Disaster Recovery Alternative Housing Study

Findings Report

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ORGANIZATION OF FINDINGS REPORT

This Report summarizes key findings from Phase I of the Texas General Land Office Disaster Recovery Alternative Housing Study. To support stakeholders in locating information most relevant to their needs, ***Table 1: Organization of Findings Report*** describes the content presented in each section.

Table 1: Organization of Findings Report

	What information does this provide?
Executive Summary	The Executive Summary section outlines **key takeaways** identified in the Findings Report.
Introduction	The Introduction section outlines **the Study approach and purpose**, particularly as guided by needs emerging from Hurricane Harvey.
Literature Review	The Literature Review section outlines **existing thought leadership and research** from a range of government, academia, and private sector resources.
Housing Assessment Tool (HAT) Survey	The Housing Assessment Tool Survey section describes **the specific inputs and outputs used in the survey methodology,** which was used to guide the Study's analysis.
Core Outputs	The Core Outputs section highlights the **specific characteristics of housing units that can meet community needs** (e.g., resilience) and the key takeaways identified among vendor submissions to the HAT survey.
Community Stakeholder Outreach	The Community Stakeholder Outreach section reviews the **Study's methodology for engaging stakeholder groups**, as well as the specific priorities that stakeholders identified for improving future housing missions.
Findings and Recommendations	The Findings and Recommendations section highlights **potential target use cases** for alternative housing, **the strengths and considerations for types of alternative housing submissions** to the Study, and the **Study's recommendations** for pursuing those types of alternative housing and use cases in the future.
Vendor Profiles	The Vendor Profiles section presents **in-depth information about each vendor submission** to the HAT survey.

EXECUTIVE SUMMARY

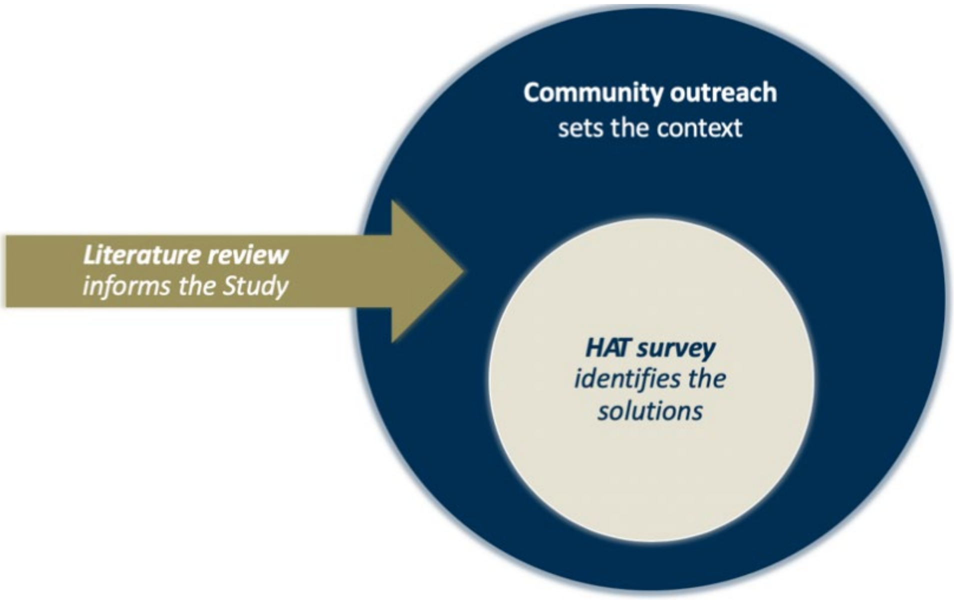
The Texas General Land Office—Community Development and Revitalization (GLO-CDR) Disaster Recovery Alternative Housing Study (Study) is setting the path for implementation of innovative alternative housing solutions to serve communities impacted by disasters. Amidst the growing impact of natural disasters across Texas, the Study was launched to identify new and forward-thinking solutions that can fill the need for rapidly deployable, affordable, and resilient post-disaster housing. These solutions are critical at a time when storms like Hurricane Harvey generate housing crises that can last for years.

Keeping in mind that there are no one-size-fits all solutions for Texas communities, the Study examined a diverse range of emerging housing technologies, as well as innovative housing solutions that are currently available in the marketplace. To do so, the Study gathered and analyzed data in three ways:

1. Literature review;
2. Community outreach; and
3. Housing Assessment Tool (HAT) survey.

This three-pronged approach contextualized research based on existing thought leadership in alternative housing technology and community expectations of how that technology might meet needs in the State of Texas (see ***Figure 1***).

Figure 1: The Study Approach



LITERATURE REVIEW

The literature review focused on pilot programs, analyses, and emerging trends in alternative housing. Findings are categorized by the following:

- **Government Pilot Programs and Case Studies**
- **Academic Analyses**

The Study identified pilot programs and reports that reflected best practices in applying alternative housing technologies in the public and private sectors. The literature demonstrated that while there has been interest at all levels of government and among community stakeholders to pursue alternative housing options, the technology and scale of production available in the marketplace has historically limited the scale at which these solutions can be implemented.

Technology and production capabilities are rapidly changing, and the Study is well-timed as alternative housing companies are building meaningful production capabilities to serve communities. Given the increasing gap in affordable housing nationwide, the construction sector is applying new innovations to embrace systematic approaches to home building. Housing construction processes have integrated concepts like the assembly line in both prefabricated housing and on-site procurement processes, resulting in growth in innovative approaches (e.g. modular) that can address the need for housing quickly, while also creating safe, resilient homes.

Key Takeaways: **Literature Review**

1. Active community engagement early in the process is important for successful implementation.
2. Design plans should be standardized throughout a program to minimize inconsistencies and misunderstandings.
3. Pilot programs to boost housing accessibility have historically been encumbered by technical and project management challenges, supply chain issues, and a lack of durability.
4. Short-term housing solutions should support long-term recovery goals for the community.
5. There is a need for greater transparency on the scope and flexibility of the Federal Emergency Management Agency's (FEMA) Individual Assistance (IA) policies.
6. Variations in building codes and standards across local jurisdictions create barriers for standardized alternative home design and construction.
7. Modular housing solutions can be a strategy to combat rising construction costs.

COMMUNITY OUTREACH

The Study's community outreach strategy was critical to framing the Study's findings and recommendations based on self-identified needs in Texas communities. Given the Study's focus on information gathering and assessment, community outreach was purposefully kept at a high level, to gather general feedback on community stakeholder requirements for disaster housing and solutions that could meet those requirements.

Community outreach therefore engaged local government and emergency management, civil society organizations, and technical experts. Discussions were held through a series of one-on-one interviews and webinars. Feedback from these discussions provided a local perspective from communities while maintaining a vision for statewide solutions.

Key Takeaways: **Community Outreach**

1. Efforts like temporary-to-permanent housing that focus on expediting the long-term recovery process can better serve the well-being of survivors and their communities.
2. The long-term affordability of a home should review cost considerations for different building features (e.g., central air conditioning) and tax increases due to the size of the structure, which may result in financial challenges for the survivor in maintaining the home.
3. Temporary solutions that cause local code enforcement to lower their standards may not be so temporary and alternative housing solutions can better keep survivors safe by meeting and exceeding code (e.g., elevation).
4. Housing solutions need to be adaptable to the local community architecture and should be mindful of aesthetics that may create the feeling of stigmatization.
5. It is important to set expectations with survivors early on, to limit any disappointment or confusion.
6. Housing programs need to account for challenges associated with limited certified tradesmen and contractors, as well as issues hooking up the electrical and plumbing systems, when developing timelines for construction.
7. Clear and simple communication should be used to explain post-disaster solutions and limitations of those solutions. For modular housing, associations that survivors may have with manufactured housing units should be addressed through education-based initiatives.
8. Survivors often want housing options that are close to their community and damaged property, so they can reduce travel expenses, keep their routine, and maintain their property.
9. State agencies should increase coordination with long-term recovery groups (LTRGs) and philanthropic groups to better leverage the information and resources available to communities.

HOUSING ASSESSMENT TOOL SURVEY

The Study developed the HAT survey to gather a comprehensive data set from vendors and architects about their unique alternative housing unit designs. Questions and analyses were structured to address the most important factors for Texas communities.

In total, the Study received survey submissions for 34 housing solutions from 24 vendors. These submissions can be grouped into seven categories of housing units (see ***Table 2***). Of the submissions, 20 vendors provided enough substantive data to be fully analyzed through the Study's algorithm. All submissions were considered when identifying the trends and types of alternative housing available in the marketplace.

Table 2: Categorization of Housing Solutions

Type of Housing	Number of Submissions
3D Printed Homes	1
Log Kit Homes	2
Traditional Kit Homes	1
Modular Foldable Units	4
Modular Panelized Units	7
Modular Prefabricated Units	5
Shipping Containers	4

During the analysis process, the Study used a hybrid quantitative and qualitative approach to review and compare the relative capabilities of different alternative housing technologies. This approach incorporated an algorithm to score the different units based on key questions. The Study Team also implemented a series of one-on-one discussions with vendors and reviewed additional supplementary materials to understand aspects of unit capabilities that would not necessarily be captured by the score. Both the quantitative and qualitative approach were informed by a series of nine HAT survey question categories that informed results under five core outputs (see ***Table 3***).

Table 3: Summary of Analytical Approach

Inputs – 177 questions in 9 categories	Outputs – 5 primary categories
Alternative Housing Categories	Resilience ➢ Flood ➢ Wind ➢ Fire ➢ Energy
Codes and Standards	
Resilience	
Unit Size and Amenities	
Ability to Customize	Livability
Structure Elements	Range of Use
Construction and Site Requirements	Timeliness
Production Capability	Cost
Cost and Cost Effectiveness	

Snapshots: **HAT Survey Building Systems and Technology Trends**

1. Some submissions include built-in foundations using jacks, helical piers, and hardened exteriors, which can avoid the need to get a site graded or leveled prior to installation.
2. Many submissions featured structures with strong load path elements and connections designed to resist code-level wind events.
3. Some submissions use structural insulated panels (SIPs) made from flood-damage resistant materials.
4. Some submissions are fully off-grid capable.
5. Many vendor participants in the Study consistently highlighted dignified housing as a priority in their building and amenity considerations.
6. Many participating vendors emphasized the ability of assembly lines to incorporate resilient building practices and reduce on-site construction needs.
7. Many participating vendors incorporate flat-packed building systems and construct within the maximum wide load so that units are easier to transport.
8. Some submissions highlighted user-friendly designs and building processes that can optimize unskilled labor (e.g., voluntary organizations active in disaster).
9. Many of the Study's participating vendors use building systems with modules that can be connected and/or stacked to accommodate different family sizes and needs.

FINDINGS AND RECOMMENDATIONS

Many alternative housing leaders are pursuing innovations to address the need for affordable and rapidly deployable housing. Use cases could be delineated by single-family versus multi-family housing and temporary versus permanent housing, though some approaches could be applied across a wide range of use cases. Submissions also represented new methods of applying housing technology to post-disaster housing needs, including the following:

- **Accessory Dwelling Units**
- **Rapidly Deployable Shelter**
- **Temporary-to-Permanent Housing**
- **Tiny Homes**
- **Waterborne Shelter**

The Study categorized vendor submissions under seven main categories (see ***Table 4***).

Table 4: Categorization of Housing Solutions
3D Printing
Log Kit Homes
Traditional Kit Homes
Modular Foldable Units
Modular Panelized Units
Modular Prefabricated
Shipping Containers

Across these submissions, the Study recommended four vendors for prototype testing under Phase II of the Study:

BOXABL

ICON

indie DWELL

LiV CONNECTED

INTRODUCTION

The need for innovative post-disaster housing solutions has never been more urgent. The State of Texas (State) is ranked first in the United States for frequency of natural disasters and has had the highest number of federally declared disasters nationwide over the last 65 years.[i] In the past 15 years, the State suffered impacts from several disasters varying in nature and severity, including Hurricane Rita in 2005, Hurricane Ike in 2008, the Bastrop County Complex Fire in 2011, the Memorial Day Flood in 2015, the Tax Day Flood in 2016, Hurricane Harvey in 2017, the Great June Flood in the Rio Grande Valley in 2018, and Tropical Storm Imelda in 2019.[ii]

The frequency and often compounding nature of disasters have lasting impacts on the housing stock. The need for post-disaster housing solutions is not unique to Texas; similar risks are faced by communities around the world. In the face of these challenges, innovation in housing technology is focusing on new and forward-thinking strategies to develop solutions that can fill the need for rapidly deployable, affordable, and resilient post-disaster housing.

BACKGROUND: HURRICANE HARVEY

Hurricane Harvey, which made landfall on August 25, 2017, brought widespread impacts across southeastern Texas resulting with over 60 inches of rainfall and affecting more than 13 million individuals. For the communities most severely impacted, thousands of homes were significantly damaged or rendered completely unlivable. To fill the housing needs resulting from Hurricane Harvey, responding housing missions leveraged significant resources; however, the needs for households supported by both temporary and long-term programs impacted efficiency and resulted in some applicants receiving both a temporary trailer and stick-built home, where others received nothing.

The impact of Hurricane Harvey in 49 counties designated as Most Impacted and Distressed (MID) Areas[1] led to 900,000 Individual Assistance (IA) application submissions to the Federal Emergency Management Agency (FEMA) within three months of the storm.[iii] FEMA first approved the request for direct housing assistance from the State of Texas on September 10, 2017.[iv] FEMA's direct housing assistance initially included approvals to 373,150 IA applications, which released $1.6 billion in funding under the FEMA IA Program, including activation of the Individuals and Households Program (IHP) to provide manufactured housing units (MHUs) and travel trailers (TTs).[v]

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[1] As HUD determines allocations for Community Development Block Grant – Disaster Recovery funds, it identifies the most heavily impacted areas from the federally declared disaster to which funds are being applied.

FEMA entered an 18-month Intergovernmental Service Agreement (IGSA) with the Texas General Land Office (GLO) on September 22, 2017, which allowed local officials to expedite MHU procurement through state-sourced vendors. Direct housing operations began on September 28, 2017, and the program's first applicant move-in date was on October 7, 2017 (see ***Figure 2***). However, as of November 30, 2017, more than 13,000 survivors approved to receive a unit were still living under FEMA-provided Transitional Shelter Assistance (TSA) (e.g., hotel rooms).

Figure 2: Timeline from Disaster to FEMA Unit Installation

The FEMA temporary housing programs addressed immediate needs for a limited number of survivors, but even for those recipients, the units' prescribed 18-month life cycle did not provide a permanent solution or contribute to the housing stock. To meet these needs, the U.S. Department of Housing and Urban Development (HUD) provided Community Development Block Grant—Disaster Recovery (CDBG-DR) funds to support long-term recovery from Hurricane Harvey. In total, HUD provided \$5.6 billion in CDBG-DR in funds that were directed to address Harvey-related needs (e.g., infrastructure, housing) in Texas, with GLO oversight.[vi] This included support for the GLO-run Homeowner Assistance Program (HAP), which started accepting applications in November 2018. The first construction sites commenced in December 2018, and the first home was completed in February 2019 (see ***Figure 3***).[vii] By April 2020, HAP granted 2,315 families rebuilt and newly constructed resilient homes.[viii]

Figure 3: Timeline from GLO HAP Applications to First Site Completed

Figure 4: FEMA MHU (left) and HAP-Funded Home Build (right)

Retrieved from https://cdn0.wideopenroads.com/wp-content/uploads/2019/02/ Untitled-design-

Retrieved from https://jwtc.net/2019/04/ 22/jwtc-builds-new-home-in-15-days-for-port-arthur-

When considering the cost-effectiveness of temporary versus permanent programs, it is important to fully account for the additional costs associated with temporary units, including the life cycle for purchase, staging, transportation, installation, recertification, maintenance, and deactivation (see ***Table 5***). Moreover, even after the deployment of these programs, homeowners still require a permanent home to meet their needs.

Table 5: Temporary Housing Costs [2]

Cost Type	MHU	Travel Trailer
Purchase	$44,500.81	$28,136.50
Haul and Install	$17,240.38	$5,517.67
Removal	$3,092.57	$1,154.26
Total	**$64,833.76**	**$34,808.43**

PURPOSE OF THE STUDY

The Disaster Recovery Alternative Housing Study (Study) was created in response to the recognized opportunities to apply innovative alternative technology as potential solutions for improving the efficiency and survivor experience during post-disaster housing missions. The purpose of the Study is to gather, analyze, and present data related to alternative housing options, including factors such as resiliency, safety, cost, and construction timeline. The Study's analysis and recommendations will inform temporary, permanent, and temporary-to-permanent housing deployments for future disaster recovery efforts.

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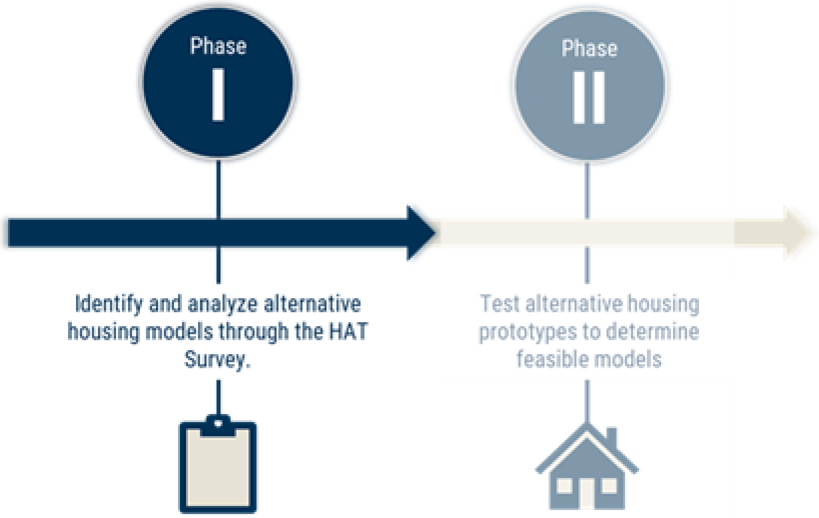
[2] Data provided by GLO-CDR.

The Study includes two phases of research (see ***Figure 5***) to identify and analyze the most effective housing models for communities. The rapidly changing landscape of building science and construction technologies means that many alternative housing solutions are available in the marketplace that can address both temporary and long-term needs after disasters.

Figure 5: Disaster Recovery Alternative Housing Study Phases



Efforts under Phase I of the Study culminated in this Findings Report (Report), which reflects the identification of innovative alternative housing options through use of the Housing Assessment Tool (HAT) survey, with context provided by a literature review and community outreach strategy. This Report presents a comprehensive analysis and set of recommendations to inform steps for mobilizing alternative housing missions in the future. Findings reflect opportunities for multiple potential solutions—rather than a single, uniform solution—to account for the varying needs across Texas communities.

STUDY DESIGN

The Study launched in January 2020. The Study's approach was structured to evaluate and pursue alternative housing technologies through three concurrent efforts:

1. **Literature Review:** Review existing literature, including case studies on previous pilot programs, academic research, and news articles, to inform the Study's understanding of past successes and failures in alternative housing option implementation.
2. **Community Outreach:** Engage community stakeholders across the State of Texas, to understand the existing needs and priorities of those target jurisdictions likely to use the end products identified by the Study as alternative housing options in the future.

3. **Housing Assessment Tool Survey:** Develop the HAT survey to build an online information platform that comprehensively captures data relating to a housing model's code compliance, structural elements, utility hook-ups, transportation and construction processes, and overall cost-effectiveness. Engage vendors across the United States—and the world—to elicit participation in the HAT survey as a method of identifying alternative housing solutions. Evaluate options based on a set of core outputs directly relating to quantitative analysis of the housing data and qualitative analysis of overall unit capabilities, identified according to prioritized needs for future housing missions in Texas.

The literature review and community outreach process provided important context for the HAT survey. Activities throughout the Study were monitored by an Oversight Committee, to provide feedback on the approach developed and implemented by the Study Team (see ***Figure 6***).

Figure 6: Oversight Committee Engagement

LITERATURE REVIEW

Progress in alternative housing has accelerated in recent years. Emerging technologies, research, and pilot programs are highlighting the actionable, forward-thinking opportunities available in the alternative housing market. This literature review captured these alternative housing research initiatives under the following categories:

Government Pilot Programs and Case Studies

Academic Analyses

Projects across the public and private sector are bringing innovative solutions to the populations that need them most, particularly in the context of post-disaster and affordable housing. The purpose of the following review is to highlight key takeaways that can inform future policy and programmatic decisions for disaster housing in Texas.

Key Takeaways: **Literature Review**

1. Active community engagement early in the process is important for successful implementation.
2. Design plans should be standardized throughout a program to minimize inconsistencies and misunderstandings.
3. Pilot programs to boost housing accessibility have historically been encumbered by technical and project management challenges, supply chain issues, and a lack of durability.
4. Short-term housing solutions should support long-term recovery goals for the community.
5. There is a need for greater transparency on the scope and flexibility of the Federal Emergency Management Agency's (FEMA) Individual Assistance (IA) policies.
6. Variations in building codes and standards across local jurisdictions create barriers for standardized alternative home design and construction.
7. Modular housing solutions can be a strategy to combat rising construction costs.

GOVERNMENT PILOT PROGRAMS

Communities grappling with the impacts of disasters on housing stock have seen multiple iterations of federal, state, and city-led programs piloting alternative housing after major disasters. During the past fifteen years, key efforts in pushing forward these solutions include the following:

- FEMA's Alternative Housing Pilot Program, 2006;
- FEMA's Joint Housing Solutions Group, 2007;
- New York City's Urban Housing Prototype, 2014; and
- Houston-Galveston Area Council's Rapid Recovery Program, 2014.

The use of these programs across urban and rural environments reflects the cross-cutting need for alternative housing in many different communities. While there are general trends in lessons learned from program management that apply across these pilot programs, they reflect an important takeaway: there is no one-size-fits-all solution to addressing alternative housing needs.

ALTERNATIVE HOUSING PILOT PROGRAM

In the wake of Hurricane Katrina, Congress allotted $400 million to launch the Alternative Housing Pilot Program for impacted communities (AHPP). Funds were granted to communities for pilot programs to address housing needs in Alabama, Florida, Louisiana, and Mississippi (see ***Table 6***).

The AHPP had varying degrees of success across each state. Public reception of the units demonstrated the impact of providing a dignified housing option for building initial community buy-in. However, long-term success depended on the effectiveness of program management by FEMA and its contractors, as well as the overall resilience of the units. Due to delays and technical challenges, few of the pilot programs reached their target number of units constructed.

Table 6: Alternative Housing Pilot Program Actuals Summary [ix]

State	Funding	Program Unit Type	Units Built	Cost Per Unit [x]	Key Findings
Alabama	$15.7M	Single-Family Modular Homes	100	$156,672	Unit quality benefitted from use of reinforced concrete. Long-term acceptability suffered due to mold growth, some of which was addressed through HVAC system improvements. Poor management and eventual reports of evictions harmed community perception.
Louisiana	$74.5M	Single-Family Factory-Built Homes	480	$155,000	Use of customizable units that could fit local architectural standards was well received in the community. Delays and program management challenges harmed community acceptance.
		One-Story Multi-Family Structures			
Mississippi	$281.3M	Park Model	1,450 Park Models 1,625 Cottages	$90,000	Fast-paced, multi-sourced procurement resulted in fast deployment. Units exceeded code standards and were resilient to future storms. Program implementation of Uniform Federal Accessibility Standards is a good reference for integrating accessibility compliance in alternative housing missions for federally funded structures.
		Green Mobile	45	$90,000	
Texas	$16.5M	Panelized Housing	6 Complete 42 Incomplete	N/A	Use of panelized units showed promise for a quick build. The housing developer/contractor failed to perform, which resulted in the project's termination. The community also rejected the unit design.

Alternative Housing Pilot Program: Alabama

Housing Type: Modular Homes	**Budget:** $15,667,293	**Goal:** 194 Units	**Dates:** April 2007 – April 2011

Photo by Amy Jones & Associates/Janet Pershing // Retrieved from https://www.fema.gov/pdf/about/programs/ahpp/ahpp_al_case_study.pdf

After Hurricane Katrina, the pilot project deployed in Bayou La Batre prioritized use of rapidly deployable, long-term affordable housing units in a range of sizes. Units were outfitted with air conditioning, front porches, washer and dryers, basic furniture, and a housing essentials kit (e.g., linens), to provide basic necessities that were lost in the storm. Homes were constructed to meet and exceed building code (e.g., International Residential Code).

In total, the Bayou La Batre project took nearly two years to construct 100 units, even with efforts to expedite construction. Notable delays resulted from poor weather as well as issues with contracts and local and federal code compliance (e.g., validation of Uniform Federal Accessibility Standard [UFAS] compliance).

Key Takeaways: **Modular Homes**

- Prioritization of quality and code compliance resulted in a higher overall cost per home and slower rate of production; however, the high-quality homes were well-received by residents and exceeded requirements under both Housing and Urban Development (HUD) Code and International Residential Code (IRC).
- Recipients highlighted a sense of relief and jubilation at having the ability to call these new units home, noting that they brought back a semblance of “normalcy."
- Land banking—designating land for the use of temporary housing—was reported as a positive asset to the program, in that it enabled residents’ property use for alternative permanent home construction.

Alternative Housing Pilot Program: Louisiana			
Housing Type: Katrina Cottages	**Budget:** $74,542,370	**Goal:** 475 Units	**Dates:** September 2007 – September 2011

Photo by Ben Brown // Retrieved from https://www.treehugger.com/tinyhouses/so-what-ever-happened-katrina-cottages.htmlpictures/

After Hurricane Katrina, Louisiana's pilot program utilized factory-built units that conformed to local traditional architecture, including a front porch. Different family sizes were accommodated through selection among five floor plans with unit sizes and dimensions ranging from 874 to 1112 square feet in size.

The program faced significant delays, to the extent that much of the target recipient population found a post-disaster housing solution by the time that units were ready. Factors contributing to delays included setbacks in finalizing grant agreements with recipients, the associated grant coordination among state agencies, and challenges identifying recipients that qualified under the program's requirements, especially once survivors had found alternative solutions.

Key Takeaways: **Katrina Cottages**

- The positive response of recipients highlighted the impact of incorporating local architectural standards in the unit design.
- Challenges in program management—particularly delays in distributing housing—resulted in perceived mismanagement by the public.
- Streamlined grant management is important to deploying alternative housing; and regardless of how strong a design and program concept may be inability to effectively connect models to recipients will inhibit the success of a housing program.

Alternative Housing Pilot Programs: Mississippi			
Housing Type: Green Mobile	**Budget:** $5,890,882	**Goal:** 100 Units	**Dates:** November 2007 – October 2011
Housing Type: Park Model and Mississippi Cottage	**Budget:** $275,427,730	**Goal:** 7,261 Park Models, 1,933 Cottages	**Dates:** February 2010 – March 2012

Pilot programs deployed in Mississippi prioritized use of temporary-to-permanent units that incorporated local architectural standards (e.g., gabled roofing). Surveys distributed to residents reflected an overall positive perception of replacing FEMA's MHUs and TTs with these options. Factory-built units reduced the cost and time to produce units (i.e., approximately 10 days per unit). They were required, under the IRC, to withstand 150 mph winds and pass visual inspections to verify quality construction.

In 2008, after Hurricane Gustav, the Mississippi Alternative Housing Program (MAHP) and its insurer performed assessments of the MAHP cottages affected by the storm. Approximately 250 units were destroyed, most consistently due to issues with displaced foundations. The units did not sustain a significant amount of structural damage, which informed speculations that location and foundation choices were the main issue.

Key Takeaways: **Green Mobile, Park Model, and Mississippi Cottages**

- Given the multitude of needs local representatives must address after a disaster, community engagement pre-disaster can improve the specificity and inclusivity of housing mission plans.
- Using a single, pre-planned design standard reduced production time.
- Recipients reported better mental health in the alternative units, particularly because they were able to resume daily routines more quickly.
- Recipients reported that mobility concerns were addressed through the units' accessibility features and exterior ramps.

Alternative Housing Pilot Program: Texas			
Housing Type: Panelized Units	**Budget:** $16,471,725	**Goal:** 250 Units	**Dates:** January 2008 – December 2011

The pilot program deployed in Texas contracted an Italian-based company for construction of panelized units that were marketed as only requiring an eight-hour construction process that could be completed by four workers.

Several delays resulted in the program being terminated. Mishandled permitting resulted in failed completions, and later, scheduling challenges with the contractor resulted in additional delays. Reports highlighted issues associated with unreliable contractors and high staff turnover. By the time the program was terminated, the program had spent approximately $5.5 million for six completed units and 42 unassembled units.

Even completed units reportedly struggled with additional long-term maintenance and other issues. These included issues with the sewage and foundation system that resulted in water damage and mold.

Key Takeaways: **Panelized Units**

- Any vendor selected for an alternative housing deployment should be thoroughly vetted to verify overall production capability, transportation logistics, and compliance with local codes and standards.
- Understaffing and high rates of staff turnover were correlated with significant administrative inefficiencies and mistakes.
- Programs can benefit from regular progress reports, to identify and alleviate challenges with contractors.
- While panelized unit systems can be resilient, they require proper construction and code compliance, to ensure that they will serve as a sustainable long-term solution for recipients.

JOINT HOUSING SOLUTIONS GROUP

In 2007, FEMA launched the Joint Housing Solutions Group (JHSG) initiative, to evaluate various disaster housing options, identify feasible alternative housing, and recommend process improvements. The project utilized a Housing Assessment Tool (HAT), which was deployed alongside field inspections to review and verify collected data. In addition to presenting a set of findings for alternative housing solutions requiring further investigation, JHSG resulted in a set of core recommendations, established to inform next steps and comprehensive strategy for engaging alternative housing missions in the future.

Key Takeaways: **JHSG Recommendations**

1. Develop an alternative housing strategy by establishing clear objectives and processes to deploy alternative housing options.
2. Continue to identify and evaluate alternative housing options.
3. Launch pilot programs in post-disaster environments, to evaluate the real-world applications of emerging technology.
4. Establish performance specifications and clear criteria for designing, developing, and constructing new alternative housing units.
5. Develop and implement a procurement plan for alternative housing units.
6. Streamline inter-agency and project coordination.
7. Conduct public information and outreach activities, to educate and inform the public about alternative housing efforts and offerings.

NEW YORK CITY'S URBAN HOUSING PROTOTYPE

In 2008, New York City Office of Emergency Management (NYC OEM) partnered with the New York City Department of Design and Construction (DDC) to launch the "What If New York City…" design competition. The competition engaged designers across the city to develop alternative housing renderings, with the prize opportunity to be funded with $10,000 to develop prototypes further. When Hurricane Sandy hit the City in 2012, next steps from the program stalled; however, one of the winning designs for Interim Housing Units (IHUs) later informed the Urban Post-Disaster Housing Prototype in 2014.

NYC Urban Post-Disaster Housing Prototype Program	
Housing Type: Stackable Interim Housing	**Goal:** Develop a prototype for alternative housing in NYC.

IHUs were designed to accommodate diverse family sizes and provide temporary-to-permanent housing through use of multi-family and multi-story units assembled in clusters and stacked on top of each other. Units incorporated both federal and local code compliance.

All units used a universal interior design layout and included furniture and accommodations (e.g., bed, appliances). IHUs were built in Red Hook, Brooklyn, a waterfront neighborhood that could test the units' coastal resiliency.

Photo by: Andrew Rugge/Garrison Architects // Retrieved from: https://tinyhousetalk.com/prefab-modular-stacking-tiny-homes/

Key Takeaways: **Stackable Interim Housing**

- In addition to the unit designs themselves, developers reviewed site vulnerability to flooding and evaluated the unit's ability to adapt to diverse site types and configurations.
- By using a competition-based platform, city officials engaged designers to identify a multi-family unit for urban spaces with recyclable, cost-effective, and energy efficient characteristics.
- The winning design highlighted the utility of stackable units, which has become a prevalent design characteristic in modern alternative housing concepts.

BACK HOME RAPID HOUSING RECOVERY PILOT PROGRAM

After Hurricane Ike, the Back Home Rapid Housing Recovery Pilot Program directed a leading-edge alternative housing deployment in the State of Texas. The Texas State Legislature funded the program as a platform for investigating the use of modular solutions for post-disaster recovery.

<table>
<tr><th colspan="2">Back Home Rapid Housing Recovery Pilot Program</th></tr>
<tr><td>Housing Type: Modular Temporary-to-Permanent Housing</td><td>Goal: Deploy a modular temporary-to-permanent solution for hurricane survivors.</td></tr>
</table>

The Houston-Galveston Area Council (H-GAC) built 10 pilot homes using RAPIDO housing units, which uses a rapidly deployable CORE model to shorten the initial timeline for delivering housing assistance to survivors. The model then transitions to a permanent structure through stick-built housing additions. The program informed its approach by engaging local community members to understand their expectations for permanent housing.

Photo by: Houston-Galveston Area Council // Retrieved from http://www.hgac.com/community -and-environmental-planning-publications/documents/Back-Home-Rapid-Housing-Recovery-Pilot-Program-Report.pdf

Key Takeaways: **Modular Temporary-to-Permanent Housing**

- The model's temporary-to-permanent construction process reportedly supported the community's long-term recovery by reintroducing homeowners back home more quickly and supporting their ability to stay in those homes long-term.
- The program's grassroots approach resulted in community buy-in to the project, a result that translated to the project's positive reputation across the State of Texas.

ACADEMIC ANALYSES

Academia provides an important lens to the relationship between alternative housing and community development. The Study captures snapshots through this lens by focusing on different stages of an alternative housing deployment:

- Mapping Community Vulnerabilities;
- Analyzing the Impact of Housing Programs; and
- Identifying Housing Production Alternatives.

