2024
Dow Fellows Report
Habitat for Humanity Team

Mapping Health & Energy Equity in Disinvested Communities

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Executive Summary

Background:

Building on a three-year partnership between the Dow Sustainability Fellows Program and Habitat for Humanity (HFH), our project developed resources focused on sustainable, healthy, and affordable housing in U.S. Climate Zones 2 and 3. These regions experience hot and humid or hot and arid climates and face significant climate change impacts. These areas have higher rates of housing insecurity, chronic disease, and limited healthcare access. Local and state residential building codes currently set building specifications, but improved codes could dramatically enhance energy efficiency and health standards. Until such changes are adopted, HFH affiliates require increased funding to support sustainable advances in affordable home design.

Our 2024 work focuses on three key deliverables:

1. **Mapping Tool Expansion**: We expanded a Healthy Housing Mapping Tool to cover Climate Zones 2 and 3 and include solar resource data. This tool overlays energy metrics with social determinants of health and existing HFH affiliate locations to enhance building opportunities for affiliates.
2. **Affiliate Fact Sheets**: We created fact sheets for affiliates in Houston, TX; New Orleans, LA; and Los Angeles, CA. These sheets offer evidence-based comparisons of current home design elements (such as HVAC and ventilation systems) with innovative options.
3. **Climate Zone Guide**: This guide provides essential background information to assist affiliates in Climate Zones 2 and 3 with grant writing and lobbying efforts.

Intended Impact:

These resources are designed to empower HFH affiliates to address immediate housing needs and systemic inequities, fostering healthier, more sustainable communities in climate-vulnerable regions. All

three deliverables can be used in tandem to secure funding through government grants and to advocate for building code reforms.

Recommendations:

Based on our research, discussions with affiliate leaders, and consultations with industry experts, we recommend:

1. **Adopting energy-efficient residential building codes**, especially in climate-impacted areas;
2. **Increasing state and federal funding** for affordable, sustainable housing;
3. **Implementing a unified system** to assess and improve residential indoor air quality (IAQ).

These recommendations align with **United Nations Sustainable Development Goals, #3** Good Health and Well-being, **#6** Clean Water and Sanitation, **#7** Affordable and Clean Energy, **#10** Reduced Inequalities, **#11** Sustainable Cities and Communities, **#13** Climate Action, and **#15** Life on Land. As climate change continues to impact vulnerable communities, advancing affordable, resilient, and healthy housing for all is crucial for a sustainable future.

Introduction & Background

The U.S. housing stock is outdated, with most homes over 35 years old, energy inefficient, costly to maintain, and often hazardous to the health and well-being of their inhabitants.[1] Meanwhile, the effects of human-induced climate change – such as increased storms and unpredictable weather patterns – continue to worsen these challenges. Residential homes and businesses account for nearly one-third of U.S. greenhouse gas emissions.[2] Vulnerable populations, including children, the elderly, residents of color, and individuals with complex medical conditions or disabilities, are disproportionately affected by climate change, housing insecurity, and chronic health issues.[3]

Addressing these overlapping crises requires a transformation in home construction to create healthier, more affordable, and climate-resilient housing. Current residential building codes fail to meet the necessary standards for energy efficiency, health, and resilience.[4] This highlights an urgent need for tangible, multifaceted solutions.

Focus on U.S. Climate Zones 2 and 3

Our project concentrated on U.S. Climate Zones 2 and 3, as defined by ASHRAE (American Society for Heating, Refrigerating, and Air-Conditioning Engineers).[5] These regions face distinct climate challenges:

- **Climate Zone 2 (Hot-Humid):** Encompassing Gulf Coast states like Texas and Louisiana, this region experiences high humidity, mold, moisture issues, and significant cooling demands. Hurricanes, flooding, and rising temperatures are increasing in frequency and severity, straining infrastructure and energy systems.[6]

- **Climate Zone 3 (Hot-Arid):** Covering parts of Texas, Arizona, and inland California, this region faces extreme heat, low humidity, droughts, and wildfires. Limited water resources and worsening heat waves exacerbate these conditions.[6]

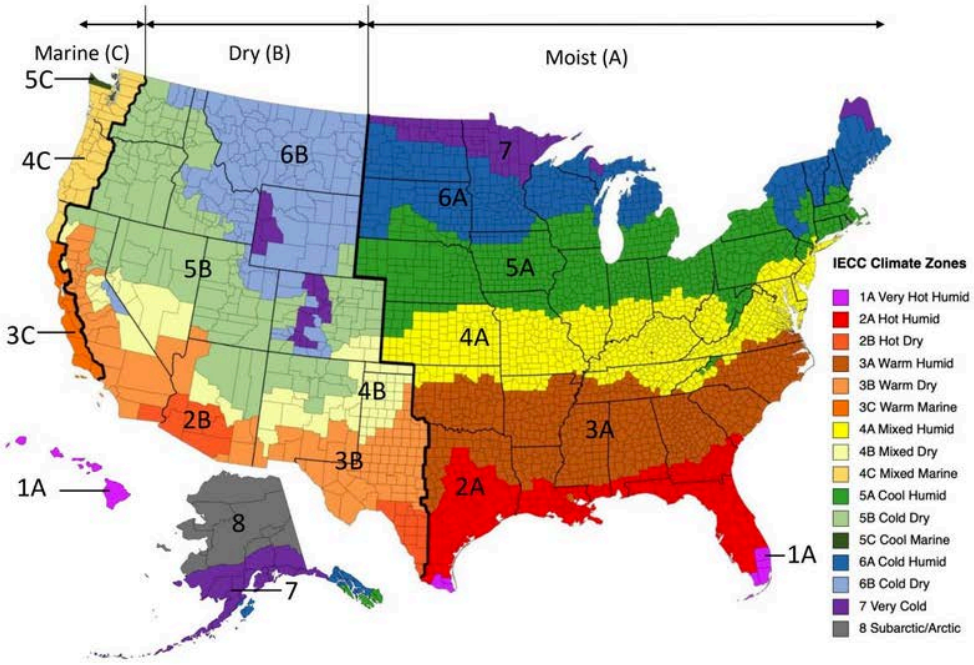

Figure N1101.7 (R301.1) Climate Zones-2021 International Residential Code (IRC)

Challenges in Climate Zone 2

Cities in Zone 2 are increasingly at risk of heat-related illnesses, respiratory conditions from poor air quality, vector-borne diseases due to flooding, and mental health burdens from climate stressors.[7] Vulnerable populations, including children, the elderly, and people with disabilities, are disproportionately affected.

Many homes in Zone 2 are older, lack modern appliances, and are ill-equipped to handle climate impacts.[8] Long-standing issues of redlining and environmental racism have left low-income and minority communities with substandard housing, limited affordable options, and insufficient resources for climate-resilient upgrades.[9]

Challenges in Climate Zone 3

Zone 3 faces rising temperatures, droughts, and intensifying wildfires, all of which endanger health and stability.[10] Prolonged heat waves can cause dehydration, heat exhaustion, and heat stroke, while wildfires release harmful particulates that worsen respiratory and cardiovascular diseases.[11, 12]

Older homes in this region were not built to address modern climate demands and often lack energy-efficient features like proper ventilation, reflective roofs, and effective air conditioning.[13] Wildfire-prone areas, such as the foothills of Los Angeles, experience displacement as fires worsen, while low-income communities often lack the resources to retrofit homes or rebuild after disasters.[14]

Takeaway

Habitat for Humanity (HFH), with its network of over 1,500 affiliates across the U.S., is well-positioned to address the affordable housing crisis.[15] By educating, training, and supporting communities, HFH can lead efforts to build sustainable, healthy, and affordable housing, particularly in areas most affected by climate change.

Cities in Climate Zones 2 and 3 face mounting energy demands, health burdens, and housing instability due to increasing severe weather events. Long-term solutions require an environmental justice approach. As defined by the EPA, **environmental justice** ensures the fair treatment and meaningful involvement of all people–regardless of background–in accessing a healthy, sustainable, and resilient environment to live, work, and grow.[16]

Methods

ArcGIS Mapping Tool

Building off the ArcGIS Mapping Tool built by the 2023 Dow Fellows Team, we expanded the mapping tool to incorporate Climate Zones 2 and 3. The layers included in this tool include all Habitat for Humanity (HFH) affiliates in these zones. Indicators related to energy burden, housing stock, social capital, environmental justice, and health were continued over into this year's mapping tool.

Solar This year, we launched a new feature called the "Annual Solar Resource Average." This data layer is based on the U.S. Annual Solar data collected from 1998 to 2016 by the National Renewable Energy Laboratory (NREL), which offers a resolution of 4 km by 4 km.[17] We chose Global Horizontal Irradiance (GHI), which is the sum of both Direct normal irradiance (DNI) and Diffuse horizontal irradiance (DHI) that are utilized in NREL's rooftop solar toolkit and are the most relevant indicators of solar resource abundance in the context of rooftop solar.[18] Besides solar irradiance, other physical features, including the roof layout and direction, inverter efficiency, and more can also influence the solar generation capacity at a specific location as well as the cost-saving potential of a rooftop solar PV system.

The following indicators and data sources were used for this project:

Spatial Data

1. U.S. Energy Information Administration, Climate Zones - DOE Building America Program[19]
   a. Information Used: U.S. Climate Zones 2 and 3
2. U.S. Census Bureau
   a. Information Used: TIGER/Line Shapefiles for 2020 Census Tracts[20]
3. Habitat for Humanity U.S. Affiliates
   a. Information Used: Addresses of Habitat for Humanity U.S. Affiliates (*Supplied by Habitat for Humanity upon request)*
4. NOAA/NCEI U.S. Climate Division Data[21]

a. Information Used: U.S. Climate Divisions

Climate Indicators

1. EPA Climate Change Indicators in the U.S.[22]
   a. Indicators utilized: Rate of Temperature Change in the United States 1901-2021

Social Indicators:

1. CDC/ATSDR Environmental Justice Index (EJI)[23]
   a. Indicators utilized:
      i. Percentile rank of domain consisting of ozone, PM2.5, air toxics cancer risk, and diesel particulate matter
      ii. Percentile rank of percentage of persons aged 65 and older estimate
2. U.S. DOE Low-Income Energy Affordability Data (LEAD) Tool[24]
   a. Indicators utilized:
      i. Energy Burden (% monthly income)
3. Social Capital
   a. Data collected from Fraser, et al 2022 article "*Social Capital's impact on COVID-19 outcomes at local levels*"[25]

Housing Indicators:

1. American Community Survey 5-Year Estimates of Physical Housing Characteristics for Occupied Housing Units (U.S. Census Tract)[26]
   a. Indicators Utilized:
      i. Year Structure Built
      ii. House Heating Fuel

Health Indicators:

Health Indicator data obtained from the CDC/ATSDR Environmental Justice Index which includes information compiled from the U.S. Census Bureau and U.S. CDC. Health Indicators utilized:

1. Percentile rank of percentage of individuals with raw high blood pressure values
2. Percentile rank of percentage of individuals with asthma
3. Percentile rank of percentage of persons with cancer
4. Percentile rank of percentage of individuals reporting not good mental health
5. Percentile rank of percentage of individuals with diabetes

Site Identification, Stakeholders, & Affiliate Fact Sheets

Building off the 2023 Dow Fellows' work on Climate Zone 4, the 2024 work focused on Climate Zones 2 and 3 based on the direction provided by project partner, Molly Berg, at Habitat for Humanity. Our primary objectives were to create resources for affiliates that would allow them to access increased governmental funding through recent legislature including the Greenhouse Gas Reduction Fund, as well as additional

funding through state and local government grants. A secondary aim was focused on creating resources for individual affiliates and HFH at large to advocate for sustainable housing improvements through reforming residential building codes at the state and federal levels.

