers or regulatory supports
- Critical funding mechanisms or incentives
- Essential partnerships or stakeholder engagement
- Community capacity building elements

- Technical assistance or support systems
- Leadership or champion roles
- Timing or contextual factors that facilitated implementation

- **Barriers/Challenges**:

  Extract obstacles and how they were addressed including:

- Financial barriers (upfront costs, access to capital, split incentives)
- Regulatory or permitting challenges
- Workforce shortages or skill gaps
- Homeowner reluctance or knowledge barriers
- Organizational capacity limitations
- Technical or logistical challenges
- How barriers were overcome or remain unresolved
- Lessons learned for future implementation

Results

Characteristics of Included Studies

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Stagg et al., 2021	Disaster recovery, high-performance homes, workforce	Rural Florida	Strategic partnership (Habitat, college, university)	Workforce development, housing resilience, economic stability
Sarin, 2009	Low-income energy efficiency, job creation	Massachusetts (case), US (policy)	Federal program, community partnerships	Weatherization jobs, energy savings, marginalized worker employment
Mattiuzzi and Simms, 2023	Energy cost reduction, resilience for low- and moderate-income households	Western US	Community development practitioner partnerships	Innovations in lending, workforce, technical assistance
Moe, 2024	Clean energy workforce gap analysis	Urban Pittsburgh	Community coalition, National Renewable Energy Laboratory technical assistance	Employment impacts, workforce gaps, retrofit strategies
Dandridge and Wallenstein, 2010	Green workforce training, field placements	Urban San Francisco Bay Area	College, agency, utility partnerships	Training for at-risk youth, retrofit experience
Goldstein et al., 2022	Racial inequity in energy efficiency	US (national)	Policy analysis	Emissions paradox, policy recommendations

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Shelby et al., 2011	Co-design for sustainable housing	Rural California, tribal	University-tribal partnership	Culturally appropriate design, funding, sovereignty
Le et al., 2012	Apprenticeships for energy retrofits	Urban Oregon/Washington	Labor-management, community workforce agreements	Training, placement, standards for disadvantaged
Barnes et al., "Field Studies..."	Grid reliability, decarbonization equity	California	Utility-led, Demand Response Emerging Technologies collaborative	Technology deployment, return on investment, community resilience
Brandin, 2010	Federal investment, retrofit strategy	Urban Oakland, California	City-led, comparative analysis	Economic, social, environmental equity
Forster and Murray, 2014	Community organizations in efficiency programs	US (multi-site)	Community-based organizations as delivery agents	Outreach, participation, program design
Strife and Yancey, 2013	Regional energy upgrades, workforce	Colorado (urban/rural)	Regional collaboration, Energy Advisors	Upgrades, jobs, cost savings, market transformation
Capella, 2015	Residential/commercial retrofits, jobs	Rural Pennsylvania	Multi-partner, grants/loans	Retrofits, workforce, energy savings
Jacob and Cyr, 2013	Clean Energy Works Oregon	Urban/rural Oregon	City-led, Better Buildings Neighborhood Program	Home retrofits, job creation, energy savings
Vergragt and Brown, 2011	Urban transitions, stakeholder collaboration	Urban Worcester, Massachusetts	Multi-stakeholder, top-down/bottom-up	Visioning, action plan, system change
Nidam et al., 2023	Urban building energy modeling	Urban Boston	Technical modeling, planners	Retrofit effectiveness, adoption barriers
Lopez et al., 2025	Resilience, ecological economy	Gulf Coast (rural/coastal)	University, community-based organization, Habitat for Humanity	Natural infrastructure, housing, engagement
Moloney et al., 2023	Long-term recovery organizations in wildfire recovery	Rural Washington/Oregon/California	Long-term recovery organizations, multi-partner	Barriers/facilitators, equity, economic recovery
Opdyke et al., 2018	Post-disaster shelter, training	Philippines	Multi-phase, household engagement	Coordination, participation, resilience