While these snapshots are non-exhaustive, they reflect how alternative housing models can fit in the arc of identifying and meeting the needs of communities.

MAPPING COMMUNITY VULNERABILITIES

The socio-economic conditions in communities directly inform target areas requiring temporary and long-term housing support. The National Low Income Housing Coalition[i] estimates the nationwide gap in affordable rental homes is 7.2 million units. Only 35 out of 100[ii] low-income families have access to affordable housing, not including the 500,000 Americans who are homeless. In the State of Texas, figures reflect an identified shortage of over 600,000 affordable and accessible rental homes for low-income residents.[iii] For those who own homes, an estimated 676,333 households in Texas are identified as cost-burdened (i.e., paying more than 30% of their income on housing).[iv] Beyond home financing, the inability to afford long-term repairs and maintenance can be an added challenge.

Snapshot: **Mobile Homes on the Coast**

According to a report by the 2017 U.S. Census Bureau, approximately 15% of mobile homes along the Gulf Coast are vulnerable to direct impacts from hurricanes and flooding. The report estimates that 73% of individuals living in these mobile homes have a gross income of $50,000 a year or less. These families face immense challenges during the recovery process after a windstorm or flood event, especially given the difficulties and poor cost-effectiveness associated with either repairing or replacing mobile homes.

Challenges and gaps in housing are significantly exacerbated by natural disasters, which can have a devastating effect on low-income areas, where housing may suffer from deferred maintenance and lack of resilient construction practices. The destruction of Hurricane Harvey resulted in $195 billion in damages and 306,993 homes were damaged or destroyed, including 25% of the affordable housing stock.[v] Lower income residents were more likely to be denied eligibility for FEMA assistance following Harvey due to reasons such as failure to verify identity, inability for inspectors to contact them, or inability to prove they lived at the identified residence.[vi] Of the individuals self-identified as homeless after the hurricane, 18% indicated their unsheltered circumstances were a direct result of the impacts of Hurricane Harvey.[vii]

Snapshot: **Aging Populations in Coastal Areas**

Researchers are tracking the demographics of populations that are most vulnerable to disasters. Statistics show that many older and aging populations live in high-risk coastal locations (Buvic et al). When these individuals are affected by disasters, it is important to account for costs associated with modifications to ensure accessibility.

Across the marketplace, many architects, builders, and entrepreneurs are developing alternative housing solutions to address the need for affordable housing. Forward-thinking non-profits and institutes, such as the Housing Lab at the University of California at Berkeley and the Ivory Prize, are incentivizing these options through competitions to seek out new national leaders innovating affordable housing. Efforts to identify the newest faces in innovative housing have highlighted companies like 2020 Ivory Prize winner Entekra, a construction company that designs Fully Integrated Off Site Solutions (FIOSS) as a method of streamlining panelized building processes.

These kinds of solutions can take precedent from expansive use of prefabrication in countries like Japan, where systematized manufacturing supports time- and resource-efficient construction dating back to post-World War II. The resulting network of Japanese companies can produce 10,000 new prefabricated homes each year and has supported construction of millions of homes across the country. As the US considers the solutions that can fill its gap in affordable housing, these figures can serve as a reflection of what continued success in prefabrication can do for the broader marketplace.

Snapshot: **Housing Innovation Collaborative**

The Housing Innovation Collaborative (HICo) is an initiative in Los Angeles, California, with the goal to help implement the best and brightest ideas in emergency shelter to support those experiencing homelessness. The initiative highlights resources and forward-thinking steps in shelter on its website, housinginnovation.co/. These include its Rapid Shelter Showcase, which presents different types of rapidly deployable shelter options available in the marketplace. HICo provided key resources to inform the Study's research, and as HICo continues its important efforts to deploy shelter options in service of the homeless, there is a clear platform for collaboration to directly connect forward-thinking affordable housing initiatives to the work taking place in disaster response and recovery.

ANALYZING THE IMPACT OF HOUSING PROGRAMS

Inequalities in communities often follow disaster survivors through the stages of expected recovery, from emergency to temporary shelter and temporary housing to permanent housing, or to failure.[viii] Sutley and Hamideh highlight the "dynamic processes and interdependencies" that define these stages of recovery, to understand how programs can better support recovery efforts.[ix] The resulting approach combines the impacts of engineering and social science to highlight "scalability, extendibility, and incorporation of policies." An important takeaway of this approach is the consideration of both the technical and social impacts from housing program decisions.

Another model that directly captures the impact of housing programs on the social well-being of recipients is El-Anwar's "optimization" model. This approach assigns metrics that track well-being under different post-disaster housing arrangements. Instead of exclusively focusing on cost effectiveness of these programs, optimization modeling tracks ideal housing solutions based on their impact on family needs and preferences.

The different modeling approaches to tracking disaster response and recovery are useful reference points. However, the key takeaway for this Study is the importance of thinking beyond the statistics of housing programs when considering whether they are successful. Rather, it is important to incorporate those characteristics that make a survivor's housing time-efficient, resilient, and supportive of their well-being.

Snapshot: **Optimization Modeling**

El-Anwar (2013) developed a socioeconomic model to assess the impact of providing displaced residents with a temporary-to-permanent home, in lieu of the traditional temporary housing unit or transitional housing. The model used a series of factors to analyze the comparison of providing a temporary unit versus a temporary-to-permanent unit, including:

- Employment opportunities;
- Quality of housing;
- Access to healthcare;
- Safety; and
- Access to essential services (e.g., transportation, supermarkets).

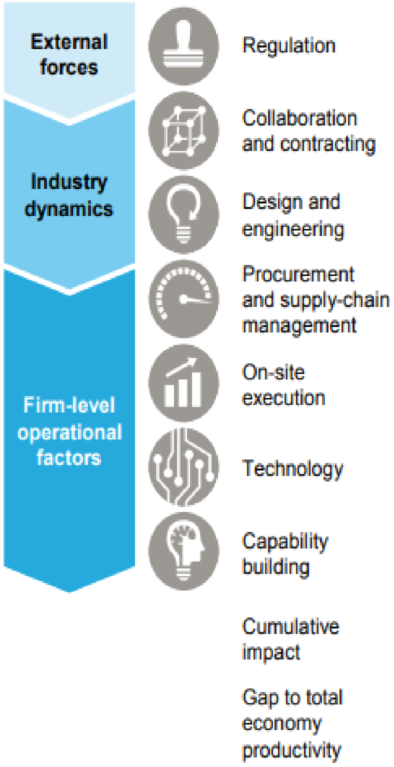
The analysis included a cost-effectiveness approach, to review the savings relating to unit purchase price and long-term maintenance. The study found that the overall benefit of providing a unit that could support the long-term needs of a survivor optimized both that individual's experience, as well as their ability to support the community's recovery.

IDENTIFYING HOUSING PRODUCTION ALTERNATIVES

A 2017 report by the McKinsey Global Institute addressed lagging productivity in the construction sector and opportunities to "reinvent construction," to increase the industry's growth by $1.3 trillion per year. The report identified several challenges contributing to this lag, including broad fragmentation across the construction sector, information asymmetries between specialized contractors and subcontractors, a lack of cost transparency across projects, and heterogenous zoning and building codes. The report proposes seven areas for action to address these challenges, with an overarching vision to embrace a "manufacturing-like system of mass production."

According to the U.S. Census, only two percent of new construction annually is constructed through modular technology. However, the growing need for affordable, mid-priced single-family homes may see rapid growth in companies that embrace technology and manufacturing strategies. From this perspective, prefabricated and 3D printed home construction are highlighted as having "progressed beyond mere hype and hope."

Snapshot: **The McKinsey Global Institute Seven Areas for Action**



In their 2017 report "Reinventing Construction," the McKinsey Global Institute highlights the following strategies as mechanisms to improve production in the construction sector by $1.3T.

- "Reshape regulation;
- Rewire the contractual framework to reshape industry dynamics;
- Rethink design and engineering processes;
- Improve procurement and supply-chain management;
- Improve on-site execution;
- Infuse digital technology, new materials, and advanced automation; and
- Reskill the workforce."

Source: McKinsey Global Institute analysis

In 2019, a report[xx] published by the Massachusetts Institute for Technology highlighted the advantages associated with modular housing through combined high rates of production with low-cost on-site construction. To this effect, the National Association of Home Builders Research Center reported that factory-built modular housing reduced overall labor expenses by 8-12% of each unit's total production cost. These cost savings are especially relevant amidst rising costs for traditional construction. According to the Turner Building Cost Index, construction prices across the nation have risen nearly five percent over a three-year period, reducing the affordability of traditional home builds. Large-scale construction projects can take more than 20% longer than their initially scheduled timeframes and run up to 80% over budget.[xxi]

HOUSING ASSESSMENT TOOL (HAT) SURVEY

HAT SURVEY DESIGN

The Housing Assessment Tool survey was developed to gather data about alternative housing unit designs directly from vendors and architects, with questions and analysis tailored based on the needs of Texas communities.

The original HAT (2007) served as a historic reference point for the creation of the new HAT survey (2020) but did not directly inform the HAT survey. [3] The process to create the HAT survey for the Study incorporated expertise from many different stakeholders, including repeated review by Texas stakeholders from GLO-CDR and the Study's Oversight Committee.

While the four core categories (i.e., range of use, livability, timeliness, cost) assessed by the original HAT are still evaluated in the HAT survey, questions expanded to evaluate 10 key categories. The transformed framework emphasized new inputs related to resilience (e.g., codes and standards), ability to customize the unit (internally and externally), temporary-to-permanent capabilities, and community acceptability. A high-level overview of the process to create the HAT survey is shown in ***Figure 7***.

An online survey platform was selected as the Study's virtual platform for data collection to reach a wide variety of participants, no matter their geographical location, as well as to simplify the process of data aggregation and analysis. The updated HAT, now an online survey, can be found in ***Appendix B: Housing Assessment Tool Survey***.

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[3] The original HAT was developed and implemented by the FEMA-launched Joint Housing Solutions Group (JHSG) from 2006 to 2007. The JHSG initiative was a multi-year effort established after Hurricane Katrina, with the intent to create a systematic process to identify, evaluate, and rate viable alternatives to traditional FEMA disaster housing (i.e., TTs, MHUs).

Figure 7: Stepwise Process to Create the HAT Survey

Gained understanding of GLO-CDR's goals for the Study and determined the necessary requirements for the HAT survey to meet those goals

Reviewed, extracted, and revised key metrics to emphasize Texas needs, with reference to the original HAT (2007), and developed the HAT survey

Focused the Study framework to capture areas of specific interest to the State of Texas (e.g., resilience, ability to customize) and refined overall metrics to be evaluated through the HAT survey, as led by the Principal Investigator

Presented proposed metrics for the HAT survey to GLO-CDR

Revised the HAT survey metrics based on GLO-CDR feedback

Translated finalized metric categories into HAT survey questions, built initially in Excel

Reviewed and refined draft HAT survey questions under the expertise of the Principal Investigator and a subject matter expert who worked on the JHSG's development of the HAT (original)

Built the first iteration of the HAT survey in Survey Monkey platform

Distributed PDF version of the HAT survey, exported from Survey Monkey, to GLO-CDR for review and approval

Revised the HAT survey further, within Survey Monkey, based on minimal feedback from GLO-CDR

Presented the final draft of metrics to be evaluated in the HAT survey to the Oversight Committee, accompanied by a moderated feedback collection session

Incorporated collected feedback from Oversight Committee into HAT survey and submitted to GLO-CDR for final approval

Received final approval from GLO-CDR to launch the 200-question HAT survey on Survey Monkey

VENDOR PARTICIPATION

The Study elicited participation from alternative housing vendors across the United States—and around the world—through a defined vendor outreach strategy that targeted emerging technologies. In total, the Study received 34 HAT survey submissions from 24 vendors (see ***Table 7***). Over the course of vetting the data submitted through these surveys, a total of 20 vendors provided enough substantive data to be analyzed through the Study's algorithm and represented in vendor profiles. All submissions were considered when identifying the trends and types of alternative housing available in the marketplace.

Table 7: Participating Vendors

Vendor Name	Type of Housing	# of Submissions
AbleNook	Panelized Modular	1
A-FOLD Houses	Foldable Modular	4
Allwood Industrials	Log Home Kit	2
Boxabl	Foldable Modular	1
Connect Homes	Prefabricated Modular	2
Core Housing Solutions	Prefabricated Modular	2
Dweller	Prefabricated Modular	1
EcoHouseMart	Log Home Kit	1
Falcon Structures	Shipping Containers	3
Forts USA	Foldable Modular	1
Gravity Architects	Panelized Modular	1
Haus.me	Prefabricated Modular	2
Hex House	Panelized Modular	1
Horizon North	Panelized Modular	1
ICON	3D Printing	1
Indie Dwell	Shipping Containers	1
Kiro Action	Panelized Modular	1
LiV-Connected	Panelized Modular	1

Vendor Name	*Type of Housing*	*# of Submissions*
M-Rad	Prefabricated Modular	2
RAPIDO	Panelized Modular	1
SnapSpace Solutions	Shipping Containers	1
SO?	Foldable Modular	1
SUNSHINE Home Kits	Traditional Kit Home	1
Urban Rigger	Shipping Containers	1

SURVEY INPUTS

The 177-question HAT survey addresses nine key categories that analyze alternative housing units. The below descriptions capture the information assessed by these categories by identifying their purpose in the context of fully understanding unit capacity and describing the overarching approach to unit analysis under that category.

ALTERNATIVE HOUSING CATEGORIES

Purpose: Identify and delineate overarching themes in the types of alternative housing units available, the lifespan of those units, and use for single or multi-family housing.

The Alternative Housing Categories section poses questions related to the stage of development of the unit, target lifespan of the unit, type of unit (e.g., TT, MHU, tiny home, shipping container), and if the unit is intended for single or multiple families. Analysis of this information contributes to understanding whether the unit is mission-ready in varied settings, including both temporary and permanent use. The answer options enable vendors, manufacturers, and builders to submit prototypes that are not yet in production but could be considered viable future options for the State of Texas.

CODES AND STANDARDS

Purpose: Determine unit durability, quality of construction, and competence in meeting industry and safety standards.

The Codes and Standards section of the HAT survey is crucial to understanding the unit’s durability and quality of construction. A variety of code and standard inputs can provide an indication of compliance with potential requirements. While the section does not preclude unit consideration for those models that may not yet meet standards, it provides an important benchmark for eventual prototype testing and development. Moreover, while the HAT survey captures information relating to the specific structural design of units, the codes and standards provide a consistent platform for unit comparison. This section includes information capture for accessibility compliance measures necessary to be eligible for federally funded housing (i.e., UFAS, ADA). For all the measures, the HAT survey requests documentation for the compliance claimed, validating the data reported.

RESILIENCE

Purpose: Evaluate the unit’s resilience to natural disasters and how units fare when exposed to flooding, fire, wind, and moisture hazards.

The Resilience section of the HAT survey underscores the cross-cutting approach to the survey’s questions, which focus on all aspects of construction and compliance. Questions are asked with a lens for resilience to stressors under extreme conditions that are common in Texas (e.g., flooding, high moisture levels). The questions posed in this section focus on resilience measures integrated into the unit’s design, such as raising electrical units and the HVAC system, that will enable units to better withstand or recover from disasters. Questions more broadly assess resilience and identify specific materials and safety mechanisms used. The survey captures “code plus potential,” which highlights vendor innovation by creating the opportunity to identify additional methods of improving unit resilience to exceed code requirements.

UNIT SIZE AND AMENITIES

Purpose: Identify the overall size of the unit and amenities provided, as well as the capacity to install future amenities.

The Unit Size and Amenities section of the HAT survey focuses on standard aspects of the unit’s total square footage (both aggregated and by living space), livability for the long-term, and capacity for residents, as well as the ability to modify size per federal requirements. The questions identify amenities by type, method of connection on site, and overall capacity. These factors, among others, support a “ready for occupancy” determination of the unit. Questions under this section focus on the availability of furniture and other critical amenities for disaster survivors who have lost their belongings. These areas of inquiry also generate key insights to unit capability to operate as a temporary, permanent, or temporary-to-permanent living space.

ABILITY TO CUSTOMIZE

Purpose: Evaluate the ability of the unit to be customized, both on the exterior and interior, to fit the needs of differing community standards and expectations across Texas.

The Ability to Customize section collects data that can inform decision-makers in communities across Texas about housing options that will best fit the cultural and aesthetic standards in their communities. Questions in this section emphasize ability to customize both interior and exterior qualities, which relates to future resident satisfaction with a living space, especially if it is a permanent home. To that point, the section also emphasizes the ability of the unit to transition from temporary to permanent.

STRUCTURE ELEMENTS

Purpose: Evaluate the overall structural design as it relates to framing, roofing, foundation, and the building envelope.

> It is important to note the HAT survey calls out "roofing" separately from "building envelope" to highlight the roof's performance in protection and insulation, as was done with foundation and other essential protective functions such as thermal, wind, and flood.

The HAT survey section relating to Structure Elements captures key insights regarding the structural integrity of the unit. As it applies to the framing of the structure, the section investigates the materials and style used for the framing; whether it is feasible to retrofit for enhanced structural integrity; and the type (e.g., standard, galvanized, stainless steel) and size of connectors used in the unit. As it applies to roofing, the section captures information on the type of roofing structure and materials used, with emphasis on the ability of the roof to withstand uplift wind pressure. For the foundation, the section captures information about whether the unit itself comes with a foundation, what type of foundation is traditionally used, the permanence of the foundation, ability to "tie-down," and the feasibility of elevating the structure. For the building envelope, the section evaluates materials and key features that determine unit permeability for vapor and moisture, particularly through sub-floors, windows, and exterior facing walls and doors.

BUILDING UTILITIES AND MAINTENANCE

Purpose: Identify the unit's electrical and plumbing systems and associated maintenance, as well as methods of hook-up to local and/or public utilities.

The Building Utilities and Maintenance section identifies the ability of the unit to self-sustain for power, water and sewage. This is especially relevant for community considerations when the electrical grid, water or sewage systems are out of service for an extended period after a disaster. The section addresses exterior components that are key to the unit’s operability, which is also an indicator of potential vulnerabilities to windstorm damage.

CONSTRUCTION AND SITE REQUIREMENTS

Purpose: Determine the construction and site requirements for unit installation in terms of clearance, equipment, transportation, and trades personnel.

The Construction and Site Requirements section tracks the unit transportation, installation process, and ability to store the unit if deployed for temporary use. Transportation considerations include type of vehicle and special permitting needed, which also has implications for total cost. As it applies to installation, the site requirements are assessed by square footage needed for clearances and those trade persons needed to conduct installation. This installation process impacts the timeline of a post-disaster deployment.

PRODUCTION CAPABILITY

Purpose: Evaluate the level and location of inventory, the ability to ramp up production, and other key production factors relevant post-disaster.

The Production Capability section addresses current production capability; that is, the overall existing capability for deployments of existing inventory and the ability to ramp up production. This is especially important for units that are being considered for large-scale housing missions after a major disaster. Units are grouped based on production timelines between one and 24 weeks. Inventories are also tracked by location, if available in the United States.

COST AND COST-EFFECTIVENESS

Purpose: Evaluate the unit cost and factors that determine overall cost-effectiveness.

Finally, the Cost and Cost-Effectiveness section addresses critical cost components that will eventually inform the Findings Report cost-effectiveness matrix. Beyond addressing the purchase price of units, the section questions operate in conjunction with other considerations (e.g., resilience, lifespan) to provide a broader sense of what the unit's value will be after use. Questions address whether a "turnkey" unit and bulk purchase discounts are available.

ANALYTICAL APPROACH

The Study utilized a hybrid analytical approach with quantitative and qualitative elements to review submissions to the HAT survey. The Study's quantitative analysis utilized a scoring method to facilitate comparison and ranking of the alternatives against each other, where the qualitative analysis provided context to the different aspects of units that might fit certain end-user needs (see ***Appendix C: HAT Survey Analysis Algorithm***).

Scores for each survey submission were generated by an algorithm in QuickBase, an online low-code application development platform. The use of scoring allowed the Study to apply a consistent approach that could facilitate comparison of housing units and ranking of the submissions. The Study's main input categories and questions (e.g., codes and standards, ability to customize) informed scoring under five key outputs: resilience (i.e., flood, wind, fire, energy), livability, range of use, timeliness, and cost (see ***Table 8***)

Table 8: Summary of Analytical Approach

Inputs – 177 questions in 9 categories	Outputs – 5 primary categories
Alternative Housing Categories	Resilience ➢ Flood ➢ Wind ➢ Fire ➢ Energy
Codes and Standards	
Resilience	
Unit Size and Amenities	
Ability to Customize	Livability
Structure Elements	Range of Use
Construction and Site Requirements	Timeliness
Production Capability	Cost
Cost and Cost Effectiveness	

In addition to the algorithm, the Study developed a cost-effectiveness analysis that reviewed the long-term cost of building and maintaining units based on their overall cost and expected resilience. This process combined the median minimum annual occupant cost per year, calculated based on cost data provided in the HAT survey (see ***Table 9***), and the overall resilience benefit ranking, calculated based on the weighted codes and resilience score (see ***Table 10***).

Table 9: Cost Ranking by Annual Occupant Cost Per Year

Median Min Annual Occupant Cost ($/year):				**$2,518**
Rating per Median Cost	**Cost Range ($/year)**		**Ranking**	**Ranking Frequency**
Significantly below median	$0	$1,007	High	3
Somewhat below median	$1,008	$2,015	Med-High	2
Within median	$2,016	$4,029	Medium	6
Somewhat above median	$4,030	$8,059	Med-Low	5
Significantly above median	$8,060	$14,162	Low	4

Table 10: Resilience Benefit Ranking

Weighted Codes & Resilience Score = [(Codes+Flood+Wind) + (0.5)x(Fire+Energy)]/4					**% of Median Resilience Cost used for Estimated Resilience Benefit**	**Ranking Frequency**
Rating per Score	**Weighted Codes & Resilience Score Range**		**Ranking**	**Estimated Resilience Benefit ($/Year)**		
Significantly below average	0.0	2.0	Low	$504	20%	2
Somewhat below average	2.1	4.0	Med-Low	$1,511	60%	5
Within average	4.1	6.0	Medium	$2,518	100%	11
Somewhat above average	6.1	8.0	Med-High	$6,044	240%	2
Significantly above average	8.1	10.0	High	$11,081	440%	0

The figures from the cost ranking and resilience benefit ranking informed an overall resilience benefit-cost ratio (BCR), which captured a projected cost effectiveness of any particular solution based on its cost and resilience (see ***Table 11***). Based on their resilience BCR, units were given a cost-effectiveness rating between low, medium-low, medium, medium-high, and high, which is reflected on their vendor profile.

Table 11: Potential Cost Effectiveness

Approximate assessment based on the following resilience benefit-cost ratio (BCR)

Estimated Resilience Benefit-Cost Ratio (BCR)		**Potential Cost Effectiveness Ranking**	**Ranking Frequency**
0.00	0.50	Low	6
0.51	0.75	Med-Low	5
0.76	1.50	Medium	5
1.51	2.50	Med-High	1
2.51	10.00	High	3

CORE OUTPUTS

The Study's analysis focused on a set of core outputs that reflect high priority needs for housing in the State of Texas. These outputs reflect the alternative housing model characteristics that most indicate the ability to produce a positive individual survivor experience, cost-efficiency in investment of taxpayer dollars, and timeliness of production (see ***Table 12***).

It is important to note that for each community and region, the balance of these criteria may differ, and there is no universal solution to all needs.

Table 12: Core Outputs Summary

	Why is it important?	Where does it apply?
Resilience	Resilience includes the ability to withstand exposure to natural hazards, including flood and wind.	In areas with high natural hazard exposure, resilience is critical to avoid future damage to housing.
Timeliness	Timeliness reviews the total amount of time from procurement to occupancy; including production, delivery, site preparation, and on-site construction.	Timeliness is critical to all disaster housing missions, and alternative housing solutions require the ability to scale capabilities to meet mission requirements in a timely manner.
Cost	Cost includes the full life-cycle cost of a unit, from the purchase price to delivery, storage, on-site construction, programmatic costs, and maintenance.	Cost effectiveness is critical in determining the feasibility of alternative housing solutions compared to traditional options.
Livability	Livability characterizes the general comfort and amenities of a housing unit in becoming a home.	Livability will determine key aspects of the target end-user experience in receiving a "home."
Range of Use	Range of use characterizes the ability of unit types to fill resident needs, as determined by site conditions, urban versus rural areas, household size, and single versus multifamily applications.	Range of use is most important for understanding the adaptability of units to different use cases (e.g., multi-family housing, urban versus rural environments).

RESILIENCE

The resilience output comprises four separate sub-outputs that together support classifying the housing unit's ability to withstand exposure to hazards. Specific resilience to natural hazards including flood, wind, and fire are addressed as well as the resilience of the housing unit in terms of energy use. More detail regarding each sub-output is presented below. One common element of resilience is the importance of building codes and standards. Structures that are designed and constructed to meet and/or exceed current codes and standards are far more likely to withstand natural hazards than those that are not built to code.

FLOOD RESILIENCE

Flood resilience is needed as a defining capability of long-term housing stock in both riverine and coastal regions across Texas, because it characterizes the viability of structures against flood and hurricane events. Flood resilience is most easily and reliably achieved by a **framing and foundation system that can elevate the unit**, as it limits the risk of flooding to the structure. The use of **flood damage-resistant building materials** for wall and roof systems is also a critical determinant of resilience because it reduces the likelihood that water will get into a home.

In addition to structural elevation, construction can also incorporate **wet floodproofing** to reduce the cost of repair after a flood event without requiring human intervention to be effective. Wet floodproofing activities include **building with flood damage-resistant materials**, **adding hydrostatic openings** (flood vents) that allow floodwaters to enter and exit the building, and **elevating utility equipment**.

> Traditional building materials—including, but not limited to drywall, fiberglass insulation, and untreated lumber—can be susceptible to water damage and mold growth after flood events. FEMA Technical Bulletin 2 provides guidance on identification and use of flood damage-resistant materials. These designations informed Study analysis of materials used to construct units.

The Study's quantitative analysis system scored flood resilience based on survey questions evaluating the following key factors:

- Compliance with national codes and standards for permanent housing (as applicable);
- Indication of code plus feasibility for flood events;
- Use of moisture and mold-resistant materials, as defined by FEMA Technical Bulletin 2;
- Type of roof framing system and use of a secondary roof protection barrier;
- Type of foundation system and its ability to be elevated;

- Characteristics of the building envelope; and
- Location of electrical and HVAC equipment above anticipated flood levels

Highest Performers in Flood Resilience

Rank	Vendor Name	Key Characteristics
1	Kiro Action	• Units are easy to elevate and include a folding base structure that supports rapid deployment. • Units meet the American Society of Civil Engineers (ASCE) 24-14 standard for Flood Resistant Design and Construction. • Units are constructed with galvanized stainless steel and are highly flood-damage resistant.
2	Haus.me	• The unit has a hardened exterior surface that makes it easy to elevate and anchor on any foundation. • Units meet the ASCE 24-14 standard for Flood Resistant Design and Construction. • Units are constructed with a patented polymer material that is conformed into a singular exterior structure and is highly flood-damage resistant.
3	indieDwell	• Units have a hardened exterior surface (shipping container) and are easy to elevate and anchor on any foundation. • Use of shipping containers make units highly flood damage-resistant. • Units can be clad with a wide selection of finishes, including those that are flood damage-resistant.

Snapshot: **Built-In Foundations**

Particularly for rapidly deployable systems, a built-in foundation system can support quick installation and meet minimum elevation needs in flood-prone areas. A few vendors incorporated temporary foundation systems that spanned use of jacks, helical pier systems, and rigid built-in foundations. Some of these systems (e.g., jacks, piers) are better equipped to adapt and avoid the need to get a site graded or perfectly leveled. For those that can either be set directly on blocks or the ground, sites may require additional preparation (e.g., leveling) prior to installation. For permanent installation, these systems often require some modification to ensure that the unit is properly anchored and elevated to meet local code requirements and withstand larger riverine and coastal floods.

WIND RESILIENCE

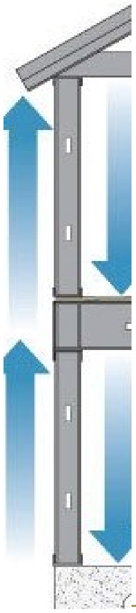
Wind resilience characterizes the ability of a unit to withstand damage from wind events. It is most easily determined by the **load path**, particularly the strength of the framing and roofing structures, as well as the **connections tying these systems to the walls and foundation.** The building envelope can further fortify a unit through use of **strong roof coverings, shutters, and impact-resistant windows and doors**.

The Study's quantitative analysis system scored wind resilience based on survey questions survey questions evaluating the following key factors:

> In response to the escalating impacts of disasters across the United States, the Insurance Institute for Business and Home Safety (IBHS) developed the FORTIFIED™ standard for homes and commercial buildings. The FORTIFIED™ standard includes evaluation of code-plus capabilities as they relate to resilient roofing systems, and, whether they incorporate wind driven rain management and uplift resistance through use of strong connectors. In addition to other codes (e.g., International Residential Code and the Texas Windstorm Insurance Association), these standards provide a strong metric for wind resilience.

- Compliance with national codes and standards for permanent housing, including the FORTIFIED™ standard (as applicable);
- Self-identified and/or certified compliance under Texas Windstorm Insurance Association (TWIA) standards, as they relate to withstanding winds up to 130 mph;
- Indication of code plus feasibility for wind events;
- Type of primary wall framing structure and connectors;
- Type of connectors from roof to wall to floor;
- Type of roof framing system;
- Type of foundation system and ability to “tie-down” for later support;
- Type of exterior siding, window, and door materials;
- Inclusion of window shutters (as applicable);
- Type and size of roof overhang (as applicable); and
- Location of electrical, plumbing, HVAC, or other critical infrastructure outside the unit.

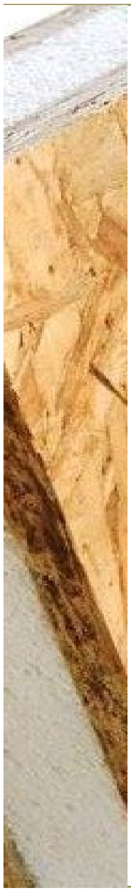
Highest Performers in Wind Resilience		
Rank	Vendor Name	Key Characteristics
1	Falcon Structures	• Units are built from shipping containers and have a high wind resilience, as long as the number of openings (e.g., doors/windows) does not compromise the structure. • Units are designed to handle wind speeds that meet TWIA and the International Residential Code (IRC).
2	AbleNook	• Units are constructed from aluminum and steel panels that connect in an interlocking building system. • Units are designed to handle wind speeds that meet TWIA and IRC.
3	A-FOLD Houses	• Units are constructed with a thick panelized system that is prefabricated and shipped in a single structure that unfolds on site. • Units are designed to handle wind speeds that meet TWIA and International Residential Code (IRC).



Snapshot: **Load Path Strength**

Many of the participating vendors featured structures with strong load path elements and connections designed to resist code-level wind events. One of the key load paths for wind design begins with a roof covering that can withstand wind uplift forces and transfer them to the roof sheathing and roof framing. These forces must be transferred through the wall-to-roof connections and wall framing, down to the wall-to-floor connections, and to the foundation and the supporting soil.

Just as a chain is only as strong as its weakest link, any weak point in the load path can lead to significant structural damage. For this reason, the vendors with load path designs that used robust building materials and strong connections had greater wind resilience than those that did not.



Snapshot: **Structural Insulated Panels (SIPs)**

Many of the participating vendors are using SIPs as a solution for developing rapidly deployable systems that can support a quality, long-term home structure. These can be pre-manufactured and then deployed to site as the unit's framing and insulation system.

The SIPs use an insulating foam core that is sandwiched between two structural facings. While these commonly use oriented strand board (OSB)—which is not a flood-damage resistant material—they can use a lightweight steel or other metal facing that can strengthen a unit's resilience to flooding. They can also be United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certified.

SIPs can be added to quickly construct new walls and additions to a unit, making them a useful platform for alternative housing solutions that can be modified in the design and on-site construction process to accommodate different family sizes.

For a range of modular units that assemble homes as a kit, the appropriate selection of materials and construction processes can support code-plus potential across key resilience factors.

FIRE RESILIENCE

Fire resilience characterizes the ability of materials used in unit construction to resist ignition and withstand fire damage. Depending on the type of fire, the unit's fire resilience will be determined by **how long the interior and exterior building materials will last before sustaining permanent damage**. For structure fires, assessment of resilience focuses on the type of building materials used, as well as the provision of **fire sprinklers, smoke detectors, fire extinguishers, and entry and exit pathways** which can support the resident's ability to safely respond to and/or exit the unit in the case of a fire. For wildland fires, assessment of resilience focuses on the **fire resistance of the building envelope**, and in particular, **the roof**.

The Study's quantitative analysis system scored fire resilience based on survey questions evaluating the following key factors:

- Compliance with fire-related building codes and standards for permanent housing such as the IRC and the International Fire Code (IFC);

- Unit's fire rating;
- Availability of fire sprinklers, smoke detectors, fire extinguishers, and additional egress pathways;
- Indication of code plus feasibility for fire events; and
- Materials used for construction of the roof, building envelope, and structural frame.