Within Climate Zones 2 and 3, we chose to focus on three unique affiliate sites that would best exemplify the climate, housing, and health conditions pertinent to their respective climate zones. Over 70 affiliate sites were reviewed based on the number of annual home repairs, the number of annual new home builds, city population, socioeconomic factors, and affiliate availability. New Orleans, LA; Houston, TX; and Los Angeles, CA were then selected as the sites of focus for further literature review and development of Affiliate Fact Sheets.

An initial literature review was conducted to identify pertinent housing, health, climate, and social factors relevant to home construction and development in these cities. We then constructed a series of standardized interview questions for stakeholders at each respective affiliate site. At each site, we conducted 1-3 interviews with leaders in home construction, development, homeowner relations, and grant writing. Through these discussions, we identified pertinent information that guided the selection of "transformative elements" or unique housing elements that could provide significant benefits to home energy use, homeowner health, and long-term financial well-being. These conversations also highlighted unique needs and challenges facing affiliates that had not previously been identified by our preliminary literature review including issues regarding differences in state building codes, lack of governmental funding across Texas HFH affiliates, rising challenges with affordable home insurance, and the impact of race and culture on home design and construction. These invaluable conversations continued to inform Affiliate Fact Sheet development and project scoping.

Additional data collection for Affiliate Fact Sheets involved a further literature review and multiple informational interviews with home Heating, Ventilation, and Air-Conditioning (HVAC) representatives in each climate zone as well as with leaders in sustainable home design and architecture. Additional data was collected and analyzed using state building codes, CDC and U.S. census data, and peer-reviewed journal publications.

As part of further analysis of the potential impact of sustainable home design, we conducted two homeowner interviews with recent HFH homeowners in the greater Houston area. Standardized interview questions were developed and interviews were conducted to assess homeowners' subjective experiences including financial impacts, the usability of new appliances, health impacts (including mental health and stress), and overall outlook on homeownership.

Deliverables

Deliverable 1: Healthy Housing Indicators Mapping Tool

The Healthy Housing Indicators Mapping Tool is an interactive GIS mapping tool that incorporates climate, housing, energy, health, and social data into a singular mapping tool with all HFH affiliate sites. This tool

allows users to overlay pertinent map layers to compare areas within Climate Zones 2, 3, and 4 and identify potential sites in need of sustainable home construction.

Target Audience & Use:

This map is intended for use by HFH affiliates across U.S. Climate Zones. HFH affiliates' primary focus is to secure funding and resources to drive meaningful change for families' housing needs; therefore, using the Healthy Housing Indicators Mapping Tool can guide affiliates by providing an in-depth exploration of Habitat for Humanity affiliate locations within Climate Zones 2, 3, and 4, overlaying key data sets with GIS to identify areas of need.

The Healthy Housing Indicators Map is an interactive tool designed to help HFH affiliates secure project funding within their affiliate location. This map is of particular use to extract data for leaders in the use of grant writing, development, advocacy, and construction. By overlaying environmental justice indicators with HFH affiliates developers can identify key areas in need for sustainable home construction projects and further tailor these projects based on the unique climate and health features of their respective areas. The tool visualizes a range of important factors, including HFH affiliate locations, housing energy efficiencies, environmental impacts from climate change and carbon footprints, as well as health indicators specific to these regions. This tool enables users to:

Visualize Community Needs: Use the tool to identify and highlight key environmental and health challenges in the area, making a compelling case for sustainable housing solutions that improve community well-being and resilience.

Showcase Regional Comparisons: Use data from nearby affiliates or similar communities to strengthen the funding proposal and provide context for local challenges, highlighting targeted support's urgency and potential impact.

This map can also be used alongside Deliverables 2 and 3 to help affiliates gather relevant information for applying for grant funding for expanded Habitat for Humanity (HFH) construction projects, particularly those incorporating energy-efficient building elements that may involve higher upfront costs. Additionally, HFH leaders may utilize this tool in advocacy and lobbying efforts to highlight the need for stronger building code standards nationwide.

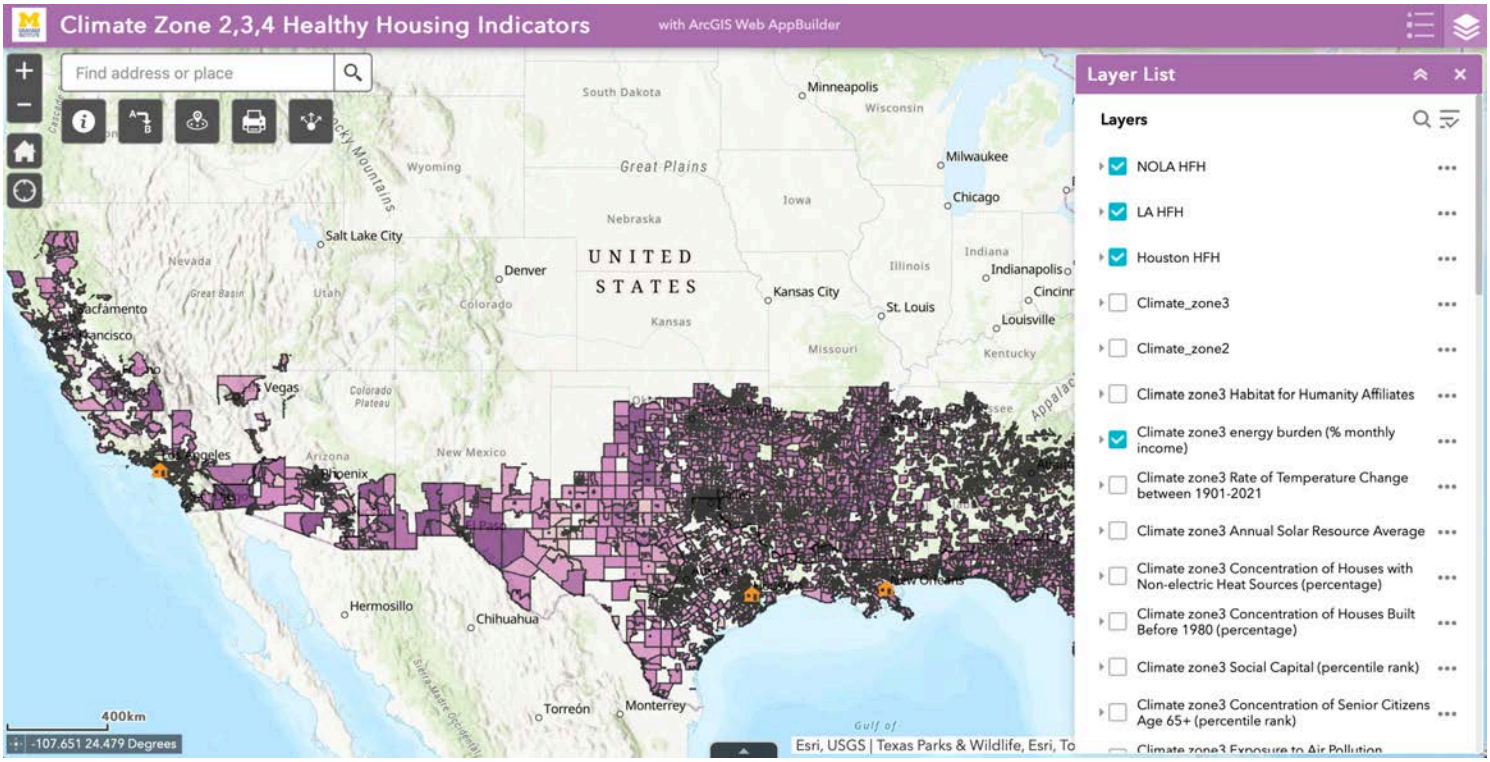

Image: Healthy Housing Indicator Mapping Tool displaying focus locations of affiliates: Houston, TX; New Orleans, LA; and Los Angeles, CA. Data represented on the map shows energy burden based on a percentage of monthly income in climate zones 2 and 3 with darker purples representing the more severely burdened areas.

StoryMap:

As an aid and how-to-use guide, a StoryMap has been developed to assist affiliates and bring awareness of how this map can be applied in their day-to-day work. The StoryMap embeds the Healthy Housing Indicators Mapping Tool with a map tour picking out relevant data and their connection with affiliates' fact sheets to be applied in grant applications, advocacy, construction, and more. The StoryMap is condensed into four sections which consist of an about the project section, background information on the existing climate zones, a mapping tool guide, and awareness for sustainable home construction.

QR Code to StoryMap

Deliverable 2: Affiliate Fact Sheets

The Affiliate Fact Sheets provide a comprehensive three-part template to help Habitat for Humanity affiliates update their construction methods and adopt more sustainable practices, addressing the limitations imposed by building code barriers. Drawing on data from site-specific affiliate meetings and

homeowner interviews, we identified key opportunities for improvement, which have been categorized as transformative elements. Focus areas include enhancing HVAC system efficiency in Houston and New Orleans, and improving indoor air quality in Los Angeles by upgrading ventilation systems.

Target Audience & Use:

The intended audience for this initiative is Habitat for Humanity Affiliates across the U.S. and internationally. The goal is to provide a system that helps identify gaps in sustainable construction practices while encouraging accountability in the application of various construction methods. This ensures healthy housing for homeowners and delivers long-term benefits in terms of cost, energy efficiency, and overall homeowner well-being. The three-part fact sheet offers clear, concise information, facts, and data to support the need for transformative changes in construction practices to be more sustainable.

Based on research and interviews conducted by the Dow Fellow Team, the focus cities of Houston, New Orleans, and Los Angeles have adopted transformative elements to address the most pressing concerns identified by affiliates. These concerns are shaped by the unique needs of their local communities, the homeowners they serve, and the specific climate impacts in each region.

In Houston and New Orleans, the primary concern was the need for more energy-efficient HVAC systems. As a result, the fact sheets for these cities focus on sustainable HVAC improvements that affiliates can implement. In Los Angeles, the primary concern was the high levels of air pollution and its impact on health, leading to a focus on HVAC filtration systems. The fact sheet for Los Angeles highlights sustainable solutions in this area.

Each fact sheet is designed to inform affiliates in similar climate zones, as well as those in the focus cities themselves, and presents the following key data:

Affiliate Fact Sheet Highlights

1. **Background/Current System:** An overview of the current home construction budget in the area, along with an existing system that requires improvements.
2. **Transformative Elements:** A comparative analysis highlighting key areas for improvement.
3. **Areas of Impact:** An evaluation of health and long-term benefits.

The fact sheets are structured in a template that smaller affiliate locations can adapt to address the specific needs of their communities, considering factors such as homeowner requirements, climate impacts, and health data.