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Tohn et al., 2020	Injury prevention in weatherization	No mention found	Occupational therapy-led, weatherization	Fall reduction, cost savings, health
Ensign, 2022	Wealth creation, rural development	Rural US (Appalachia, South, Rio Grande)	Value chain, market-driven	Asset mapping, inclusion, sustainability
Yu et al., 2024	Rural housing sustainability	Rural Southeast Asia/Eastern Europe	Participatory, vocational training	Energy savings, jobs, community engagement
Taylor et al., 2023	Housing adaptation, networks	Rural Alaska	Social network analysis, organization survey	Network centrality, adaptation capacity
Li et al., 2025	Solar plus storage, university-community-based organization	Washington State	Capstone, technical analysis	Energy justice, resilience, grant success
Schmeltz et al., 2023	Electrification equity planning	California	City-led, data-driven	Screening, outreach, health/economic impacts
McCreery et al., 2022	Ventilation retrofits, health	Urban Chicago	Retrofit, health study	Indoor air quality, asthma, health disparities
Vergragt and Brown, 2015	Grassroots vs. cluster initiatives	Urban Worcester, Massachusetts	Business-led, grassroots	Stakeholder engagement, barriers
Rohe et al., 2010	Weatherization/rehab coordination	No mention found	Nonprofit-led, coordination	Affordability, home value, policy gaps
Knight et al., 2012	Deep energy savings, California homes	California	State/local, utility/federal	Whole-house upgrades, jobs, barriers
Branson, 2018	Yurok Tribe housing efficiency	Rural California, tribal	Tribal government	Woodstove/insulation, cultural fit, savings
Berkland and Hoque, 2012	Youth building science education	Urban Massachusetts	Outreach, graduate-student led	Skills, job placement, at-risk youth
Arena and Vijayakumar, 2012	SmartRegs, rental retrofits	Urban Boulder, Colorado	City, advisor model	Compliance, training, energy savings
Patterson, 2016	Regional retrofit, fuel poverty	Wales, United Kingdom	Government, Warm Wales, contractors	Energy savings, jobs, carbon dioxide reduction
Kime et al., 2023	Equity in low-carbon transitions	US, Europe	Policy review	Justice metrics, jobs, cost savings

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Brown et al., 2023	Clean energy employment impacts	US (national)	Department of Energy, Local Energy Action Program, Interstate Renewable Energy Council	Occupational analysis, workforce
Vergragt and Brown, 2012	Grassroots innovation, retrofits	Urban Worcester, Massachusetts	Coalition, community development	System change, collaboration
Rhodes and McNichols, 2025	Age-in-place, health equity	Urban, high-eviction ZIP code	Community-based organization, health partnership	Home modifications, stability, accessibility
Bowen, 2024	Louisville Local Energy Action Program, energy efficiency	Urban Louisville, Kentucky	City, National Renewable Energy Laboratory technical assistance, community-based organizations	Retrofits, jobs, benchmarking, policy
Will and Baker, 2013	Nonprofits in home repair	No mention found	Nonprofit, public funding	Affordability, accessibility, stabilization
Bowen et al., 2024	Louisville Local Energy Action Program, envelope upgrades	Urban Louisville, Kentucky	City, National Renewable Energy Laboratory, Kentucky Housing Corporation	Retrofits, jobs, standards, rebates

Geographic Context:

- 34 studies were conducted in the United States, with 16 in urban areas, 11 in rural areas, and 2 in tribal contexts; 2 studies included both urban and rural sites.
- 4 studies were international (Philippines, Southeast Asia/Eastern Europe, United Kingdom, Europe).
- California was the most common US state (8 studies), followed by Massachusetts (5), Oregon (3), and Washington (3).
- We did not find mention of the location for three studies.

Delivery Model:

- 14 studies used partnership, coalition, or multi-partner models.
- 10 studies used technical, modeling, or technical assistance approaches.
- 6 studies were city or government-led.
- 6 studies were led by community-based organizations or nonprofits.
- 4 studies were university or college-led.
- 3 studies were utility-led.

- 4 studies used policy analysis or review as the primary delivery model.
- 2 studies used business or market-driven models.
- 2 studies were led by tribal governments.
- 1 study used a labor/management model.
- 1 study used a grassroots approach.

Primary Outcomes Measured:

- Workforce, jobs, or training outcomes were measured in 18 studies.
- Energy savings, retrofits, or upgrades were measured in 10 studies.
- Equity, justice, or inclusion outcomes were measured in 15 studies.
- Economic impacts or cost savings were measured in 11 studies.
- Community engagement or participation was measured in 10 studies.
- Resilience or adaptation outcomes were measured in 6 studies.
- Policy or program design outcomes were measured in 7 studies.
- Barriers or facilitators were measured in 4 studies.
- Health outcomes were measured in 4 studies.
- Affordability or accessibility was measured in 3 studies.
- Environmental outcomes were measured in 1 study.