Highest Performers in Fire Resilience		
Rank	Vendor Name	Key Characteristics
1	Boxabl	• Unit has a 2-hour fire rating. • Units use fire-resistant panels constructed of sheet steel, EPS foam, and magnesium oxide board.
2	Connect Homes	• Unit has a 2-hour fire rating. • Units are constructed with fire-resistant steel framing and a cement-board exterior.
3	AbleNook	• Unit has a 1.5-hour fire rating, though it has not yet been tested. • Units are constructed by fixing aluminum and steel panels, which support a fire-resistant structure.

ENERGY RESILIENCE

Energy resilience characterizes the overall energy efficiency of units, both in terms of their production processes and daily energy use. Energy efficiency can be tracked through **code compliance with green building standards**, as well as **how efficiently the unit maintains its temperature (e.g., insulation R-values)**. Forward-thinking energy solutions include off-grid capabilities, which are also captured in this score. Availability of alternative power sources (e.g., solar panels) and plumbing system connections can reduce the units' dependence on local utilities, which can be an important advantage immediately after a disaster.

The Study's quantitative analysis system scored energy resilience based on survey questions evaluating the following key factors:

- Compliance with energy efficiency and green building codes and standards, including the International Energy Conservation Code (IECC 2015), International Green Construction Code (IgCC 2015), and the USGBC LEED® Version 3;
- Type of insulation used for the walls, attic, and flooring;

- Type of exterior siding materials used;
- Availability of alternative power options; and
- Ability to connect to different plumbing and electrical systems

Highest Performers in Energy Resilience		
Rank	Vendor Name	Key Characteristics
1	Haus.me	• Units feature EnergyStar appliances and are compliant with the IECC 2015, IgCC 2015, and USGBC LEED® Version 3. • Units only requires 800 watts per hour to control the interior temperature (insulation has an estimated R-80 value). • Units can operate fully off-grid and include a solar panel system.
2	Sunshine Home Kits	• Units are compliant with the IECC 2015, IgCC 2015, and USGBC LEED® Version 3. • Units come stocked with EnergyStar-rated, "All Electric" appliances.
3	Connect Homes	• Units are compliant with the IgCC 2015 and USGBC LEED® Version 3. • Units have EnergyStar appliances and can operate fully off-grid through use of a generator with a transfer switch.

Snapshot: **Off-Grid Ready**

The alternative housing market includes a number of units capable of being deployed fully off-grid by integrating electrical and plumbing systems in the building system. There's some variation in the autonomy of these systems. The off-grid electrical systems used by participating vendors typically relied on solar panels or external generators, the latter of which may require fuel.

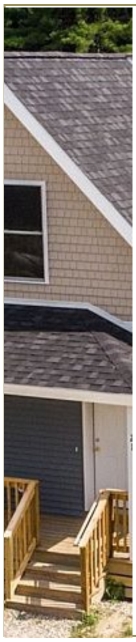
Integrated septic systems require regular servicing (i.e., similar to porta potties), the frequency of which is determined by the holding capacity of the grey and black water tanks. That said, some units do include composting toilets that, used correctly, can be fully autonomous. Especially in a post-disaster environment, where electricity and sewage systems may be overwhelmed, off-grid capabilities can make a significant difference in supporting disaster survivors' needs.

LIVABILITY

Unit livability captures elements of post-disaster housing options that primarily dictate the survivor's experience when receiving a home. Unit livability is determined by the unit's general comfort and quality, as well as its adaptability to meet different preferences. Key characteristics tracked for meeting resident preferences emphasize the **ability to customize the interior and exterior finishes**, the **ability of the unit to satisfy both temporary and permanent housing needs**, and the **unit's size and available amenities**. **Unit accessibility** is captured in this score, as defined by both the Americans with Disabilities Act of 1990 (ADA) and Uniform Federal Accessibility Standards (UFAS).

The Study's quantitative analysis system scored livability based on survey questions evaluating the following key factors:

- Ability of the unit to transition from temporary-to-permanent housing;
- Total unit size and maximum number of occupants;
- Unit size and amenities in the bedrooms, bathrooms, kitchen, and living room;
- Provision of appliances and furniture as a turnkey service;
- Availability of ADA- and/or UFAS-compliant units;
- Ability to customize the unit's interior and exterior finishes; and
- Provision of exterior additions (e.g., porch, garage).



Snapshot: **Prioritizing Dignified Housing**

Across participating vendors in the Study, there is a wide range of amenities and customizations that can support livable housing. Outside post-disaster environments, these are elements that can support a unit's competitiveness in the market. Within a post-disaster environment, they reflect an important platform to provide dignified and comfortable housing for survivors.

Some participating vendors explicitly called out the importance of providing dignified housing in the development of their designs. Across these companies' defined purposes, a common reflection was the importance of investing in those characteristics of the home's interior and exterior design that can meet local expectations and needs.

Highest Performers in Livability		
Rank	**Vendor Name**	**Key Characteristics**
1	ICON	• Use of the 3D printer can allow units to be set in a wide diversity of configurations without requiring significant added time to the build. • Units have an exterior finish and construction that aligns with local Texas architecture and can include additional aesthetic materials. • Unit has temporary-to-permanent capabilities.
2	Boxabl	• Units can be stacked or added to accommodate many different family sizes and needs. • Units include significant flexibility for exterior finishes that can meet local Texas architectural standards. • Unit has temporary-to-permanent capabilities.
3	RAPIDO	• Units incorporate traditional construction that directly engages the resident to build a home that will meet their needs. • Unit designs incorporate outdoor spaces that can transform even the core unit into an engaging social area. • Unit has temporary-to-permanent capabilities.

TIMELINESS

Timeliness characterizes a vendor's production capacity and the time required for transportation, on-site construction, and other activities to make the unit ready for occupancy. This output is a critical metric for **evaluating existing production capacity and experience deploying post-disaster housing units**, which can inform the accuracy of a vendor's projected timeline for a housing deployment. Transportation timelines are evaluated based on the **how the unit is transported and whether special permitting is required**, as well as the **ability to reduce units in size and/or transport multiple units in one shipment**. On-site construction timeliness is informed by the **total amount of projected time for site preparation, foundation construction (if applicable) and other on-site construction or assembly activities**. Evaluation of timeliness also incorporates considerations for units that need to be converted **to accommodate different use purposes** (e.g., unit accessibility).

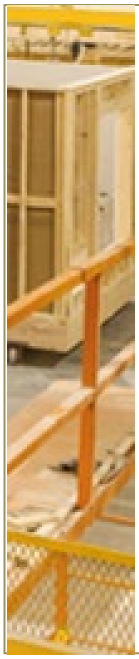
The Study's quantitative analysis system scored timeliness based on survey questions evaluating the following key factors

- Vendor credibility and experience developing, producing, and launching alternative housing deployments;
- Previous use of units for post-disaster housing;
- Ability to convert units for compliance with accessibility standards (e.g., UFAS);

- Availability of a built-in foundation;
- Ability to be quickly installed (e.g., off-grid capable);
- Ease and method of transportation needed;
- Ability to reduce units in size and/or transport multiple units in one shipment;
- Days, personnel, and equipment needed for on-site construction;
- Ability to disassemble and redeploy;
- Total production capacity and units in stock; and
- Location of manufacturing points.

Highest Performers in Timeliness

Rank	Vendor Name	Key Characteristics
1	ICON	• The primary construction materials do not require special permitting for transportation and once the printer is on-site, the only significant supply chain and/or logistics need is transportation of magma, the proprietary concrete material used for construction. • Units can be printed and completed very quickly (approximately 1-2 weeks), though this does not include completion of plumbing, electrical, and HVAC installation. The estimated capability of a single printer assuming streamlined logistics and sites sized at approximately 500 square feet is 200 homes per year. • ICON is based in Texas.
2	Kiro Action	• Multiple units can flat-pack in a flat-bed semi-truck and do not require special permitting for transportation. • Units can be assembled in approximately 1 day with 4 people. • Kiro Action is based in Texas.
3	Boxabl	• Units fold down for transportation and can be towed or packed in a flat-bed truck (one per shipment). • Units can be assembled in approximately 1 day with 4 people. • Boxabl is based in Nevada.



Snapshot: **Assembly Line Production**

Participating vendors in the Study frequently referenced the application of production principles from the Ford Model T assembly line to building homes. Beyond mass-producing homes, these executives and builders emphasized the ability of assembly lines to incorporate resilient building practices and consider pre-fabrication strategies that can reduce on-site construction needs.

There are multiple interpretations of what alternative housing assembly lines can look like—where some vendors are almost entirely pre-fabricating home systems in 10-12 days, others are optimizing construction material selection and on-site assembly processes. Timelines to complete prefabrication will vary across vendors depending on their ability to fully develop units in-house, versus rely on additional supply chains and external manufacturing partners.

Key Takeaway: **Preparing for Transport**

When developing rapidly deployable housing, a core aspect of a unit's timeliness is its ability to be easily transported to its destination. Many of the Study's participating vendors have incorporated these considerations, to enable units that can be transported by flat-bed truck or shipping container.

For kit and panelized modular units, vendors flat-pack construction materials into containers for transportation. Depending on the type and size of unit, some vendors can fit multiple units into a shipment.

For those units that are fully prefabricated and assembled upon delivery, it's size must be within the maximum wide load for highway transportation. Units that exceed those size restrictions require special permitting, which can make movement slower and more expensive.

Finally, as with more traditional trailer solutions, some alternative housing vendors do include use of permanent chassis, such that a unit can maintain its transportability.

COST

Unit cost-effectiveness captures the full range of cost considerations in a unit deployment, including those costs associated with **unit purchase, transportation, installation, ability to redeploy, and maintenance**. These cost considerations are applicable to both the funding entity and end-user and can inform the up-front and long-term investment needed to maintain a unit. From this perspective, a key priority is identification of units that can satisfy **both immediate and long-term housing needs** (e.g., temporary-to-permanent housing).

The Study's quantitative analysis system scored cost-effectiveness based on survey questions evaluating the following key factors:

- Unit purchase price;
- Existing production capability;
- Cost of transportation;
- Ability to support bulk purchases and transportation;
- Personnel and equipment expenses for on-site construction;
- Cost of the foundation and utility system hook-ups;
- Ability of the unit to transition from temporary to permanent housing;
- Ability of the unit to redeploy;
- Energy efficiency and expected annual costs;
- Maintenance needs and cost; and
- Length and type of system warranties.

Highest Performers in Cost

Rank	Vendor Name	Key Characteristics
1	Connect Homes	• Units cost $94 per square foot and have a minimum occupant cost of $806 per year. • Units could significantly offset the cost of transitional housing for disaster survivors. • Unit resilience indicates a high projected cost-effectiveness over its lifespan.

2	Kiro Action	• Units cost $167 per square foot and have a minimum occupant cost of $1,007 per year. • Units do not require any heavy machinery for installation. • Unit resilience indicates a high projected cost-effectiveness over its lifespan.
3	Falcon Structures	• Units cost $112 per square foot and have a minimum occupant cost of $1,694 per year. • The main cost associated with installation is use of a forklift. • Unit resilience indicates a high projected cost-effectiveness over its lifespan.

Snapshot: **Designing for Unskilled Labor**

Many communities are supported by a significant number of volunteers during their post-disaster recovery, particularly for home repair and rebuild. As participating vendors described their applications to post-disaster environments, some highlighted the importance of creating user-friendly designs and building processes that can optimize these skilled and unskilled capabilities outside the contracted workforce.

For panelized and kit systems, a strictly defined, teachable process for building a unit may reduce the time and cost associated with identifying and paying contractors, particularly when the local construction market is inundated with need. That noted, it is critically important that the pre-fabrication and construction process be developed in close coordination with local codes, to ensure that buildings are safe for residents.

RANGE OF USE

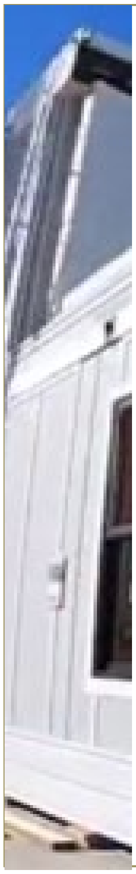
Range of use characterizes a unit's adaptability to diverse site requirements, community needs, and end-user needs, particularly for a large-scale deployment. From an operational perspective, range of use highlights a **unit's total lifespan** and **ability to serve different family sizes and needs** (e.g., accessibility). From an aesthetic perspective, range of use also captures the unit's **ability to customize its interior and exterior finishes to meet local architectural expectations**.

The Study's quantitative analysis system scored range of use based on survey questions evaluating the following key factors:

- Projected unit lifespan;
- Flexibility of unit size to adapt to different family sizes;
- Provision of a kitchen and living room;
- Availability of ADA and/or UFAS-compliant units;
- Ability to customize to meet local architectural standards;
- Ability to stack and/or connect multiple units for multi-family housing; and
- Ability to modify housing capabilities.

Highest Performers in Range of Use

Rank	Vendor Name	Key Characteristics
1	Boxabl	• Units are highly adaptable and use a concept similar to "building with Legos™" to create a wide range of structures, up to multi-story multi-family housing. • Units are rapidly deployable but have a total projected lifespan that can last more than 30 years.
2	ICON	• Units are capable of adapting to a wide set of configurations and can be deployed to accommodate both individual and multi-family needs. • Units are rapidly deployable but have a total projected lifespan that can last more than 30 years.
3	LiV-Connected	• Use of the cartridge system makes these units highly adaptable to a number of different configurations and can range from single-family to multi-family use purposes. • Units are rapidly deployable and can last more than 30 years.



Snapshot: **Made to Add-On**

Many of the Study's participating vendors use building systems with modules that can be connected and/or stacked to accommodate different family sizes and needs. These capabilities distinguish units that may be optimal for temporary-to-permanent housing deployments.

There's wide variability in the specific method of supporting unit add-ons. Some vendors use shipping containers or other box-like structures that can be assembled "like Legos™," even creating multi-story apartment buildings. Others use panel systems that can be modified into different configurations, based on the total size and number of rooms needed. The use of 3D printing expands the realm of possibilities for unit configurations, such that if a configuration can be developed in the system's software, it can be built.

The ability to add to a unit is not limited to proprietary or panelized technology. Some vendors also include systems that provide a base unit for immediate use, which can be easily transitioned into a permanent housing unit through stick-built additions that transform the structure into a full home.

COMMUNITY STAKEHOLDER OUTREACH

COMMUNITY OUTREACH PLAN

To frame the Study's findings and recommendations based on self-identified needs in Texas communities, the team developed a Community Outreach Plan to engage community stakeholders under Phase I of the Study. The outreach strategy purposefully limited stakeholder engagement to groups that could provide high-level insight to expectations for future alternative housing missions and the types of units that could meet those expectations. By doing so, the data collection and general scoping efforts under Phase I were informed by stakeholder conversations that built a general understanding of which alternative housing units could realistically meet community needs.

The outreach strategy targeted specific community stakeholders, including non-profits, elected officials, emergency management leaders, technical experts, and other critical partners across jurisdictions impacted by Hurricane Harvey, while maintaining a vision for statewide solutions. The Study worked towards established outcomes for the Community Outreach Plan (see ***Figure 8***):

Figure 8: Key Outcomes of the Study's Community Stakeholder Outreach

Identify key stakeholders and community decision-makers to better understand success factors for disaster housing

Provide context to survey findings by identifying the local conditions and community requirements that will inform implementation of post-disaster housing solutions

Build strong relationships and rapport among key community stakeholders in disaster-prone areas, both between organizations and with GLO-CDR

Stakeholder participants in the Study's community outreach process were grouped into three primary stakeholder groups:

- **Group #1:** Local Government and Emergency Management Stakeholders
- **Group #2:** Civil Society Organizations
- **Group #3:** Technical Experts

The Study engaged stakeholders to garner both targeted and general feedback through a series of webinars and one-on-one interviews that utilized guided questions to focus on local knowledge and expertise of the stakeholders. Engagement was structured in a three-staged approach, to enable formats that could be efficient, flexible, and accessible to stakeholder needs.

- **Stage 1**: Recruit individual stakeholders via outbound emails and calls to participate in informational, discussion-based webinars and/or one-on-one brief interviews (also to be made available via "email interviews"). Begin to schedule and conduct interviews on a rolling basis, to continue throughout Stages 2 and 3.
- **Stage 2**: Engage members of all three stakeholder groups collectively in informational webinars to explain the purpose of the Study and its general strategy for providing communities improved post-disaster alternative housing. Elicit general discussion based on the experiences of stakeholders under previous post-disaster housing missions.
- **Stage 3**: Hold a second set of webinars to gather insights and lessons learned. Delineate and engage stakeholders in three separate webinars, created based on distinct sets of expertise. Encourage feedback on the overarching types of alternative housing that might be made available to stakeholders in the future.

Distinct focus areas in the expertise-driven feedback sessions and interviews were determined based on the considerations for each stakeholder group.

GROUP #1: LOCAL GOVERNMENT STAKEHOLDERS

Goal: Understand the local government and emergency management opportunities, concerns, and other insights for alternative housing, as well as how any future products from the Study can be developed to ensure utility for these individuals (e.g., Texas Disaster Information System [TDIS]).

Individuals in this stakeholder group hold crucial knowledge about what may feasibly work, as well as how to gain acceptance, in their communities. Disaster response officials also have previous experience with temporary housing options used in prior disasters. The Study targeted the following aspects of local government and emergency management expertise in webinars and interviews:

- Overarching community challenges as they apply to post-disaster housing;
- Key post-disaster needs to be accounted for when considering temporary or temporary-to-permanent housing;

- Capacity of local infrastructure to administer post-disaster housing deployments (particularly those that may result from the Study); and
- City and county planning goals as they apply to housing and low-income community members.

GROUP #2: CIVIL SOCIETY STAKEHOLDERS

Goal: Understand community needs and perspectives, especially for individuals that fall outside of eligibility requirements for government-funded programs.

Civil society organizations encompass the full community of non-profit groups, faith-based organizations, and voluntary organizations active in disaster (VOAD)[2].

Many of these organizations are housed under collaborative platforms like long-term recovery groups and committees, which are still active in addressing the significant levels of need that exist in areas across Texas that were affected by Hurricane Harvey. The Study specifically targeted the following aspects of civil society expertise in webinars and interviews:

- Challenges related to post-disaster housing missions by civil society organizations;
- Opportunities for alternative housing to address community need;
- Key concerns regarding fair and affordable housing;
- Additional considerations to account for related to sustainability, environmentally-friendly building techniques, and accessibility;
- Perspectives on dignified housing that meets community expectations; and
- Non-traditional housing strategies and solutions utilized by civil society organizations.

GROUP #3: TECHNICAL EXPERTS

Goal: Understand how codes and permitting impact the feasibility of alternative housing solutions and identify high-performing building practices from each region.

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[2] VOAD is a humanitarian association of independent voluntary organizations who may be active in all phases of disaster. There are multiple VOADs in Texas that cover needs both statewide and by region. NVOAD is the national association and includes membership from many organizations that work in Texas.

Technical experts have key information about the compliance and design standards with which post-disaster housing units must comply. The Study Team will specifically target the following aspects of technical expertise:

- Key codes and standards that require consideration for any housing mission;
- Common challenges as they related to unit code compliance for temporary and temporary-to-permanent housing implementation;
- Opportunities for flexibility and change to housing standards; and
- Codes and standards that are prohibitive or would need to be amended.

TARGET JURISDICTIONS

The Study engaged individuals within each of the three stakeholder groups based on MID counties for Hurricane Harvey. MID areas were targeted due to their recent disaster housing experience from Harvey, and because they comprise urban, suburban, and rural communities, which provides the Study a diverse sample of built environments. Areas were targeted by county, listed in ***Table 13***.

Table 13: Target Stakeholder Jurisdictions Per HUD MID Areas

Counties		
Aransas	Liberty	75979 - Tyler
Brazoria	Montgomery	77320 - Walker
Chambers	Newton	77335 - Polk
Fayette	Nueces	77351 - Polk
Fort Bend	Orange	77414 - Matagorda
Galveston	Refugio	77493 - Waller
Hardin	San Jacinto	77482 - Matagorda
Harris	San Patricio	77423 - Harris
Jasper	Victoria	77979 - Calhoun
Jefferson	Wharton	78934 - Colorado

ANALYSIS

Based on feedback from the community stakeholders from interviews and webinars conducted, **a series of eight key themes emerged** for needs in the post-disaster housing space (see ***Figure 9***).

These themes include the recovery process, local aesthetic standards, housing construction, location, housing affordability, ancillary costs, communication, and coordination; and are further discussed in the section below. This analysis reflects themes both from the survivor-centric and programmatic perspective.

Figure 9: Themes of Community Outreach Analysis

Recovery Process	**Local Aesthetic Standards**	**Housing Construction**	**Location**
Housing Affordability	**Ancillary Costs**	**Communication**	**Coordination**

RECOVERY PROCESS

Through the outreach process, stakeholders reflected how **an expedited recovery improves the well-being of the survivors and community**. Indicators of progress and a sense of normalcy were cited as critical to creating resilience within the community. Moreover, an expedited recovery was noted to improve the independence of survivors and contribute to the upward mobility of a community post-disaster. Stakeholders emphasized the importance of survivors having space to congregate, like community centers, to support this community resilience.

> "When you think about the culture of a place—and **recognize people's investment both financially and emotionally in their homes**—these homes have really worked well as a temporary-to-permanent option."
>
> - *Stakeholder Response*

Additionally, **post-disaster housing for survivors should have temporary-to-permanent options** to best support survivors through the recovery process. Current options are discarded after the units are no longer being used. Instead, communities favored a model where the investment that survivors begin to make immediately after the disaster into their homes again is recognized. In practice, this could mean having adaptable solutions that can be modified or expanded to turn units into traditional homes.

LOCAL AESTHETIC STANDARDS

Stakeholders noted the need to focus on supporting housing solutions that **are adaptable to local community architecture**. Survivors want housing that fits into the community and looks like a real house. Moreover, stakeholders noted that housing that looks too unique or out of place can create the feeling of stigmatization among survivors.

> "A lot of this is about aesthetics, particularly if you are talking temporary to permanent. Does this fit into the neighborhood? **Does this look and feel like a real house?**"
>
> - *Stakeholder Response*

HOUSING CONSTRUCTION

A key initial highlight from the community stakeholders regarding housing construction is **accurately setting survivors' expectations**. Early on, boundaries and expectations should be set to limit the disappointment and confusion of survivors and communities. Having conversations about the limitations of recovery support, including financing and construction limitations will ultimately best serve communities by finding the best option and compromise within the boundaries of feasibility.

Additionally, stakeholders mentioned a variety of challenges related to the process of constructing housing post-disaster. For example, **limited certified tradesmen and contractors** made construction of housing at an expedited rate a challenge. Moreover, there are issues with **relying on public utilities** in post-disaster housing – specifically sewage and septic systems. Lastly, stakeholders noted challenges with preparing the land for construction, including land grading and proper placement. All factors impacted expedited construction of post-disaster housing.

> "You need to set expectations early on. **If the expectation is set in the beginning of what you can do, then there can be some leeway.** Sometimes we don't want to have those hard conversations, but I think we need to come at it differently and not be so rigid."
>
> - *Stakeholder Response*

LOCATION

Fundamentally, stakeholders noted that survivors wanted housing options that are close to their original community, or on their damaged property. Survivors want to remain close to their existing communities for the sake of cohesion and normalcy. There are also increased expenses, such as transportation, when survivors are moved away from a community to which they are tied. Additionally, survivors may have responsibilities related to their property, especially for survivors from rural areas, like care of livestock or property upkeep.

> "When we're talking about bringing in units for people to relocate (temporarily or permanently), a lot of **people have vested interest in staying close to where they were before**."
>
> - *Stakeholder Response*

HOUSING AFFORDABILITY

Stakeholders stressed the need for **long-term affordability for survivors**. Many survivors lived in homes that had been in families for generations, not paying rent or mortgages. Thus, any additional cost can be highly burdensome to these individuals, especially in a post-disaster scenario. Low-income

> "Low income households are **vulnerable to additional hardships** due to their lack of resources."
>
> - *Stakeholder Response*

survivors may need additional financial support, as they are more likely to be vulnerable due to displacement after a disaster. Additionally, assistance for post-disaster housing is provided immediately after disaster, but the cost of options should be considered for the future. The focus of permanent construction should be on quality construction promoting affordability in the long run. The buildings should be energy efficient, for example, built to Energy Star standards. Buildings should also be constructed to be resilient so required repairs will be less likely following future storms.

> "They need to **change the way they invest**, and we need a blended method of temporary to semi-permanent homes."
>
> - *Stakeholder Response*

Additionally, stakeholders stressed the **need for efficient investment in post-disaster housing**. Investment in post-disaster housing is currently considered inefficient. Too much money is invested for a product that is not ideal for survivors. A lot of times taxpayer money is utilized for this purpose. Overall, stakeholders would like to see a method of transitioning temporary to permanent homes to maintain financial investment.

ANCILLARY COSTS

Stakeholders identified multiple ancillary costs that are often not considered at the programmatic level. A priority should be **registering families that need temporary housing**. This promotes efficient use of funds by understanding the type of support each family needs.

Another additional cost in post-disaster housing provision involves **the management of donations**. Donations from the community illustrate generosity and community support. However, funding and space for warehousing of donations, as well as any costs for transportation should be considered. It is important to know which donations to accept and when to accept them.

Implementing **additional preparedness measures related to procurement and construction** would also limit ancillary costs. Specifically, stakeholders suggested that pre-positioning housing vendors within regions (per council of governments) would help limit extra transportation and service costs in contracts. Additionally, identification of construction and project managers prior to the disaster supports investment in a strong workforce.

COMMUNICATION

> "The communication is key – the **more frequent the communication and the simpler the wording**, the better."
>
> - *Stakeholder Response*

Clear and simple communication should be used to explain post-disaster housing solutions and limitations of those solutions. Overly technical language may come across as foreign to survivors, leading to miscommunication or frustration. Terminology and explanation of programs should be accessible and standardized across disasters, so systems are easy for stakeholders and survivors to explain and understand. Stakeholders also reported challenges with resources (e.g., fact sheets) explaining the differences between programs and eligibility.

COORDINATION

Stakeholders noted an **increased need to coordinate with long-term recovery groups (LTRGs) and philanthropic groups**. This leads to efficiency in information sharing—for example, between government-run housing programs and programs run by LTRGs and philanthropic organizations. Moreover, this coordination would help clarify which individuals received or are set to receive assistance, thus allowing philanthropic groups to identify survivors with unmet need and make targeted investment. Collaboration can also create more successful public-private partnerships, alleviating some of the barriers facing housing response.

KEY TAKEAWAYS

Through stakeholder interviews and webinars, feedback in the context of the Study highlights some of the key factors that must go into post-disaster housing relief. As technology continues to advance and more post-disaster alternative housing options become reality, the information will serve as a foundational database that will continually be developed, providing a resource for future alternative housing research.

A clear channel of communication is critical when responding to a disaster with displaced residents. It starts with giving residents a timeline for rebuilding and educating them on case management, while encouraging responsibility to move towards recovery. It is critical to ensure that effective tools are available to survivors, such as counseling and social workers, as mental health strategies are critical in forging resilience and health for residents.

Present models of post-disaster relief can be used as a blueprint to effectively shape future housing missions, with the understanding that areas of a post-disaster relief plan might need improvements (e.g., generating supplementary housing option vouchers to help reduce the waiting list for Section 8). A quick response to disaster can minimize the impact of destruction; a state’s investment in permanent housing solutions *before* disaster hits can make all the difference in a rapid recovery.

FINDINGS AND RECOMMENDATIONS

Each engineer and executive representing vendor submissions to the HAT survey reflected on their process for landing at the solution they determined the best fit for addressing housing needs. The Study's analysis found that many of them were effective; and the submissions reflected a range of applicability to distinct use cases (e.g., single family home, temporary shelter). These included post-disaster needs as delineated by needs in rural versus urban areas; single-family versus multi-family housing; and temporary versus permanent housing. However, submissions also highlighted new methods of applying housing technology to post-disaster housing needs, including the following:

- **Accessory Dwelling Units**
- **Rapidly Deployable Shelter**
- **Temporary-to-Permanent Housing**
- **Tiny Homes**
- **Waterborne Shelter**

Diversity in viable solutions and optimal use cases is beneficial to communities because there is not one specific solution that is best equipped to meet all needs. While keeping in mind the potential needs of different communities, the Study categorized vendor submissions under seven main categories (see ***Table 14***). Strengths, weaknesses, and optimal use cases are examined by category, for both traditional and innovative applications.

Table 14: Categorization of Alternative Housing Technologies
3D Printing
Log Kit Homes
Modular Foldable Units
Modular Panelized Units
Modular Prefabricated
Shipping Containers
Traditional Kit Homes

INNOVATIVE USE CASES

ACCESSORY DWELLING UNITS

Accessory dwelling units (ADUs) are small, independent residential dwellings that are co-located on lots with single-family homes. Government research in the early 2000s emphasized the opportunity these units present for communities to grow the housing stock for elderly, disabled, and young residents, while simultaneously providing homeowners a source of income if made available for rent.[x] Their use is trending upwards in the United States, particularly in states like California, Oregon, and Vermont, where they have increased the affordable housing pool.[xi]

During the Study's community outreach discussions, stakeholders emphasized the desire for homeowners to be able to stay on or near their own property after a disaster, where individuals can maintain their daily routine and support home repair. However, w here traditional programs have placed MHUs and TTs on a homeowner's property and then demobilized them after the home repair is complete, programmatic approaches that support homeowners with ADUs could be a more appropriate solution.

Dweller, a participating vendor in the HAT survey, focuses its model on specifically applying alternative housing units for use as ADUs, supporting cost-efficient housing solutions in Oregon. Their units are constructed by manufacturing partner Champion Home Builders and expertise internal to Dweller focuses on high-quality ADU deployment. Particularly given the emphasis by community stakeholders on survivors being able to stay close to their home property—as well as the influx of elderly persons in coastal areas—ADUs have potential as an innovative use case.

Figure 10: Example of Detached ADU Layout

Retrieved from https://arvada.org/business/permits-and-applications/accessory-dwelling-unit

Key Takeaways: **ADUs**

- A rapidly deployable ADU can fill the same direct need as interim housing and provide the added benefit of keeping a survivor on their property.
- When built for permanent use, an ADU can potentially support the ability of families to maintain housing for elderly or disabled family members.
- ADUs can be used to support the broader need for rentable housing stock—an identified gap by community stakeholders—which can become a source of income for the homeowner.

RAPIDLY DEPLOYABLE SHELTER

The ability to operate as rapidly deployable shelter was a significant strength among alternative housing vendors, and the Study identified a number of multi-family units (e.g., Connect Homes) and single-family units that could be installed quickly (e.g., Boxabl). The proposed timeline for a majority of the participating vendors was less than two weeks—if not less than one week—though some did not incorporate time for transportation and hook-ups for electrical and plumbing systems.

Figure 11: Connect Shelters Estimated Occupancy

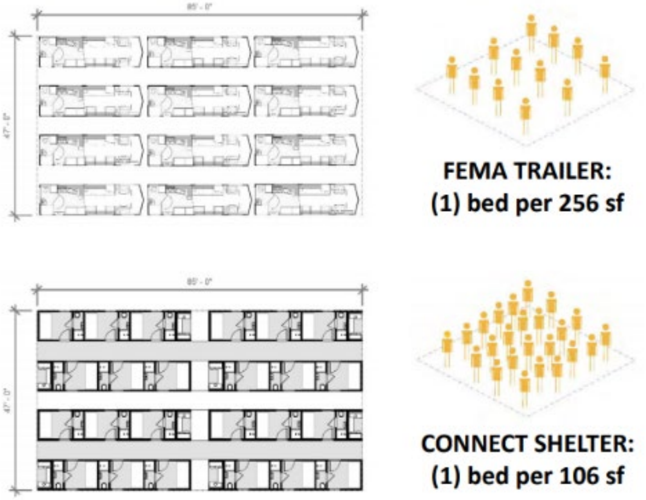


Photo retrieved from Connect Homes co-founder Gordon Stott.

The benefits of rapidly deployable single-family housing are intuitive to traditional post-disaster housing programs, because they reduce the timeline to support Individual Assistance and other temporary programs (see). It is also worth noting the different range of benefits that can result from temporary multi-family shelters, particularly as compared to existing transitional housing used post-disaster to support moving impacted survivors from congregate shelters to more stable and accommodating facilities (e.g., hotels).[xii]

A primary feature of these multi-family rapidly deployable shelters is that they are more flexible compared to traditional transitional housing options in terms of structure and location. Instead of being tied to the location of existing available facilities, rapidly deployable shelters can utilize available land close to existing communities to better maintain a sense of community. Additionally, deliberately designed transitional housing options allow for increased density of households and therefore reduced space required (see ***Figure 11***). The design can also be minimal and appropriate, limiting the chance that survivors overstay.

Figure 12: Connect Shelters in Factory

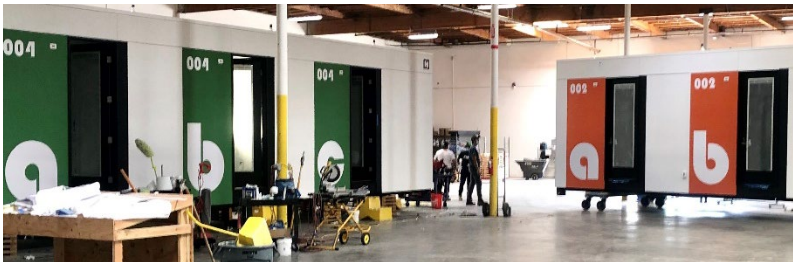


Photo retrieved from Connect Homes co-founder Gordon Stott.