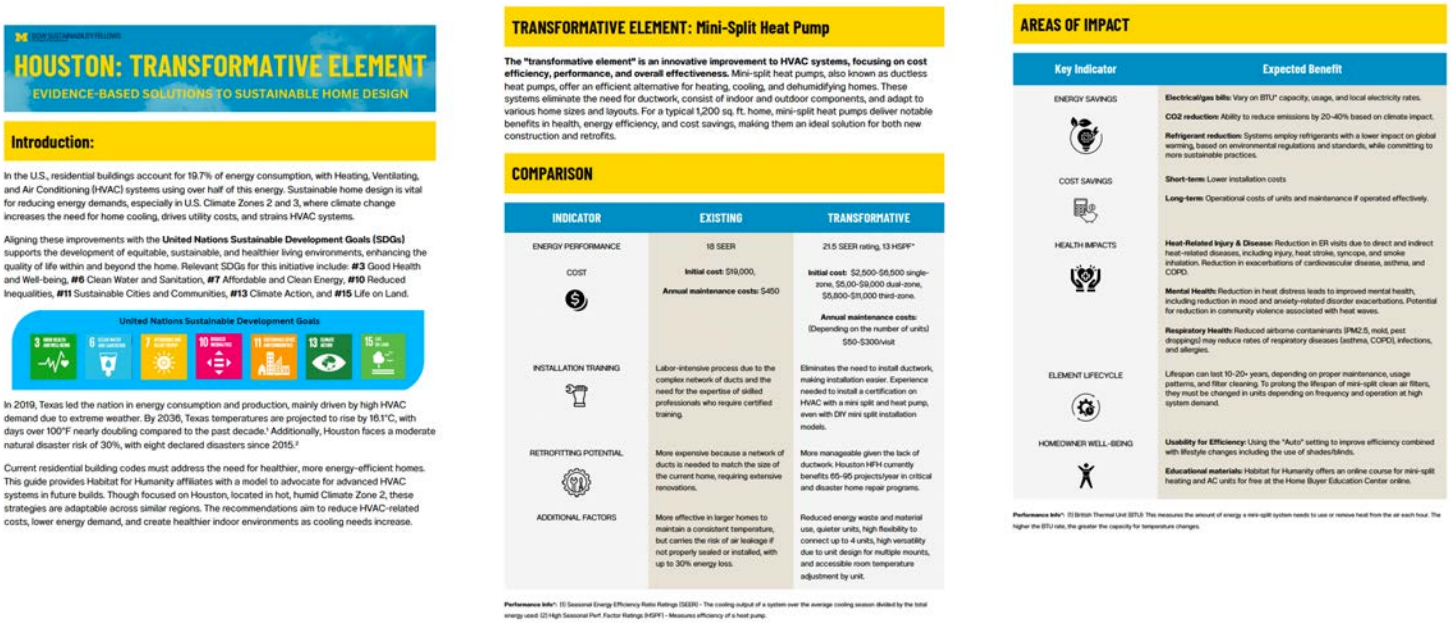

Image: Represented are three pages of the Houston Affiliate Factsheets. Readings left to right, page one is an introduction page of existing context and relationship to the Sustainable Design Goals. Page three is a comparison of the existing HVAC unit and how it can be transformed into a more efficient energy system. Page five shows areas of impact that can produce certain benefits in choosing to adapt to the transformative element chosen from page three. See Appendix A3.1 for further details.

Deliverable 3: A Guide to Climate Zones 2 & 3

A Guide to Climate Zones 2 & 3 for Habitat for Humanity Affiliates provides critical context on the geography, history, climate impacts, health effects, and housing needs of these zones, highlighting the importance of sustainable construction. The guide emphasizes the historical role of environmental racism and redlining in creating inequities in these regions, arguing that sustainable building practices are essential in communities disproportionately affected by climate change due to past and present discrimination.

Target Audience & How to Use:

The guide is designed for Habitat for Humanity affiliates in Climate Zones 2 and 3 to enhance their understanding of the unique challenges in their regions and strengthen their grant and funding applications.

Affiliates can use the guide in the following ways:

1. **Supplementing Applications**: Adapt or incorporate relevant sections of the guide directly into grant and funding proposals.

2. **Citing as a Resource**: Reference the guide in applications or explore its comprehensive "References" section for additional credible sources.
3. **Expanding Knowledge**: Consult the "Further Reading" section for key articles on environmental justice and disinvestment to deepen understanding and craft stronger arguments.

Recommendations

Through researching, developing, and adapting these deliverables we have come across multiple recommendations around sustainable and healthy housing as well as potential next steps for future Dow Fellows in partnership with Habitat for Humanity.

Mapping Expansions:

Our team foresees multiple avenues that can be pursued by future Fellows with HFH. First, the Mapping Tool can be further expanded to include Climate Zones 1, 5, 6, and 7 within the U.S. to ensure all HFH affiliates are included in this resource. Furthermore, this tool has already started to be used by affiliates in Climate Zone 4, but further discussions and evaluation of affiliates' use of this tool may help inform how the tool can be enhanced and edited to be of the greatest value. This may include further expansion of health, environmental justice, or resiliency indicators based on environmental justice metrics and aligning with the CDC's *Healthy People 2030* goals.[27] For example, this year we added a solar resource layer that can be used for affiliates to assess the utility of adding solar to future builds, allowing for future layers to be informed by new design elements, health, or climate risks.

Housing Elements:

The Affiliate Fact Sheets presented include transformative elements identified by conversations with affiliates in tandem with literature reviews to identify key elements that can address energy, health, and affordability in home design. However, these are far from comprehensive analyses, and additional work to assess the long-term cost savings, maintenance, and energy impacts of these elements and additional elements may provide further fodder for affiliates to obtain grants to incorporate these elements into new home construction. The Fact Sheets also serve as a template for additional affiliates to analyze unique housing elements that may be more relevant to their specific geographic, climate, energy, and health concerns. Further work may also involve analysis of fact sheet utilization by affiliates for obtaining government grants and impacting policy measures on local and state levels.

Resiliency, Retrofitting, & Repairs:

The growing threat of climate change to disinvested communities, as seen most recently by Hurricanes Beryl, Helene, and Milton, highlights the need to focus on resiliency strategies in home design and building.[28] Future work could include research and development of additional transformative elements

that are specifically focused on resiliency-based home design elements. Potential design elements discussed with affiliates included pilling design in New Orleans to address flood risk or insulation innovations in California to withstand increased wildfire risk. Given the development of Habitat for Humanity living communities such as Rising Oaks in New Orleans or Robins Landing in Houston, further project work could also develop tools for assessing building resiliency in community-based models or multi-family units. Additional projects may focus on retrofitting existing HFH homes and addressing disaster-related repairs rather than new builds. For a significant amount of affiliates, retrofitting and repairs make up the majority of their work and have the potential to provide significant enhancements in home sustainability and resiliency.

Energy & Healthy Building Codes

Professional associations have established codes to ensure minimum standards for energy efficiency and indoor air quality (IAQ) across various climate zones. For IAQ, ASHRAE 62.2, last updated in 2022, outlines air filtration and ventilation standards specific to regions.[29] For HVAC efficiency, the U.S. Department of Energy now mandates that systems sold in the Southeast and Southwest (Climate zones 2 and 3) meet a minimum of 15 SEER as of 2023.[30] Additionally, Energy Star 3.2 (supported by the EPA and DOE) and the International Residential Code (IRC) set broader standards, including appliance efficiency and building envelope requirements.[31, 32]

State and municipal adoption of these codes varies widely. California's Title 24 incorporates ASHRAE 62.2 and enforces stricter standards than the 2021 IRC, including solar requirements.[33] In contrast, Texas and Louisiana rely on older IRC versions and focus less on IAQ.[34] However, cities like Houston and New Orleans have adopted more advanced codes, leading to diverse building efficiency practices among HFH affiliates. For instance, the affiliate in Los Angeles prefers to adhere strictly to code requirements, whereas the Houston affiliate strives to exceed regulations, aiming to get closer to net-zero builds.

Given the wide range of organizational bodies and standards regulating residential building code energy and health metrics, we recommend that affiliates and HFH at large incorporate advocacy and lobbying efforts to advance their local residential building codes. Affiliates that aspire to build more efficient and healthy homes should consider these standards holistically, evaluating cost-benefit analyses where local codes fall short.

Impact

Current residential building codes fail to address the health, energy, or resiliency needs of future home construction. Through the development of multi-faceted and interconnected deliverables, our project work will allow Habitat for Humanity affiliates to apply for increased government funding and lobby for residential building code reform at federal and state levels. These deliverables work to highlight the significant housing, energy, health, and social needs in Climate Zones 2 and 3.

The Mapping Tool expansion allows over 70 more affiliates across Climate Zones 2 and 3 to access relevant information pertinent to site selection for future builds, and identify the most pressing climate, health, and energy needs of their particular construction areas. The Affiliate Fact sheets provide examples of specific advancements and their numerous benefits to homeowners with detailed analyses. Combining these two deliverables with the information in the Climate Zones 2 & 3 Guide provides affiliates with the tools needed to apply for government funding. This is of particular importance for smaller affiliates that do not have a dedicated grant writer or large development office. Additionally, this tool has the ability for affiliates to apply for government funding that has previously been untouched. For example, all Texas HFH affiliates had never applied for government grants until 2024. Including federal, state, and local government grants provides significant sources of funding that help to expand HFH efforts in myriad ways.

These three deliverables also lend themselves to lobbying efforts at state and federal levels for improved building codes. One of the most significant findings in our work was the discrepancies in standards of residential building code from state to state. For example, the SEER rating or Seasonal Energy Efficiency Ratio (SEER), which measures a system's cooling output during the average cooling season relative to its total energy consumption, varies widely between states. Despite a lower SEER requirement in Houston, TX, construction leaders at this affiliate site took it upon themselves to build to a higher SEER rating of 18. As such, this became a critical example of how reforming the residential building code itself shifts the burden of funding and advocating for more energy-efficient or healthier home standards away from individual affiliates and onto governmental bodies. Additionally, the lack of standardization in Indoor Air Quality (IAQ) standards on a federal or state level is of huge concern given the numerous health impacts of IAQ on homeowners and the expected worsening of IAQ with increased heat, drought, and wildfires. These tools highlight the energy and health benefits of design elements focused on improved IAQ, providing further resources to advocate for standardization and improvement of IAQ measures in residential buildings.

More broadly, this project addresses U.N. Sustainable Development Goals #3 Good Health and Well-being, #6 Clean Water and Sanitation, #7 Affordable and Clean Energy, #10 Reduced Inequalities, #11 Sustainable Cities and Communities, #13 Climate Action, and #15 Life on Land. By aligning with a global framework, this project and its deliverables for HFH affiliates across Climate Zones 2 and 3, hope to contribute to meaningful advancements in the sustainability and health of our planet and its people.

Our Impact in Words

To better understand the impact of clean and safe homes for families in need, we conducted homeowner interviews with recent HFH homeowners in the greater Houston, TX area. These interviews helped elucidate the tangible benefits to well-being provided through the work of Habitat for Humanity and the capacity for sustainable home development to influence homeowners' financial, spiritual, and physical well-being.

Jessie Burts, Houston HFH Homeowner

"My utility bills have decreased dramatically. With my new home, I'm saving over $200/month on utilities. I can focus on saving money to support my family."

The implementation of cost and energy-saving appliances, including HVAC systems, have significant impacts on reducing home emissions while improving homeowner financial savings and stability.

Annissa Adams, Houston HFH Homeowner

"Having a new home elevates you to a level of comfort and security that brings healing to all those wayward places in your mind that tend to wander towards overthinking and damage control."

The physical and mental distress caused by the increasing threats of climate change, housing instability, and reduced home safety are critical to address in home design. Homeowners repeatedly emphasized the mental and emotional benefits of healthy housing for themselves and their families.

Acknowledgments

Our team would like to thank the numerous mentors, project partners, content leads, and community members involved in this work. We would like to thank Molly Berg at Habitat for Humanity for her guidance and support. From Dow, we acknowledge our strong mentor, Jarod Davis, and his team - Justin Land, Fabio Mendes, and Annemieke De Wilde for their guidance with this project. From Habitat for Humanity Houston, we extend thanks to Kevin Vargas, Cassandra Robinson, Annissa Adams, and Olivia Bush. From Habitat for Humanity Los Angeles, we thank Robert Dwelle and Jecenia Gonzalez. From HFH New Orleans we thank Brad Holland, Marguerite Ostreicher, and Fernando Rivera. Additional thanks to Jon Maxwell at Energy Efficiency Now New Orleans. This work was supported by the Dow Company Foundation through the Dow Sustainability Fellows Program at the University of Michigan.

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Appendix

A1: StoryMap: Healthy Housing Indicators

QR Code to StoryMap Tool

A2: ArcGIS Map: Healthy Housing Indicators

QR Code to Interactive ArcGIS Healthy Housing Indicators Mapping Tool

A3: Affiliate Fact Sheets:

- A3.1: Houston, TX
- A3.2: New Orleans, LA
- A3.2: Los Angeles, CA

A4: Climate Zone 2 & 3 Guide

DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN

HOUSTON: TRANSFORMATIVE ELEMENT

EVIDENCE-BASED SOLUTIONS TO SUSTAINABLE HOME DESIGN

Introduction:

In the U.S., residential buildings account for 19.7% of energy consumption, with Heating, Ventilating, and Air Conditioning (HVAC) systems using over half of this energy. Sustainable home design is vital for reducing energy demands, especially in U.S. Climate Zones 2 and 3, where climate change increases the need for home cooling, drives utility costs, and strains HVAC systems.