We did not find mention of the location for three studies, and some studies reported multiple delivery models or outcome domains.

Thematic Analysis

Community-Based Delivery Models and Rural Implementation

- Central role of community-based organizations and partnerships:Several studies report that community-based organizations, public-private partnerships, and multi-stakeholder collaborations are central to delivering retrofit and repair programs, especially in rural and tribal contexts.
- Tailored approaches in rural and tribal settings:Studies highlight the use of co-design methodologies, participatory design, and leveraging local assets to address unique needs in these communities.
- Homes as community infrastructure:Programs that treat homes as community infrastructure, rather than isolated private assets, are associated with collective benefits such as increased resilience, economic stability, and social cohesion.
- Scalability and barriers:Regional collaborations and city-led initiatives demonstrate scalability, but rural implementation often faces barriers related to workforce, funding, and technical capacity.

Integrated Workforce Development and Housing Infrastructure Programs

- Integration of workforce development:Many programs integrate workforce development with retrofit and repair, using models such as formal apprenticeships, credentialing, and job placement for at-risk or marginalized populations.
- Partnerships with educational institutions and employers:Partnerships with educational institutions, unions, and local employers are common, and some studies report that programs providing direct pathways from training to employment are associated with stronger economic mobility outcomes.

- Variation in workforce integration:The depth and structure of workforce integration vary, with some programs lacking robust credentialing or long-term career advancement mechanisms.
- Limited evidence on wage improvements:We found limited evidence of wage improvements and sustained employment; however, several studies report job creation and skill development as key outcomes.

Intergenerational Equity and Age-in-Place Strategies

- Dual benefits for older adults and young workers:Programs that combine home modifications with workforce development demonstrate benefits for both older adults and younger workers entering the field.
- Support for age-in-place outcomes:Accessibility improvements, health and safety upgrades, and efforts to prevent displacement are reported as supporting age-in-place outcomes.
- Cultural preservation:In tribal and rural contexts, retrofit programs are designed to align with local traditions and values, supporting cultural preservation and community identity.

Climate Adaptation Through Housing Resilience

- Operationalizing climate adaptation:Weatherization, disaster preparedness, and resilience upgrades are common strategies. Several studies report significant energy savings, emission reductions, and resilience improvements, particularly in comprehensive and well-funded programs.
- Certification standards and renewables:Certification standards (such as FORTIFIED and Energy Star) and renewable energy installations are less common but present in some models.
- Health and environmental co-benefits:Improved indoor air quality and reduced asthma rates are documented in a subset of studies.

Funding Mechanisms and Policy Frameworks

- Importance of policy and funding levers:Several studies identify federal and state grants, utility incentives, and local economic development funds as essential for scaling and sustaining programs.
- Regulatory supports:Energy efficiency standards and benchmarking ordinances provide additional impetus for action.
- Barriers and solutions:Barriers related to funding, regulatory complexity, and misaligned financial incentives are common, particularly in rental and low-income contexts. Successful programs often address these through flexible financing, technical assistance, and targeted outreach.

Economic Resilience and Community Wealth Creation

- Economic outcomes:Job creation (both temporary and permanent), local economic development, cost savings for homeowners, and, in some cases, intergenerational wealth building are reported.
- Integration with workforce development:Programs that integrate workforce development with retrofit and repair report the strongest economic mobility outcomes, especially for marginalized or underemployed populations.
- Cost-effectiveness and return on investment:Some studies document substantial energy bill reductions and leveraging of private investment, while others report on asset preservation, increased property values, and the development of local supply chains.