Key Takeaways: **Rapidly Deployable Shelter**

- Multi-family shelters can potentially improve space efficiency for transitional shelters, bring survivors closer to their home properties, and provide a non-congregate sheltering option.
- Rapidly deployable single-family homes can more quickly support the ability of survivors to return to their property.
- Resilient multi-family and single-family units can be stored for use in multiple disasters.
- Shelters can be an especially useful tool during pandemics and other circumstances that demand additional health protocols, because their provision of separate rooms can reduce the risk of individuals being in close proximity to one another.

TEMPORARY-TO-PERMANENT HOUSING

A key trend across all stages of the Study—the literature review, community outreach, and the HAT survey—was the improved cost-effectiveness and survivor experience under temporary-to-permanent programs. In Texas, these findings take an important precedent from the RAPIDO program. Temporary-to-permanent housing programs are a departure from traditional programs that use distinct temporary solutions (e.g., MHUs) and permanent solutions.

Many of the Study's participating vendors had temporary-to-permanent capabilities. These were identified on the basis of being able to both rapidly deploy and meet permanent housing requirements under codes and standards. For many units, this incorporated the ability to expand living space. The improved quality and production capabilities in building technology (e.g., SIPs) are enabling alternative housing to meet these needs more successfully than they have in the past.

Among the participating vendors, the approaches to supporting temporary-to-permanent housing were varied. All could anchor the unit to a permanent foundation system and hook-up the plumbing and electric through use of local tradespersons. Some include multiple modules that can stack and connect to increase living space (e.g., indieDwell), where others rely on additions built via traditional construction methods (e.g., RAPIDO).

Future programs might consider a hybrid of using proprietary core models (e.g., Boxabl) that can deploy quickly through use of highly resilient building materials, with traditional construction during the community's long-term recovery. The overall success of RAPIDO's programmatic approach in Texas warrants serious consideration in future housing programs.

Figure 13: RAPIDO Temporary-to-Permanent Model

Photo retrieved from https://rapidorecovery.org/

Key Takeaways: **Temporary-to-Permanent Housing**

- Existing vendors have the technology and production capability to begin implementing temporary-to-permanent housing widely in post-disaster housing environments.
- Investment is warranted in groups like RAPIDO that are building their capabilities to support large-scale deployments, so that these systems can become more commonplace after major disasters.

TINY HOMES

Tiny homes came to popularity in a movement that started in the 1990s and grew in the 2010s, inspiring homeowners to live simply and downsize in housing. media attention was put on the tiny house movement through television shows such as "Tiny House Nation." While there are not reliable statistics regarding the number of tiny homes across the United States, it is known that tiny home construction and sales has been rapidly increasing since the mid-2010s.

Some participating vendors highlighted the advantages of tiny home living in their design submissions, with emphases on their reduced carbon footprint and affordability. However, community stakeholders highlighted that tiny home solutions might only be accepted as a temporary solution, especially for homeowners who are used to a larger home.

Although there is no set definition for a tiny house, they are often defined as being 400 square feet or less. Given their size and the difference in manufacturing processes between vendors, tiny homes can be characterized under building codes for recreational vehicles, manufactured homes, modular dwellings, or site-built dwellings.[xiii] It is important to note that under CDBG-DR funding, home rebuilds have a size requirement that is not typically met by tiny homes, and their use for permanent housing would either require additional construction or changes to the requirements.

COMMUNITY VOICES

- "If you are talking about a permanent solution, people are going to look at the home they had before. Someone who was in a two- to three-bedroom home before is not going to be satisfied with a tiny home as a permanent solution."
- "If it were designed with one room efficiency that could be added on, it could be a temporary solution upfront. A tiny home in and of itself would not be a reasonable expectation that families would be satisfied with."
- "I agree with the prior comments, but this option does provide a permanent housing solution at a reduced cost, so it's something to consider in an environment where we don't have the funds to do a full rebuild on a normally-sized home."

Figure 14: Core Housing Solutions Tiny Home Submission

Retrieved from Core Housing Solutions Partner Bruce Chatterton.

Key Takeaways: **Tiny Homes**

- Tiny homes are growing in popularity across the United States and may garner some interest as permanent housing; however, they were generally regarded by community stakeholders as a temporary solution, or a strategy for addressing homelessness.
- For use as permanent housing, tiny homes will require additional review of code compliance to ensure that sizing meets both local and federal regulations.

WATERBORNE SHELTER

Waterborne shelters, for the purposes of the Study, are shelters that can utilize the surface of water, rather than land, as the base of the structure. This use case was identified as a trend from two HAT survey submissions, SO? and Urban Rigger, two international companies which used docks, piers, and other waterbodies.

Waterborne shelters have grown in popularity in dense urban areas, particularly in cities where there is limited land available for construction and therefore major issues finding land to construct temporary or transitional housing. Again, in this situation, waterborne shelters may provide an innovative opportunity in the post-disaster housing space.

A challenge with waterborne shelters is that due to their innovative nature, there is not a clear process for permitting these types of sheltering solutions. Therefore, this shelter might not be immediately actionable. But it will be important to maintain awareness over time, especially for communities with land-use issues or a lot of water access.

Figure 15: Waterborne Shelter Submissions from SO? (left) and Urban Rigger (right)

Retrieved from SO? Architects Sevince Bayrak and Oral Goktas. *Retrieved from https://urbanrigger.com/*

Key Takeaways: **Waterborne Shelter**

- Internationally, waterborne shelter is emerging as a sheltering option for densely populated cities that may lack alternative areas in the case of a disaster.
- There is no clear precedent or path to permit waterborne shelters for use in Texas, but they warrant awareness as innovative alternative housing technologies.

ALTERNATIVE HOUSING TECHNOLOGIES

3D PRINTING

The Study received a 3D printing submission from **ICON**, a company based in Austin, TX. ICON built the first 3D printed home in the U.S. in 2018. This home was printed from the Vulcan printer, which constructs the home design from a concrete mixture, or "magma."

To construct a building, software engineers load a home design into the printer's system, which is then capable of creating any configuration, up to approximately 2,000 SF.

COMMUNITY VOICES

- "I like the concept, since it has long-term durability potential."
- "This would have more curbside appeal than some other options."
- "They look really nice. I am impressed."

To create a structure's walls, the printer lays three adjacent beads that become a single wall system that is then filled with insulation and topped by a wood framed roofing system. The completed wall structure is equivalent to concrete construction with additional chemicals to fortify the structure against specific hazards. The full construction process takes approximately five days.

Figure 16: ICON Printer and Completed Homes

Photos retrieved from ICON co-founder Evan Loomis.

STRENGTHS

- The concrete wall structure is extremely resilient. It is a highly flood damage-resistant material that can significantly reduce the amount of time needed for home reconstruction after a disaster.
- 3-D printed designs garnered positive feedback and initial buy-in from all community stakeholder groups.
- Units can be constructed quickly, particularly if more than one home is being built on the same slab.
- ICON is based in Austin, TX, and has constructed permitted homes in Texas.

CONSIDERATIONS

- The wood roofing system is integrated with the concrete wall system through pre-set slots but presents the weakest part of the building system (though no more so than traditional construction).
- Construction costs rely on significant investment in the printer, which can result in high costs when constructing few homes but rapidly becomes more cost efficient with bulk scenarios.
- The building process currently uses a slab-on-grade foundation, and while pier-and-beam is under review, this may prevent ability to elevate much higher than a few feet.

Optimal Use Cases:

3D printing can be quickly deployed in a post-disaster environment to address housing needs.

3D printed homes could be a cost-efficient solution in a post-disaster environment where a significant number of temporary-to-permanent homes need to be constructed.

LOG KIT HOMES

The Study received log kit home submissions from **EcoHouseMart** and **Allwood Industrials**, based in Forest Hills, NY, and Palm Beach Gardens, FL, respectively. Both companies sell log homes that are constructed with interlocking logs that can support quick assembly of full kit homes.

Logs are constructed with a specific spruce lumber—EcoHouseMart uses northern white spruce and Allwood Industrials imports Nordic spruce from Finland and Estonia. Logs are built with a tongue and groove technology that enables the fully finished unit to reportedly withstand winds up to 120 mph. The use of interlocking technology is much quicker than traditional construction and can take less than a week for smaller units. That noted, the log kit construction creates the exterior shell of a unit but has varying needs for interior construction.

COMMUNITY VOICES

- “We would have a strong interest in getting more data on kit homes. We have 12 undeveloped acres, and I could see us pursuing this type of concept.”
- “When we are talking proprietary, we would need to explore what happens down the road, if repairs need to be made. Can they be done by the homeowner or general contractor?”

Figure 17: Kit Logs and Completed Home

Photos retrieved from www.ecohousemart.com/.

Photo retrieved from https://allwoodoutlet.com/

STRENGTHS

- Smaller units are designed for construction in a matter of days, and depending on the complexity of unit design, can employ unskilled labor (i.e., volunteers).
- The finished log home looks like more traditional home construction and thereby garnered positive feedback from Texas community stakeholders.
- When constructed correctly, the units are built as one fully connected system that is built to stay fully interlocked, which can support wind resilience.
- Products are exceptionally low in cost, and a 209 SF structure costs approximately $9,000 per unit (only including the shell).

CONSIDERATIONS

- The log kit system primarily provides the exterior shell, which does not address needs for interior finishes, plumbing or electrical. The resulting time and cost to complete a home triples initial estimates, from one week at $9,000 for the smallest unit, to three weeks or more for $30,000.
- The base log kit structure requires additional lumber treatments (e.g., lamination, termite prevention) to enable resilience to key hazards, including fire and flood damage.
- Units have not yet been permitted for use in Texas and given their non-traditional construction process, require in-depth review from local permitting officials to ensure and apply code compliance to unit construction.

Optimal Use Cases:

A small log structure can be constructed at low cost as an accessory dwelling unit for families with homes that can be repaired from storm damage.

Smaller log home kit models can be fully outfitted with interior finishes, electrical, and plumbing to serve as a tiny home.

MODULAR FOLDABLE UNITS

The Study received foldable home submissions from **Boxabl** (Las Vegas, NV), **Forts USA** (Coconut Creek, FL), **A-FOLD Houses** (Italy), and **SO?** (Turkey). The exterior shell of these building systems is fully prefabricated, connected, and flat-packed for deployment. Across these submissions, shells were constructed through use of SIPs.

Upon arrival on-site, the systems use a crane to unfold into a fully complete structure, a process that takes less than a day. Additional interior construction, if expedited, can be completed within approximately one week.

There are variations across each of the foldable home systems. Boxabl and Forts USA use a similar process, in which the walls fold out from the middle of the unit, much like a cardboard box. These systems allow for a range of building sizes through their ability to stack and connect.

COMMUNITY VOICES

- "The modular housing is more appealing if you can start with a structure, add on to it, and turn it into more of a traditional home."
- "We don't have zoning in the unincorporated part of the county, so it really doesn't matter what unit is installed, as long as that unit meets our floodplain regulations."
- "We do have zoning that includes locally incorporated historic districts. If these are permanent homes, they might conflict with the design standards for historic properties."
- "When we are talking proprietary, we would need to explore what happens down the road, if repairs need to be made. Can they be done by the homeowner or general contractor?"

A-FOLD Houses and SO? use an unfolding process that results in a more traditional triangular roof structure. By doing so, the systems require installation of the sheer walls on the ends of the unit to complete the exterior.

Figure 18: Boxabl Prototype

Photo retrieved from https://www.google.com/url?sa=i&url

Photo retrieved from https://www.businessinsider.com/boxabl-tiny-homes-shipping-containers-2020-5.

Figure 19: A-FOLD Houses

Photos retrieved from Freedom Resource Group (U.S. distributor) representative Todd Roberts.

STRENGTHS

- Units can be rapidly deployed and reliably built within a week, given the standardization of their paneling and construction systems.
- Smaller units are designed for construction in a matter of hours, and depending on the complexity of unit design, can employ unskilled labor (i.e., volunteers).
- The use of SIPs in the exterior shell can support a wind and flood-resilient structure that is well-suited to hazard-prone environments.
- The relatively low cost per unit is much more cost-effective and resilient than other solutions, particularly compared to traditional housing methods.
- Depending on the type of building system, traditional construction can be used to further add on to a unit and transition to a permanent home.

CONSIDERATIONS

- If construction requires more than one unit to build a full structure, the compounded cost of multiple modules can quickly become expensive.
- Many modular systems are not currently allowed under local codes in Texas and will require new laws that can effectively regulate their construction.
- These building systems have not yet undergone a large-scale deployment, and there may be programmatic elements of their use that cannot yet be fully predicted.
- Community stakeholders highlighted that residents relate modular to manufactured housing, and units that use a non-traditional building style will likely require community education prior to deployment.

Optimal Use Cases:

Foldable modular structures can be rapidly deployed, especially given their capability for on-site construction within approximately 2-3 days.

Many foldable modular structures meet codes and standards for permanent housing and can expand by connecting or stacking units. Alternatively, additions can be built with traditional construction methods.

MODULAR PANELIZED UNITS

The Study received modular panelized unit submissions from **AbleNook** (Tampa, FL), **Gravity Architects** (Los Angeles, CA), **Hex House** (Minneapolis, MN), **Horizon North** (Canada), **Kiro Action** (Austin, TX), **LiV-Connected** (New York, NY), and **RAPIDO** (Dallas, TX). For this Study, panelized systems were identified as building systems constructed by prefabricated panels—most typically SIPs—that could be assembled on-site for rapidly deployable construction. These systems benefit from the ability to flat-pack those panels and construction materials for transport.

There are distinctions among the different approaches to panelized systems. Proprietary system submissions were submitted by AbleNook—using an aluminum structural framing system that snaps together through use of SIPs—and LiV-Connected—using a cartridge composition with hardy plank. Others (i.e., Horizon North, RAPIDO) use a more traditional prefabricated 2x4 framed wall system to construct panels. Kiro Action, Gravity Architects, and Hex House emphasize optimization in use of SIPs.

COMMUNITY VOICES

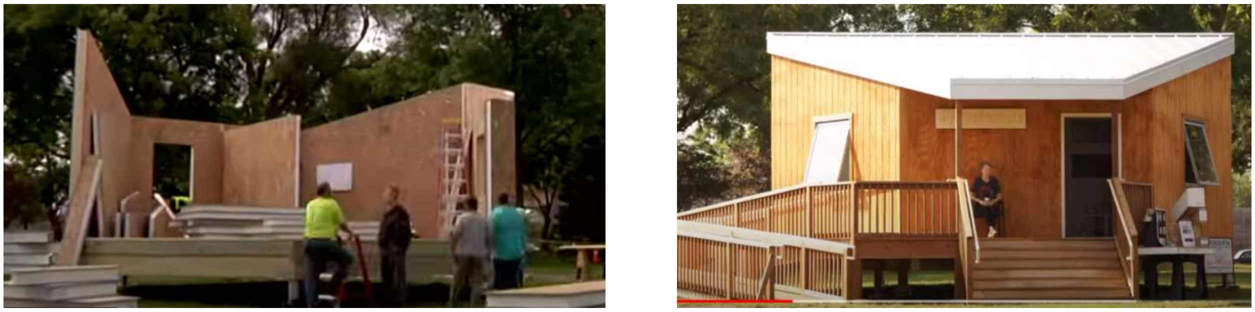
- "Our view comes back to the idea of being stigmatized, that folks don't want an odd or new home. I would resist the temptation to get too unique looking with the design."
- "Many of these structures are a lot nicer than a family's original home, and it might be something a family wouldn't want to leave (creating challenges if used temporarily)."
- "There is a lot education that needs to happen about modular homes and the fact that they are not interchangeable with manufactured homes. In their mind, it's a trailer."

These different panelized systems provide an important answer to the challenge of balancing the need for rapidly deployable housing in a post-disaster environment, while ensuring that building materials can translate to resilience and long-term use purposes. Depending on the type of connectors and foundation used, they can also be disassembled and stored for deployment again in the future, potentially optimizing the total investment in each unit.

Figure 20: AbleNook

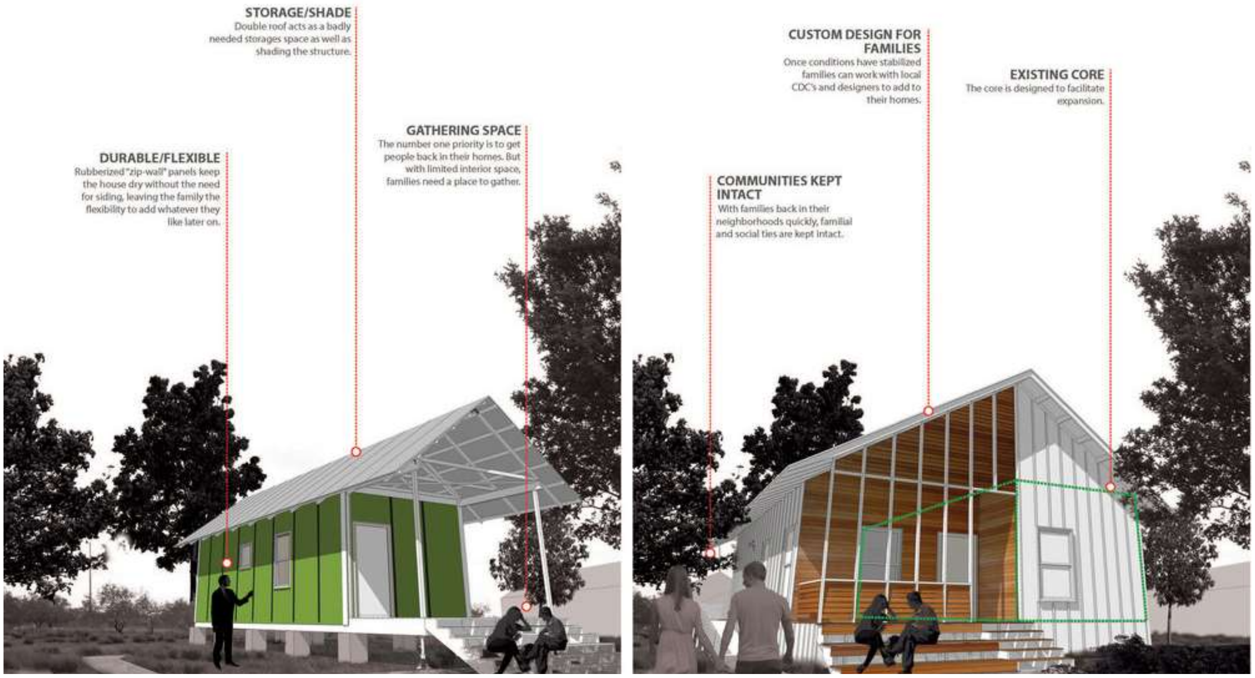
Photos retrieved from www.ablenook.com.

Figure 21: Hex House



Photos retrieved from www.hex-house.com.

Figure 22: RAPIDO



STORAGE/SHADE
Double roof acts as a badly needed storages space as well as shading the structure.

DURABLE/FLEXIBLE
Rubberized "zip-wall" panels keep the house dry without the need for siding, leaving the family the flexibility to add whatever they like later on.

GATHERING SPACE
The number one priority is to get people back in their homes. But with limited interior space, families need a place to gather.

CUSTOM DESIGN FOR FAMILIES
Once conditions have stabilized families can work with local CDC's and designers to add to their homes.

EXISTING CORE
The core is designed to facilitate expansion.

COMMUNITIES KEPT INTACT
With families back in their neighborhoods quickly, familial and social ties are kept intact.

Photo retrieved from http://www.rapidorecovery.org/the-idea.

STRENGTHS

- Panelized systems can be flat-packed based on different unit sizes and specific needs.
- Panelized systems can often be assembled in several configurations and sizes, which can be especially important when considering needs for large family and/or multi-family housing.
- Smaller units are designed for construction in a matter of days, and depending on the complexity of unit design, can employ unskilled labor (i.e., volunteers).
- The use of SIPs in the exterior shell can support a wind and flood-resilient structure that is well-suited to hazard-prone environments.
- Depending on the type of panelized system, traditional construction can be used to further add on to a unit and transition to a permanent home.
- Panelized systems can be more easily disassembled, stored, and redeployed for future use.

CONSIDERATIONS

- Many modular systems are not currently allowed under local codes in Texas and will require new laws that can effectively regulate their construction.
- Proprietary building systems may require specialized maintenance to address issues, which can impact the unit's longevity and cost-effectiveness for the recipient.
- Community stakeholders highlighted that more unique modular designs could result in stigmatization of recipients.

Optimal Use Cases:

Panelized modular units can be rapidly deployed and constructed, oftentimes taking from a few days up to a week.

Panelized modular units are an ideal temporary-to-permanent building application because they often entail expandable configurations to accommodate different family sizes.

MODULAR PREFABRICATED UNITS

The Study received modular fully prefabricated unit submissions from **Connect Homes** (Los Angeles, CA), **Core Housing Solutions** (Leesburg, FL), **Dweller** (Portland, OR), **Haus.me** (Reno, NV), and **M-Rad** (Los Angeles, CA). Each of these vendors has a new approach to fully prefabricated modular housing, which was identified by the Study as being modular systems fully constructed prior to transportation to site. These systems are perhaps the closest to traditional MHUs and TTs; however, they are distinct from these systems in their use of building materials and processes that translate to more resilient structures.

Dweller and M-Rad produce units that are more like traditional construction. However, these vendors are distinct in that they prioritize selecting quality interior materials and providing opportunities to customize.

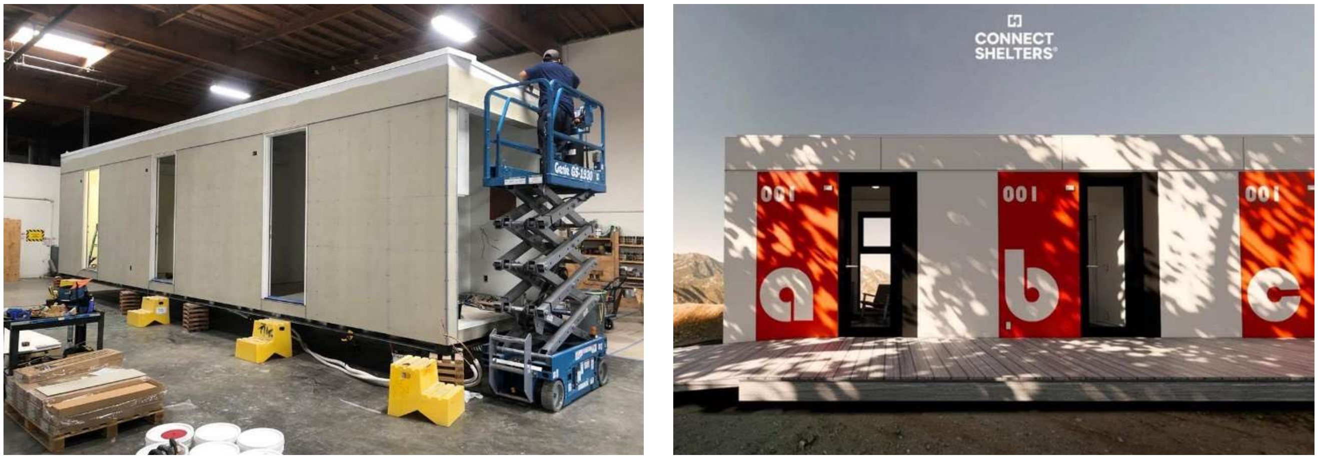
COMMUNITY VOICES

- "A lot of our cities put this in the same box as a manufactured home, and a lot of our towns by ordinance have outlawed manufactured homes. If someone wants to build modular, they have to go through an arduous process of getting special classifications with planning and zoning boards."
- "We had two partners (World Renew and Lutheran Social Services) work together on a modular home in Calhoun County, and the community was impressed. There are good quality and affordable options out there, and it was a good fit for that survivor."

Both M-Rad and Connect Homes use a metal framing system. Connect Homes has specifically focused on the prefabrication process as a competitive advantage by refining the movement of units through its assembly stations and ensuring that units can be reliably produced at a high quality and speed. These processes incorporate built-in plumbing and electrical systems, which enables unit operability off-grid.

Haus.me prefabricates homes using a patented polymer shell. The unit includes several advanced digital amenities, including regulation of the air quality, and can operate off-grid. While these specific high-tech amenities are not directly applicable to post-disaster use cases, their development in a prefabricated system reflects the ability of these models to produce high-quality, resilient building systems.

Figure 23: Connect Shelters



Photos retrieved from Connect Homes co-founder Gordon Stott.

Figure 24: Dweller

Photo retrieved from https://www.dweller.com/floorplans-options/448.

Figure 25: Haus.me

Photo retrieved from https://haus.me/gallery/.

STRENGTHS

- Standardization in high-quality prefabrication can support consistency in structure resilience and code compliance.
- Fully prefabricated systems can more easily incorporate built-in plumbing and electrical systems to the factory construction process, allowing units to deploy with off-grid capabilities.
- Use of metal framing and other strong proprietary exterior metals can support unit resilience to damage during transportation, installation, and long-term hazard exposure.
- Fully prefabricated units will incorporate fewer on-site construction needs and can therefore support rapidly deployable housing missions.

CONSIDERATIONS

- While some design customizations can be included in the prefabrication process, deployed units offer residents fewer options to customize their home.
- Transportation of prefabricated units limits their total size to a certain width, reducing options for different unit sizes and configurations.
- Community stakeholders emphasized that modular units are culturally understood as being the same as trailers and their use will require education-based initiatives to cultivate buy-in.
- Local building codes that prohibit manufactured housing often also apply to modular homes and will need to either be changed or addressed through significant additional planning processes.

Optimal Use Cases:

Prefabricated modular housing is a strong option for rapidly deployable housing because on-site construction needs are reduced by the ability to complete interior finishes in the factory.

Many prefabricated modular housing units are built to accommodate maximum wide loads and therefore fit needs effectively as tiny homes in their as-is condition.

Especially given their ability to install on-site quickly, prefabricated modular housing may be considered for use as ADUs.

SHIPPING CONTAINERS

The Study received shipping container submissions from **Falcon Structures** (Manor, TX), **indieDwell** (Boise, ID), and **Urban Rigger** (Denmark). Each of these building systems uses the base structure of shipping containers as the initial framing of a housing unit, utilizing stacking and connecting to develop larger homes and multi-family housing. The strength of shipping containers naturally creates very resilient building systems that can be easily adapted to different elevations and hazard mitigation.

The specific industrial aesthetic associated with shipping containers became a priority for the Study's review analysis. The Urban Rigger system is well-defined and targets specific needs in coastal areas requiring multi-family housing. Falcon Structures and indieDwell are more adaptable to different use purposes and aesthetic preferences. They can incorporate different exterior finishes and optional roof systems that can make units look more like a traditional home.

The use of shipping containers naturally lends itself to straightforward transportation via any system that might typically use shipping containers. In conjunction with their prefabrication process, these systems are therefore potential solutions for needs of rapidly deployable resilient housing.

COMMUNITY VOICES

- "On the Bolivar Peninsula, we have a house that has three shipping containers locked side-by-side and supported by two-inch drill stem pipe that sits 16 feet up from the ground. The community out there accepts it, and some of these are nicer than what we've seen in the past."
- "These are too far away from the architectural standards in our community. It looks like a safe home environment, but it's not going to blend into anything in existing communities."
- "Counties don't necessarily have the building code enforcement capability for these, but I have a seal from an engineer saying it meets the load requirements."
- "It could be good temporary housing, but based on the survivors and communities I've worked with, this would not go over well as permanent housing, and you'd have people saying, 'The government moved me into a shipping container.'"

Figure 26: Falcon Structures

Photo retrieved from Falcon Structures representative Daniela Grugnale.

Figure 27: indieDwell

Photo retrieved from indieDwell representative Chris Blanchard.

Figure 28: Urban Rigger

Photo retrieved from https://www.urbanrigger.com/view-urban-rigger/.

STRENGTHS

- Shipping container structures exhibit significant code-plus potential for natural hazards and can be easily elevated and anchored to prevent wind and flood damage.
- Shipping containers can serve as a reliable base shell for prefabrication assembly.
- Shipping containers are made for transportation and may simplify logistics related to housing deployments.
- The installation process for shipping containers further enables their ability to support rapid housing deployments.
- Community stakeholders noted the initial use of shipping container models by local businesses, particularly in coastal communities, as having garnered community acceptance.

CONSIDERATIONS

- Shipping containers received the most negative feedback from community stakeholder groups. They will require aesthetic customizations to match local architecture, as well as efforts to earn community buy-in.
- Shipping containers are increasingly seeing new codes and regulations that apply directly to their construction; however, many communities lack code enforcement to support shipping container construction.
- Rapidly deployable shipping container construction is limited to specific, pre-designed configurations. More complex larger housing will require additional investment and processing in the prefabrication process.

Optimal Use Cases:

Shipping containers are able to incorporate much of the building process in the factory and can therefore be rapidly deployed and installed.

By incorporating additional livable space through stacking or connections, as well as aesthetic finishes that meet local community standards, shipping containers can transition from temporary-to-permanent use purposes.

TRADITIONAL KIT HOMES

The Study received a traditional home build kit submission from **Sunshine Home Kits** (Salem, OR). The unit concept is like that of the Sears Homes sold in the early 1900s. In the same way that prefabricated homes highlight the assembly line system to deploy housing quickly, the Sunshine Home Kits model employs an assembly line process in procurement through use of palletized home kits with traditional building materials. The vendor leverages the inventory and distribution capability of retailers such as Home Depot to deliver palletized supplies in a defined sequence as the builder reaches construction milestones.

COMMUNITY VOICES

- "From what I've seen, this is the most attractive option yet."
- "If you compare this to the temporary trailers in the past, this is hands down way better than what we've invested in previously."
- "One advantage on a kit home could be that if they're pre-engineered and designed, it could address those concerns about windstorm and flood requirements."

Buildings then follow a consistent high-quality construction standard to support either the contracted workforce or mobilize an unskilled volunteer workforce. The concept follows that if the same steps are needed for each unit, builders can more quickly learn about and complete housing construction. The standardized building plans also support local code enforcement, by creating consistency in the quality of the design and building process.

Figure 29: Sunshine Home Kits

Photo retrieved from https://sunshinehomekits.com/product-description-1/.

STRENGTHS

- Traditional kit homes already employ the massive production and distribution capabilities of corporate construction companies.
- Traditional kit homes can meet to the local standards and aesthetic expectations of communities because they use existing construction practices and materials.
- Traditional kit homes can establish a common process and standard that streamlines procurement, code enforcement, contracted or volunteer labor, and completion of construction.
- Provides an affordable option for survivors with the construction skills to perform some or all of the construction on their own.

CONSIDERATIONS

- Traditional kit homes can only optimize local production systems through a strictly defined layout and material selection, which reduces options in the size and ability to customize homes.
- Traditional kit homes will meet the same resilience standard as existing high-quality constructed homes, and do not present the same opportunities for code-plus potential as alternative material selection and proprietary technology.
- Traditional kit homes rely on the quality of general contractors building units in communities and cannot be as easily standardized as prefabricated options.

Optimal Use Cases:

Traditional kit homes cannot deploy as quickly as other solutions identified through the Study, but their streamlined procurement and construction process can support a more timely rebuild and long-term recovery process. These also provide an affordable option for survivors with the construction skills to perform some or all of the construction.

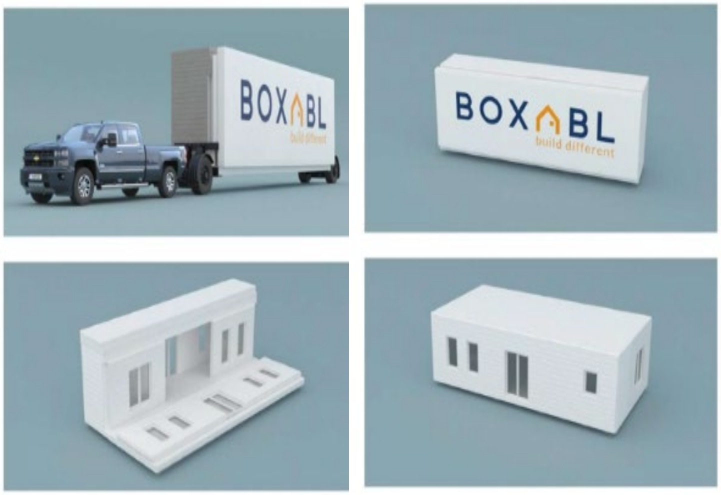
Traditional kit homes are designed to incorporate high-quality construction in a well-defined home size that optimizes energy efficiency and use of space in a manner similar to tiny homes.

PHASE II RECOMMENDATIONS

The following recommendations reflect findings in alternative housing that can translate innovation in the construction sector to tangible next steps serving disaster survivors. Each vendor submission to the HAT survey had a total score and analysis associated with their model. The Study identified four vendor submissions that demonstrated a proof-of-concept that accounted for community needs, achieved high technical scores, and demonstrated viable applications of innovative housing technology. These units are recommended for prototype testing under Phase II.

Boxabl: Boxabl stood out among the modular building submissions due to its steel and concrete laminated building system using SIPs. The structure is built to rapidly deploy and install on-site within less than a day through its foldable construction system. Boxabl is also one of the easiest base units upon which to add more rooms—either Boxabl or traditional construction—to create a permanent home. The combined quality of construction materials with the unit's temporary-to-permanent model warrants additional consideration under Phase II.

Figure 30: Boxabl Foldable Concept



ICON: ICON's use of 3-D printing technology to build concrete structures translated to high overall resilience scores. Housing deployments have the potential for high cost-effectiveness because bulk construction scenarios can optimize the main cost, the Vulcan printer. Their construction process relies on a streamlined supply chain—primary material being the proprietary concrete mixture—and each printer can support production of approximately 200 homes per year. Community stakeholders responded positively to the aesthetic of these, suggesting they meet local architectural standards.