Aligning these improvements with the **United Nations Sustainable Development Goals (SDGs)** supports the development of equitable, sustainable, and healthier living environments, enhancing the quality of life within and beyond the home. Relevant SDGs for this initiative include: **#3** Good Health and Well-being, **#6** Clean Water and Sanitation, **#7** Affordable and Clean Energy, **#10** Reduced Inequalities, **#11** Sustainable Cities and Communities, **#13** Climate Action, and **#15** Life on Land.

In 2019, Texas led the nation in energy consumption and production, mainly driven by high HVAC demand due to extreme weather. By 2036, Texas temperatures are projected to rise by 16.1°C, with days over 100°F nearly doubling compared to the past decade.[1] Additionally, Houston faces a moderate natural disaster risk of 30%, with eight declared disasters since 2015.[2]

Current residential building codes must address the need for healthier, more energy-efficient homes. This guide provides Habitat for Humanity affiliates with a model to advocate for advanced HVAC systems in future builds. Though focused on Houston, located in hot, humid Climate Zone 2, these strategies are adaptable across similar regions. The recommendations aim to reduce HVAC-related costs, lower energy demand, and create healthier indoor environments as cooling needs increase.

Current Budget & Housing Details:

Home Size	1,821 ft^2
HVAC System	American Standard, AccuComfort 18 SEER 3-2 ton units, heat pump, and full electrical
Materials Cost	3-ton unit: $15,211* 2-ton unit: $14,302*
Labor Cost	3-ton/2-ton unit: $2,500-$5,000, 2-3 Days
Maintenance Cost	$450-1,500 per repair. Basic maintenance is needed once a year for filter and system drain.
TOTAL	$19,000 +/- + $450 maintenance per year Basic

Price Cost Variables*: (1) Installation difficulty can affect the price. (2) Depending on the size of the home can affect the cost of ductwork, which can increase material cost: $2,500-5,000+. (3) The higher SEER rating can affect upfront costs but offer more energy efficiency in the long run operational costs. For example, 18 SEER saves 12.5% more energy efficiency than 16 SEER.

Our Problem:

The need for affordable, healthy, and energy-efficient housing is paramount to Houston's vitality, particularly that of its most vulnerable residents.

Houston, with a population of 2.3 million, is located in Climate Zone 2, characterized by high temperatures, humidity, and an increasing frequency of natural disasters, including hurricanes. **Houston has experienced 26 natural disasters in the past 40 years, with 8 occurring since 2015**.[3] Over the past 20 years, average daily summer temperatures have risen, with daily highs now nearly 2.5°C higher than historical averages.[4]

According to the Centers for Disease Control and Prevention (CDC), housing is a critical social determinant of health.[5] Housing is foundational to addressing leading health indicators, including exposure to unhealthy air, high blood pressure, diabetes, and suicide. Over half the U.S. building stock is over 35 years old, often built with hazardous materials, poor insulation, and outdated HVAC systems. In Houston, 25% of residents report poor health status, 1.4 times the national average.[6] Additionally, **22% of Houston residents faced housing insecurity in the past year, with 15% reporting threats to utility services, double the national average.**[7] Houston residents experience higher-than-average rates of disability, mental distress, lack of health insurance, and diabetes.

Housing influences health through air quality and exposure to particulate matter (PM2.5), which affects the risk of respiratory illness, cancer rates, cardiovascular disease (including heart attack and stroke), and mental health. Rising temperatures contribute to increasing rates of heat-related disease and injury while exacerbating existing chronic conditions, disproportionately impacting vulnerable populations, including seniors, individuals with disabilities, and those with housing instability.[8] With over 25% of Houston adults lacking health insurance, these challenges become even more perilous, underscoring the social vulnerability of these populations.

Addressing health and housing inequities requires an environmental justice approach that considers how contextual deprivation and structural racism contribute to these disparities. Currently, **homeownership in Houston remains far below national averages, with only 40% of residents owning homes, compared to the national rate of 65%**.[9] This gap is further divided along racial lines, with a 34-point homeownership gap between white and black households. Housing costs for renters have risen significantly, with half of Houston renters spending over 30% of their income on housing. Additionally, the availability of subsidized housing for low-income households in Houston is among the worst in the nation, with only 19 affordable homes for every 100 renters in need.[10]

Improving energy efficiency in HVAC systems can reduce financial and energy burdens, benefiting all communities and supporting a more equitable future.

TRANSFORMATIVE ELEMENT: Mini-Split Heat Pump

The "transformative element" is an innovative improvement to HVAC systems, focusing on cost efficiency, performance, and overall effectiveness. Mini-split heat pumps, also known as ductless heat pumps, offer an efficient alternative for heating, cooling, and dehumidifying homes. These systems eliminate the need for ductwork, consist of indoor and outdoor components, and adapt to various home sizes and layouts. For a typical 1,200 sq. ft. home, mini-split heat pumps deliver notable benefits in health, energy efficiency, and cost savings, making them an ideal solution for both new construction and retrofits.

COMPARISON

INDICATOR	EXISTING	TRANSFORMATIVE
ENERGY PERFORMANCE	18 SEER	21.5 SEER rating, 13 HSPF*
COST 	**Initial cost:** $19,000, **Annual maintenance costs:** $450	**Initial cost:** $2,500-$6,500 single-zone, $5,00-$9,000 dual-zone, $5,800-$11,000 third-zone. **Annual maintenance costs:** (Depending on the number of units) $50-$300/visit
INSTALLATION TRAINING 	Labor-intensive process due to the complex network of ducts and the need for the expertise of skilled professionals who require certified training.	Eliminates the need to install ductwork, making installation easier. Experience needed to install a certification on HVAC with a mini split and heat pump, even with DIY mini split installation models.
RETROFITTING POTENTIAL 	More expensive because a network of ducts is needed to match the size of the current home, requiring extensive renovations.	More manageable given the lack of ductwork. Houston HFH currently benefits 65-95 projects/year in critical and disaster home repair programs.
ADDITIONAL FACTORS	More effective in larger homes to maintain a consistent temperature, but carries the risk of air leakage if not properly sealed or installed, with up to 30% energy loss.	Reduced energy waste and material use, quieter units, high flexibility to connect up to 4 units, high versatility due to unit design for multiple mounts, and accessible room temperature adjustment by unit.

Performance Info*: (1) Seasonal Energy Efficiency Ratio Ratings (SEER) - The cooling output of a system over the average cooling season divided by the total energy used. (2) High Seasonal Perf. Factor Ratings (HSPF) - Measures efficiency of a heat pump.

AREAS OF IMPACT

Key Indicator	Expected Benefit
ENERGY SAVINGS 	**Electrical/gas bills:** Vary on BTU* capacity, usage, and local electricity rates. **CO2 reduction:** Ability to reduce emissions by 20-40% based on climate impact. **Refrigerant reduction:** Systems employ refrigerants with a lower impact on global warming, based on environmental regulations and standards, while committing to more sustainable practices.
COST SAVINGS 	**Short-term:** Lower installation costs **Long-term:** Operational costs of units and maintenance if operated effectively.
HEALTH IMPACTS 	**Heat-Related Injury & Disease:** Reduction in ER visits due to direct and indirect heat-related diseases, including injury, heat stroke, syncope, and smoke inhalation. Reduction in exacerbations of cardiovascular disease, asthma, and COPD. **Mental Health:** Reduction in heat distress leads to improved mental health, including reduction in mood and anxiety-related disorder exacerbations. Potential for reduction in community violence associated with heat waves. **Respiratory Health:** Reduced airborne contaminants (PM2.5, mold, pest droppings) may reduce rates of respiratory diseases (asthma, COPD), infections, and allergies.
ELEMENT LIFECYCLE 	Lifespan can last 10-20+ years, depending on proper maintenance, usage patterns, and filter cleaning. To prolong the lifespan of mini-split clean air filters, they must be changed in units depending on frequency and operation at high system demand.
HOMEOWNER WELL-BEING 	**Usability for Efficiency:** Using the “Auto” setting to improve efficiency combined with lifestyle changes including the use of shades/blinds. **Educational materials:** Habitat for Humanity offers an online course for mini-split heating and AC units for free at the Home Buyer Education Center online.

Performance Info*: (1) British Thermal Unit (BTU): This measures the amount of energy a mini-split system needs to use or remove heat from the air each hour. The higher the BTU rate, the greater the capacity for temperature changes.

CONCLUSION

Improved HVAC systems address rising heat, humidity, and increased storm frequency rates that increasingly affect the health and well-being of Hoston's most vulnerable homeowners. Through improved cooling and dehumidification systems, homeowners stand to reduce their carbon footprint, lower monthly utility bills, and improve their health and that of their communities. With only 13% of U.S. homes currently equipped with mini-split heat pumps, there is a great need to improve the existing housing stock through more efficient new home builds and retrofitting existing houses with these units.[11]

Energy	Health	Financial
Key Takeaways:	**Key Takeaways:**	**Key Takeaways:**
• Reduction of energy waste due to ductless system • Zoned temperature control of individual rooms • Easier to maintain due to lack of regular cleaning • Inverter technology saves operation energy • Advanced features possible include smart home integration, advanced air quality control, and Wi-Fi control.	• Reduction in frequency of heat-related illness, injury, & death • Improved indoor air quality with lower risk of respiratory illness and infection • Reduced mental health burden due to heat stress • Decreased healthcare burden, including fewer ED visits and hospitalizations • Reduction in rates of community violence	• Reduced installation costs due to a ductless system. • Possible higher upfront cost depending on the number of mini split units required. • Given a 30% increase in efficiency, significant long-term savings can easily cover the initial purchase price.

Improved HVAC systems combat the effects of climate change by creating affordable, sustainable homes that support a healthier future for Houston.

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DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN

NEW ORLEANS TRANSFORMATIVE ELEMENT

EVIDENCE-BASED SOLUTIONS TO SUSTAINABLE HOME DESIGN

INTRODUCTION:

The U.S. housing stock primarily consists of homes over 35 years old, many of which fall short of modern energy efficiency and health standards. Heating, Ventilation, and Air Conditioning (HVAC) systems account for nearly 20% of residential energy use, making advancements in HVAC technology a significant opportunity to enhance sustainable housing by improving energy efficiency, resident health, and homeowner financial well-being.[1,2]

Aligning these improvements with the **United Nations Sustainable Development Goals (SDGs)** supports the development of equitable, sustainable, and healthier living environments. Relevant SDGs for this initiative include: **#3** Good Health and Well-being, **#6** Clean Water and Sanitation, **#7** Affordable and Clean Energy, **#10** Reduced Inequalities, **#11** Sustainable Cities and Communities, **#13** Climate Action, and **#15** Life on Land.

In New Orleans, LA –located in U.S. Climate Zone 2, characterized by a hot and humid climate– rising temperatures and increased frequency of extreme weather events heighten the need for resilient, energy-efficient, and affordable housing. High temperatures and humidity exacerbate heat stress, reduce air quality, and increase demands on HVAC systems, which raises utility costs. Limited financial and legislative support currently hampers efforts to meet these growing demands, especially for affordable housing construction.

This guide offers practical solutions for improving home HVAC systems in New Orleans and similar cities in Climate Zone 2, addressing the challenges of heat, humidity, and extreme weather. By focusing on climate-conscious cooling systems, the guide aims to support home designs that enhance energy efficiency, reduce maintenance costs, and promote healthier indoor environments.