Cross-Cutting Findings

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Stagg et al., 2021	Strategic partnership, workforce-integrated	Local jobs, tax base, cost savings	Workforce for youth, community cohesion, age-in-place	Energy savings, resilience certification
Sarin, 2009	Federal program, community collaboration	Weatherization jobs, economic stimulus	Jobs for marginalized, housing stability	Carbon dioxide reduction, weatherization
Mattiuzzi and Simms, 2023	Community development partnerships, innovation	Implied cost savings, workforce	Housing stability, economic participation	No mention found
Moe, 2024	Coalition, National Renewable Energy Laboratory technical assistance, workforce focus	Projected jobs, wage data	Young worker opportunities, comprehensive support services	Utility bill savings
Dandridge and Wallenstein, 2010	Green workforce, youth focus	No mention found	At-risk youth, soft/hard skills	Solar installation, retrofits
Goldstein et al., 2022	Policy analysis, equity	No mention found	Housing stability, policy for equity	Emissions paradox, solar photovoltaics access
Shelby et al., 2011	Co-design, tribal	No mention found	Cultural preservation, health, self-sufficiency	Greenhouse gas reduction, renewables
Le et al., 2012	Apprenticeship, community workforce agreements	No mention found	Access for disadvantaged	No mention found
Barnes et al., "Field Studies..."	Utility, Demand Response Emerging Technologies, technology demonstration	Return on investment, financial benefits	Community resilience	No mention found
Brandin, 2010	City-led, comparative	No mention found	Young worker opportunities, equity	No mention found
Forster and Murray, 2014	Community-based organizations, outreach	No mention found	Community ties, engagement	No mention found
Strife and Yancey, 2013	Regional collaboration, Energy Advisors	85 jobs, $5.9M savings, return on investment	Jobs for youth, comfort, engagement	$5.9M savings, 19,350 tons carbon dioxide

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Capella, 2015	Multi-partner, grants/loans	Green jobs, 15% savings	Inclusive, open to all	15% energy savings
Jacob and Cyr, 2013	City, Better Buildings Neighborhood Program	No mention found	No mention found	Carbon dioxide reduction
Vergragt and Brown, 2011	Multi-stakeholder, visioning	No mention found	Stakeholder engagement	No mention found
Nidam et al., 2023	Technical modeling	Jobs (implied), cost-effective upgrades	Health, jobs, energy insecurity	No mention found
Lopez et al., 2025	University-community-based organization, solar plus storage	Grant, cost savings, resilience	Next-generation resilience, engagement	Solar plus storage, greenhouse gas reduction
Moloney et al., 2023	Long-term recovery organizations, wildfire recovery	Economic recovery, workforce	Equity, health, displacement	No mention found
Opdyke et al., 2018	Post-disaster, training	No mention found	Household engagement, development	Resilience, sheltering
Tohn et al., 2020	Occupational therapy-led, weatherization	Cost savings, fall reduction	Age-in-place, accessibility	No mention found
Ensign, 2022	Value chain, rural	Asset development, inclusion	Marginalized inclusion	No mention found
Yu et al., 2024	Participatory, vocational	100+ jobs, $2M, internal rate of return 8%	Young worker jobs, satisfaction	40% energy, 3.5 tons carbon dioxide, renewables
Taylor et al., 2023	Social network analysis, adaptation	No mention found	Cultural identity, networks	No mention found
Li et al., 2025	Capstone, energy justice	Grant, cost savings, resilience	Health, partnership	Solar plus storage, greenhouse gas reduction
Schmeltz et al., 2023	Data-driven, equity	Cost savings, wellbeing	Health, stability, displacement	Greenhouse gas, electrification, resilience
McCreery et al., 2022	Retrofit, health	No mention found	Health, equity, indoor air quality	Indoor air quality, asthma reduction
Vergragt and Brown, 2015	Cluster vs. grassroots	No mention found	No mention found	No mention found
Rohe et al., 2010	Nonprofit, coordination	No mention found	Affordability, health, stability	Energy cost reduction

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Knight et al., 2012	State/local, whole-house	Jobs, economic development	Job creation	40% energy savings
Branson, 2018	Tribal, woodstove	$1,000+/year savings	Quality of life, tradition	No mention found
Berkland and Hoque, 2012	Youth, outreach	No mention found	Young worker opportunities, placement	Weatherization training
Arena and Vijayakumar, 2012	City, SmartRegs	No mention found	Rental stability, engagement	23-52% energy, 18-22% greenhouse gas
Patterson, 2016	Government, Warm Wales	Jobs, £216/year savings	Aesthetics, engagement	33%+ carbon dioxide, 50%+ energy
Kime et al., 2023	Policy review, equity	261-389k jobs, $670/year savings	Health, displacement	1 exajoule energy, net-zero
Brown et				

Results

Characteristics of Included Studies

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Stagg et al., 2021	Disaster recovery, high-performance homes, workforce	Rural Florida	Strategic partnership (Habitat, college, university)	Workforce development, housing resilience, economic stability
Sarin, 2009	Low-income energy efficiency, job creation	Massachusetts (case), US (policy)	Federal program, community partnerships	Weatherization jobs, energy savings, marginalized worker employment
Mattiuzzi and Simms, 2023	Energy cost reduction, resilience for low- and moderate-income households	Western US	Community development practitioner partnerships	Innovations in lending, workforce, technical assistance
Moe, 2024	Clean energy workforce gap analysis	Urban Pittsburgh	Community coalition, National Renewable Energy Laboratory technical assistance	Employment impacts, workforce gaps, retrofit strategies