Figure 31: Completed ICON Home

Figure 32: Completed indieDwell Home

indieDwell: The Study received four shipping container submissions to the HAT survey that reflected well-established capabilities to transform resilient base framing systems to safe, livable housing. The indieDwell model distinguished itself among the submissions by its third-party certification in meeting and exceeding codes and standards. It also has notable production capabilities through use of pop-up factories—in the timeframe of the Study, the company launched such a facility in Boulder, CO. The indieDwell model presented the most variety of configurations and exterior finishes, which during community outreach discussions, was highlighted as being critical to community acceptance for shipping container solutions.

LiV-Connected: The LiV-Connected modular building system was a high performer due to its use of SIPs to support a cartridge design that can be efficiently transported (three units per two flat-bed trucks) and constructed on-site (less than one day). The unit also had high scores due to its ability to customize and adapt to local architectural standards, which the designing architects included as core elements, connecting home construction to mental health and well-being. Resilience scores reflected reported abilities to meet code-plus potential, which can be validated and furthered through Phase II testing. The building system is also easily adapted for multifamily construction use cases.

Figure 33: LiV-Connected Model

The identification of these top performers does not preclude the potential strength or application of other alternative housing technologies or vendor submissions in their appropriate contexts.

For full awareness of what is available in the marketplace, readers are encouraged to review comprehensive analysis presented under ***Alternative Housing Technologies*** and ***Appendix A: Vendor Profiles***.

APPENDIX A: VENDOR PROFILES

Vendor profiles reflect the accumulated information gathered from 20 vendor submissions to the HAT survey. The accumulated information provided data for a complete analysis under the Study's hybrid quantitative and qualitative process. In addition to completed submissions under the HAT survey, snapshots of four participating vendors that provided partial data to the Study are included.

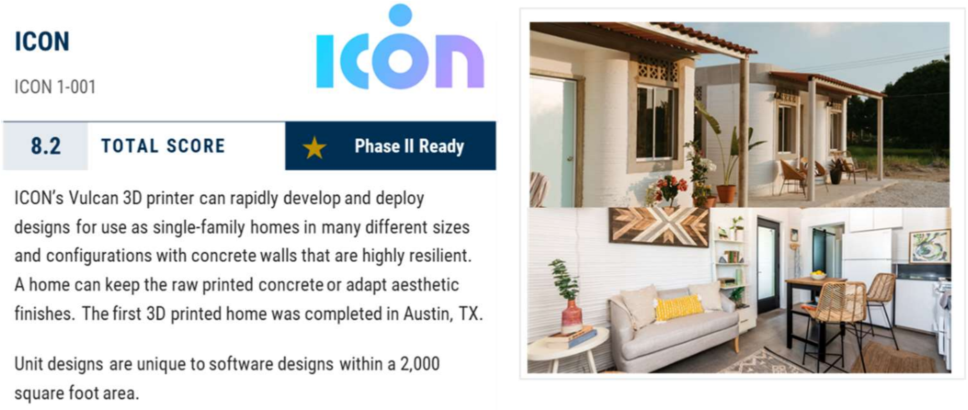
HOW TO READ THE VENDOR PROFILE

The vendor profile is written to capture key datapoints and capabilities for participating vendors in the HAT survey. The following "How-To" guide is a useful reference to note both where information can be found and the Study's methodology for presenting data.

GENERAL INFORMATION

Vendor profiles are titled by the name of the company and include the logo and primary unit evaluated under the Study. The first page includes a general description of the type of alternative housing that the company provides, the unit's capabilities, the key characteristics that distinguish the company's model in the Study, and the range of units both submitted and indicated as available through the vendor. The description is accompanied by an exterior image of the unit and a floorplan of the interior. For units that are capable of expanding and/or connecting, these images reflect the base model that is available.

Figure 34: Vendor Description and Images



ICON

ICON 1-001

8.2 **TOTAL SCORE** ★ **Phase II Ready**

ICON's Vulcan 3D printer can rapidly develop and deploy designs for use as single-family homes in many different sizes and configurations with concrete walls that are highly resilient. A home can keep the raw printed concrete or adapt aesthetic finishes. The first 3D printed home was completed in Austin, TX.

Unit designs are unique to software designs within a 2,000 square foot area.

The profile includes a "Bottom Line Up Front" section to outline a standardized set of data points as they relate the unit's type, size, and cost.

Table 15: Bottom Line Up Front	
Data Point	**Notes**
Unit Type	Defined based on the Study's identified seven categories of alternative housing: 3D printed homes, log kit homes, traditional kit homes, modular foldable units, modular panelized units, modular prefabricated units, and shipping containers.
Size	Delineated by the required lot size to install the unit ("Min. Lot Size") and the overall interior square footage ("Interior SQFT").
Cost Per Square Foot	Calculated per square foot according to the base unit cost and not accounting for reduced expenses for larger sized units (for those housing types that can add-on).
Lifespan	Ranges are identified as being from 7 to 10 years, 11 to 30 years, and more than 30 years.
Stage of Development	Vendor profiles are grouped based on their total production capability (i.e., manufacturing established, units lived in, prototype developed) to indicate the ability to establish a contract. The stage of development identified in this section further elaborates the stage of development based on the following categories: Design Developed, Prototype Developed, and Units Lived In.

Figure 35: Bottom Line Up Front

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
3D Printing	$200	Flexible	Flexible	30+ Years	Units Lived In

The vendor's general contact information, year founded, and experience with post-disaster housing is outlined on page two of the vendor profile (see ***Figure 36***). Contact information is listed for the main point of contact for the Study. It is recommended to go to the vendor's website for the most up-to-date information on changing products and company capabilities.

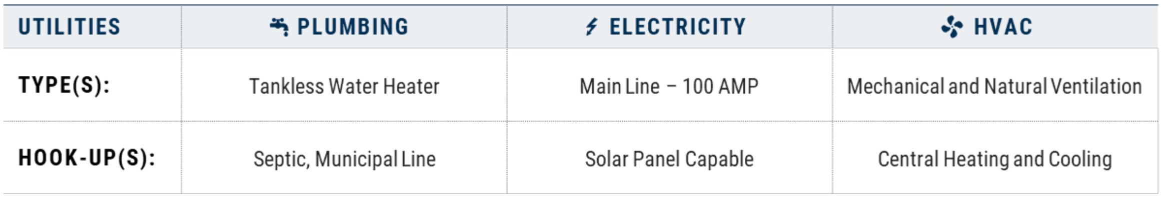
Figure 36: Contact Information

WEBSITE	www.iconbuild.com
CONTACT	Evan Loomis
PHONE	(703) 517-4932
EMAIL	evan@iconbuild.com

ICON was founded in 2017.
It has deployed post-disaster housing.

The unit's ability to hook up to local utility systems (or operate off-grid) is also reviewed on page two of the vendor profile. This includes review of the type and hook-up capabilities of the unit's plumbing, electricity, and heating, ventilation, and air conditioning (HVAC) systems. Any unique capabilities as they relate to unique built-in systems are included under this section.

Figure 37: Utility Types and Hook-ups

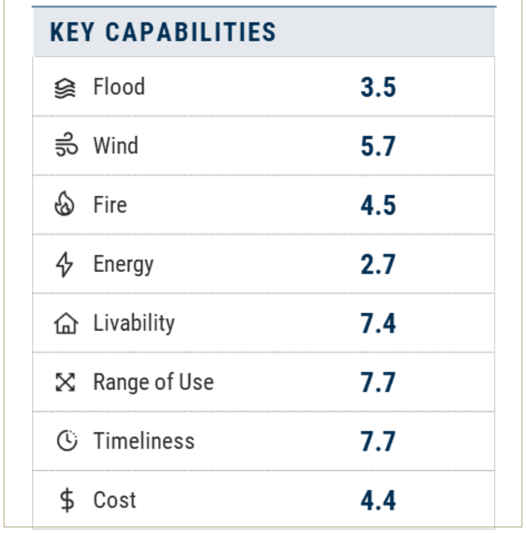


UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Tankless Water Heater	Main Line – 100 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Central Heating and Cooling

SCORING

Units were scored under the Study's hybrid quantitative and qualitative algorithm under a series of categories that were prioritized based on the Study's core outputs. Scores that best indicate the capabilities of a unit are indicated in the "Key Capabilities" section of the vendor profile.

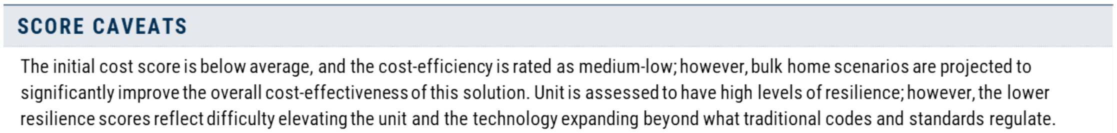
Figure 38: Key Capabilities



KEY CAPABILITIES	
Flood	3.5
Wind	5.7
Fire	4.5
Energy	2.7
Livability	7.4
Range of Use	7.7
Timeliness	7.7
Cost	4.4

Vendors received higher scores under the Study's algorithm when their HAT survey submissions provided more detailed information. This trend in the Study's algorithm skewed the scoring in favor of well-established companies that were able to answer all questions on the survey, as compared to younger companies and start-ups that haven't fully developed their models. The "Score Caveats" section of the vendor profile outlines some of these considerations and qualifications to the overall scores, such that the reader is able to identify companies that, even if they didn't score as high, might be viable for their community.

Figure 39: Score Caveats

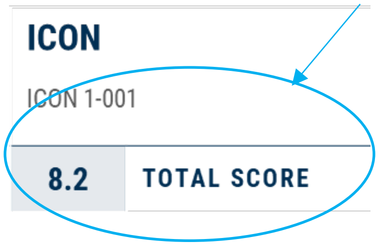


SCORE CAVEATS

The initial cost score is below average, and the cost-efficiency is rated as medium-low; however, bulk home scenarios are projected to significantly improve the overall cost-effectiveness of this solution. Unit is assessed to have high levels of resilience; however, the lower resilience scores reflect difficulty elevating the unit and the technology expanding beyond what traditional codes and standards regulate.

The average score of units across key categories is calculated in an overall score at the top of the vendor profile. Vendors are sequenced in each section based on their overall score (i.e., highest performers followed by lower performers).

Figure 40: Overall Score



ICON

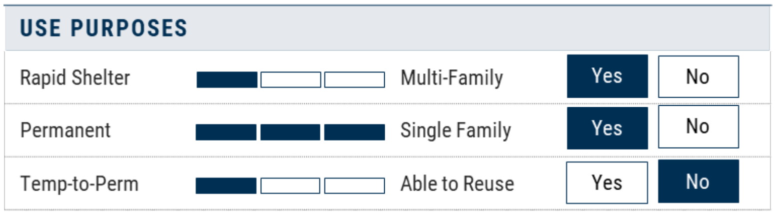
ICON 1-001

8.2 **TOTAL SCORE**

USE PURPOSES

In order to clearly identify units that can fit specific use purposes, the vendor profile identifies the ability of a unit to meet distinct use purposes based on household size and type (i.e., single family housing, multi-family housing), as well as its ability to be reused (i.e., able to disassemble, store and deploy for multiple uses). Use purposes are also reviewed based on the ability of the unit to meet different programmatic needs as they relate to rapid shelter, permanent housing, and temporary-to-permanent housing.

Figure 41: Use Purposes



USE PURPOSES

Rapid Shelter	■□□	Multi-Family	■ Yes	□ No
Permanent	■■■	Single Family	■ Yes	□ No
Temp-to-Perm	■□□	Able to Reuse	□ Yes	■ No

Units were rated between zero and three based on their ability to serve the type of housing need. Ratings were evaluated based on a consistent set of capabilities that were clearly defined within the HAT survey submission (see ***Table 16***).

Table 16: Use Purpose Ratings

Use Purpose	Rating			
	0 bars	1 bar	2 bars	3 bars
Rapid Shelter	Takes more than two weeks to construct on-site	Takes 1 to 2 weeks to construct on-site	Takes less than one week to construct on-site	Takes less than 3 days to construct on-site
Permanent Housing	Less than 7-year lifespan	7 to 10-year lifespan	11 to 30-year lifespan	More than 30-year lifespan
Temporary-to-Permanent Housing	Cannot provide either temporary or permanent housing	Indicated temporary to permanent capability	Takes one week or less to construct AND has a minimum 30-year lifespan AND can expand total size	Meets the standards for a 2-bars rating AND can be constructed in less than 3 days

LIFECYCLE

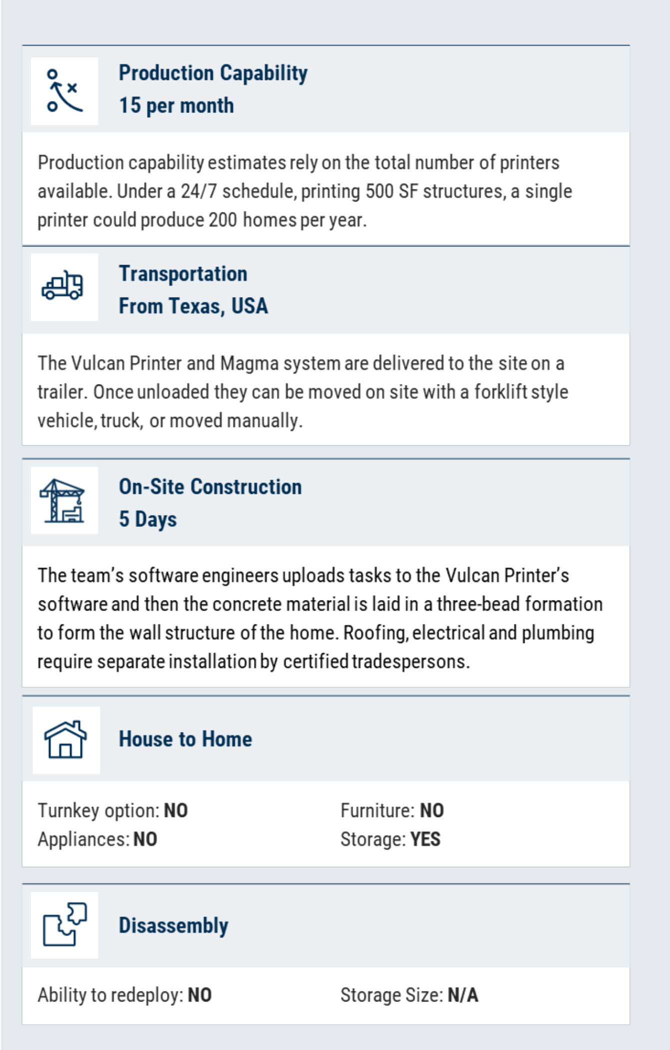
The overall lifecycle of a unit's production is outlined on page two of the vendor profile. The unit's lifecycle is divided into three key sections: "Production," "Transportation," and "On-site Construction." Each of these stages include a narrative section to describe the key factors that inform the identified timeline. Additional considerations are outlined for the final steps to transition a house to a home (i.e., what amenities are included) and the disassemble the unit for redeployment.

The overall production capability for each vendor is based on the projected number of units that can be prefabricated for deployment per month. When comparing these figures, it is important to keep in mind the varying levels of overall completion between different vendors (i.e., modular prefabricated versus panelized). These estimates are based on the assumption of a sustained supply chain and do not account for unexpected challenges during production.

The transportation stage identifies where the unit would be shipped from, assuming production relies on the existing factory locations for the vendor. Some vendors incorporate small "pop-up" factories as a component of their model and may be able to relocate their manufacturing capabilities closer to a desired location, if requested.

The on-site construction stage exclusively accounts for what the vendor provides, which does not account for the additional time to complete the electrical and plumbing systems. This timeline also does not account for the permitting process to install the unit, which will vary by county.

Figure 42: Unit Lifecycle



Production Capability
15 per month

Production capability estimates rely on the total number of printers available. Under a 24/7 schedule, printing 500 SF structures, a single printer could produce 200 homes per year.

Transportation
From Texas, USA

The Vulcan Printer and Magma system are delivered to the site on a trailer. Once unloaded they can be moved on site with a forklift style vehicle, truck, or moved manually.

On-Site Construction
5 Days

The team's software engineers uploads tasks to the Vulcan Printer's software and then the concrete material is laid in a three-bead formation to form the wall structure of the home. Roofing, electrical and plumbing require separate installation by certified tradespersons.

House to Home

Turnkey option: **NO**
Appliances: **NO**
Furniture: **NO**
Storage: **YES**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

UNIT ANALYSIS

The Study includes analysis of each vendor throughout the profile, with emphasis on general qualitative analysis under the general "Strengths" and "Considerations" sections. The general strengths and considerations were used to highlight specific characteristics of units that may not be captured in other aspects of the profile. These generally synopsize those reasons that a community would either select or opt out of selecting a particular vendor.

Figure 43: Strengths and Considerations

STRENGTHS	CONSIDERATIONS
- Approved for use in Texas. ICON built America's first permitted 3D printed homes in Austin, TX. - Printer's ability to utilize nearly any design means that there will be opportunities for resident customization. - Unit materials are classified as flood damage-resistant under FEMA Technical Bulletin 2.	- Given the relative newness of the technology, there may be long-term issues with the printed construction that have not yet been identified. - The company and its production capability are still under five years old, and do not yet have experience in large-scale housing missions.

Outputs that were prioritized in the vendor profile were resilience, range of use, and cost, particularly because these characteristics may qualify and/or disqualify certain units from consideration by different communities. Evaluation under these outputs is framed in the "Resilience Potential," "Ability to Customize," and "Codes & Standards" sections (see ***Figure 44***). Capabilities and compliance are indicated by a fully shaded square next to the identified characteristic. The "Codes & Standards" section further clarifies ongoing evaluation to meet codes and/or qualifications of the identified scores. For example, some international submissions may meet U.S. codes and standards, but were unable to indicate so due to their lack of existing deployments in the U.S.

Figure 44: Evaluation by Output

RESILIENCE POTENTIAL

■ Ability to Raise Electrical Units
■ Structurally Capable of Elevating
■ Sprinkler System
■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

■ Temporary to Permanent
■ Ability to Modify Number of Rooms
■ Customizable Interior Finishes
■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

■ Americans with Disabilities Act
■ Uniform Federal Accessibility Standards
■ Minimum Size and Occupancy under HUD HOME
■ International Residential Code 2012
☐ Texas Windstorm Insurance Association
☐ ASCE 7-10
☐ ASCE 24-14
■ Fortified
☐ ANSI A117.1 Visibility Standard
☐ Green Building Standards

3D printed structures to be tested based on newly recommended standards for the International Residential Code 2021. Units were permitted for use in Travis County, Texas.

Finally, the “Cost Effectiveness” section utilizes an overall benefit-cost ratio—accounting for its resilience, lifespan, and total projected cost—to calculate a resilience cost rating between low, medium-low, medium-high, and high. The section also clarifies the total estimated annual cost per occupant to complement the cost data on the first page of the vendor profile. Finally, the “Cost Effectiveness” section identifies additional costs that are not accounted for in the HAT survey data, which should be accounted for when developing any program estimates using a particular vendor.

Figure 45: Cost Effectiveness

COST EFFECTIVENESS

ICON received a **medium-low** resilience cost rating.

The estimated annual cost per occupant per year is $5,372.

The main identified costs outside the purchase price are transportation and tradespersons.

STEPS TO BECOMING TEXAS READY

A key focus of the Study was reviewing the ability of alternative housing to translate to actionable support for communities in the State of Texas. While the general recommendations and evaluation of vendors can inform the discussion of which vendor might best serve each community’s unique needs, the “Steps to Becoming Texas Ready” section directly identifies what steps need to be taken to logistically support a contract between the vendor and a Texas entity. The existing level of completion for each step is identified based on the shading in the box, with a white box indicating that it has not yet been completed; a partially shaded box indicating that the step is in progress (i.e., there has been tangible progress); and a fully shaded box indicating that the step is complete.

Figure 46: Steps to Becoming Texas Ready

STEPS TO BECOMING TEXAS READY

Prototype Developed

Factory Available

Meets Texas Codes & Standards

Community Buy-in

The Study identified a series of four key steps that are needed to provide a vetted unit that will be accepted by communities (see). The ability to both develop a prototype and establish community buy-in will not directly inform the supply chain or contract established with a vendor, but will inform the programmatic success of a deployment in Texas, and are recommended to be treated as preliminary steps before launching a deployment.

Table 17: Definitions for Steps to Becoming Texas Ready

Step	Notes
Prototype Developed	Indicates that a vendor has fully constructed a prototype of the unit and can establish a supply chain to produce at least one unit.
Factory Available	Indicates that the vendor has established a factory and/or manufacturing partnership that is currently producing units and can support and order of units for shipment to Texas.
Meets Texas Codes and Standards	Indicates that vendors noted their compliance with codes and standards relevant to Texas (e.g., Texas Windstorm Insurance Association) and/or have successfully permitted their buildings in Texas.
Community Buy-In	Indicates that units have been successfully constructed and accepted by recipient communities in Texas and/or that community stakeholders consistently noted approval of the unit.

Units that are recommended for Phase II of the Disaster Recovery Alternative Housing Study—which will entail physical testing of prototypes to verify resilience—are identified with a "Phase II Ready Star" next to the unit's total score.

Figure 47: Phase II Ready Star

Manufacturing Established

The following vendors have existing manufacturing capabilities to launch housing deployments.

TEXAS GENERAL LAND OFFICE
ESTABLISHED 1836

ICON
indieDwell
Connect Homes
Falcon Structures
Horizon North
Dweller

ICON

ICON 1-001

8.2 **TOTAL SCORE** ★ **Phase II Ready**

ICON's Vulcan 3D printer can rapidly develop and deploy designs for use as single-family homes in many different sizes and configurations with concrete walls that are highly resilient. A home can keep the raw printed concrete or adapt aesthetic finishes. The first 3D printed home was completed in Austin, TX.

Unit designs are unique to software designs within a 2,000 square foot area.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
3D Printing	**$200**	**Flexible**	**Flexible**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**3.5**
Wind	**5.7**
Fire	**4.5**
Energy	**2.7**
Livability	**7.4**
Range of Use	**7.7**
Timeliness	**7.7**
Cost	**4.4**

USE PURPOSES

Rapid Shelter	■□□	Multi-Family	[✓ Yes] No
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	Yes [✓ No]

STEPS TO BECOMING TEXAS READY

- **Prototype Developed**
- **Factory Available**
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

The initial cost score is below average, and the cost-efficiency is rated as medium-low; however, bulk home scenarios are projected to significantly improve the overall cost-effectiveness of this solution. Unit is assessed to have high levels of resilience; however, the lower resilience scores reflect difficulty elevating the unit and the technology expanding beyond what traditional codes and standards regulate.

STRENGTHS

- Approved for use in Texas. ICON built America's first permitted 3D printed homes in Austin, TX.
- Printer's ability to utilize nearly any design means that there will be opportunities for resident customization.
- Unit materials are classified as flood damage-resistant under FEMA Technical Bulletin 2.

CONSIDERATIONS

- Unit construction will require education and familiarization in communities to garner buy-in.
- There may be long-term issues with the printers that have not yet been identified.
- The company and its production capability are still under five years old, and do not yet have experience in large-scale housing missions.

WEBSITE	www.iconbuild.com
CONTACT	Evan Loomis
PHONE	(703) 517-4932
EMAIL	evan@iconbuild.com

ICON was founded in 2017.
It has deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ■ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

3D printed structures to be tested based on newly recommended standards for the International Residential Code 2021. Units were successfully permitted for use in Travis County, Texas.

Production Capability
15 per month

Production capability estimates rely on the total number of printers available. Under a 24/7 schedule, printing 500 SF structures, a single printer could produce 200 homes per year.

Transportation
From Texas, USA

The Vulcan Printer and Magma system are delivered to the site on a trailer. Once unloaded they can be moved on site with a forklift style vehicle, truck, or moved manually.

On-Site Construction
5 Days

The team's software engineers uploads tasks to the Vulcan Printer's software and then the concrete material is laid in a three-bead formation to form the wall structure of the home. Roofing, electrical and plumbing require additional time for installation by certified tradespersons.

House to Home

Turnkey option: **NO**
Furniture: **NO**
Appliances: **NO**
Storage: **YES**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

COST EFFECTIVENESS

ICON received a **medium-low** resilience cost rating (see Score Caveat).

The estimated annual cost per occupant per year is $5,372.

The main identified costs outside the purchase price are transportation and tradespersons.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Tankless Water Heater	Main Line – 100 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Central Heating and Cooling

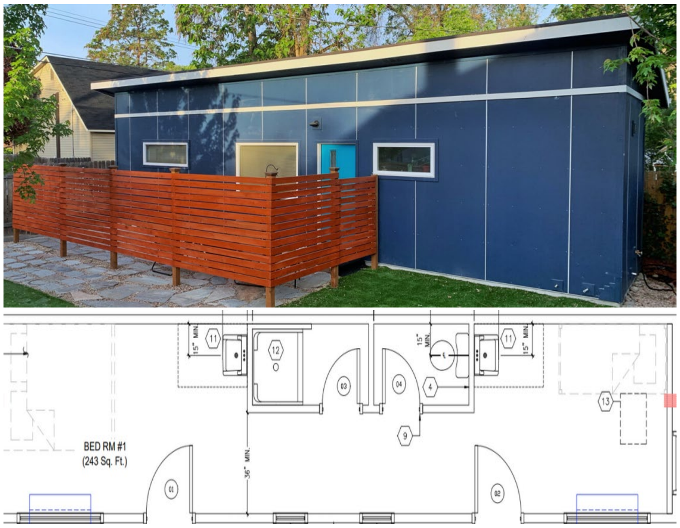
indieDwell

Family Unit

8.2	TOTAL SCORE	★ Phase II Ready

indieDwell manufactures modular housing through partnership networks to support community growth through factory establishment and mixed-income housing developments. The modular housing model uses shipping containers that can be installed individually or in a variety of configurations and/or designs for single family purposes.

indieDwell submitted its standard unit design to the Study.



BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Shipping Container	**$172**	**320 SF**	**320 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**6.1**
Wind	**5.7**
Fire	**3.7**
Energy	**3.9**
Livability	**6.1**
Range of Use	**7.0**
Timeliness	**5.9**
Cost	**5.7**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	[✓ Yes]	No
Permanent	■■■	Single Family	[✓ Yes]	No
Temp-to-Perm	■■■	Able to Reuse	[✓ Yes]	No

STEPS TO BECOMING TEXAS READY

Prototype Developed	**Factory Available**	**Meets Texas Codes & Standards**	**Community Buy-in**

SCORE CAVEATS

indieDwell's scores were adjusted upwards due to the extent of its ability to customize, which was unique in its extent of both unit configurations and availability of interior and exterior finishes. The low fire score is due to a lack of information about the unit's overall fire rating, though it meets IFC 2015.

STRENGTHS

- At the time of this report, units are being mobilized for a temporary-to-permanent deployment in San Jose, CA, with units exceeding local standards.
- Ability to connect and stack units, customize both interior and exterior finishes, and create a home roofing system will engage resident buy-in.
- Units are third party certified.

CONSIDERATIONS

- Community stakeholders emphasized concerns as they relate to shipping container units, underscoring the importance of education and community buy-in to this kind of model, if selected.
- Without connecting units, the total size of the base unit is limited to 320 SF.

WEBSITE	www.indieDwell.com
CONTACT	Chris Blanchard
PHONE	(208) 392-8726
EMAIL	cblanchard@indiedwell.com

indieDwell was founded in 2016.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME (modified)
- ■ International Residential Code 2012
- ■ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ■ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Units are third party certified by the International Code Council. They are Zero Energy Ready Home and Indoor airPLUScertified under federal energy standards.

Production Capability

60 per month

Production capability estimates that one unit takes approximately six days to produce. The assembly line system can translate this into production of one unit per day.

Transportation

From Idaho, USA

Units are shipped one at a time on a flatbed truck. The unit is designed within the wide load such that it does not require special permitting.

Transportation costs would be incurred for each individual unit.

On-Site Construction

5 Days

Units are installed using a crane or forklift to set the container in place, which requires two individuals to support. Utility hook-ups will require the associated tradespersons.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **320 SF**

COST EFFECTIVENESS

indieDwell received a **medium** resilience cost rating.

The estimated annual cost per occupant per year is $2,216.

Costs outside the purchase price are transportation, foundation (est. $10K), and tradespersons.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Water Heater Tank	Main Line – 200 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable Generator Hook-Up Available	Condenser Unit

Connect Homes

Shelter 3 (3br)

8.0 **TOTAL SCORE**

Connect Homes mobilizes a streamlined mass-scale production system to deploy modular non-congregate shelters. Units are designed to improve the space and cost efficiency of rapidly deployable shelter, with multi-family units that can optimize existing open spaces (e.g., open lots) in the case of a disaster.

Connect Homes submitted three shelter designs to the Study, including a 2-br unit, 3-br room unit, and an administrative unit.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Prefabricated Modular	**$94**	**400 SF**	**320 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**4.5**
Wind	**3.4**
Fire	**6.9**
Energy	**7.5**
Livability	**3.9**
Range of Use	**5.9**
Timeliness	**6.2**
Cost	**8.1**

USE PURPOSES

Rapid Shelter	■■■	Multi-Family	[✓ Yes] No
Permanent	☐☐☐	Single Family	Yes [✓ No]
Temp-to-Perm	☐☐☐	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

Prototype Developed	**Factory Available**	**Meets Texas Codes & Standards**	**Community Buy-in**

SCORE CAVEATS

The high energy and fire performance reflects the use of resilient materials, including cement board, to meet green building codes and LEED certification. Units have not yet been deployed or built to code in Texas, and therefore do not yet demonstrate certification of wind resilience, though they reportedly can do so.

STRENGTHS

- Streamlined production system can integrate community design preferences with rapidly deployable structures.
- Units can supplement or entirely replace transitional housing programs through hotels and provide significant cost savings with dignified temporary housing.

CONSIDERATIONS

- The standard shelter units are designed for temporary shelter use and will not satisfy the long-term housing needs in shelter configuration.
- Units can be installed fully off-grid but require regular maintenance (e.g., septic).

WEBSITE	www.connect-homes.com
CONTACT	Gordon Stott
PHONE	(323) 697-2386
EMAIL	gordon@connect-homes.com

Connect Homes was founded in 2013.
It has deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ■ ASCE 7-10
- ■ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Unit has been designed for compliance with US standards, and to reach code-plus potential for wind and fire resilience.

Production Capability
20 per month

Production capability estimates that one unit takes approximately six days to produce. The assembly line system can translate this into production of one unit per day.

Transportation
From California, USA

Units are shipped one at a time on a flatbed truck. The unit is designed within the wide load such that it does not require special permitting.

Transportation costs would be incurred for each individual unit.

On-Site Construction
2-3 Days

Unit is designed for rapid deployment, with an installation process supported by equipment to set the unit on its foundation, and then hook-up utilities (as needed).

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **320 SF**

COST EFFECTIVENESS

Connect Homes received a **high** resilience cost rating.

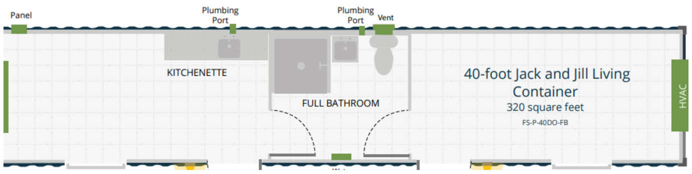
The estimated annual cost per occupant per year is $806.

The main identified costs outside the purchase price are transportation and servicing the septic system.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Water Heater – Flexible Capacity Off-Grid Capable	Main Line	Mechanical and Natural Ventilation
HOOK-UP(S):	Integrated System Included Empty Once per Week	Generator Hook-up Available	Central Heating and Cooling

Falcon Structures

40’ Jack and Jill



7.9 **TOTAL SCORE**

Falcon Structures specializes in shipping containers for use as storage, living, and workspaces. The company’s background includes construction of a 700-container city in Clovis, NM. Many units have been successfully deployed in the marketplace, and the company is informing codes to guide shipping container regulation.

Falcon Structures submitted the Jack and Jill unit, a 1BR-1BA 640 square foot unit, and an open office unit.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Shipping Container	**$112**	**420 SF**	**320 SF**	**11-30 Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**6.1**
Wind	**6.2**
Fire	**4.0**
Energy	**3.5**
Livability	**4.4**
Range of Use	**7.0**
Timeliness	**6.1**
Cost	**7.8**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	Yes [✓ No]
Permanent	■■□	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

Prototype Developed	**Factory Available**	**Meets Texas Codes & Standards**	**Community Buy-in**

SCORE CAVEATS

Although not able to demonstrate wind resilience by code, the overall strength of these structures is likely to be wind resilient if there are a moderate number of cutouts. Fire and energy code scores were a result of lacking direct verification of code compliance, though the company has been a leader in driving forward code certification processes specific to shipping container construction.

STRENGTHS

- Falcon Structures is a well-established company with experience in developing code-compliant models in the State of Texas.
- Shipping containers are rapidly deployable and well suited to fill immediate post-disaster needs.
- Shipping containers have a high level of resilience to wind and rain damage.

CONSIDERATIONS

- Shipping containers were identified by community stakeholders as being negatively received by potential beneficiaries, due to exterior appearance.
- The overall size and livability of the unit is limited by the constraints associated with the layout of the shipping container.

WEBSITE	www.falconstructures.com
CONTACT	Stephen Shang
PHONE	(512) 615-8160
EMAIL	stephen@falconstructures.com

Falcon Structures was founded in 2000.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Under a task force initiative with the International Code Council, Falcon Structures' shipping containers can be permitted under AC462 from the Evaluation Service Report 4163. It is also compliant under the IBC 2015.