Current Budget & Housing Details:

Home Size	1,210 ft^2
HVAC System	Amana or Daikin, standard central split, 15.5 SEER, 1.5-2 ton, 8.5 HSPF
Materials Cost	Amana Brand, $3,875-$6,350* + Daikin Brand, $4,200-$5,300* +
Labor Cost	$1,200-$4,000*, 1 day if ductwork is in place
Maintenance Cost	Annual Costs, $50-$500 Repair Costs, $100-$650
TOTAL	$10,00-$15,400 +/- + $250 Basic maintenance per year

Price Cost Variables*: (1) Installation difficulty can affect the price. (2) Depending on the size of the home can affect the cost of ductwork, which can increase material cost: $2,500-5,000+. (3) The higher SEER rating can affect upfront costs but offer more energy efficiency in the long run operational costs. For example, 18 SEER saves 12.5% more energy efficiency than 16 SEER.

Our Problem:

The need for affordable, healthy, and energy-efficient housing is critical for the vitality of New Orleans, particularly for its most vulnerable residents.

New Orleans, Louisiana, with a population of nearly 384,000, is located in U.S. Climate Zone 2, known for its hot, humid conditions and increasing extreme weather events, such as tropical cyclones, floods, and tornadoes.[3] By 2050, the city is expected to experience over 50 days annually with temperatures exceeding 95.5°F, along with increased rainfall levels.[4] Innovative housing solutions are necessary to protect homeowners' immediate needs, reduce emissions, and create sustainable ways to mitigate the effects of climate change.

Beyond energy efficiency, housing is essential to public health. As part of its *Healthy People 2030* initiative, the Centers for Disease Control and Prevention (CDC) has identified housing as a critical social determinant of health.[5] Housing affects several health indicators, including exposure to unhealthy air, high blood pressure, diabetes, and suicide.[6] New Orleans residents report higher-than-average rates of poor health (22%), mental distress (20%), and chronic conditions such as asthma (11%), high blood pressure (37%), diabetes (14%), stroke (4.5%), and depression (26%).[7] Housing impacts health through air quality and exposure to particulate matter (PM2.5), which contributes to respiratory illnesses, cardiovascular diseases (including heart attack and stroke), cancer, asthma, and mental health issues.[8] Rising temperatures are increasing heat-related diseases and injuries while worsening existing chronic conditions, especially among vulnerable groups such as seniors, individuals with disabilities, and those with housing instability.[9] Low-income households are disproportionately affected, as older buildings often lack energy-efficient features, making it harder to maintain safe indoor temperatures and increasing the risks associated with heat-related health issues.

Recent U.S. Census data highlights key socioeconomic factors contributing to housing disparities in New Orleans. The city has a poverty rate of 22.6%, nearly double the national average of 11.1%, with this poverty concentrated in Black communities.[10] Homeownership rates also lag behind the national average, with only 56% of New Orleans residents owning homes compared to 68% nationally.[11] The availability of affordable housing is limited, with many homes being older, less energy-efficient, and located in areas more susceptible to the effects of future storms. Through improved HVAC systems, Habitat for Humanity affiliates can offer housing solutions that reduce utility costs, improve cooling, and better withstand the environmental challenges of Climate Zone 2.

Improving energy efficiency in HVAC systems can reduce financial and energy burdens, benefiting all communities and supporting a more equitable future.

TRANSFORMATIVE ELEMENT: Mini-Split Heat Pump

The "transformative element" is an innovative improvement to HVAC systems, focusing on cost efficiency, performance, and overall effectiveness. Mini-split heat pumps, also known as ductless heat pumps, offer an efficient alternative for heating, cooling, and dehumidifying homes. These systems eliminate the need for ductwork, consist of indoor and outdoor components, and adapt to various home sizes and layouts. For a typical 1,200 sq. ft. home, mini-split heat pumps deliver notable benefits in health, energy efficiency, and cost savings, making them an ideal solution for both new construction and retrofits.

COMPARISON

INDICATOR	EXISTING	TRANSFORMATIVE
ENERGY PERFORMANCE	15.5 SEER rating, 8.5 HSPF*	21.5 SEER rating, 13 HSPF*
COST 	**Initial cost:** $10,000-$15,400; higher installation costs due to ductwork. **Annual maintenance costs:** $250 +/- per visit	**Initial cost:** $2,500-$6,500 single-zone; $5,000-$9,000 dual-zone; $5,800-$11,000 third-zone. **Annual maintenance costs:** (Depending on the number of units) $50-$300/visit
INSTALLATION TRAINING 	Labor-intensive process due to the complex network of ducts and the need for skilled professionals who require certified training.	Ductwork installation eliminated. Experience needed to install a certification on HVAC with a mini split and heat pump, even with DIY mini split installation models.
RETROFITTING POTENTIAL 	More expensive because a network of ducts is needed to match the size of the current home, requiring extensive renovations.	More manageable without associated ductwork. HFH NOLA currently services 454 existing homes for repair and potential for retrofitting.
ADDITIONAL FACTORS	More effective in larger homes to maintain a consistent temperature but carries the risk of air leakage if the duct is not properly sealed or installed, with up to 30% energy loss.	Reduced energy waste and material use, quieter units, high flexibility to connect up to 4 units, high versatility due to unit design for multiple mounts, and easy room-temperature adjustment by unit.

Performance Info*: (1) Seasonal Energy Efficiency Ratio Ratings (SEER) - The cooling output of a system over the average cooling season divided by the total energy used. (2) High Seasonal Perf. Factor Ratings (HSPF) - Measures efficiency of a heat pump.

AREAS OF IMPACT

Key Indicator	Expected Benefit
ENERGY SAVINGS 	**Electrical/gas bills:** Vary on BTU* capacity, usage, and local electricity rates. **CO2 reduction:** Ability to reduce emissions by 20-40%. **Refrigerant reduction:** Based on environmental regulations and standards, systems employ refrigerants that have a lower impact on global warming.
COST SAVINGS 	**Short-term:** Lower installation costs. **Long-term:** Lower operational costs and maintenance if operated correctly.
HEALTH IMPACTS 	**Heat-Related Injury & Disease:** Reduction in ER visits due to direct and indirect heat-related diseases, including injury, heat stroke, syncope, and smoke inhalation. Reduction in exacerbations of cardiovascular disease, asthma, and COPD. **Mental Health:** Reduction in heat distress leads to improved mental health, including reduction in mood and anxiety-related disorder exacerbations. Potential for reduction in community violence associated with heat waves. **Respiratory Health:** Reduced airborne contaminants (PM2.5, mold, pest droppings) may reduce rates of respiratory disease (asthma, COPD), infection, and allergies.
DISASTER RESILIENCY 	Mini-split units are easier to install and repair, given the lack of ductwork, which is often damaged in storms due to its more exposed surface area. Climate change is extending hurricane season annually with increased numbers of homes facing storm-related damage.
ELEMENT LIFECYCLE 	Lifespan can last 10-20+ years, depending on proper maintenance, usage patterns, and filter cleaning.
HOMEOWNER WELL-BEING 	**Usability for Efficiency:** Use the “Auto” setting for more efficiency, minimize heat sources during cooling, such as shades or blinds, and keep the system on unless the room is used infrequently.

Performance Info*: (1) British Thermal Unit (BTU): This measures the amount of energy a mini-split system needs to use or remove heat from the air each hour. The higher the BTU rate, the greater the capacity for temperature changes.

CONCLUSION

Improved HVAC systems address rising rates of heat, humidity, and increased storm frequency that increasingly affect the health and well-being of New Orleans' most vulnerable homeowners. Through improved cooling and dehumidification systems, homeowners stand to reduce their carbon footprint, lower monthly utility bills, and improve their health and that of their communities. With only 13% of U.S. homes currently equipped with mini-split heat pumps, there is a great need to improve the existing housing stock through more efficient new house builds and retrofitting existing homes with these units.[12]

Energy	Health	Financial
Key Takeaways:	**Key Takeaways:**	**Key Takeaways:**
• Reduction of energy waste due to ductless system • Zoned temperature control of individual rooms • Easier to maintain due to lack of regular cleaning • Inverter technology saves operation energy • Advanced features possible include smart home integration, advanced air quality control, and Wi-Fi control.	• Reduction in frequency of heat-related illness & injury • Improved indoor air quality with lower risk of respiratory illness and infection • Reduced mental health burden due to heat stress • Decreased healthcare burden, including fewer ED visits and hospitalizations • Reduction in rates of community violence	• Reduced installation costs due to a ductless system. • Possible higher upfront cost depending on the number of mini split units required. • Given a 30% increase in efficiency, significant long-term savings can easily cover the initial purchase price.

Improved HVAC systems combat the effects of climate change by creating affordable, sustainable homes that support a healthier future for New Orleans.

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DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN

LOS ANGELES: TRANSFORMATIVE ELEMENT

EVIDENCE-BASED SOLUTIONS TO SUSTAINABLE HOME DESIGN

INTRODUCTION:

Over half of the current U.S. housing stock is over 35 years old, with many homes lacking sufficient ventilation systems.[1] This contributes to poor energy efficiency, increased heating and cooling costs, and worsened indoor air quality for homeowners. Human-related climate change exacerbates these effects, creating a need for sustainable and affordable home design, particularly in U.S. Climate Zones 2 and 3, where these issues are most pronounced.

Aligning these improvements with the **United Nations Sustainable Development Goals (SDGs)** supports the development of equitable, sustainable, and healthier living environments. Relevant SDGs for this initiative include: **#3** Good Health and Well-being, **#6** Clean Water and Sanitation, **#7** Affordable and Clean Energy, **#10** Reduced Inequalities, **#11** Sustainable Cities and Communities, **#13** Climate Action, and **#15** Life on Land.

Los Angeles, CA–located in U.S. Climate Zone 3 and characterized by a hot and arid climate–is expected to experience increased temperatures and extreme weather events such as heatwaves, wildfires, and droughts.[2] Additionally, rising temperatures and extreme weather significantly worsen the health outcomes of California residents. Although current residential building codes in California lead the country regarding energy efficiency and health considerations, further advancement is needed to address the increased wildfire burden and indoor air quality concerns.

This guide serves as a resource to provide tangible solutions for improving home ventilation in Los Angeles and similar cities in Climate Zone 3. By addressing climate-conscious improvements in home ventilation, we aim to support home designs with improved energy efficiency, lower maintenance costs, and healthier indoor environments for homeowners.

Current Budget & Housing Details:

Home Size	1,290 ft^2
HVAC System	Carrier (CH14NB036 - B) with The Comfort™ FJ4 fan coil
Cost of HVAC System, Including Bathroom Fans	$12,000
Labor Cost for Fan Coils	$700-$2,700*
Maintenance Cost	$100-$2,500*
TOTAL	$12,000 + $100 Basic maintenance per year

Price Cost Variables*: (1) Installation difficulty can affect the price based on local contractor rates. (2) Maintenance for fan coils consists of various ranges based on individual needs. Listed are common repairs for fan coils and their average prices: a cleaning costs $100, a new thermostat costs $180-400, and a new fan motor costs $400-$600.

Our Problem:

As climate change worsens health and housing disparities, the need for affordable, energy-efficient, and healthy housing is essential to the vitality of Los Angeles, CA.

In the 21st century, Los Angeles has faced an increasing burden from climate change, with rising temperatures and a threefold increase in days over 95°F, which are expected to continue. In 2021 alone, California endured four of its worst wildfires in history, significantly impacting air quality.[3] Additionally, extreme droughts are worsening in L.A., contributing to higher forest fire risks and damage. Los Angeles is **the 6th most particle-polluted U.S. city and 1st in ozone pollution.**[4] With substantial impacts on residents' health and existing infrastructure, addressing air quality issues through sustainable home design is crucial.

As identified in the CDC's *Healthy People 2030* survey, social determinants of health, including the built environment, play pivotal roles in health outcomes for U.S. citizens.[5] The CDC lists exposure to unhealthy air as a leading health indicator linked to respiratory diseases, heart disease, and cancer.[6] Indoor air quality (IAQ) is influenced by numerous pollutants, including mold, carbon monoxide, radon, ozone, and smoke, and worsening IAQ is linked to poor health outcomes, including increased respiratory disease, vectorborne illnesses, psychological distress, and worsened allergies.[7] This is particularly significant in Los Angeles, where nearly 10% of adults have asthma, and 22% report poor self-rated health.[8] With multiple sources affecting IAQ–such as HVAC systems, frequent poor air quality days, wildfires, heatwaves, and droughts–the health of LA residents continues to decline.