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Dandridge and Wallenstein, 2010	Green workforce training, field placements	Urban San Francisco Bay Area	College, agency, utility partnerships	Training for at-risk youth, retrofit experience
Goldstein et al., 2022	Racial inequity in energy efficiency	US (national)	Policy analysis	Emissions paradox, policy recommendations
Shelby et al., 2011	Co-design for sustainable housing	Rural California, tribal	University-tribal partnership	Culturally appropriate design, funding, sovereignty
Le et al., 2012	Apprenticeships for energy retrofits	Urban Oregon/Washington	Labor-management, community workforce agreements	Training, placement, standards for disadvantaged
Barnes et al., "Field Studies..."	Grid reliability, decarbonization equity	California	Utility-led, Demand Response Emerging Technologies collaborative	Technology deployment, return on investment, community resilience
Brandin, 2010	Federal investment, retrofit strategy	Urban Oakland, California	City-led, comparative analysis	Economic, social, environmental equity
Forster and Murray, 2014	Community organizations in efficiency programs	US (multi-site)	Community-based organizations as delivery agents	Outreach, participation, program design
Strife and Yancey, 2013	Regional energy upgrades, workforce	Colorado (urban/rural)	Regional collaboration, Energy Advisors	Upgrades, jobs, cost savings, market transformation
Capella, 2015	Residential/commercial retrofits, jobs	Rural Pennsylvania	Multi-partner, grants/loans	Retrofits, workforce, energy savings
Jacob and Cyr, 2013	Clean Energy Works Oregon	Urban/rural Oregon	City-led, Better Buildings Neighborhood Program	Home retrofits, job creation, energy savings
Vergragt and Brown, 2011	Urban transitions, stakeholder collaboration	Urban Worcester, Massachusetts	Multi-stakeholder, top-down/bottom-up	Visioning, action plan, system change
Nidam et al., 2023	Urban building energy modeling	Urban Boston	Technical modeling, planners	Retrofit effectiveness, adoption barriers
Lopez et al., 2025	Resilience, ecological economy	Gulf Coast (rural/coastal)	University, community-based organization, Habitat for Humanity	Natural infrastructure, housing, engagement

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Moloney et al., 2023	Long-term recovery organizations in wildfire recovery	Rural Washington/Oregon/California	Long-term recovery organizations, multi-partner	Barriers/facilitators, equity, economic recovery
Opdyke et al., 2018	Post-disaster shelter, training	Philippines	Multi-phase, household engagement	Coordination, participation, resilience
Tohn et al., 2020	Injury prevention in weatherization	No mention found	Occupational therapy-led, weatherization	Fall reduction, cost savings, health
Ensign, 2022	Wealth creation, rural development	Rural US (Appalachia, South, Rio Grande)	Value chain, market-driven	Asset mapping, inclusion, sustainability
Yu et al., 2024	Rural housing sustainability	Rural Southeast Asia/Eastern Europe	Participatory, vocational training	Energy savings, jobs, community engagement
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Schmeltz et al., 2023	Electrification equity planning	California	City-led, data-driven	Screening, outreach, health/economic impacts
McCreery et al., 2022	Ventilation retrofits, health	Urban Chicago	Retrofit, health study	Indoor air quality, asthma, health disparities
Vergragt and Brown, 2015	Grassroots vs. cluster initiatives	Urban Worcester, Massachusetts	Business-led, grassroots	Stakeholder engagement, barriers
Rohe et al., 2010	Weatherization/rehab coordination	No mention found	Nonprofit-led, coordination	Affordability, home value, policy gaps
Knight et al., 2012	Deep energy savings, California homes	California	State/local, utility/federal	Whole-house upgrades, jobs, barriers
Branson, 2018	Yurok Tribe housing efficiency	Rural California, tribal	Tribal government	Woodstove/insulation, cultural fit, savings
Berkland and Hoque, 2012	Youth building science education	Urban Massachusetts	Outreach, graduate-student led	Skills, job placement, at-risk youth
Arena and Vijayakumar, 2012	SmartRegs, rental retrofits	Urban Boulder, Colorado	City, advisor model	Compliance, training, energy savings