Production Capability
4 per month

Manufactured in Manor TX with minimal on-site construction. Production capability is currently two units every two weeks but may be able to scale up with market demand.

Transportation
From Texas, USA

Units are shipped one at a time on a flatbed truck. The unit is designed within the wide load such that it does not require special permitting.

Transportation costs would be incurred for each individual unit.

On-Site Construction
2-3 Days

Units are installed using a crane or forklift to set the container in place, which requires two individuals to support. No foundation required; can be placed on a level, stable surface.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **320 SF**

COST EFFECTIVENESS

Falcon Structures received a **medium-high** resilience cost rating.

The estimated annual cost per occupant per year is $1,694.

The main identified costs outside the purchase price are transportation and on-site tradespersons.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Tankless Water Heater	Main Line – 125 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Generator Hook-up Available	Central Heating and Cooling

Horizon North

Rapid Response Housing

HORIZON NORTH

6.9 **TOTAL SCORE**

Horizon North is a Canada-based company that provides multi-family modular units. Its design utilizes a rapidly deployable, reusable structure that can include a relocatable foundation. Estimated occupancy is 60. Horizon North currently has 1,500 units in use in British Columbia.

Horizon North submitted one modular apartment submission to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$278**	**30,000 SF**	**300 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**3.6**
Wind	**3.7**
Fire	**1.6**
Energy	**1.6**
Livability	**5.0**
Range of Use	**7.3**
Timeliness	**5.8**
Cost	**5.2**

USE PURPOSES

Rapid Shelter	■□□	Multi-Family	● Yes	○ No
Permanent	■■■	Single Family	○ Yes	● No
Temp-to-Perm	■□□	Able to Reuse	● Yes	○ No

STEPS TO BECOMING TEXAS READY

- **Prototype Developed**
- **Factory Available**
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

Vendor provided limited information on code compliance, which negatively impacted scores. The unit has been used widely in Canada, suggesting that actual performance is higher than score indicates.

STRENGTHS

- Horizon North has deployed 1500 units across Canada and can apply previous construction experience to set realistic expectations in costs and capabilities.
- Rapidly deployable multi-family apartment buildings can offset the cost of temporary shelter and support services to renters.
- Horizon North has experience with emergency shelter, and deployed units after fires in Canada in 2019.

CONSIDERATIONS

- Total suite size per occupant is 300 SF, which may be too small for permanent accommodations.
- Horizon North is exclusively applicable to multi-family applications.
- Manufacturing and operational capabilities are based in Canada.

WEBSITE	www.horizonnorth.ca/
CONTACT	Rhys Kane
PHONE	(403) 402-3206
EMAIL	rhys.kane@horizonnorth.ca

Horizon North was founded in 2006.
It has deployed post-disaster housing.

RESILIENCE POTENTIAL

■ Ability to Raise Electrical Units
■ Structurally Capable of Elevating
■ Sprinkler System
☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

■ Temporary to Permanent
■ Ability to Modify Number of Rooms
■ Customizable Interior Finishes
■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

■ Americans with Disabilities Act
■ Uniform Federal Accessibility Standards
☐ Minimum Size and Occupancy under HUD HOME
■ International Residential Code 2012
☐ Texas Windstorm Insurance Association
■ ASCE 7-10
☐ ASCE 24-14
☐ Fortified
■ ANSI A117.1 Visibility Standard
■ Green Building Standards

Units have been permitted under Canadian building codes and are approved for use in the U.S. Additional certifications needed for Texas.

Production Capability
120 per month

Production estimates are based on total number of panelized suites manufactured per month. Manufacturing points are established in Alberta, British Columbia, and Ontario. Manufacturing may be considered in the US if there is demand.

Transportation
From Canada

Units are flat-packed for shipment via flat-bed truck. A full building packaged for shipment is approximately 800 SF. Shipment sizes will vary based on specific building sizes and needs (e.g. pre-fabricated elevator).

On-Site Construction
10 Days

Units use panelized modular system that takes approximately 10 days for on-site construction. Buildings were previously deployed for rapid response after fires in British Columbia, Canada.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **YES**

Disassembly

Ability to redeploy: **YES**
Storage Size: **Varies**

COST EFFECTIVENESS

Horizon North received a **low** resilience cost rating.

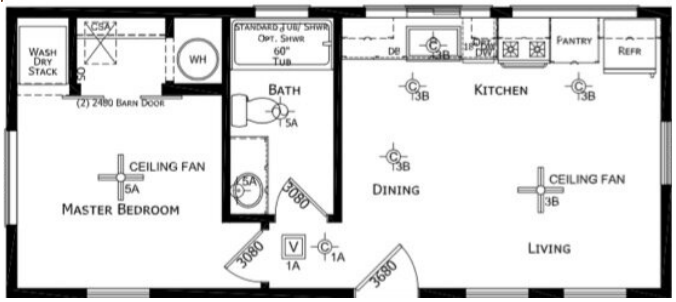
The estimated annual cost per occupant per year is $10,073.

The main identified cost outside the purchase price is transportation.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Tankless Water Heater	Main Line – 200 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Generator Hook-up Available	Central Heating and Cooling

Dweller

Cascades 448



5.9 **TOTAL SCORE**

Dweller builds and installs accessory dwelling units (ADUs), which are pre-fabricated units that use traditional building materials. Dweller specializes in producing ADUs off-site, which lends itself to affordable, efficient housing solutions. Units are constructed using a wood frame system and traditional interior and exterior finishes.

Dweller submitted one unit to the Study but has multiple unit configurations between 435 to 660 square feet.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Prefabricated Modular	**$268**	**1125 SF**	**448 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**3.8**
Wind	**3.3**
Fire	**3.4**
Energy	**2.7**
Livability	**4.2**
Range of Use	**5.2**
Timeliness	**4.6**
Cost	**2.9**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	Yes [✓ No]
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	Yes [✓ No]

STEPS TO BECOMING TEXAS READY

- **Prototype Developed**
- **Factory Available**
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

The cost-effectiveness score does not reflect the overall benefit to homeowners of use as an ADU; rather, it reflects usage as a temporary-to-permanent home. Low resilience scores reflect limited information about applicability of codes in Texas to these units, which are permitted in Oregon. Units have been built to building code as ADUs in Portland, OR.

STRENGTHS

- Unit designs would fit in with existing Texas designs and architecture.
- ADUs can be used to add affordable housing stock to a community after the permanent home is rebuilt.

CONSIDERATIONS

- Unit size would make this option viable exclusively for 1-2 residents.
- Units incur a high total cost for temporary housing and wouldn't necessarily sustain a family's needs over the long-term, unless it could be used as an accessory dwelling unit over the long-term.

WEBSITE	https://www.dweller.com/
CONTACT	Patrick Quinton
PHONE	(503) 330-6568
EMAIL	pquinton@dweller.com

Dweller was founded in 2017.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ☐ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System (modified)
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ■ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ☐ Green Building Standards

Units are approved under Oregon Residential Building Code and can be built under HUD code, as necessary.

Production Capability
1.6 per month

Partners with a major housing manufacturer to produce units, with the potential to scale up quickly if need.

Transportation
From Oregon, USA

Units are shipped one at a time on a flatbed truck. The unit is designed within the wide load such that it does not require special permitting.

Transportation costs would be incurred for each individual unit.

On-Site Construction
2-3 Days

Unit is designed to expedite on-site construction, with an installation process supported by equipment to set the unit on its foundation, and then hook-up utilities (as needed).

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **450 SF**

COST EFFECTIVENESS

Dweller received a **medium-low** resilience cost rating.

The estimated annual cost per occupant per year is $4,835.

The main identified costs outside the purchase price are the foundation, transportation, and tradespersons.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Water Heater – 26-50 Gallons	Main Line – 200 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	No Additional Power Source	Condenser Unit

Units Lived In

The following vendors have deployed and constructed units under U.S. building codes. Large scale manufacturing capabilities may be in progress but are not yet fully capable of supporting a housing deployment.

TEXAS GENERAL LAND OFFICE
ESTABLISHED 1836

Haus.me
Kiro Action
A-FOLD Houses
Hex House
RAPIDO
Urban Rigger
M-Rad
Allwood Industrials

Haus.me

mTwo

9.3 **TOTAL SCORE**

Haus.me models are off-grid capable units that use a patented polymer material to optimize energy efficiency. It includes an online self-diagnosis system and air quality recuperation system. Units are deployed as fully constructed home units on flatbed trucks, with installation taking less than a day.

Haus.me submitted its mOne and mTwo units the Study (indicating number of bedrooms). It also has an mFour unit.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Prefabricated Modular	**$475**	**800 SF**	**700 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**6.4**
Wind	**4.7**
Fire	**6.6**
Energy	**9.4**
Livability	**6.3**
Range of Use	**7.3**
Timeliness	**6.7**
Cost	**6.4**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	Yes [✓ No]
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

■ **Prototype Developed**	■ **Factory Available**	□ **Meets Texas Codes & Standards**	□ **Community Buy-in**

SCORE CAVEATS

High scores reflect of the unit's high quality and superior energy efficiency. However, these characteristics are part of a niche design, use purpose, and cost that do not directly align with identified priorities in Texas.

STRENGTHS

- The polymer construction is highly resilient.
- Haus.me model is the most energy efficient unit evaluated.
- Ability to deploy units entirely off-grid could provide critical support to areas lacking functional utilities after a disaster.
- Unit does not require a foundation to install.

CONSIDERATIONS

- High cost of unit may be prohibitive. However, this is a luxury unit, and the company could design a less expensive version.
- Use of online systems will not be a critical need for many homeowners, increasing the total cost and causing frustration for residents unfamiliar with those technology systems.
- Exterior architecture may not fit in with existing traditional building standards.

WEBSITE	www.haus.me
CONTACT	Max Gerbut
PHONE	(415) 849-5140
EMAIL	max@haus.me

Haus.me was founded in 2017.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ■ ASCE 7-10
- ■ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Unit is approved under industry-accepted standards in the U.S., though it is undergoing certification and approvals. Haus.me is licensed in Nevada and Washington.

Production Capability
5 per month

Production capability can ramp up to 2.5 units developed per week. While large-scale manufacturing capabilities are not yet established, the company is structured with the ability to launch as assembling facilities in 4-5 months, based on need.

Transportation
From Washington, USA

Units are shipped on a flatbed truck, fully constructed and ready for installation. The mTwo system requires two separate unit shipments that are then joined on-site.

On-Site Construction
2-3 Days

Units are installed using a crane to set the structure in place. One trained engineer is needed to install the home and launch its online self-diagnosis system.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **800 SF**

COST EFFECTIVENESS

Haus.me received a **low** resilience cost rating.

The estimated annual cost per occupant per year is $11,956.

The main identified cost outside the purchase price is transportation.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Water Tank – 400+ Gallons	Solar System – 30 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Integrated Septic	Solar System Only	Central Heating and Cooling Includes Air Quality Recuperation System

KIRO ACTION

KIRO ACTION Popup

KIRO ACTION HOUSING
HOUSING & SHELTERS WITH A PURPOSE

8.8 **TOTAL SCORE**

KIRO ACTION is a social good enterprise focused on crisis response and homelessness. Units are designed as a rapid rehousing solution for under-utilized city-owned land (e.g., parking lots). Units are constructed with structural steel panelized walls and utilize a rollaway feature to connect units through a modular building design.

Kiro Action submitted its base model design to the Study. Two- and three-bedroom options are also available.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$167**	**300 SF**	**300 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	7.1
Wind	4.5
Fire	6.0
Energy	5.5
Livability	4.9
Range of Use	7.4
Timeliness	7.3
Cost	8.1

USE PURPOSES

Rapid Shelter	■■■	Multi-Family	Yes [✓ No]
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■■□	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

- ■ Prototype Developed
- ■ Factory Available
- ■ Meets Texas Codes & Standards
- □ Community Buy-in

SCORE CAVEATS

KIRO ACTION received high scores due to the resilience of the metal panelized system and its ability to rapidly deploy. However, the existing layouts of homes and the company's programmatic approach (e.g., deployment in parking lots) indicate highest applicability for service of persons experiencing homelessness.

STRENGTHS

- At the time of this report, KIRO ACTION is currently deploying a pilot program in Austin, TX, to support housing for homeless veterans, indicating existing capabilities to support state housing missions.
- The units use a rollaway model that allows for customization, depending on resident needs.

CONSIDERATIONS

- While KIRO ACTION is currently deploying units for use in the State of Texas, it's very recent launch date as a company (2020) warrants review to ensure production and deployment capabilities.
- Each individual unit comprises a total 200 square feet, most clearly intended for transitional housing, meaning that long-term single-family housing solutions will require multiple units

WEBSITE	www.kiroaction.com
CONTACT	Sam Haytham
PHONE	(972) 763-5794
EMAIL	sh@kiroaction.com

KIRO ACTION was founded in 2020.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ■ ASCE 7-10
- ■ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Compliance with IRC is contingent on use of concrete foundation structure. Additional testing for wind resilience is pending.

Production Capability
200 per month

Factories are not yet established but are in the process of being launched. The company designed the unit to minimize logistics needed to launch factories. 4,000 SF is needed to assemble units (no special equipment needed).

Transportation
From Texas, USA

The unit can be flat-packed for transport, fitting 10 units per semi-truck.

On-Site Construction
1 Day

Unit installation primarily requires unfolding the structure from its transportation configuration. Approximately 3-4 individuals are needed to assemble a completed home.

House to Home

Turnkey option: **YES**	Furniture: **YES**
Appliances: **YES**	Storage: **NO**

Disassembly

Ability to redeploy: **YES**	Storage Size: **320 SF**

COST EFFECTIVENESS

KIRO ACTION received a **high** resilience cost rating.

The estimated annual cost per occupant per year is $453 .

The main identified cost outside the purchase price is transportation.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Water Tank	Main Line – 50 AMP	Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line Off-Grid Capable	Solar Panel Capable	N/A

A-FOLD Houses

Young Model

7.6 TOTAL SCORE

A-FOLD Houses is an Italy-based company that uses a patented prefabricated modular structure that can fold into transportable compact units. The construction process takes between two to three days. The model utilizes a two-level design. Distribution in the United States is facilitated by Freedom Resource Group.

A-FOLD Houses submitted four units to the Study, ranging from 377 to 934 square feet in size.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Foldable Modular	**$175**	**520 SF**	**740 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**3.6**
Wind	**5.9**
Fire	**2.7**
Energy	**3.5**
Livability	**5.3**
Range of Use	**7.4**
Timeliness	**5.2**
Cost	**7.3**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	[✓ Yes] No
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

■ **Prototype Developed**	■ **Factory Available**	□ **Meets Texas Codes & Standards**	□ **Community Buy-in**

SCORE CAVEATS

Low scores in resilience reflect lack of certification under US codes and standards. However, units have been successfully deployed in Europe and are built with a thick panelized system that is expected to be highly resilient.

STRENGTHS

- The patented modular system allows for multiple units to be transported simultaneously.
- Foldable design enables rapid construction.
- The design is intended for a dignified, modern home that is available in multiple sizes.
- The largest unit size (Villa) can be divided into two apartments.

CONSIDERATIONS

- Manufacturing capability is based in Europe will require additional investment to establish a reliable supply chain to target communities.
- While the design is modern and dignified, it may not align with traditional architectural designs in some Texas communities.

WEBSITE	www.a-fold.com
CONTACT	Todd Roberts
PHONE	(918) 409-5158
EMAIL	troberts@freedomresource.group

A-FOLD Houses was founded in 2018.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Units are built to European code compliance. The company built the structures for earthquake resistance and to withstand 140 mph winds.

Production Capability
1 per Month

Manufacturing is based in Italy. The pre-fabricated construction focuses on the shell structure, which is then folded to prepare for transportation.

Transportation
From Italy

Units can be shipped in containers from Italy. Transportation logistics will require significant upfront investment to ensure that all shipping systems can support a pipeline of product.

On-Site Construction
2-3 Days

Homes unfold on site through use of a crane.

An optional foundation can be included that uses a screw pier system, such that the foundation does not need to be pre-installed.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **320 SF**

COST EFFECTIVENESS

A-FOLD Houses received a **medium-high** resilience cost rating.

The estimated annual cost per occupant per year is $2,015.

The main identified costs outside the purchase price are transportation and on-site tradespersons.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Water Tank	Main Line	Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Additional Unit Can Be Provided

Hex House

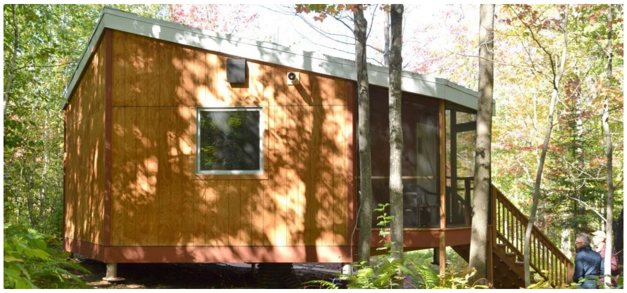
HEX HOUSE

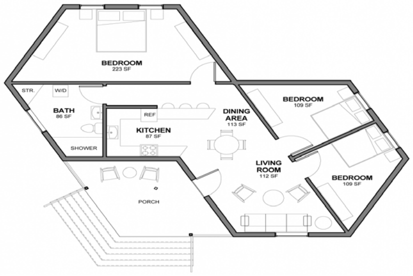
Double-Unit

7.7 **TOTAL SCORE**

The Hex House is a scalable modular design developed in the context of refugee and post-disaster housing needs that can be deployed off-grid and constructed in 5-8 days. The hexagonal structure is anchored through a helical pier system. Each individual unit can be combined in a cluster of up to five.

Hex House submitted its single and double-units to the Study, though a single home can incorporate up to five units.





BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$50**	**1500 SF**	**1020 SF**	**11-30 Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**5.9**
Wind	**5.3**
Fire	**3.3**
Energy	**4.1**
Livability	**5.9**
Range of Use	**7.7**
Timeliness	**4.1**
Cost	**7.4**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	[✓ Yes]	No
Permanent	■■□	Single Family	[✓ Yes]	No
Temp-to-Perm	■■□	Able to Reuse	[✓ Yes]	No

STEPS TO BECOMING TEXAS READY

[✓ **Prototype Developed**]

Factory Available

Meets Texas Codes & Standards

Community Buy-in

SCORE CAVEATS

Hex House received high scores for its overall cost-efficiency but received lower scores for fire and energy resilience due to lack of certification under the identified codes and standards. A unit was successfully permitted and constructed in Wisconsin, USA, indicating that in practice, its energy efficiency is high.

STRENGTHS

- Combination of structural insulated panels (SIPs) and helical pier system lends itself to code-plus fire and wind resilience.
- Clusters of Hex Houses (i.e., five or more units) can support community-building in disaster-affected communities.

CONSIDERATIONS

- Exterior finish can be changed, but overall shape may not align with local community expectations or architecture.
- Units are not currently supported by existing large-scale manufacturing capability, outside of that for individual prototypes.
- Interior wall angles (sharp concave angles) may lead to some wasted space and diminish livability.

WEBSITE	www.hex-house.com
CONTACT	Adam Whipple
PHONE	(312) 515-9467
EMAIL	a.whipple@architectsforsociety.org

Architects for Society was founded in 2015.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Unit has been designed for compliance with US standards.

Production Capability
4 per Month

Manufacturing is not currently established. Production capability estimates 20 days for the design process and 30 days to produce; but this can be launched for multiple units concurrently.

Transportation
From California

Units can flat pack into a regular sized flat-bed truck or trailer.

On-Site Construction
5-7 Days

Unit is designed to be installed in 5-7 days, with support of a crane and equipment to drive in the helical pier foundation system. Volunteers or residents can be trained to support unit installation.

House to Home

Turnkey option: **YES**
Furniture: **YES**
Appliances: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **320 SF**

COST EFFECTIVENESS

Hex House received a **medium-high** resilience cost rating.

The estimated annual cost per occupant per year is $1,215.

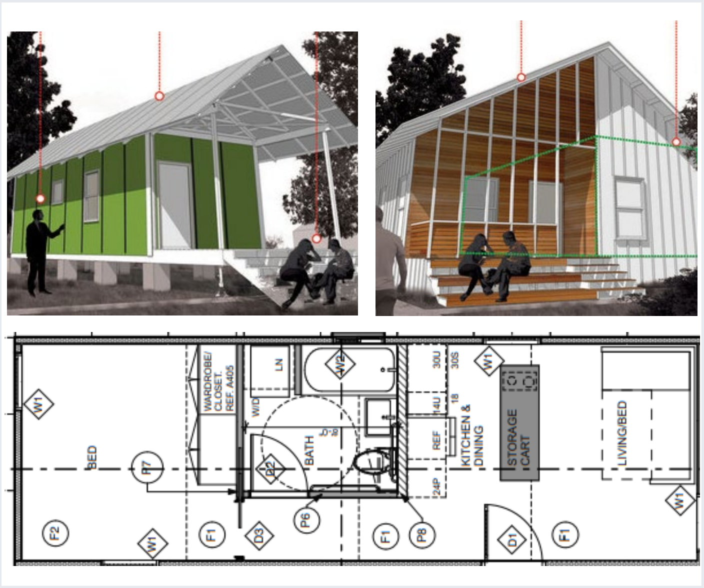
The main identified costs outside the purchase price are transportation and tradespersons (as needed).

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Rainwater Harvesting Water Tank	Main Line	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line, Composting Toilets	Solar Panel Capable	Mini-Split Unit

RAPIDO

B2 Unit

7.1 **TOTAL SCORE**



The RAPDIO model uses a CORE constructed with zip-wall panels, designed to support add-ons that enable the unit's temporary-to-permanent use purpose. The final permanent structure is designed to match local traditionally-built homes, to meet the resident and community's preferences.

RAPIDO submitted its base model to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$110**	**600 SF**	**440 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**5.9**
Wind	**5.9**
Fire	**3.6**
Energy	**3.4**
Livability	**7.2**
Range of Use	**7.0**
Timeliness	**4.2**
Cost	**3.3**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	Yes [✓ No]
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■■■	Able to Reuse	Yes [✓ No]

STEPS TO BECOMING TEXAS READY

- **Prototype Developed**
- **Factory Available**
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

The systematic approach to RAPIDO was very strong and informed the Study's recommendations. However, the unit reflected use of materials that could still be implicated by flood damage. A lack of information on certification under fire and energy codes reduced the scores, though units are successfully serving residents in Texas.

STRENGTHS

- Units were deployed and well received in Texas communities across the Houston-Galveston area and Rio Grande Valley; as a result, community buy-in is widespread in the State of Texas.
- Units enable a temporary-to-permanent deployment that aligns with local community standards.

CONSIDERATIONS

- The unit's use of traditional materials and construction for the long-term construction process may inhibit its resilience, particularly to flooding.
- The unit's long-term construction process will rely on local contractors and may result in variability between quality of permanent home construction.

WEBSITE	www.rapidorecovery.org
CONTACT	Benje Feehan
PHONE	(214) 738-8514
EMAIL	benje@bcworkshop.org

RAPIDO was founded in 2014.
It has deployed post-disaster housing in Texas.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ■ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ☐ Green Building Standards

Unit has been successfully permitted, elevated, and built to local standards in the State of Texas, including Brownsville and the Houston-Galveston area.

Production Capability (Unknown)

Manufacturing capabilities are being developed under a grant from the Rebuild Texas Fund. The full extent of that capability and timeline for deployment is to be determined.

Transportation
From Texas, USA

Units are flat packed on a standard flatbed truck or trailer for transportation.

On-Site Construction
3-4 Days

Unit utilizes a panelized system that can be constructed in 3-4 days during the initial deployment.

Longer-term construction requires additional traditional construction.

House to Home

Turnkey option: **NO**
Appliances: **NO**
Furniture: **NO**
Storage: **YES (temp-to-perm)**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

COST EFFECTIVENESS

RAPIDO received a **medium-high** resilience cost rating.

The estimated annual cost per occupant per year is $1,915.

Costs outside the purchase price are transportation, tradespersons, and permanent construction.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Water Tank – 11-25 Gallons	Main Line	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Mini-Split Unit

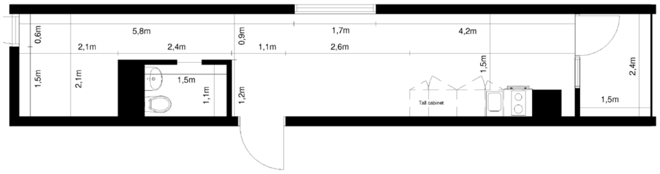
Urban Rigger

Urban Rigger

5.7	TOTAL SCORE

The Urban Rigger is a design patented multi-family housing system constructed from shipping containers on a floating concrete base that optimizes space in unused bodies of water where in areas lacking sufficient land for housing. The system is constructed with stacked containers.

Urban Rigger submitted its 12-apartment building system. It is currently developing an 18-apartment building system.



BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Shipping Container	**$113**	**2,871 SF**	**2,211 SF**	**30+ Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**1.6**
Wind	**3.4**
Fire	**4.1**
Energy	**3.9**
Livability	**4.6**
Range of Use	**5.3**
Timeliness	**3.6**
Cost	**2.8**

USE PURPOSES

Rapid Shelter	☐☐☐	Multi-Family	[✓ Yes]	No
Permanent	■■■	Single Family	Yes	[✓ No]
Temp-to-Perm	☐☐☐	Able to Reuse	Yes	[✓ No]

STEPS TO BECOMING TEXAS READY

■ **Prototype Developed**	■ **Factory Available**	☐ **Meets Texas Codes & Standards**	☐ **Community Buy-in**

SCORE CAVEATS

Urban Rigger did not provide information verifying compliance with codes and standards in the US, which negatively impacted resilience scores. Units are successfully serving Copenhagen, Denmark, indicating compliance with European codes and standards that may translate to successful transition to the US.

STRENGTHS

- Unit can support coastal areas with vacancies left by industries, particularly in ports or other areas with some built-in infrastructure.
- Unit utilizes sustainability-focused utilities that use water and solar panels to power the facility.
- Urban Riggers incorporate multiple community spaces to their design.

CONSIDERATIONS

- Unit is focused on niche use purposes that require availability of a port or other industry-based lot that is no longer in use.
- Systems do not fit in with existing Texas designs.
- Production capability is currently based in Denmark, and applications in Texas would require establishment of new manufacturing facilities and/or incur significant transportation costs.

WEBSITE	www.urbanrigger.com
CONTACT	Lars Funding
PHONE	(452) 780-2208
EMAIL	lf@urbanrigger.com

Urban Rigger was founded in 2013.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

■ Ability to Raise Electrical Units
☐ Structurally Capable of Elevating
☐ Sprinkler System
☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

■ Temporary to Permanent
☐ Ability to Modify Number of Rooms
■ Customizable Interior Finished
☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

☐ Americans with Disabilities Act
☐ Uniform Federal Accessibility Standards
☐ Minimum Size and Occupancy under HUD HOME
☐ International Residential Code 2012
☐ Texas Windstorm Insurance Association
☐ ASCE 7-10
☐ ASCE 24-14
☐ Fortified
☐ ANSI A117.1 Visibility Standard
☐ Green Building Standards

Unit has been designed for compliance with building standards in Europe.

Production Capability
1 per Year

Production capability estimates a year needed to fully construct an Urban Rigger system. Approximately 50% of the unit is built in the factory.

Transportation
From Denmark

Units are transported as separate shipping containers to site.

Upon being fully constructed, transportation will require use of a tugboat to move the structure.

On-Site Construction
90 Days

Unit is designed for installation in 90 days. While the structure is prefabricated, components are flat-packed and require on-site construction.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **YES**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

COST EFFECTIVENESS

Urban Rigger received a **medium** resilience cost rating.

The estimated annual cost per occupant per year is $3,358.

The main identified cost outside the purchase price is transportation.

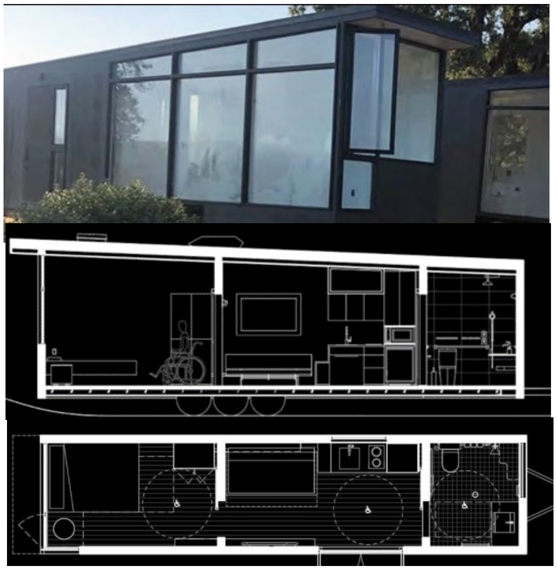
UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Water Tank – 50 Gallons	Included – 30 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable Sea Water Generators	Central Heating and Cooling

M-Rad

Mohe

5.6 **TOTAL SCORE**

M-Rad utilizes an ergonomic design for recreational vehicles. Units are equipped with a permanent chassis for continued transportability. These units were first commissioned as prototypical mobile units for a site in Yosemite National Park. These units are currently used for luxury tourist accommodations and will require material changes to support post-disaster housing.



M-Rad submitted its base model to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Prefabricated Modular	**$255**	**420 SF**	**320 SF**	**11-30 Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**2.3**
Wind	**0.6**
Fire	**1.7**
Energy	**5.0**
Livability	**5.1**
Range of Use	**6.0**
Timeliness	**5.2**
Cost	**2.6**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	Yes [✓ No]
Permanent	■■□	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

■ **Prototype Developed**	■ **Factory Available**	□ **Meets Texas Codes & Standards**	□ **Community Buy-in**

SCORE CAVEATS

Units were identified as having similar code compliance and overall resilience capabilities to a travel trailer. The unit's use of high-quality interior finish materials and prioritization of comfort translated to higher livability and range of use scores.

STRENGTHS

- Units are mobile and equipped with a permanent chassis for continued transportability.
- Units can be re-deployed for temporary use.
- The units meet standards and propose a high-quality recreational vehicle design.

CONSIDERATIONS

- Units do not clearly exceed standards for resilience, and use traditional materials (e.g., wood) for construction, which may result in significant damage during a flood or wind event.
- Units will not address long-term needs of survivors.

WEBSITE	www.m-rad.com
CONTACT	Matthew Rosenberg
PHONE	(323) 202-0950
EMAIL	matthew@m-rad.com

M-Rad was founded in 2012.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Unit is certified for use under the ANSI A119.5-15 Recreational Park Trailer Standard, 2015. It has been reviewed and received third party certification.

Production Capability
1 per Month

Company recently started fabricating its product in California and Colorado. The full extent of that manufacturing capability is to be determined.

Transportation
From California, USA

Units are towable and do not require any special permit or vehicle for transportation. They are equipped with a permanent chassis to maintain transportability. Units can only be shipped one at a time, per vehicle.

On-Site Construction
2-3 Days

Units are equipped with a permanent chassis for transportability. The units can be driven to the lot and left on wheels or tied down to a foundation system for permanent use.

House to Home

Turnkey option: **YES**	Furniture: **YES**
Appliances: **YES**	Storage: **NO**

Disassembly

Ability to redeploy: **YES**	Storage Size: **320 SF**

COST EFFECTIVENESS

M-Rad received a **medium** resilience cost rating.

The estimated annual cost per occupant per year is $2,821.

The main identified cost outside the purchase price is transportation.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Tankless Water Heater	Main Line	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	No Additional Power Source	Air Conditioners, Space Heaters

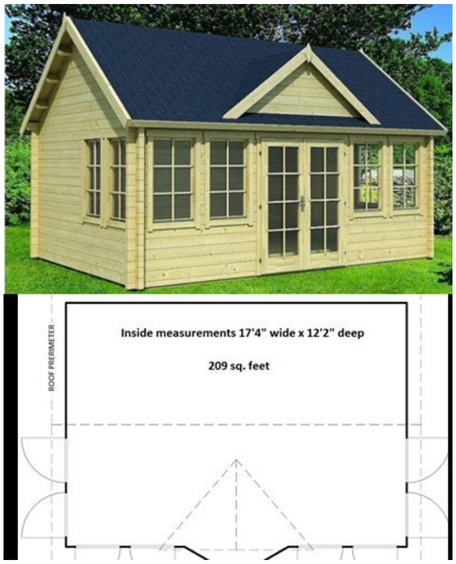
Allwood Industrials

Urban Rigger

4.6 **TOTAL SCORE**

Allwood Industrials retails eco-friendly Millwork and Engineered Wood products manufactured and imported from Scandinavia and the Baltic States. Products use interlocking tongue-and-groove logs to construct small and mid-size cabins in less than a week. The product solely includes the shell of the home.

Allwood Industrials submitted its smallest unit to the Study. It has a range of small, mid-size, and large units available.



BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Log Kit Home	**$42**	**250 SF**	**209 SF**	**11-30 Years**	**Units Lived In**

KEY CAPABILITIES

Flood	**1.6**
Wind	**3.4**
Fire	**4.1**
Energy	**3.9**
Livability	**2.8**
Range of Use	**4.8**
Timeliness	**4.4**
Cost	**4.0**

USE PURPOSES

Rapid Shelter	■□□	Multi-Family	Yes [✓ No]
Permanent	■■□	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	Yes [✓ No]

STEPS TO BECOMING TEXAS READY

[✓ **Prototype Developed**]	[✓ **Factory Available**]	**Meets Texas Codes & Standards**	**Community Buy-in**

SCORE CAVEATS

Low scores reflect the primary use purpose of Allwood Industrials as being for recreational purposes, rather than permanent construction. However, the unit provides a useful reflection of available log kit home technology and its ability to support rapid construction of a building shell.