Much of LA's housing stock is old: one-fifth of homes were built before 1939, and 75% were built before 1980.[9] **Housing insecurity affects 19% of LA residents–nearly double the national average–and 9% of homeowners report threats to utility services.**[8] However, housing insecurity does not impact all residents equally; significant disparities exist in homeownership, reflecting similar patterns in exposure to air pollutants. Vulnerable populations–including seniors, children, people of color, low-income residents, pregnant individuals, and those with pre-existing conditions–are at greater risk from poor IAQ.[10] Solutions that simultaneously address health and housing disparities are, therefore, crucial.

With over 4 million residents, L.A.'s size, diversity, and vulnerability to climate change position it as a potential leader in sustainable construction. As Americans spend nearly 90% of their time indoors, enhancing home ventilation to improve IAQ, energy efficiency, and affordability is essential for the success of future home construction.[11]

Improvements in home ventilation can bolster residents' health, energy efficiency, and financial stability, benefiting all communities and supporting a more equitable future.

TRANSFORMATIVE ELEMENT: Ventilation and Air Filtration

Presented is the "transformative element," which spotlights a unique feature in HFH Los Angeles Affiliate home construction designed to address local health and environmental challenges. This element promises significant improvements in crucial areas including residents' health outcomes, home energy performance optimization, and cost-effectiveness.

The transformative approach emphasizes enhancing **ventilation and air filtration systems** beyond code requirements. Informed by interviews with the HFH Los Angeles Affiliates and a literature review, these elements were identified as most relevant to tackling the region's severe particle pollution. Key elements that could improve ventilation and air quality include installing **high-efficiency bathroom and kitchen exhaust fans and integrating air filters into HVAC systems**.

COMPARISON

INDICATOR	Code Requirement	HFH L.A.	TRANSFORMATIVE
HVAC ENERGY PERFORMANCE	15 SEER	15.4 SEER/SEER2	High-efficiency heat pumps can maintain energy performance with the addition of air filters.
AIR FILTER EFFICIENCY	MERV 11 near highway	MERV 13	Air filters remove particles from incoming outside air
VENTILATION SYSTEMS	Bathroom and kitchen exhaust fans	Bathroom exhaust fan	Reduce indoor particulate matters
VENTILATION RATE/TOTAL AIR EXCHANGE	50 CFM (5 exchange/hour)	80 CFM	Air exchanges are required to bring in fresh air when the outside air quality is good.

AREAS OF IMPACT

Key Indicator	Expected Benefit
COST SAVINGS 	**Efficiency:** The MERV 13 fan filter, priced as low as $50, can effectively remove **at least** 50% of particles sized between 0.3 and 1 micrometer. Strategically choosing filters with **low pressure drop** could significantly improve air quality while ensuring HVAC efficiency.[12]
HEALTH IMPACTS 	**Respiratory Health:** Improved IAQ may reduce the frequency and severity of exacerbations and hospitalizations for chronic respiratory conditions, including asthma and COPD. **Cardiovascular Disease:** Improved IAQ is linked to decreased rates of heart disease, including stroke and hypertension. **Cancer:** Reduction of in-home air contaminants, especially all causes of smoke, may reduce the risk of lung cancer development. **Pregnancy:** Improved IAQ will benefit the health of pregnant persons and developing fetuses, including a reduction in preterm births, low birth weights, impaired neurological development, and fetal mortality. **Mental & Cognitive Health:** Improved IAQ may reduce the risk of cognitive decline and reduce rates of depression and anxiety.
DISASTER RESILIENCY 	**Wildfires:** Wildfire smoke can significantly increase outdoor PM2.5 concentrations. Utilizing indoor air filters can help mitigate the infiltration of these particles into indoor air.
ELEMENT LIFECYCLE 	Filters are recommended to be replaced every 60-90 days. Bathroom and kitchen exhaust fans should be deep cleaned 1-2X/year.
HOMEOWNER WELL-BEING 	With an adequate ventilation rate and high-efficiency air filters, homeowners can enjoy fresh air when outdoor air quality is good and reduce exposure to fine particles on days with poor air quality.

CONCLUSION

Enhanced home ventilation systems are designed to mitigate the adverse health effects of rising heat waves, droughts, and wildfires, which increasingly impact Los Angeles' most vulnerable residents. Homeowners can significantly improve their health in the short and long term by utilizing high-efficiency exhaust fans in bathrooms and kitchens alongside advanced air filters. To promote a truly sustainable future, advancing residential building codes, including Title 24 requirements, could be further strengthened to improve IAQ in future home builds.

Air Quality

Key Takeaways:

- In California, single-family homes below 1500 sqft are recommended to maintain indoor air quality by using a combination of bathroom and kitchen exhaust fans and HVAC air filters.
- Due to outdoor air quality issues, houses must balance reducing air leakage and ensuring good ventilation, carefully considering timing for optimal air exchange.

Health

Key Takeaways:

- Numerous health benefits can be gained from improved IAQ including a reduction in exacerbations of respiratory conditions, improved mental health, lower lung cancer risk, and reduced prenatal complications.
- Additional benefits include decreased healthcare burden and improved efficiency at work and school.

Financial

Key Takeaways:

- A low-cost fan filter with a MERV 13 rating or higher removes PM2.5 and PM1 particles.
- In California's predominantly hot and dry climate, ERV and HRV systems are less commonly recommended than in New Orleans or Houston due to the lower need for moisture removal and their high cost.

Improved ventilation systems combat the effects of climate change by creating affordable, sustainable homes that support a healthier future for L.A.

Supported by:

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DOW SUSTAINABILITY FELLOWS
UNIVERSITY OF MICHIGAN

A GUIDE TO CLIMATE ZONES 2 & 3 for Habitat for Humanity Affiliates

Mapping Health and Energy Inequity in Disinvested Communities

2024 DOW FELLOWS: DEVON GINGRICH, CHEN LYU, LAUREN PETTINGA, MARYAM SYED

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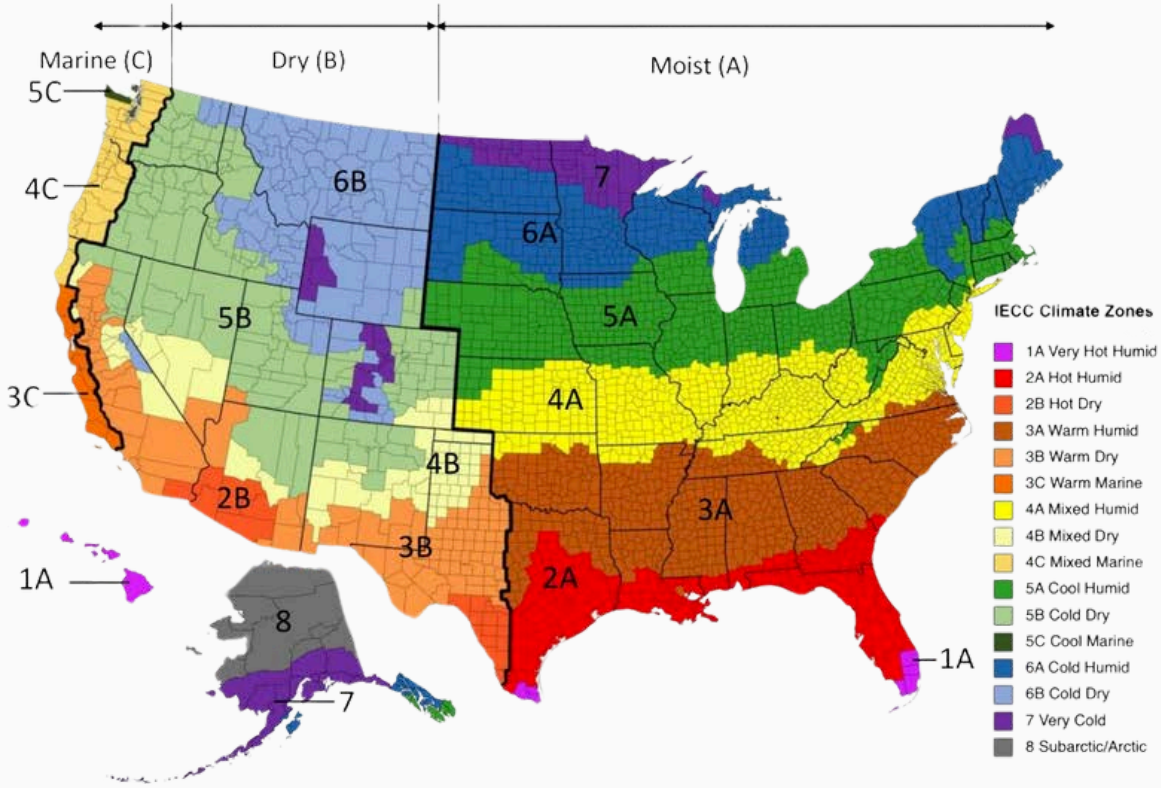
INTRODUCTION

This report aims to support Habitat for Humanity affiliates in Climate Zones 2 and 3 by providing background knowledge about these regions, highlighting their historical marginalization to strengthen grant applications and funding opportunities.



Source: "Building America Climate Zone Map." *Building America*, Pacific Northwest National Laboratory.

Climate Zone 3 is a **hot and dry** region, including parts of Texas, Arizona, and inland California. This zone experiences high temperatures and low humidity.[1]

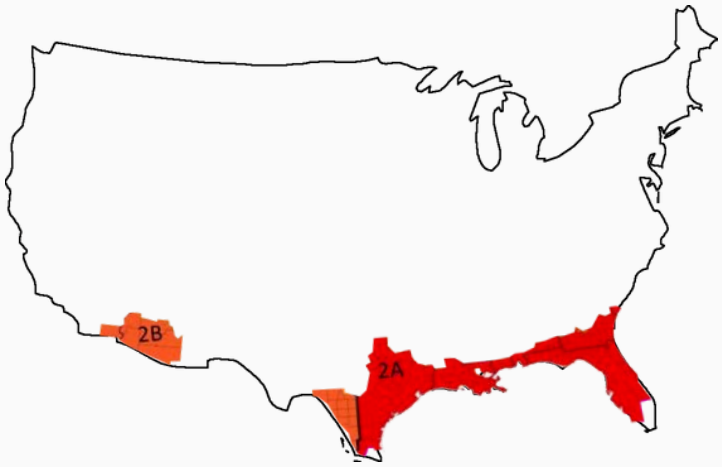
Climate Zone 2 is characterized as a **hot-humid** region, with long, sweltering summers, high humidity levels, and mild winters. This zone, encompassing areas like the Gulf Coast, faces issues like mold, moisture control, and high cooling demands.[1]

The challenges faced by Habitat for Humanity affiliates in Climate Zones 2 and 3 are complex and multi-layered. From extreme heat and high humidity to the growing intensity and frequency of hurricanes and other severe weather events, these zones require design approaches that consider both environmental resilience and long-term durability.[1]

CLIMATE ZONE 2

Geography

Climate Zone 2 spans areas with **hot and humid conditions** across several states in the southern United States. This zone primarily covers large portions of the **Gulf Coast**, including the entirety or parts of states such as **Texas, Louisiana, Mississippi, Alabama, Georgia, Florida,** and **South Carolina**. Additionally, smaller portions of states like **Arkansas** and **North Carolina** fall under this zone.[2]



Climate Zone 2 is characterized by its proximity to the **Gulf of Mexico**, which significantly influences the region's weather patterns and high humidity levels. Key geographical features include extensive coastal plains, river systems such as the Mississippi, and wetlands like the **Louisiana Bayous** and **Florida Everglade**s. The coastal location of many areas in Zone 2 makes them **prone to hurricanes and flooding**, further shaping the region's geography.[3]