Study	Study Focus	Geographic Context	Delivery Model	Primary Outcomes Measured
Patterson, 2016	Regional retrofit, fuel poverty	Wales, United Kingdom	Government, Warm Wales, contractors	Energy savings, jobs, carbon dioxide reduction
Kime et al., 2023	Equity in low-carbon transitions	US, Europe	Policy review	Justice metrics, jobs, cost savings
Brown et al., 2023	Clean energy employment impacts	US (national)	Department of Energy, Local Energy Action Program, Interstate Renewable Energy Council	Occupational analysis, workforce
Vergragt and Brown, 2012	Grassroots innovation, retrofits	Urban Worcester, Massachusetts	Coalition, community development	System change, collaboration
Rhodes and McNichols, 2025	Age-in-place, health equity	Urban, high-eviction ZIP code	Community-based organization, health partnership	Home modifications, stability, accessibility
Bowen, 2024	Louisville Local Energy Action Program, energy efficiency	Urban Louisville, Kentucky	City, National Renewable Energy Laboratory technical assistance, community-based organizations	Retrofits, jobs, benchmarking, policy
Will and Baker, 2013	Nonprofits in home repair	No mention found	Nonprofit, public funding	Affordability, accessibility, stabilization
Bowen et al., 2024	Louisville Local Energy Action Program, envelope upgrades	Urban Louisville, Kentucky	City, National Renewable Energy Laboratory, Kentucky Housing Corporation	Retrofits, jobs, standards, rebates

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- 34 studies were conducted in the United States, with 16 in urban areas, 11 in rural areas, and 2 in tribal contexts; 2 studies included both urban and rural sites.
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- 14 studies used partnership, coalition, or multi-partner models.
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- 6 studies were led by community-based organizations or nonprofits.
- 4 studies were university or college-led.
- 3 studies were utility-led.
- 4 studies used policy analysis or review as the primary delivery model.
- 2 studies used business or market-driven models.
- 2 studies were led by tribal governments.
- 1 study used a labor/management model.
- 1 study used a grassroots approach.

Primary Outcomes Measured:

- Workforce, jobs, or training outcomes were measured in 18 studies.
- Energy savings, retrofits, or upgrades were measured in 10 studies.
- Equity, justice, or inclusion outcomes were measured in 15 studies.
- Economic impacts or cost savings were measured in 11 studies.
- Community engagement or participation was measured in 10 studies.
- Resilience or adaptation outcomes were measured in 6 studies.
- Policy or program design outcomes were measured in 7 studies.
- Barriers or facilitators were measured in 4 studies.
- Health outcomes were measured in 4 studies.
- Affordability or accessibility was measured in 3 studies.
- Environmental outcomes were measured in 1 study.

We did not find mention of the location for three studies, and some studies reported multiple delivery models or outcome domains.

Thematic Analysis

Community-Based Delivery Models and Rural Implementation

- Central role of community-based organizations and partnerships:Several studies report that community-based organizations, public-private partnerships, and multi-stakeholder collaborations are central to delivering retrofit and repair programs, especially in rural and tribal contexts.
- Tailored approaches in rural and tribal settings:Studies highlight the use of co-design methodologies, participatory design, and leveraging local assets to address unique needs in these communities.
- Homes as community infrastructure:Programs that treat homes as community infrastructure, rather than isolated private assets, are associated with collective benefits such as increased resilience, economic stability, and social cohesion.
- Scalability and barriers:Regional collaborations and city-led initiatives demonstrate scalability, but rural implementation often faces barriers related to workforce, funding, and technical capacity.

Integrated Workforce Development and Housing Infrastructure Programs

- Integration of workforce development:Many programs integrate workforce development with retrofit and repair, using models such as formal apprenticeships, credentialing, and job placement for at-risk or marginalized populations.
- Partnerships with educational institutions and employers:Partnerships with educational institutions, unions, and local employers are common, and some studies report that programs providing direct pathways from training to employment are associated with stronger economic mobility outcomes.
- Variation in workforce integration:The depth and structure of workforce integration vary, with some programs lacking robust credentialing or long-term career advancement mechanisms.
- Limited evidence on wage improvements:We found limited evidence of wage improvements and sustained employment; however, several studies report job creation and skill development as key outcomes.

Intergenerational Equity and Age-in-Place Strategies

- Dual benefits for older adults and young workers:Programs that combine home modifications with workforce development demonstrate benefits for both older adults and younger workers entering the field.
- Support for age-in-place outcomes:Accessibility improvements, health and safety upgrades, and efforts to prevent displacement are reported as supporting age-in-place outcomes.
- Cultural preservation:In tribal and rural contexts, retrofit programs are designed to align with local traditions and values, supporting cultural preservation and community identity.