STRENGTHS

- Allwood Industrials is a low-cost solution for rapid construction shelter, particularly as an accessory dwelling unit on a property.
- The design aligns with community standards in many Texas communities.

CONSIDERATIONS

- Allwood Industrials exclusively provides the shell structure. No interior wiring or plumbing is included. Insulation and interior finishes would require coordination with local contractors.
- Units are built as recreational structures and are therefore not permitted for residential housing.

WEBSITE www.allwoodoutlet.com
CONTACT Robin Pekkala
PHONE (561) 799-1991
EMAIL robbin.pekkala@allwoodindustrials.com

Allwood Industrials was founded in 2000.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ☐ Green Building Standards

Unit is deployed as a recreational structure shell and does not currently meet code compliance for permanent residences.

Production Capability
24 per Month

Production capability relies on sourcing from Estonia and Finland. Capacity can be increased with advance notice.

The Claudia model is a stock model that is already in production.

Transportation
From Baltics

Units are packed in a crate container for shipment, which is deployed from either Finland or Estonia. Shipments can include 8 units in a 40-ft container.

On-Site Construction
3 Days +

Unit is designed for installation in approximately 3 days, with support from 2 people. Construction is designed to be intuitive for non-skilled laborers. Interior finishes and utilities will require tradespersons and an added timeline.

House to Home

Turnkey option: **NO**
Appliances: **NO**
Furniture: **NO**
Storage: **NO**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

COST EFFECTIVENESS

Allwood Industrials received a **high** resilience cost rating.

The estimated annual cost per occupant per year is $418.

The cost for a residential unit would triple the purchase price, for wiring, plumbing, and interior finishes.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Not Included	Not Included	Not Included
HOOK-UP(S):	N/A	N/A	N/A

Prototype Developed

The following vendors have fully developed concepts and prototypes that can inform innovative approaches to post-disaster housing. Units are not currently deployed or lived-in.

TEXAS GENERAL LAND OFFICE
ESTABLISHED 1836

Boxabl
LiV-Connected
SUNSHINE Home Kits
AbleNook
Gravity Architects
SO?

Boxabl

Casita

9.3	TOTAL SCORE	★ Phase II Ready

Boxabl uses an assembly line model to construct structures made from steel, EPS foam, LVL lumber, and magnesium oxide board. Units rapidly deploy to site and can be installed in less than a week. Individual units stack or connect to create larger structures, which can be designated for permanent use to rebuild communities.

Boxable submitted its base unit to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Foldable Modular	**$124**	**400 SF**	**400 SF**	**30+ Years**	**Prototype Developed**

KEY CAPABILITIES

Flood	**6.1**
Wind	**4.7**
Fire	**7.9**
Energy	**7.3**
Livability	**7.2**
Range of Use	**7.9**
Timeliness	**7.0**
Cost	**7.6**

USE PURPOSES

Rapid Shelter	■■■	Multi-Family	[✓ Yes]	No
Permanent	■■■	Single Family	[✓ Yes]	No
Temp-to-Perm	■■■	Able to Reuse	[✓ Yes]	No

STEPS TO BECOMING TEXAS READY

- **Prototype Developed**
- **Factory Available**
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

Boxabl receive high scores in across resilience and livability-focused categories due to the strength of the concept and its compliance to codes and standards. However, units have not yet been deployed for use in the US and may incur unexpected costs or delays during their initial use.

STRENGTHS

- The company has existing funding sources to grow its mass production model, which may result in manufacturing capacity to support large-scale deployments.
- Units can take on any exterior finish, allowing them to shift with shapes and aesthetics that fit local housing standards.

CONSIDERATIONS

- The units cost approximately $50K per each module, which is a compounding price for a building requiring more than one unit.
- The company has not yet launched a full post-disaster housing deployment.

WEBSITE www.boxabl.com/disaster
CONTACT Galiano Tiramani
PHONE (203) 550-4493
EMAIL gtiramani@boxabl.com

Boxabl was founded in 2017.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ☐ Customizable Interior Finished
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Unit has been designed for compliance with US standards. The unit is currently undergoing third party certification to verify this compliance prior to distribution.

Production Capability
4 per Month

Production capability is being established in Nevada. Estimates project the ability to launch at approximately 1 unit per week. Units are almost entirely prefabricated prior to deployment.

Transportation
From Nevada, USA

Units are folded down for transportation to site. Their size for transport allows for one unit per flat-bed truck.

On-Site Construction
1 Day

Unit is designed to be installed in two hours (with preinstalled foundation) with the use of a crane and four laborers.

Units can be stacked or connected to other Boxabls or combined with traditional construction to establish permanent housing.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **8.5x4 SF**

COST EFFECTIVENESS

Boxabl received a **medium-high** resilience cost rating.

The estimated annual cost per occupant per year is $1,995.

The main identified costs outside the purchase price are transportation and on-site tradespersons.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Water Tank – 11-25 Gallons	Main Line – 100 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Condenser Unit

LiV-Connected

CH-1

8.4	TOTAL SCORE	★ Phase II Ready

The Connected Home is a modular, prefabricated home designed to provided dignified housing for disaster survivors. The model is intended for rapid deployment, fitting three units to two flatbed trucks and requiring two people and only a few hours to assemble. Its modular design is also purposed with the ability to customize to a permanent home.

LiV-Connected submitted its base unit to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$170**	**525 SF**	**440 SF**	**30+ Years**	**Prototype Developed**

KEY CAPABILITIES

Flood	**4.6**
Wind	**5.3**
Fire	**4.8**
Energy	**5.3**
Livability	**7.1**
Range of Use	**7.6**
Timeliness	**6.2**
Cost	**5.1**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	[✓ Yes]	No
Permanent	■■■	Single Family	[✓ Yes]	No
Temp-to-Perm	■■■	Able to Reuse	[✓ Yes]	No

STEPS TO BECOMING TEXAS READY

[✓ **Prototype Developed**]	**Factory Available**	**Meets Texas Codes & Standards**	**Community Buy-in**

SCORE CAVEATS

Units have not yet permitted homes in the US and have therefore not certified compliance. However, their design and material use reflects highly resilient and code compliant construction.

STRENGTHS

- Units are designed for high level of code compliance.
- Unit design includes ability to customize both the interior and exterior.
- Units can stack and connect for large or multi-family groups.
- Ability to rapidly deploy and install housing would allow for immediate service to survivors.
- The unit provides an adjustable Auger helical pier system.

CONSIDERATIONS

- The unit has not yet been deployed, so the functional elements of its design that have high promise (e.g., code compliance) have not been tested.
- The company was founded recently (2018) and doesn't have experience with large scale modular housing deployments.

WEBSITE	www.liv-connected.com
CONTACT	Herb Rogove
PHONE	(949) 307-8288
EMAIL	hrogove@liv-connected.com

LiV-Connected was founded in 2018.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ■ Customizable Interior Finished
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act (modified)
- ■ Uniform Federal Accessibility Standards (modified)
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ■ Texas Windstorm Insurance Association
- ■ ASCE 7-10
- ■ ASCE 24-14
- ☐ Fortified
- ■ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Unit has been designed to filling standards, pending application to the municipal government.

Production Capability
(Unknown)

Production capability is not yet established. Projections expect that upon establishing a supply chain and factory, the cartridge system can be built at a rate of 250 units per month.

Transportation
From New York, USA

Units are packed for transportation to site. Their size allows for 1.5 units per truck or 3 units per two trucks.

On-Site Construction
3 Days

Unit is designed to be installed in two hours (with preinstalled foundation) and requires two skilled laborers. Additional utilities hook-ups will require associated tradespersons.

Units can be altered for permanent housing.

House to Home

Turnkey option: **YES**
Furniture: **YES**
Appliances: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **294 SF**

COST EFFECTIVENESS

LiV-Connected received a **medium** resilience cost rating.

The estimated annual cost per occupant per year is $3,540.

The main identified costs outside the purchase price are transportation and on-site tradespersons.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Water Tank – 11-25 Gallons	Main Line – 100 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Condenser Unit

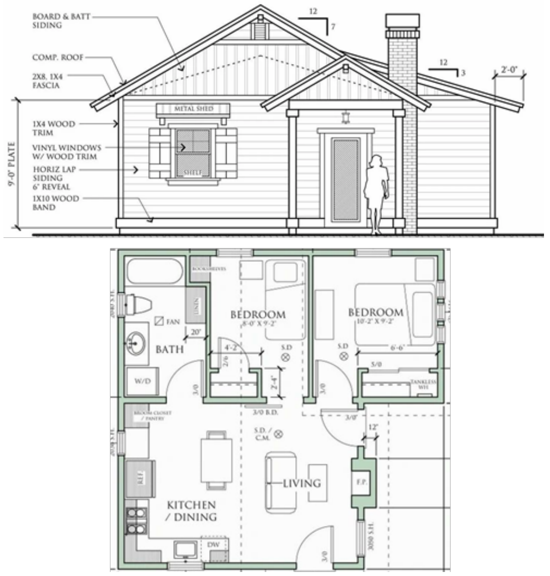
SUNSHINE Home Kits

2020 Model A-600 SF

8.0 **TOTAL SCORE**

SUNSHINE Home Kits mobilizes a network of partnerships with supply distribution corporations that can rapidly develop and deploy home building kits. Their construction system uses local assembly lines to enable rapid home construction and streamlined training for local workers.

SUNSHINE Home Kits submitted its base configuration to the Study. Two floor plans and four theme variations are available.



BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Traditional Kit Home	**$208**	**850 SF**	**600 SF**	**30+ Years**	**Prototype Developed**

KEY CAPABILITIES

Flood	**3.6**
Wind	**6.0**
Fire	**2.3**
Energy	**9.0**
Livability	**5.5**
Range of Use	**7.7**
Timeliness	**4.4**
Cost	**4.2**

USE PURPOSES

Rapid Shelter	■□□	Multi-Family	Yes [✓ No]
Permanent	■■■	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	Yes [✓ No]

STEPS TO BECOMING TEXAS READY

- **Prototype Developed** ✓
- **Factory Available** ✓
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

Incorporation of EnergyStar appliances and construction under green building code resulted in high energy resilience ratings. Low fire and flood ratings reflect the lack of certification under codes and standards in Texas, though the company's model is designed to incentive code-plus building practices.

STRENGTHS

- Business model optimizes volunteer and contracted workforce to support rapid procurement and construction.
- Traditional construction look will align with local architecture.
- Assembly line model can support the growth of the workforce.
- Existing partnerships with corporate manufacturers and distributors can enable rapid production process.

CONSIDERATIONS

- Materials used are high quality, but do not entail the same level of resilience as proprietary options.
- Deployment of this system requires a strong general contractor.
- Units are entirely standardized in look and interior.

WEBSITE	www.sunshinehomekits.com
CONTACT	William A. Sagona
PHONE	(541) 497-3585
EMAIL	info@sunshinehomekits.com

SUNSHINE Home Kits was founded in 2010.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ☐ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ■ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ☐ Customizable Interior Finished
- ☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ■ Minimum Size and Occupancy under HUD HOME
- ■ International Residential Code 2012
- ■ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ■ Fortified
- ■ ANSI A117.1 Visibility Standard
- ■ Green Building Standards

Sunshine Home Kits highlights its compliance with Earth Advantage standards, which prioritize code-plus green building standards

Production Capability
76,000 per Month

Manufacturing is facilitated by corporate distributors. The resulting production capability aligns with existing stock by those distributors, estimated at 76,000 per month.

Transportation
From Local Distributor (e.g., Home Depot)

Kits palletized, shrink-wrapped, and sent to site by distributors.

On-Site Construction
14 Days

Unit is designed to streamline construction through local contractors and/or volunteer labor, by using an assembly line process that standardizes home construction. Estimated on-site construction timeline is alleviated by facilitated procurement process.

House to Home

Turnkey option: **YES**
Furniture: **YES**
Appliances: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

COST EFFECTIVENESS

Sunshine Home Kits received a **medium** resilience cost rating.

The estimated annual cost per occupant per year is $3,358.

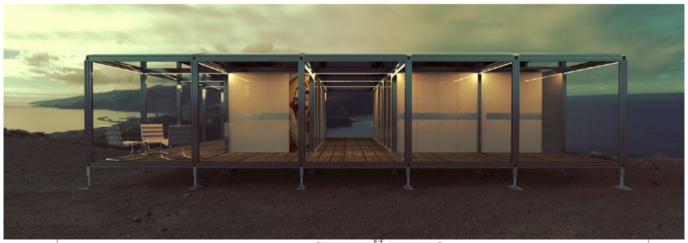
The main identified cost outside the purchase price is on-site construction (e.g., general contractor).

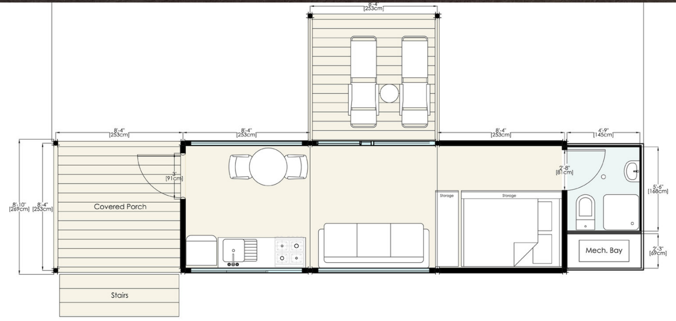
UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Water Tank	Main Line	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Mini-Split Unit

AbleNook

A1

6.7	TOTAL SCORE





AbleNook is a flat-packed, site assembled kit made from aircraft-grade aluminum structural framing that slides/snaps together with SIPs (structural insulated panels) for floors, walls and roof. AbleNook can be deployed on uneven terrain using adjustable leg jacks. The standard unit size is 270 SF but can expand to many different configurations.

AbleNook submitted its base unit to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$278**	**300 SF**	**270 SF**	**11-30 Years**	**Prototype Developed**

KEY CAPABILITIES

Flood	**3.6**
Wind	**5.9**
Fire	**6.7**
Energy	**3.8**
Livability	**4.4**
Range of Use	**5.1**
Timeliness	**6.0**
Cost	**5.4**

USE PURPOSES

Rapid Shelter	■■■	Multi-Family	Yes	[✓ No]
Permanent	■■□	Single Family	[✓ Yes]	No
Temp-to-Perm	■■□	Able to Reuse	[✓ Yes]	No

STEPS TO BECOMING TEXAS READY

■ **Prototype Developed**	■ **Factory Available**	□ **Meets Texas Codes & Standards**	□ **Community Buy-in**

SCORE CAVEATS

The AbleNook's low flood and energy scores reflect a lack of information certifying its code compliance. However, units are built with a resilient steel and aluminum panels that are projected to have high resilience qualities, and as the company launches units in the US this year, additional information may become available.

STRENGTHS

- Units are designed for high level of code compliance.
- AbleNook provides a hurricane package option to include cross braces, corner brackets, and/or tie downs.
- Construction process enables a wide diversity of potential configurations, to meet various size needs.
- The built-in leg jacks allow for rapid deployment without an existing foundation.

CONSIDERATIONS

- The company just launched its manufacturing capabilities, and large-scale deployments have not yet undergone testing processes to verify capability.
- Units do not allow for interior or exterior customizability and may not meet some local community preferences.

WEBSITE	www.ablenook.com
CONTACT	Sean Veredicia
PHONE	(813) 477-8819
EMAIL	sean@ablenook.com

AbleNook was founded in 2017.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System
- ■ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ■ Ability to Modify Number of Rooms
- ☐ Customizable Interior Finished
- ☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ■ Americans with Disabilities Act
- ■ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ☐ Green Building Standards

Unit has not yet been tested or certified to meet codes and standards in the U.S. However, all construction and code compliance is built to meet Miami-Dade permanent building code.

Production Capability
15 per Month

Manufacturing capabilities recently launched and are serving the company's first customers. Production capability estimates growth of capacity over time to 8 units per week for large orders.

Transportation
From Florida, USA

Units can fit one per shipping container for transportation.

On-Site Construction
1-2 Days

Unit requires a minimum of two people for assembly, which does not require any major equipment.

Warranties are only applicable if an approved team of builders supports construction.

House to Home

Turnkey option: **YES**
Appliances: **YES**
Furniture: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **80 SF**

COST EFFECTIVENESS

AbleNook received a **medium** resilience cost rating.

The estimated annual cost per occupant per year is $3,540.

The main identified costs outside the purchase price are transportation and on-site tradespersons.

UTILITIES	PLUMBING	ELECTRICITY	HVAC
TYPE(S):	Water Tank – 11-25 Gallons	Main Line – 100 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	Solar Panel Capable	Condenser Unit

Gravity Architects

Treehouse

5.1 **TOTAL SCORE**

The Treehouse uses modular OSB SIPs in a unit design that prioritizes rapid rollout and accessibility accommodations. The flexibility of the design to community input is representative of interest in the marketplace to develop design concepts based on community needs. Production capabilities are based on existing partnerships with manufacturers.

Gravity Architects submitted its base model to the Study

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Panelized Modular	**$320**	**420 SF**	**420 SF**	**11- 30 years**	**Design Developed**

KEY CAPABILITIES

Flood	**2.8**
Wind	**2.8**
Fire	**2.8**
Energy	**3.3**
Livability	**6.6**
Range of Use	**5.8**
Timeliness	**2.3**
Cost	**0.2**

USE PURPOSES

Rapid Shelter	■□□	Multi-Family	Yes [✓ No]
Permanent	■■□	Single Family	[✓ Yes] No
Temp-to-Perm	■□□	Able to Reuse	Yes [✓ No]

STEPS TO BECOMING TEXAS READY

- **Prototype Developed**
- **Factory Available**
- **Meets Texas Codes & Standards**
- **Community Buy-in**

SCORE CAVEATS

Low scores reflect the design being in its initial development stages and not yet meeting codes for construction in the US. However, the company is reputable in US construction and the design concept's consideration of accessibility is highlighted in its livability and range of use scores.

STRENGTHS

- Unit design prioritizes accessibility and comfort, which will benefit overall livability for the resident.
- The principal architect's experience in rapidly deployable shelter in New Orleans after Hurricane Katrina can support real-world knowledge needed to transition the shelter design to implementation.
- The Treehouse unit is intentionally open to building the design process collaboratively with communities.

CONSIDERATIONS

- The design is not yet at a prototype phase and cannot fully account for all challenges or other considerations that may emerge through the manufacturing process.
- The Treehouse design does not yet have a proof of concept that the building process can meet codes and standards.
- The size of one model restricts total capacity to 1-2 residents.

WEBSITE	www.gravity-architects.com
CONTACT	Carlos Augusta Garcia
PHONE	(410) 991-6156
EMAIL	gravityarx@gmail.com

Gravity Architects was founded in 2019.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ☐ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System (modified)
- ■ Uplift Rating Above 130 mph (as designed)

ABILITY TO CUSTOMIZE

- ■ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ■ Customizable Interior Finishes
- ■ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ☐ Green Building Standards

Design is currently at a prototype phase that does not yet include certifications under codes and standards.

Production Capability
1.6 per month

Production capability not yet established. Projected to utilize partnerships with OSB SIPs and modular manufacturers to fully prefabricate units prior to delivery.

Transportation
7-10 Days (From CA)

Units are shipped one at a time on a flatbed truck. The unit is designed within the wide load such that it does not require special permitting.

Transportation costs would be incurred for each individual unit.

On-Site Construction
30 Days

Unit is designed to expedite on-site construction with an installation process supported by equipment to set the unit on its foundation, and then hook-up utilities (as needed).

House to Home

Turnkey option: **YES**
Furniture: **YES**
Appliances: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **NO**
Storage Size: **N/A**

COST EFFECTIVENESS

Gravity Architects received a **low** resilience cost rating.

The estimated annual cost per occupant per year is $14,161.

The main identified costs outside the purchase price are transportation, the foundation, and tradespersons.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Tankless Water Heater	Main Line – 200 AMP	Mechanical and Natural Ventilation
HOOK-UP(S):	Septic, Municipal Line	No Additional Power Source	Wall-Hung Split System

SO?

Fold and Float

3.7 TOTAL SCORE

The Hope on Water design is a floating structure that utilizes a cement base with a foldable framing system that can accommodate up to six people. The structure's design was originally conceptualized in response to the lack of emergency accommodation in Istanbul, particularly in the case of an earthquake.

SO? submitted its base unit to the Study.

BOTTOM LINE UP FRONT

TYPE	COST PER SF	MIN. LOT SIZE	INTERIOR SQFT	LIFESPAN	STAGE
Foldable Modular	**$43**	**400 SF**	**235 SF**	**7-10 Years**	**Prototype Developed**

KEY CAPABILITIES

Flood	**1.6**
Wind	**0.5**
Fire	**1.4**
Energy	**1.5**
Livability	**2.5**
Range of Use	**3.6**
Timeliness	**4.3**
Cost	**3.7**

USE PURPOSES

Rapid Shelter	■■□	Multi-Family	Yes [✓ No]
Permanent	□□□	Single Family	[✓ Yes] No
Temp-to-Perm	□□□	Able to Reuse	[✓ Yes] No

STEPS TO BECOMING TEXAS READY

- ■ **Prototype Developed**
- □ **Factory Available**
- □ **Meets Texas Codes & Standards**
- □ **Community Buy-in**

SCORE CAVEATS

Units are currently built in Turkey and do not integrate code compliance for the US and the use of a concrete pontoon, and the interior design require significant review prior to permitting in Texas. Scores reflect the SO? model not being an immediately feasible option but the technology and use of water is worth highlighting.

STRENGTHS

- Units are designed for high level of code compliance.
- Unit design includes ability to customize both the interior and exterior.
- Units can stack and connect for large or multi-family groups.
- Ability to rapidly deploy and install housing would allow for immediate service to survivors.

CONSIDERATIONS

- The unit has not yet been deployed, so the functional elements of its design that have high promise (e.g., code compliance) have not been tested.
- The company was founded recently (2018) and doesn't have experience with large scale modular housing deployments.
- The unit has limited ability to increase in size for larger households.

WEBSITE	www.soistanbul.com
CONTACT	Sevince Bayrak and Oral Goktas
PHONE	+90 2122387724
EMAIL	info@soistanbul.com

SO? was founded in 2007.
It has not deployed post-disaster housing.

RESILIENCE POTENTIAL

- ■ Ability to Raise Electrical Units
- ■ Structurally Capable of Elevating
- ☐ Sprinkler System
- ☐ Uplift Rating Above 130 mph

ABILITY TO CUSTOMIZE

- ☐ Temporary to Permanent
- ☐ Ability to Modify Number of Rooms
- ☐ Customizable Interior Finished
- ☐ Customizable Exterior Finishes

CODES & STANDARDS

Unit is compliant with the following:

- ☐ Americans with Disabilities Act
- ☐ Uniform Federal Accessibility Standards
- ☐ Minimum Size and Occupancy under HUD HOME
- ☐ International Residential Code 2012
- ☐ Texas Windstorm Insurance Association
- ☐ ASCE 7-10
- ☐ ASCE 24-14
- ☐ Fortified
- ☐ ANSI A117.1 Visibility Standard
- ☐ Green Building Standards

Units are built to code compliance in Turkey.

Production Capability
(Unknown)

Production capability is not yet established. Would likely need to change the concrete-base system and establish factory capabilities in the US.

Transportation
(Unknown)

Units splits into 8x4 ft sections that can be stored, such that three separate units can fit into a single shipping container for transport.

On-Site Construction
1-2 Days

Unit is designed to be installed in 1-2 days through use of a crane, with support from 3-4 laborers. Primary need is unfolding and placement of the unit on a concrete pontoon, and then installation of the sheer walls.

House to Home

Turnkey option: **YES**
Furniture: **YES**
Appliances: **YES**
Storage: **NO**

Disassembly

Ability to redeploy: **YES**
Storage Size: **320 SF**

COST EFFECTIVENESS

SO? received a **high** resilience cost rating.

The estimated annual cost per occupant per year is $712.

The main identified cost outside the purchase price is transportation.

UTILITIES	**PLUMBING**	**ELECTRICITY**	**HVAC**
TYPE(S):	Integrated Septic	Main Line	Natural Ventilation
HOOK-UP(S):	Integrated Septic	Solar Panel Capable	N/A

Vendor Snapshots

The following vendors submitted general information (e.g., contact, unit type) to the HAT survey but did not provide sufficient data to inform a score under the Study’s algorithm or support development of a full vendor profile.

TEXAS GENERAL LAND OFFICE
ESTABLISHED 1836

Core Housing Solutions
EcoHouseMart
Forts USA
SnapSpace Solutions

Core Housing Solutions

Firefly and Dragonfly

TYPE: Prefabricated Modular

Core Housing Solutions produced lightweight, strong tiny home units built from composite SIPS and transported on a chassis (option to install on a permanent foundation or maintain permanent chassis). Core Housing Solutions contributed in-depth and valuable data to the Study. It is not represented as a full vendor profile due to the company no longer being in production at the time of this report.

Website: N/A

EcoHouseMart

Log House #104

TYPE: Log Kit Homes

EcoHouseMart distributes log and timber home kits made of engineered wood. Laminated rectangular logs with tongue-and-groove technology are constructed from Northern America coniferous species. The company highlights healthy living through use of eco-friendly material. Unit sizes vary from 400 to 2,000+ square feet and can include a range of wall packages to incorporate a different roof, wall, and flooring systems.

Website: https://ecohousemart.com/

Forts® USA

Dormitory Suite
Family Housing Suite

TYPE: Foldable Modular

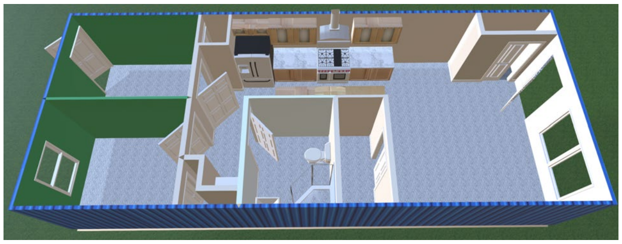
Forts® Fold-Out Shelters are a rapidly deployable foldable building system that can be constructed in 30 minutes. They are constructed with inorganic rigid-wall interlocking insulated panels. Units can include portable kitchen, laundry, and bathroom modules to serve wrap-around housing needs. Temporary to mid-term housing are the ideal use cases for these structures, though they can be leased long-term.

Website: https://fortsusa.com/

SnapSpace Solutions

SS640

TYPE: Shipping Containers



SnapSpace Solutions constructs customizable commercial and residential spaces using recycled shipping containers. Units are designed for wind resistance up to 200 mph. The company's previous use cases are unique to clients, and include a houseboat, concessions stands, and classrooms. Sizes vary based on the specific project needs and optimize the ability to stack and connect containers for full structures.

Website: https://www.snapspacesolutions.com/

APPENDIX B: HOUSING ASSESSMENT TOOL SURVEY

The Housing Assessment Tool (HAT) survey was distributed to vendors via an online platform. The HAT survey posed 177 questions that captured data relevant to the Study's identified nine inputs (see ***Survey Inputs***):

1. Alternative Housing Categories
2. Codes and Standards
3. Resilience
4. Unit Size and Amenities
5. Ability to Customize
6. Structure Elements
7. Construction and Site Requirements
8. Production Capability
9. Cost and Cost Effectiveness

Specific questions and points of inquiry are identified below. Please note that while the initial survey submissions were able to support the Study's analysis, surveys were augmented through direct follow-up with participating vendors.

HAT SURVEY QUESTIONS

1. Please fill out the following fields for the Provider's Organization:

Name of Provider's
Organization
Address
Address 2
City/Town
State/Province
ZIP/Postal Code
Country

2. What year was the organization founded?

3. Please provide the website address for the organization.

4. Please fill out the following fields for the contact person providing this input to the Housing Assessment Tool:

Name
Position / Title
Phone Number 1
Phone Number 2

Email Address

5. Please fill out the following fields for a secondary point of contact, should there be any questions from the Study Team about survey responses.

Name
Position / Title
Phone Number 1
Phone Number 2
Email Address

6. Is the vendor completing this survey the same entity as the manufacturer / builder?
If no, please provide the name of the manufacturer / builder.

7. Is the vendor registered / licensed to do business in at least one of the 50 U.S. states and/or U.S.
territories?
Please specify the U.S. states and/or territories the vendor is registered / licensed to do business in.

ALTERNATIVE HOUSING CATEGORIES

8. Please fill out the following fields about the unit to be assessed.
Unit Model Name
Unit Model Number

9. What is the unit's stage of development / production / deployment?
Choose one of the following:
Design and prototype developed
Not in production, but approved under industry-accepted standards
Unit(s) being lived in
Other (please specify)

Skip to #12 if no unit(s) have been produced and / or deployed.

10. If unit(s) are being lived in:
How many?
Where?

11. Has the unit previously been utilized for post-disaster housing?
If yes, please identify the disasters for which the unit was deployed and the number of units deployed for use (i.e. Hurricane Harvey - 50 units).

12. What is the minimum target lifespan of the unit?

Choose one of the following:
1–6 month(s)
7–12 months
13–24 months
25 months – 10 years
11–30 years
More than 30 years

13. Which category best describes the unit?

Choose one of the following:
Tiny homes
Modular homes
Manufactured housing units
Travel trailers
Recreational vehicles
Shipping containers
Panelized units
Kit homes
3D printed homes
Proprietary
Other (If the unit is not captured in the above categories or is a hybrid, please describe in detail)

14. Is it a single or multi-family unit?

Skip to #16 if you are responding about a single family unit.

15. What is the style of multi-family housing?

Choose one of the following:
Apartment style
Duplex
Row
Other (please specify)

16. Please upload a drawing, floor plan, or picture of the unit, if available.
Please only upload one file, not to exceed 16 MB. You may also email relevant files to TX.AltHousing@hagertyconsulting.com.

17. Please provide a website link to the model being evaluated.

18. Do you have any additional comments as it relates to the general model being surveyed?

CODES AND STANDARDS

This section tracks code compliance as it applies to building standards, wind resistance, fire codes, green building codes, appliance energy standards, visitability, accessibility, and performance testing.

19. Has the unit design been approved / certified under any industry-accepted standards (i.e., HUD, fire rating) for use in the U.S. and Texas?

Choose one of the following:
Yes, approved for use in U.S.
Yes, approved for use in U.S. (including Texas specifically)
No
Please provide additional detail, as necessary.

If no, please skip to the next section (Resilience), starting at #46.

20. If the roof system has been tested under either the FM or UL standards, what is the unit's roof uplift resistance rating?

Choose one of the following:
UL Class-30 (nominal static uplift pressure 30)
UL Class-60 (nominal static uplift pressure 60)
UL Class-90 (nominal static uplift pressure 90)
FM I-60 (uplift pressure 60 psf)
FM I-90 (uplift pressure 90 psf)
FM I-120 (uplift pressure 120 psf)
N/A

21. Please select HUD and related compliance standards met by the unit. Check all that apply.

Choose one of the following:
HUD 24CFR §3280, Manufactured Home Construction and Safety Standards (MHCSS)
HUD 24CFR §3285, Model Manufactured Home Installation Standard
Uniform Plumbing Code TDHCA, Texas Manufactured Housing Standards Code, 2017
ANSI A119.5-15, Recreational Park Trailer Standard, 2015 Edition
NFPA 1192-15, Standard on Recreational Vehicles, 2015 Edition
N/A

22. If applicable under HUD and related Code, which wind zones is the unit designed for use in? Check all that apply.

Choose one of the following:
Zone I (70 mph)
Zone II (100 mph)

Zone III (110 mph)
N/A

23. If applicable under HUD and related Code, which wind exposure is unit designed for use in? Check all that apply.

Choose one of the following:
Exposure A
Exposure B
Exposure C
Exposure D
N/A

24. Is the unit compliant as a permanent residence under International Residential Code® 2015 (IRC 2015)?

Please provide additional detail, as necessary.

25. Please select ASCE compliance standards met by the unit. Check all that apply.

Choose one of the following:
ASCE 7-10, Minimum Design Loads for Buildings and Other Structures
ASCE 24-14, Flood Resistant Design and Construction
N/A
Please provide design Wind Exposure Categories (A-D) and additional details, as necessary.

26. Does the unit qualify as wind resistant under the Texas Windstorm Insurance Association?

Choose one of the following:
Yes, designed for 130-mph (3-second gust) wind speed
Yes, designed for 120-mph (3-second gust) wind speed
Yes, designed for 110-mph (3-second gust) wind speed
No
Please provide additional detail, as necessary.

27. Please identify any of the following codes / standards for which the unit meets compliance standards. Check all that apply.

FORTIFIED standards
International Existing Building Code® 2015 (IEBC 2015)
International Fuel Gas Code® 2015 (IFGC 2015)
International Mechanical Code® 2015 (IMC 2015)
International Plumbing Code® 2015 (IPC 2015)
NFPA 70, National Electric Code® 2014 (NEC 2014)
Standards for ventilation under ASHRAE-62 series
Visitability Standard in 2009 ANSI A117.1 Accessible and Useable Buildings and Facilities
N/A

28. Is the unit compliant under the International Fire Code® 2015 (IFC 2015)?
Please provide additional detail, as necessary.

29. If known, what is the overall Fire Rating of the unit? Check all that apply.
Choose one of the following:

Unknown
None (0-hour)
1/2-hour
1-hour
2-hour

30. Is the unit equipped with a functional sprinkler system?
If no, can the unit be modified to include sprinklers?

31. How many of each of the following are in the unit?

Smoke detectors
Fire extinguishers
Doorway entrances / exits

32. Does the unit meet compliance with minimum net clear opening dimensions?
Please provide additional detail, as necessary.