Photo Caption: Bourbon Street in New Orleans, Louisiana
Source: National Geographic, Susanne Kremer

New Orleans lies along the Mississippi River near its delta and the Gulf of Mexico. It is renowned for its complex system of wetlands, bayous, and levees, which are crucial for managing floodwaters. The city sits below sea level in many areas, making it **particularly vulnerable to flooding and hurricanes**.[4]

Houston is built on a mix of coastal plains and bayous, with Buffalo Bayou running through the city center. Houston's proximity to the Gulf makes it **susceptible to tropical storms and hurricanes**, while its expansive flat terrain increases the risk of flooding.[5]

Photo Caption: Aerial view of Houston
Source: Getty Images

History

The southern states in Climate Zone 2 were central to the institution of **slavery**, with vast agricultural plantations relying on enslaved African labor[6]. The legacy of slavery continues to influence the region, as does the history of **segregation** and discriminatory policies, such as the **Jim Crow laws** that enforced racial segregation well into the 20th century.[7] These policies have had lasting impacts on the economic and social development of the region, with Black communities facing **systemic inequalities in education, employment, and housing**.[8] Environmental challenges in these areas, including heat, humidity, and frequent extreme weather events such as hurricanes, have exacerbated existing social inequities, making the need for sustainable construction and resilience-building even more urgent.[9]

ENVIRONMENTAL RACISM

The systematic and institutionalized practices that disproportionately expose marginalized communities, particularly communities of color, to environmental hazards while denying them access to environmental benefits.[10]

Climate Zone 2 is also a prime example of **environmental racism**. In many southern cities and rural areas, these communities often live in areas that are more vulnerable to the impacts of extreme weather, such as flooding, heat islands, and poor air quality.[10]

Urban areas like New Orleans and Houston have witnessed how environmental hazards disproportionately affect **low-income, minority neighborhoods**, which are frequently situated in **flood-prone areas or near industrial zones with high pollution levels.**[11] Additionally, the economic disparities stemming from historical disenfranchisement have made it harder for these communities to access resources for climate resilience, further entrenching **cycles of poverty** and **environmental vulnerability**.[12] The consequences of these structural inequities are compounded by the ongoing effects of climate change, which increases the frequency and intensity of extreme weather events, posing significant challenges to housing infrastructure, public health, and community well-being.[13]

Redlining systematically denied Black and immigrant communities access to housing loans and federal benefits.[14] The **economic disparities stemming from historical disenfranchisement** have made it harder for these communities to access resources for climate resilience, further entrenching cycles of poverty and environmental vulnerability.[14] The consequences of these structural inequities are compounded by the ongoing effects of climate change, which increases the frequency and intensity of extreme weather events, posing significant challenges to housing infrastructure, public health, and community well-being.[15]

REDLINING

Redlining was discriminatory practice originating in the 1930s where the federal government, through the **Home Owners' Loan Corporation (HOLC)**, systematically denied loans or financial services to neighborhoods primarily based on racial composition. Neighborhoods predominantly occupied by Black and other minority populations were graded poorly (marked in red on HOLC maps), leading to disinvestment, reduced property values, and long-term structural inequities in housing, health, and environmental conditions.[14]

Climate Impacts

Climate change is expected to exacerbate existing environmental challenges. Rising temperatures will likely lead to **more frequent and intense heatwaves.**[16] This will put added strain on **energy infrastructure** as demand for air conditioning and cooling increases, further intensifying the **urban heat island effect**, where densely built areas experience higher temperatures compared to surrounding areas.[17] In addition to temperature increases, more frequent and **severe rainfall** events are expected, leading to heightened **flooding risks**, particularly in coastal cities like New Orleans and Miami, which are already vulnerable to **storm surges** and **rising sea levels**.[18] The increased frequency and intensity of hurricanes and tropical storms will likely result in more significant **damage to infrastructure and homes**, which will disproportionately affect low-income communities that have historically been excluded from climate resilience efforts.[19]

Health Impacts

In Climate Zone 2, the hot-humid conditions pose several significant health risks, especially for vulnerable populations.[1]

The combination of high temperatures and humidity exacerbates the risk of **heat-related illnesses,** such as **heat exhaustion** and **heat stroke,** particularly among the elderly, children, and those with preexisting health conditions.[2]

Poor air quality, worsened by intense heat and humidity, can lead to **respiratory problems** like asthma and bronchitis, as well as **cardiovascular issues**.[21]

Flooding, which is common in this region due to heavy rainfall and rising sea levels, increases the risk of **waterborne diseases**, while also causing **mold** and mildew growth in homes, contributing to **respiratory issues.**[21]

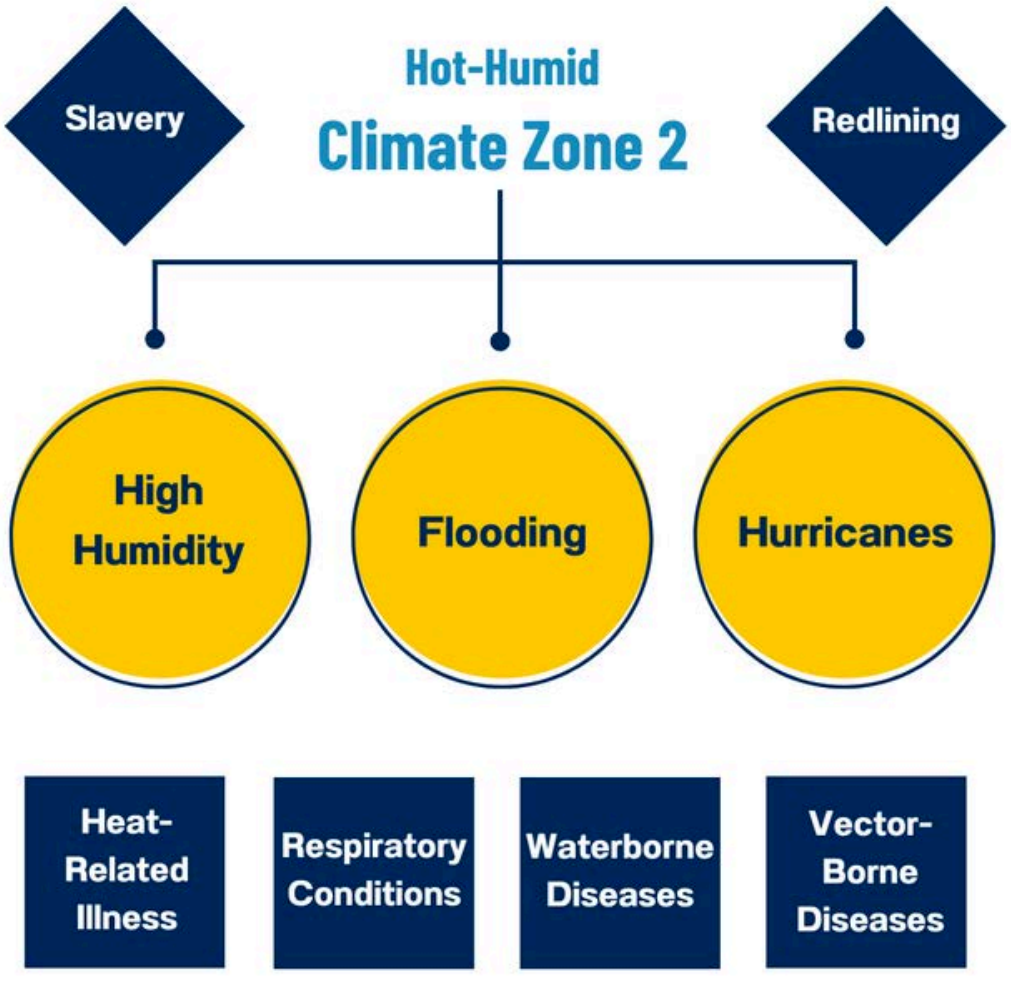
Additionally, increased temperatures can lead to the spread of **vector-borne diseases** like West Nile virus and Zika, as the warmer environment supports the growth of mosquitoes.[22]

The disproportionate exposure to these health risks is compounded in marginalized communities, particularly those that have faced **historical disinvestment** and **environmental racism**, which **limit their access to healthcare, clean water, and climate-resilient infrastructure**.[23]

Housing

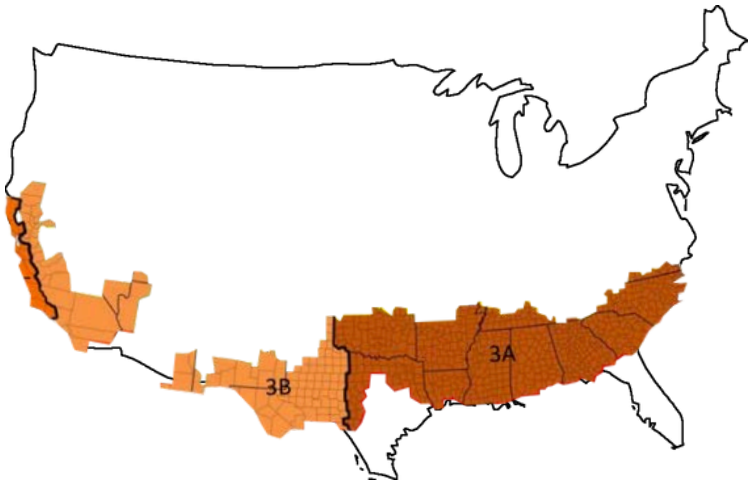
Many of the region's homes are older, and a significant portion of the housing stock **lacks modern climate resilience features**, making them vulnerable to these weather events.[24] In addition to the physical risks, areas with a **history of redlining** and **environmental racism** have faced **long-term disinvestment**, contributing to substandard housing conditions in many low-income and minority communities.[25] These neighborhoods often experience a **cycle of neglect**, where affordable housing options are limited, and the costs of repairs and retrofits for climate resilience are unaffordable for residents.[26] As housing demand increases in some areas, such as New Orleans, **housing prices have risen**,[27] exacerbating the affordability crisis. At the same time, **climate-induced displacement** due to flooding and storm damage is pushing more vulnerable populations into overcrowded, inadequate housing, further deepening the region's housing challenges.[28]

A Summary of Climate Zone 2



CLIMATE ZONE 3

Geography



Climate Zone 3 covers regions in the southwestern and parts of the western United States characterized by a **hot and dry** climate.[2] This zone includes areas in states like **Texas, Arizona, California, Nevada,** and **New Mexico**, extending into parts of **Utah** and **Oklahoma**. Climate Zone 3 is dominated by **deserts, plateaus**, and **rugged terrain**.[2] The **Sonoran, Mojave**, and **Chihuahuan Desert** are among the prominent features of the region, with vast stretches of **arid land and minimal rainfall**.[29]

This zone experiences significant diurnal temperature variations, with **hot daytime** temperatures and **cooler nights**, especially in higher elevation areas.[29] The region's dry conditions, combined with **limited water resources**, shape its ecosystems, which include desert vegetation and wildlife adapted to low moisture environments.[30]

Photo Caption: Hollywood Boulevard in Los Angeles
Source: Visit the USA

Los Angeles' geography is marked by its proximity to the coast, with coastal plains, hills, and the Santa Monica Mountains, which contribute to the varied climate.[31] Los Angeles is also subject to the influence of the Pacific Ocean, which moderates temperatures along the coast, while areas further inland experience more **extreme heat** and drier conditions.[31] The city's geography is characterized by a mix of coastal, mountainous, and urban areas, with significant variations in rainfall and temperature between different parts of the city.[32] As a result, Los Angeles faces challenges related to water conservation, air quality, and energy efficiency, all of which are shaped by its hot, arid climate and geographical features.[32]

History

Historically, the development of this region has been shaped by complex social, political, and economic[33] forces, particularly the legacy of **colonization**, **migration**, and **settlement patterns**. The expansion of agriculture, mining, and the railroad industry in the late 19th and early 20th centuries led to **rapid urbanization** and the growth of cities like Phoenix, Las Vegas, and Albuquerque[34]. The economic activities that thrived in this region often relied on **cheap labor**, particularly from Native American, Mexican, and later, Asian immigrant populations[35]. This dynamic laid the foundation for the **racial and economic disparities** that continue to affect the region.[36]

Racism, both social and institutional, has played a significant role in shaping the development of states in Climate Zone 3.