Climate Adaptation Through Housing Resilience

- Operationalizing climate adaptation:Weatherization, disaster preparedness, and resilience upgrades are common strategies. Several studies report significant energy savings, emission reductions, and resilience improvements, particularly in comprehensive and well-funded programs.
- Certification standards and renewables:Certification standards (such as FORTIFIED and Energy Star) and renewable energy installations are less common but present in some models.
- Health and environmental co-benefits:Improved indoor air quality and reduced asthma rates are documented in a subset of studies.

Funding Mechanisms and Policy Frameworks

- Importance of policy and funding levers:Several studies identify federal and state grants, utility incentives, and local economic development funds as essential for scaling and sustaining programs.
- Regulatory supports:Energy efficiency standards and benchmarking ordinances provide additional impetus for action.
- Barriers and solutions:Barriers related to funding, regulatory complexity, and misaligned financial incentives are common, particularly in rental and low-income contexts. Successful programs often address these through flexible financing, technical assistance, and targeted outreach.

Economic Resilience and Community Wealth Creation

- Economic outcomes:Job creation (both temporary and permanent), local economic development, cost savings for homeowners, and, in some cases, intergenerational wealth building are reported.

- Integration with workforce development:Programs that integrate workforce development with retrofit and repair report the strongest economic mobility outcomes, especially for marginalized or underemployed populations.
- Cost-effectiveness and return on investment:Some studies document substantial energy bill reductions and leveraging of private investment, while others report on asset preservation, increased property values, and the development of local supply chains.

Cross-Cutting Findings

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Stagg et al., 2021	Strategic partnership, workforce-integrated	Local jobs, tax base, cost savings	Workforce for youth, community cohesion, age-in-place	Energy savings, resilience certification
Sarin, 2009	Federal program, community collaboration	Weatherization jobs, economic stimulus	Jobs for marginalized, housing stability	Carbon dioxide reduction, weatherization
Mattiuzzi and Simms, 2023	Community development partnerships, innovation	Implied cost savings, workforce	Housing stability, economic participation	No mention found
Moe, 2024	Coalition, National Renewable Energy Laboratory technical assistance, workforce focus	Projected jobs, wage data	Young worker opportunities, comprehensive support services	Utility bill savings
Dandridge and Wallenstein, 2010	Green workforce, youth focus	No mention found	At-risk youth, soft/hard skills	Solar installation, retrofits
Goldstein et al., 2022	Policy analysis, equity	No mention found	Housing stability, policy for equity	Emissions paradox, solar photovoltaics access
Shelby et al., 2011	Co-design, tribal	No mention found	Cultural preservation, health, self-sufficiency	Greenhouse gas reduction, renewables
Le et al., 2012	Apprenticeship, community workforce agreements	No mention found	Access for disadvantaged	No mention found
Barnes et al., "Field Studies..."	Utility, Demand Response Emerging Technologies, technology demonstration	Return on investment, financial benefits	Community resilience	No mention found

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Brandin, 2010	City-led, comparative	No mention found	Young worker opportunities, equity	No mention found
Forster and Murray, 2014	Community-based organizations, outreach	No mention found	Community ties, engagement	No mention found
Strife and Yancey, 2013	Regional collaboration, Energy Advisors	85 jobs, $5.9M savings, return on investment	Jobs for youth, comfort, engagement	$5.9M savings, 19,350 tons carbon dioxide
Capella, 2015	Multi-partner, grants/loans	Green jobs, 15% savings	Inclusive, open to all	15% energy savings
Jacob and Cyr, 2013	City, Better Buildings Neighborhood Program	No mention found	No mention found	Carbon dioxide reduction
Vergragt and Brown, 2011	Multi-stakeholder, visioning	No mention found	Stakeholder engagement	No mention found
Nidam et al., 2023	Technical modeling	Jobs (implied), cost-effective upgrades	Health, jobs, energy insecurity	No mention found
Lopez et al., 2025	University-community-based organization, solar plus storage	Grant, cost savings, resilience	Next-generation resilience, engagement	Solar plus storage, greenhouse gas reduction
Moloney et al., 2023	Long-term recovery organizations, wildfire recovery	Economic recovery, workforce	Equity, health, displacement	No mention found
Opdyke et al., 2018	Post-disaster, training	No mention found	Household engagement, development	Resilience, sheltering
Tohn et al., 2020	Occupational therapy-led, weatherization	Cost savings, fall reduction	Age-in-place, accessibility	No mention found
Ensign, 2022	Value chain, rural	Asset development, inclusion	Marginalized inclusion	No mention found
Yu et al., 2024	Participatory, vocational	100+ jobs, $2M, internal rate of return 8%	Young worker jobs, satisfaction	40% energy, 3.5 tons carbon dioxide, renewables
Taylor et al., 2023	Social network analysis, adaptation	No mention found	Cultural identity, networks	No mention found
Li et al., 2025	Capstone, energy justice	Grant, cost savings, resilience	Health, partnership	Solar plus storage, greenhouse gas reduction

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Schmeltz et al., 2023	Data-driven, equity	Cost savings, wellbeing	Health, stability, displacement	Greenhouse gas, electrification, resilience
McCreery et al., 2022	Retrofit, health	No mention found	Health, equity, indoor air quality	Indoor air quality, asthma reduction
Vergragt and Brown, 2015	Cluster vs. grassroots	No mention found	No mention found	No mention found
Rohe et al., 2010	Nonprofit, coordination	No mention found	Affordability, health, stability	Energy cost reduction
Knight et al., 2012	State/local, whole-house	Jobs, economic development	Job creation	40% energy savings
Branson, 2018	Tribal, woodstove	$1,000+/year savings	Quality of life, tradition	No mention found
Berkland and Hoque, 2012	Youth, outreach	No mention found	Young worker opportunities, placement	Weatherization training
Arena and Vijayakumar, 2012	City, SmartRegs	No mention found	Rental stability, engagement	23-52% energy, 18-22% greenhouse gas
Patterson, 2016	Government, Warm Wales	Jobs, £216/year savings	Aesthetics, engagement	33%+ carbon dioxide, 50%+ energy
Kime et al., 2023	Policy review, equity	261-389k jobs, $670/year savings	Health, displacement	1 exajoule energy, net-zero
Brown et al., 2023	Department of Energy, Local Energy Action Program, Interstate Renewable Energy Council	1.17M jobs, entry/advanced	Young worker jobs	No mention found
Vergragt and Brown, 2012	Coalition, grassroots	No mention found	Collaboration, system change	30% greenhouse gas potential
Rhodes and McNichols, 2025	Community-based organization, health	No mention found	Age-in-place, accessibility	No mention found
Bowen, 2024	City, National Renewable Energy Laboratory, community-based organizations	550-750 jobs/year, $480-120M savings	Equity jobs, health, stability	11-37% energy, 19-24% greenhouse gas
Will and Baker, 2013	Nonprofit, public	No mention found	Elder/disabled, stability	No mention found

Study	Program Model	Economic Outcomes	Social Outcomes	Environmental Outcomes
Bowen et al., 2024	City, National Renewable Energy Laboratory, Kentucky Housing Corporation	550-750 jobs/year, $120M savings	Young worker jobs, health	8-11% electricity, 31-37% gas, 19-24% greenhouse gas

Economic Outcomes:

- Jobs created or projected as an economic outcome in 17 studies.
- Cost savings or financial benefits reported in 19 studies.
- Economic development or stimulus mentioned in 4 studies.
- Return on investment or internal rate of return reported in 3 studies.
- Asset development reported in 1 study.
- We did not find economic outcome information for 19 studies.

Social Outcomes:

- Youth or young worker opportunities reported in 9 studies.
- Health or wellbeing outcomes reported in 11 studies.
- Housing stability or affordability reported in 8 studies.
- Community engagement or cohesion reported in 12 studies.
- Equity or inclusion reported in 11 studies.
- Age-in-place or accessibility reported in 3 studies.
- Cultural preservation or identity reported in 3 studies.
- Displacement mentioned in 3 studies.
- We did not find social outcome information for 2 studies.

Environmental Outcomes:

- Energy savings reported in 11 studies.
- Greenhouse gas or carbon dioxide reduction reported in 15 studies.
- Renewables or solar reported in 6 studies.
- Resilience reported in 3 studies.
- Indoor air quality or asthma outcomes reported in 1 study.
- Electrification reported in 1 study.
- Environmental cost savings reported in 6 studies.
- We did not find environmental outcome information for 16 studies.

Many studies reported multiple outcomes within a domain. We did not find outcome information for all domains in every study.

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