The practice of **redlining** particularly affected cities like Los Angeles, where Black and Hispanic communities were systematically excluded from housing and mortgage opportunities.[37] This resulted in **segregated neighborhoods**, many of which were situated in areas prone to environmental hazards, such as near industrial zones, floodplains, or in regions with limited access to city infrastructure.[38] The **environmental racism** experienced in these areas is evident in the disproportionately **high levels of pollution**, **poor air quality**, and **water scarcity** faced by marginalized communities.[39]

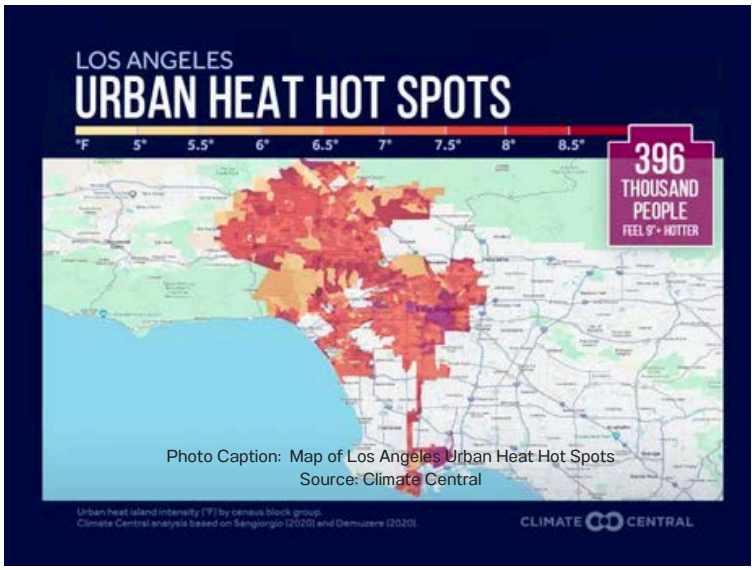


Photo Caption: Map of Los Angeles Urban Heat Hot Spots
Source: Climate Central

In cities like Los Angeles, low-income communities of color are more likely to live in **heat islands, areas** that experience higher temperatures due to the lack of vegetation and urban sprawl.[40]

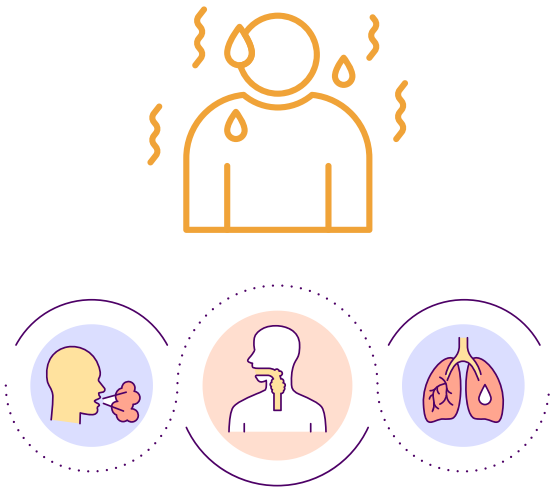
Climate Impacts

Rising temperatures will lead to more **frequent and intense heat waves.** The increase in heat, coupled with **prolonged droughts**, will contribute to water scarcity, impacting agricultural production, drinking water supplies, and ecosystems.[41] **Wildfires**, already a major concern in states like California, are expected to become more frequent and severe, threatening both the natural environment and human settlements.[42] With increased temperatures and reduced rainfall, the risk of **desertification** will rise, affecting both urban and rural communities across the region.[43]

The impacts of climate change in Climate Zone 3 will **disproportionately affect marginalized communities,** many of which are already vulnerable due to historical and ongoing social, environmental, and economic inequalities.[39] Communities in areas that were subject to redlining, such as certain neighborhoods in Los Angeles, are at heightened risk due to **inadequate infrastructure, poor housing quality, and limited access** to resources for adaptation.[37] The combination of rising temperatures, water scarcity, and more frequent wildfires poses significant challenges to these communities.

Health Impacts

Extended periods of heat can lead to **heat exhaustion, heat stroke, and dehydration,** especially in areas like Arizona and California, where extreme summer temperatures are common.[44]

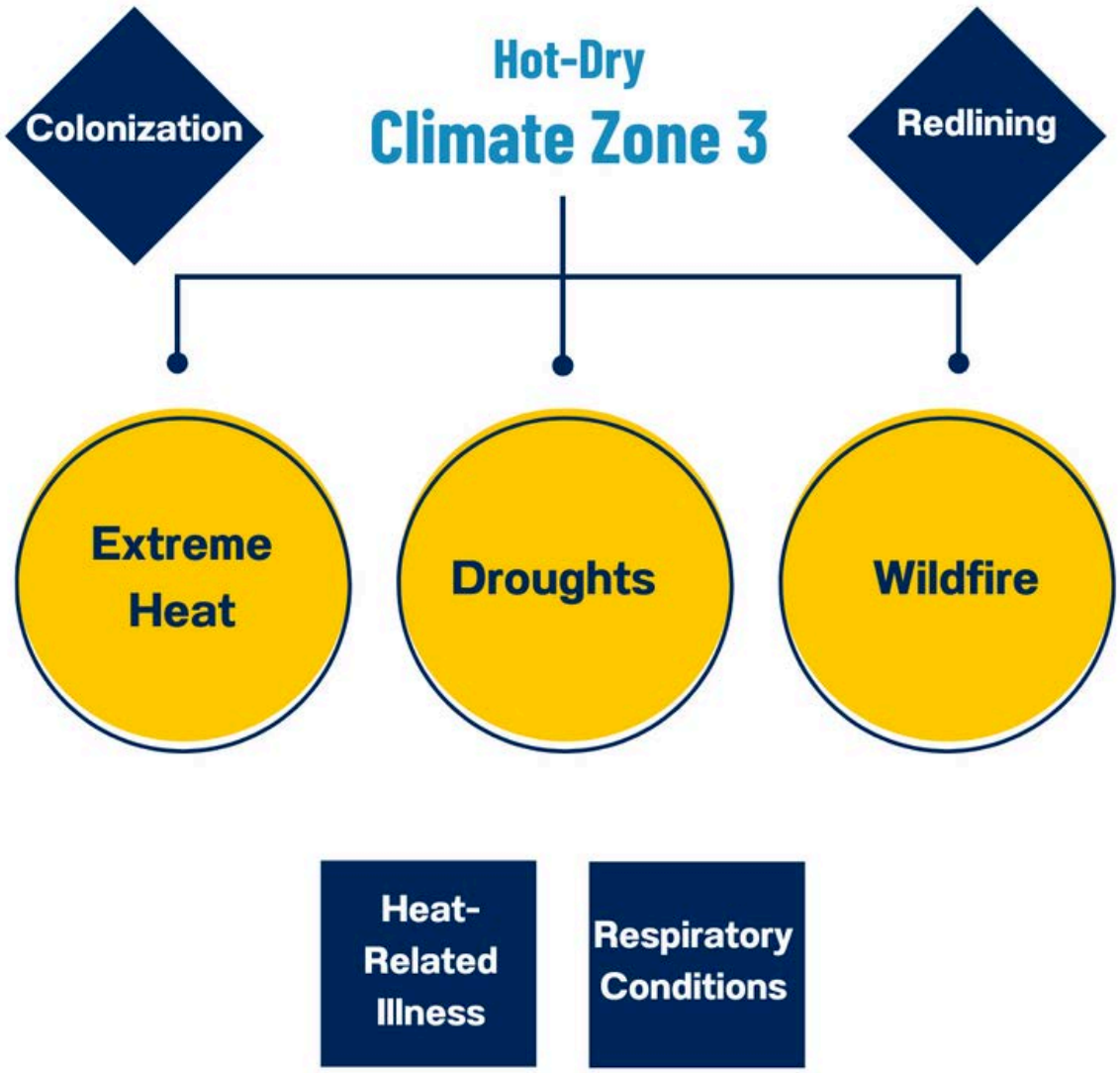


The dry environment also increases the risk of **respiratory problems** due to poor air quality, exacerbated by dust storms and wildfires.[45] Wildfires, which have become more frequent and intense due to climate change, release harmful particulate matter into the air, worsening conditions for individuals with **asthma, chronic respiratory diseases, and cardiovascular issues**.[45]

Housing

Many homes in this zone were built without consideration for climate change, and older housing stocks often **lack energy-efficient features** such as proper insulation, reflective roofing, and air conditioning systems that can help mitigate extreme heat.[46] Furthermore, areas at **risk of wildfires**, such as those in the hills and foothills of LA, are increasingly seeing **displacement** as fires worsen due to climate change.[47] Many vulnerable communities in these areas also lack the financial resources to retrofit homes or rebuild following damage from natural disasters, making them more susceptible to **housing instability**.[48]

A Summary of Climate Zone 3



THE NEED FOR SUSTAINABLE DESIGN

Sustainable home construction and design are essential in Climate Zones 2 and 3, where **distinct climate pressures and historical challenges create an urgent need for resilient, affordable housing**.[49]

Climate Zone 2 regularly experiences intense storms, flooding, and rising temperatures, all of which take a toll on housing infrastructure and health. The dense humidity increases the prevalence of mold, pests, and heat-related illnesses.[20]

Climate Zone 3 faces arid conditions, high summer temperatures, drought, and wildfire risks which strain local water resources, air quality, and housing stability.[29]

In both zones, **disinvested and historically marginalized communities bear the brunt** of these environmental stressors, which are exacerbated by long-standing patterns of **racial and economic disinvestment** that leave residents in homes lacking basic climate resilience features.[39]

A Mini Split Heat Pump is one example of sustainable housing element.

Sustainable housing design offers these communities a **vital pathway toward health, safety, and financial security** by reducing vulnerability to climate extremes and lowering the long-term costs of maintenance and energy.[49] For example, implementing energy-efficient cooling not only shields residents from environmental hazards but also helps reduce utility costs,[50] ensuring more stable living conditions. Effective, **climate-adaptive** housing that is insulated and resilient not only supports physical health by providing better air quality and temperature regulation but also helps protect these historically underserved communities from ongoing climate threats.[51] Sustainable home construction in Climate Zones 2 and 3 is therefore critical–not only as a response to current environmental challenges but as a foundation for achieving **housing equity, resilience, and long-term affordability.**[51]

FURTHER READING

A list of readings and videos on topics related to environmental racism and racism in the United States that has led to disinvestment in Climate Zones 2 and 3.

- **Robert D. Bullard, PhD;** Father of Environmental Justice
  - How Environmental Racism Shapes the United States
  - Environmental Racism and Invisible Communities
  - Pollution is Segregated

- **Richard Rothstein,** Distinguished Fellow at Economic Policy Institute
  - The Color of Law: A Forgotten History of How Our Government Segregated America
  - Richard Rothstein on “The Color of Law”

- **Jamie Tijerina, BSc, MBA;** Scientific Researcher at California Institute of Technology
  - The Legacy of Redlining in Los Angeles: Disinvestment, Injustice, and Inefficiency Finding a Path Forward in 2019 and Beyond

- **Brian Williams, PhD;** Assistant Professor of Geography at Mississippi University
  - That We May Live: Pesticides, Plantations, and Environmental Racism in the United States South

- **W. Malcom Byrnes, PhD;** Associate Professor of Biochemistry at Howard University
  - Climate Justice, Hurricane Katrina, and African American Environmentalism

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