33. Does the unit meet compliance under any of the following green building codes? Check all that apply.

Choose one of the following:
International Energy Conservation Code® 2015 (IECC 2015)
International Green Construction Code® 2015 (IgCC 2015)
U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design Version 3 (LEED® Version 3)
N/A
Please provide additional detail, as necessary.

34. Are the building materials used in the structure low-emitting under industry standards (e.g., USGBCLEEDs,
HUD, OSHA, EPA)?
Please provide additional detail, as necessary.

If the building materials used are not low-emitting under industry standards, skip to #37.

35. Do you have documentation verifying the use of low-emitting building materials?
Please provide additional detail, as necessary.

36. Please upload any available documentation verifying the use of low-emitting building materials here.
Please only upload one file, not to exceed 16 MB. You may also email relevant files to TX.AltHousing@hagertyconsulting.com.

37. Do you have access to material safety data sheets (MSDSs) for all materials used in the unit?
Please provide additional detail, as necessary.

38. Are the unit and all amenities and appliances compliant with federal Energy Star standards?

Choose one of the following:
Yes
No, but minimum energy performance standards met
No
Please provide additional detail, as necessary.

39. Is unit in its "as is" condition compliant with the Americans with Disabilities Act (ADA)?

Choose one of the following:
Yes, compliant as-is
Not compliant, but can be modified for compliance
Not designed for ADA compliance
Please provide additional detail, as necessary.

40. Is unit in its "as is" condition compliant with Uniform Federal Accessibility Standards (UFAS)?

Choose one of the following:
Yes, compliant as-is
Not compliant, but can be modified for compliance (e.g., minimum 32" W doorways, 60" turning space in all rooms, <48" high lock)
Not designed for UFAS compliance

If the unit is not designed for UFAS compliance, skip to #43.

41. How fast can the Producer convert one unit in the field into a fully UFAS compliant unit? Please specify the additional cost.

42. If there is a UFAS compliant version of the unit, please provide its model number and name. Specify any additional cost of a UFAS compliant unit.

43. Has the unit been reviewed by an independent third-party contractor?
If yes, please identify the third-party contractor.

44. Do you have certification of approval for all identified code compliance?

Please provide additional detail, as necessary.

45. Do you have any additional comments as it relates to the codes and standards met by the unit being surveyed?

RESILIENCE

This survey analyzes unit resilience to natural disasters throughout each section; however, additional inquiries under this section are focused on how units will fare when exposed to flooding and fire hazards.

46. What is the height of electrical units above the floor?

Choose one of the following:
< 1 foot
1–2 feet
2–3 feet
> 3 feet
Please provide additional detail, including whether the outlets can be raised above three feet.

47. Where is the HVAC air handler located in the unit?

Choose one of the following:
Inside of the unit
Outside of the unit
N/A
Please provide additional detail, including whether the HVAC air handler can be moved.

48. At what level is the HVAC duct work located in the unit?

Choose one of the following:
Along the floor
Along the ceiling
Below the floor level
No duct work
Please provide additional detail, including whether the HVAC duct work can be raised.

49. What are the floor covering materials utilized in the unit? Check all that apply.

None (bare concrete)
Tile (ceramic, terrazzo)
Vinyl (sheet flooring, tiles)
Wood flooring (engineered wood, hardwood)
Carpeting
Other (please specify)

50. Are the walls constructed with structural and finish materials and assemblies that are classified as flood damage-resistant materials in accordance with FEMA NFIP Technical Bulletin 2 (2008)?

Yes — All structural wall and wall finish materials and assemblies are composed of flood damage-resistant materials (Class 4 or Class 5) listed in FEMA NFIP Technical Bulletin 2.

No — Structural wall and wall finish materials and assemblies include some materials that are not flood damage-resistant (Class 1, 2, or 3) per FEMA NFIP Technical Bulletin 2

Unknown — Structural wall and wall finish materials and assemblies may include some materials that are not listed in FEMA NFIP Technical Bulletin 2
Please provide additional detail, as necessary.

51. Are the floors and foundations constructed with finish materials and assemblies that are classified as flood damage-resistant in accordance with FEMA NFIP Technical Bulletin 2 (2008)?

Yes — All structural floor and foundation finish materials and assemblies are classified as flood damage-resistant materials (Class 4 or Class 5) under FEMA NFIP Technical Bulletin 2
No — Structural floor and foundation and floor and foundation finish materials and assemblies include some materials that are not flood damage-resistant (Class 1, 2, or 3) per FEMA NFIP Technical Bulletin 2
Unknown — Structural floor and foundation finish materials and assemblies may include some materials that are not listed in FEMA NFIP Technical Bulletin 2
Please provide additional detail, as necessary.

52. Please identify the description that best describes the resistance of finish materials to moisture and mold growth.

Choose one of the following:
Not resistant to moisture and mold growth, materials require conditions of complete dryness
Not resistant to significant levels of moisture, materials are used predominantly in dry spaces that are subject to occasional water vapor
Resistant to some moisture, but not prolonged exposure to high levels of moisture
Resistant to consistent exposure to moisture, materials do not require special water or mold proofing protection.
Highly resistant to moisture and mold growth
Please provide additional detail, as necessary.

53. Is the unit "All Electric" (i.e., all electrical heating and cooking equipment with no open flame exposure)?

Please provide additional detail, as necessary.

54. Are all partitioned areas in the unit equipped with at least one egress window?
Please provide additional detail, as necessary.

55. Can all door and window locks (including interior room doors), latches, or other closing mechanisms be manually unlocked from the inside without the use of tool or key?
Please provide additional detail, as necessary.

56. What is the unit's ability to reach code plus potential as it applies to:

Moisture and flood mitigation: Feasible?
Wind hazards : Feasible?
Fire hazards : Feasible?
Please provide additional detail, as necessary.

Code plus potential is identified across these factors as a summary of a unit's overall ability to implement resilience best practices based on previous factors local to the unit's site deployment.

57. Do you have any additional comments as it relates to the resilience of the unit being surveyed?

UNIT SIZE AND AMENITIES

This section addresses the overall size of the unit, in order to get a sense of space provided, livability for the long-term, and capacity for residents. Amenities are identified by type, method of connection on site, and overall capacity.

58. What are the measurements of the unit? Please report in feet or decimal feet.

Height (highest elevation from grade, exterior measurement)
Depth (exterior measure of longest side from front to back)
Width (exterior measures from side to side)
Square Footage of Unit's Interior (total length x total width)

59. What is the maximum number of occupants per unit (as-is / without modification)?

60. Fill out each column for every bedroom available in the unit.

- Bedroom 1:
  - Max Persons
  - Total Sq. Ft.
  - Max. Beds
  - Type of Beds Fit
  - Closet Sq. Ft.
  - Closet
  - Number of Exterior-Facing Windows
- Bedroom 2:

Bedroom 3:
Bedroom 4:
Bedroom 5:
Bedroom 6:
Please provide additional detail, as necessary.

61. Can the total number of bedrooms in the unit be modified per the specific needs of residents and/or regulations?
Please provide additional detail, as necessary.

62. Fill out each column for every bathroom available in the unit.

Bathroom 1:
  Total Square Footage per Bathroom
  Toilet?
  Sink?
  Shower?
  Bathtub?
Bathroom 2:
Bathroom 3:
Bathroom 4:
Bathroom 5:
Bathroom 6:
Please provide additional detail, as necessary.

63. Can the total number of bathrooms in the unit be modified per the specific needs of residents and/or regulations?
Please provide additional detail, as necessary.

64. What is the capacity of the water heater?

Choose one of the following:
Not equipped
Less than 10 gallons
11–25 gallons
26–50 gallons
More than 50 gallons
Tankless water heater

65. Please identify the unit's ability to accommodate the following appliances, even if not included in the unit model's initial installation / base model. Check all that apply.

Washer
Dryer
Deep freezer
Refrigerator
Dishwasher

Other
Please provide additional detail, as necessary.

66. Does the unit provide a kitchen or a kitchenette?

Choose one of the following:
Neither
Kitchen — Separate room fully equipped with all standard cooking appliances (stove-top, oven, refrigerator, microwave required; dishwasher optional)
Kitchenette — Separate room or portion of room equipped with smaller, limited appliances (refrigerator, microwave, stove required; other appliances optional)
Please provide additional detail, as necessary.

If the unit does not have a kitchen or kitchenette, skip to #70

67. What amenities does the kitchen include? Check all that apply.

Sink
Dishwasher
Stove
Oven
Microwave
Refrigerator
Freezer
Pots and wares
Table and chairs
Other (please specify)

If there is no sink in the unit's kitchen, skip to #69.

68. How many gallons does the sink hold, if known?

69. What is the square footage of the unit's kitchen cabinet space?

70. Does the unit provide a living room?

If there is no living room in the unit, skip to #72.

71. If the unit provides a living room, please identify which of the following the living room comes equipped with. Check all that apply.

Couch
Chair(s)
Table(s)
Lamp(s)
Television
Please provide additional detail, as necessary.

72. Do you have any additional comments as it relates to the size and amenities of the unit being surveyed?

ABILITY TO CUSTOMIZE

This section addresses the ability of the unit to be customized, both on the exterior and interior, to fit the needs of differing community standards and expectations across Texas.

73. Does the unit have exterior "architectural flexibility" to meet local aesthetics of the neighborhood it might be placed in and/or resident preference?
Please describe in detail.

74. Is the unit's interior design customizable?
Please describe in detail.

75. Are the units capable of stacking on top of each other and/or connecting side-by-side to one another for conversion from single to multi-family units?

Choose one of the following:
Yes, capable of stacking
Yes, capable of connecting
Yes, capable of both stacking and connecting
No.
Please provide additional detail.

A "temporary-to-permanent" model can undergo modifications (e.g., increasing square footage, installing permanent appliances / amenities, further customization) to extend the unit's target lifespan as a livable space to more than 30 years.

76. Does this unit have the ability to be a "temporary-to-permanent" model?
If yes, what additional modifications are needed to be a permanent residence?

If the unit does not have the ability to be a "temporary-to-permanent" model, skip to #78.

77. If applicable, where and when has this temporary to permanent transition been completed?

78. Please describe any relevant capabilities of the unit to be modified for resident and/or community standards.

STRUCTURE ELEMENTS

This section identifies the framing structure, whether it is feasible to retrofit the framing, and also the type (e.g., standard, galvanized, stainless steel) and size of connectors used in the unit.

79. Please identify the primary wall framing structure of the unit.

Wood
Concrete
Masonry
Metal
Proprietary
Other (please specify)

80. Does this unit have documented instruction and recent cost estimates for retrofitting against natural hazards / disasters (e.g., earthquake, hurricane)?
If applicable, please describe vendor possibilities, recommendations, and costs for retrofits to the unit.

81. If available, please upload documentation related to retrofitting instructions and/or recent cost estimates here.
Please only upload one file, not to exceed 16 MB. You may also email relevant files to TX.AltHousing@hagertyconsulting.com.

82. Identify the connectors used to assemble the wall framing structure. Check all that apply.

Wood connectors: Nails
Wood connectors: Screws, bolts, and nuts
Wood connectors: Anchor plates and straps
Concrete / Masonry reinforcement: Steel reinforcing bars
Concrete / Masonry reinforcement: Wire mesh
Metal framing connectors: Bolted
Metal framing connectors: Welded
Proprietary / Other (please specify)

83. How many connectors are used to assemble the wall framing structure?

None
Please specify number

If no connectors are used to assemble the wall framing structure, skip to #85.

84. For the number of connectors reported directly above:

What type (e.g., standard, galvanized, stainless steel, other)?
What diameter?
What length?
Please describe any other relevant characteristics.

85. Identify the floor system(s) of the unit. Check all that apply.

Proprietary system
Wood subfloor supported by wood joists
Concrete subfloor: Precast panels
Concrete subfloor: Cast-in-place
Concrete subfloor: Insulated concrete form
Pre-engineered metal framing (e.g., shipping containers)
None - Wall framing structure connected directly to foundation
Other (please specify)

If the floor system of the unit does not include a wood subfloor supported by wood joists, skip to #87.

86. If the primary floor system of the unit is a wood subfloor supported by wood joists, please specify the following:

Subfloor type (plywood, OSB)
Subfloor thickness (inches)
Joist size (inches)
Joist spacing (inches)

87. Identify the connectors used to join the wall framing structure to the roofing and floor systems. Check all that apply.

Wood connectors: Nails
Wood connectors: Screws, bolts, and nuts
Wood connectors: Anchor plates and straps
Concrete / Masonry framing connectors: Tied into existing wall
Concrete / Masonry framing connectors: Grouted in-place
Metal framing connectors: Bolted
Metal framing connectors: Welded
Proprietary / Other (please specify)

88. How many connectors are used to join the wall framing structure to the roofing and floor systems?

None
Please specify number

If no connectors are used to join the wall framing structure to the roofing and floor systems, skip to #90.

89. For the number of connectors reported directly above:

What type (e.g., standard, galvanized, stainless steel, other)?
What diameter?
What length?
Please describe any other relevant characteristics.

90. Do you have any additional comments as it relates to the framing or structure of the unit being surveyed?

This section captures information related to the unit's roofing structure, including materials used, ratings of the roof, and others.

Please only fill out information for the roof framing system that best describes the unit's primary structure.

91. Please identify the materials used for the wood roof framing system.

Shingles
Plywood grade
Plywood thickness
OSB grade
OSB thickness

92. Please identify the following characteristics of the metal roof framing system.

Metal roof framing type:
Metal roof framing thickness:
Metal roof covering type:
Metal roof covering thickness:

For units with a concrete roofing system, compressive strength of roofing systems is measured as (fc) - 3,000 psi; 3,500 psi; 4,000 psi; or greater.

93. Please identify the following characteristics of the concrete roof system.

What is the roof's compressive strength?
What is the thickness?
What rebar is used?
What is the spacing of the rebar?
Is wire mesh used?
What cover material is used?
What type of membrane roof covering is used?
Please provide any additional details about the membrane roof covering.

94. Is there a secondary protection barrier for the unit, if the primary roof covering is lost?
If used, describe secondary protection barrier (e.g., type, thickness).

95. Do you have any additional comments as it relates to the roofing system of the unit being surveyed?

This section captures information about the unit's foundation, including if it comes with a foundation, the permanence of the foundation, feasibility to elevate, and availability to "tie-down."

96. Does the unit come with its own foundation?

Choose one of the following:
Yes
Yes, unit is constructed as-is directly on a grade slab foundation
No, but unit can be modified for placement on a foundation
Please provide additional information, as needed.

97. Does the foundation include capacity for "tie-down" requirements?
If yes, please describe in detail.

98. Can the unit be placed on an elevated foundation?

Choose one of the following:
No
No, but ability to design for elevation
Yes

99. Please describe design changes that would make elevation feasible.

100. Please describe the most appropriate process for elevating the structure.

101. Please identify the type of foundation typically used for the unit.

Choose one of the following:
Temporary (CMU block piers on concrete)
Temporary (CMU block piers on ABS pads)
Temporary on wheels
Crawlspace
Stem wall
Columns / piers
Piles
Basement
Slab-on-grade

Foundation Types (Models from FEMA P-784)

102. Do you have any additional comments as it relates to the foundation of the unit being surveyed?

This section evaluates materials and key features used for aspects of the building envelope, which includes the sub-floors, windows, and exterior facing walls and doors. Please note the Housing Assessment Tool calls out "roofing" separately from "building envelope" to highlight the roof's performance in protection and insulation, as was done with foundation and other essential protective functions such as thermal, wind, and flood.

103. Does the unit's envelope include material designed to be air barriers or vapor retarders?

104. Is the building envelope treated or built with materials that are resistant to flood damage and mold in accordance with FEMA NFIP Technical Bulletin 2 (2008)?
If yes, please describe in detail.

105. Is the building envelope constructed with materials that are resistant to moisture and humidity?
If yes, please describe in detail.

106. Are the building envelope materials and secondary protection resistant to wind-driven rain?
If yes, please describe in detail.

107. Is the building envelope treated or built with materials that are resistant to insect damage (i.e., termites, carpenter ants)?
If yes, please describe in detail.

108. What type of insulation material is used? Check all that apply.

Sprayed polyurethane foam (SPUF) or closed-cell plastic foam board
Inorganic — fiberglass or mineral wool (e.g., batts, blankets, or blown-in fibers)
All other types — cellulose, cotton, open-cell plastic foams, etc.
Please provide additional detail on the type of insulation material used, as necessary.

109. What thermal zone is the unit's insulation designed for (under HUD code)?

Choose one of the following:
N/A
Zone I (warmest zone, includes all of Texas – R min= 8.62)
Zone II (moderate zone – R min= 10.42)
Zone III (coldest zone – R min= 12.66)

110. What insulation zone (under U.S. Department of Energy) is the unit designed for?

Choose one of the following:
N/A
Zone 1 (warmest zone, excludes Texas)
Zone 2 (includes South Texas)
Zone 3 (includes Central Texas)
Zone 4 (includes North Texas)

Zone 5 (colder zone)
Zone 6 (colder zone)

111. What are the minimum R-Values of the following:

Walls
Roof / Attic
Floor

112. What material is used for the exterior siding? Check all that apply.

Vinyl
Aluminum
Wood
Fiber-cement board
Stucco
Brick veneer
Bare block or concrete
Proprietary / Other (please specify)

113. What material is used for the exterior doors? Check all that apply.

Solid wood
Steel
Fiberglass
Aluminum
Sliding glass
French doors
Other (please specify)

114. What are the windows composed of?

Wood frames with solid glass panels
Vinyl frames with insulated glass
Aluminum frames with insulated glass
Other (please specify)

115. Do the unit windows have shutters?

If the unit's windows do not have shutters, skip to #117.

116. What type of shutters are used?

Metal panels
Wood panels
Impact-resistant glazing
Other (please specify)

117. Does the unit have any ancillary storage (e.g., shed)?

If yes, what is the square footage?

118. Does the unit include a garage?

If the unit does not include a garage, skip to #123.

119. If a garage is included, can the unit also be modified for construction without the garage?

120. What size is the garage?
Golf cart
1-car
2-car
Other (please specify)

121. Is the garage size customizable?
Please provide additional detail, as necessary.

122. What type of material is the garage door made of?
Wood panel
Metal panel
Fiberglass
Other (please specify)

123. What are the roof vents composed of?
No overhang
Vinyl
Metal
Automatic
Other (please specify)

124. What is the size of the roof overhang?
Minimal (less than 6")
Moderate (6–12")
Significant (more than 12")

125. What are the overhang enclosures composed of?
Solid wood panel eaves
Flexible vinyl panel eaves
No eaves

126. What is the size of the porch or deck? Please specify units of measurement.
N/A
Size (specify units of measurement)

127. Do you have any additional comments as it relates to the building envelope of the unit being surveyed?

BUILDING UTILITIES AND MAINTENANCE

This section evaluates the unit's utility systems and associated maintenance.

128. Is any critical equipment located outside of the interior unit structure?
If yes, please identify which equipment and where it is located.

129. Is there an alternative power source available if the unit loses main power? Check all that apply.

Generator with a transfer switch
Transfer switch (not equipped with a generator)
Solar panels
Please specify generator wattage (if applicable) and other details, as necessary.

130. What is the overall amperage of the electrical system?

30 Amp or less
50 Amp
100 Amp
200 Amp
N/A

131. What are the electrical wiring system ratings?

110/120 VAC
220/240 VAC
Other (please specify)

132. Is a DC converter available inside of the unit?

Yes
No
N/A
Unknown

133. What is the unit's primary means for ventilation?

Mechanical ventilation system
Natural ventilation (e.g., openings)
Both mechanical and natural
Please provide additional detail, as necessary.

If the unit's primary means for ventilation is exclusively natural ventilation, skip to #135.

134. If equipped with a Mechanical Ventilation System, what is the air flow capacity? Air flow capacity is measured in cubic feet per minute (CFM).

- < 50 CFM
- 51–100 CFM
- 101–150 CFM
- 151–200 CFM
- 201–250 CFM
- > 250 CFM
- N/A

135. Please identify the capacity of the interior space HVAC. Check all that apply.

- Minimal (window, air conditioners, space heaters)
- Extensive (central heating and cooling)
- Installed within the unit or in crawlspaces underneath the first floor
- Other (please describe in detail)

136. Does the unit include vent systems for any fume or exhaust producing equipment?
Please provide additional detail, as necessary.

137. Does the unit include a carbon monoxide detector?
Please provide additional detail, as necessary.

138. What is the holding capacity of the fuel tank for the heating / cooking system in gallons?

- Not equipped
- 120 gallons
- 275 gallons
- 500 gallons
- 1,000 gallons
- > 1,000 gallons

139. What is the primary energy source for the unit's cooking fuel?

- Natural gas from a municipal supply line
- Natural gas from an on-site storage tank
- Propane on-site storage tank
- Electricity
- Other (please specify)

140. What water system does the plumbing hook up to?

- Municipal water line
- On-site well water / potable water tank
- Capable of connecting to either
- Please specify the holding capacity of the on-site well water / potable water tank in gallons, if applicable.

141. What sewage system does the plumbing hook up to?

Municipal sewage
On-site septic system
Capable of connecting to either
Please provide additional details, as necessary.

142. Is the provider required to supply ongoing maintenance support for the unit?
If yes, please describe the nature of this support.

143. Can the vendor provide a comprehensive maintenance schedule / instruction manual for the entire unit? The "entire unit" would include the core and shell, its internally installed or externally placed systems (e.g., a central HVAC unit), and its internal finishes, fixtures, fittings, furnishings, and major appliances.

144. If available, please upload comprehensive maintenance schedule / instruction manual for the unit.
Please only upload one file, not to exceed 16 MB. You may also email relevant files to TX.AltHousing@hagertyconsulting.com.

145. Please identify the type and length of warranty (in years) for the following:

Structure (type and length of warranty)
Electrical system (type and length of warranty)
Plumbing system (type and length of warranty)
HVAC system (type and length of warranty)
Appliances (type and length of warranty)

146. Do you have any additional comments as it relates to the building utility systems of the unit being surveyed?

CONSTRUCTION AND SITE REQUIREMENTS

This section assesses the construction and site requirements, as well as needs for unit installation in terms of clearance, equipment, transportation, and trades personnel. Questions also discuss capacity to disassemble and store units when not in use.

147. What is the minimum footprint and dimensions (in feet) needed for the unit?

148. Is the unit equipped with a permanent chassis for initial and continued transportability?
Please describe in detail.

149. How can the unit be transported to site? Check all that apply.

Self-driven (e.g., RV)
Towable (e.g., MHU)

- Flat-bed truck
- Other (please describe in detail)

150. What is the minimum class of vehicle required to tow or transport?

151. Is a special highway movement permit or escort vehicle needed to transport the unit?
If yes, please describe in detail.

152. Can the unit be reduced in size for transportation and storage?
Please provide additional detail.

If the unit cannot be reduced in size for transportation and storage, skip to #154.

153. For the unit that can be reduced in size for transportation and storage:

- To what dimensions? Please specify unit of measurement.
- How many can be fit in one shipment?
- What needs does the unit have for storage?

154. What is the unit's shipment weight? Specify unit of measurement.

155. For units that are not self-driven, how many units can be towed or transported by a single vehicle?

156. How many days are needed for the installation / construction / assembly of a unit?

157. How many people are needed to conduct "field" set up, installation, and construction?

158. Does the unit installation require presence of a manufacturer / provider-trained crew for field assembly and installation?
If yes, please describe in detail.

159. Please identify the number and type of tools / equipment and tradesperson(s) needed for installation of
the unit.

- Crane
- Forklift
- Backhoe
- Electrician / lineworker
- Plumber
- HVAC technician
- Drywall installer / finisher
- Carpenter
- Iron worker
- Stone / masonry craftsman

Painter
Window installer
Other (specify)

160. Is the unit designed to be easily disassembled for relocation, storage, or reuse
Please provide additional detail.

161. What is the dimension of the unit when reconfigured for transportation and/or storage?

162. Please identify the type and number of tools / equipment or tradesperson(s) needed for disassembly of
the unit.

Crane
Backhoe
Forklift
Electrician / lineworker
Plumber
HVAC technician
Drywall installer / finisher
Carpenter
Iron worker
Stone / masonry craftsman
Painter
Window installer
Other (please specify)

163. What is the projected cost of disassembly?

164. Do you have any additional comments as it relates to the construction and site requirements of the unit being surveyed?

PRODUCTION CAPABILITY

This section addresses current production capacity.

165. What is the maximum number of units that can be produced / built within the specified time periods? Please assume 100% utilization of facilities / equipment / staff with ample materials, supplies, and fuel.

Number of units within 1 week
Number of units within 2 weeks
Number of units within 4 weeks
Number of units within 8 weeks
Number of units within 12 weeks

Number of units within 24 weeks

166. What additional considerations impact the maximum numbers of units reported directly above? Please describe factors that influence your current production capacity and ability to ramp-up if required following a disaster.

167. Are units currently in production and capable of deployment?
Please provide additional detail.

If units are not currently in production and capable of deployment, please skip to the next section (Cost and Cost Effectiveness), starting at #172.

168. How many units are currently in stock?

169. What state(s) are unit inventories located in? Please indicate the number of units available per state
(e.g., Alabama–10; New York–20).

170. If applicable, where are established unit manufacturing points in the U.S. (by state)?

171. Do you have any additional comments as it relates to the production or transportation of the unit being surveyed?

COST AND COST EFFECTIVENESS

172. What is the unit purchase price?

173. Do you offer a "turnkey" price to perform transportation and installation?

If yes, what is the cost for these services?

174. What is the site construction cost for the foundation?
N/A
Please specify cost and any key factors that influence this cost.

175. What is the site construction cost for unit assembly / installation / construction?
N/A
Please specify cost and any key factors that influence this cost.

176. Are there any discounts available for bulk purchases?
Please describe in detail.

177. Do you have any additional comments as it relates to the cost of the unit being surveyed?

DISCLAIMER

The HAT survey included a disclaimer to set vendor expectations for participation in the Study:

Please note that the Housing Assessment Tool is not a request for proposals and serves exclusively as a data collection tool for the analysis of alternative housing solutions. Vendor participation in the Housing Assessment Tool does not constitute an agreement to purchase by the Texas General Land Office – Community Development and Revitalization, nor does it in any way commit any party to compensation or further engagement. By proceeding with this survey, you are recognizing that the information you provide will be used to inform research by the State of Texas.

APPENDIX C: HAT SURVEY ANALYSIS ALGORITHM

The HAT survey included 177 questions categorized under seven distinct question types, providing a total of 720 answer options, each of which produced an automated score in (see ***Table 18***). Scoring per question was standardized using a decimal-system approach, such that each question could be set on a 10-point scale.

The Study analysis used a standardized approach with automated scores in order to inform a tracking system that could directly connect viable alternative housing models to communities. The Study's consideration of local priorities (i.e., core outputs) and assignment of scores directly to corresponding capabilities enables communities to use HAT survey data to identify high scoring units based on their priorities.

The Study's algorithm is anchored on the HAT survey (see ***Appendix B: Housing Assessment Tool Survey***), which is a key ingredient to redeveloping the scoring system and core output analysis outlined below. The following description outlines the general scoring structure and alignment of questions with different sections, such that future analyses can utilize the HAT survey alongside its scoring system to serve future alternative housing needs. This information is provided, in part, to inform requirements for a future HAT application should GLO-CDR wish to develop a similar application within the Texas Disaster Information System (TDIS) or another platform.

Table 18: Question Types and Scoring

Question Type	Question ID	Number of Questions	Description	Scoring
Information Only	INFO	65	Question with multiple sub-questions	One (1) point is given for each sub-question answered per question. For example, Question 1 contains multiple sub-questions about the vendor's organization. More points received reflects completeness to the question answered.
Yes/No	YN	49	Question with answer options of either Yes/No, or Yes/No plus Maybe/Not sure	0 point for No answers; 1 point for Maybe, and 2 points for Yes (opposite if No indicates positive attribute)

Question Type	Question ID	Number of Questions	Description	Scoring
Non-Progressive Single Select	NPSS	22	Multiple choice question requesting only one answer selected	1 point for the positive value option selected: 0 point for negative option
Progressive Single Select	PSS	19	Multiple choice question requesting only one answer, but each answer is scored based on value	Scoring from 0 to 10 based on the answer option selected
Formula or Condition Based	FML	1	Question 2 which asks if the vendor's organization was founded before 2015 or in 2015 and after	2 point for >/= 2015; 1 point for <2015
Written Comments	ADD	79	Question requesting additional details to assist with evaluation	Written comments or document uploads are recognized but not initially scored. They are used to assist with engineering evaluation and subsequent ranking adjustments
Uploads	UL	4	Question requesting document upload to the system, such as the housing unit design plans.	

Within QuickBase, each vendor submission was represented as a separate entry. Questions and answers were each assigned distinct identification numbers based on their question type. The distinct question IDs allowed the system to automatically apply the scoring system based on question types. The total 177 questions in the HAT survey translated to 1770 points possible for each unit overall.

The total scores for units (as indicated at the top of the profile) were **not** calculated based on the total number of points scored per unit. The size of the survey, range of question applicability to different models, and level of detail for questions in some categories meant that focus on the total number of questions—and type of answers—might unfairly skew analysis towards certain units. Instead, the Study compiled scores under different categories to understand how scores translated to meaningful capabilities that were identified as priorities for the State of Texas.

The Study focused on scoring that calculated scores for different unit capabilities, as defined by the Study's key outputs and a set of additional considerations (e.g., credibility of the vendor) that might inform the logistics or other vendor capabilities to effectively fulfill a contract (see ***Table 19***). Questions that were more important to the overall capability of a unit were weighted to anchor the score in key considerations for each category. For example, the use of resilient materials was more important as compared to the availability of a garage.

Table 19: Scoring by Category

	Description	Number of Questions	Questions Included in Score	Notes
Codes and Standards	Compliance with the Study's identified codes and standards	15	19. Approved standards 21. HUD and related compliance 24. IRC 2015 compliant residence 25. ASCE 7-10 and 24-14 compliance 26. TWIA wind-resistant unit 27. Other I-Codes, NEC, ASHRAE 28. IFC 2012 compliant unit 29. Overall fire rating 31. Smoke detectors, entrances/exits 34. Low-emitting building materials 39. Energy Star appliances 40. "As-is" unit UFAS compliant 41. UFAS compliant conversion cost 42. UFAS compliant unit version, cost	A weight of 1.25x is applied to questions 25 and 29, concerning respectively a housing unit's compliance with ASCE standards and fire rating.
Cost ***Core Output**	Includes all cost-related data for the full unit lifecycle	28	167. Currently in production 168. Units currently in stock 172. Unit purchase price 152. Unit size reduction for transport 155. How many units per vehicle 165. Max number of units built/week 176. Discounts for bulk purchase 148. Unit with permanent chassis 149. Unit transportability to site 150. Tow/transport vehicle class 151. Special permit/escort vehicle 161. Unit dimensions for transport 169. State locations of inventories 170. Unit manufacturing points 157. People needed for "field" set-up 158. Manufacturer-trained crew? 159. Install tools/equipment details 173. "Turnkey" price to install	Weights applied to overall purchase price, the resilience BCR, and location of manufacturing points. Vendor profiles also identify price per square foot and per occupant per year.

	Description	Number of Questions	Questions Included in Score	Notes
Cost (continued) ***Core Output**			174. Site foundation construction 175. Site assemble/install/build cost 76. "Temporary-to-permanent" 80. Retrofit details 160. Unit easy to disassemble 162. Disassembly tools/equipment 163. Projected disassembly cost 145. System warranties	
Energy Resilience ***Core Output**	Overall efficiency of units production processes and daily energy use	14	33. Green building code compliance 108. Types of insulation materials 110. Insulation design zone - USDOE 111. Minimum R-values 112. Exterior siding materials 128. Critical equipment outside unit 129. Alternative power source 137. Carbon monoxide detector 139. Primary energy source of fuel 140. Water system connection 141. Sewage system connection 142. Ongoing maintenance required	A weight of 1.25x is applied to questions 110 and 129, concerning respectively a housing unit's design to and/or compliance with USDOE insulation zone and available alternative energy source.
Fire Resilience ***Core Output**	Ability of materials used in unit construction to resist ignition and withstand fire damage	23	19. Approved standards 21. HUD and related compliance 24. IRC 2015 compliant residence 25. ASCE 7-10 and 24-14 compliance 27. Other I-Codes, NEC, ASHRAE 28. IFC 2015 compliant unit 29. Overall fire rating 31. Smoke detectors, entrances/exits 34. Low-emitting building materials 56. Code plus feasibility for fire 79. Primary wall framing structure 91-93. Roof system 94. Secondary roof protection barrier 98. Potential unit elevated foundation	Weights applied to IFC 2015 and other code compliance, as indicated in questions 19 to 28, as well as the unit's overall fire rating.

	Description	Number of Questions	Questions Included in Score	Notes
Fire Resilience (continued) ***Core Output**			101. Typical unit foundation used 112. Exterior siding materials 113. Exterior door materials 114. Window materials 123. Roof vent composition 124. Roof overhang size 125. Roof overhang enclosure	
Flood Resilience ***Core Output**	Viability of structures against flood and hurricane events	42	19. Approved standards 21. HUD and related compliance 24. IRC 2015 compliant residence 25. ASCE 7-10 and 24-14 compliance 27. Other I-Codes, NEC, ASHRAE 34. Low-emitting building materials 56. Code plus feasibility for flood 50. Wall materials per NFIP TB 2 79. Primary wall framing structure 82, 84, 87, 89. Framing connectors 85. Floor system(s) used in unit 91-93. Framing system details 94. Secondary roof protection barrier 49. Floor covering material(s) 51. Floors, foundations per NFIP TB2 96. Unit comes with own foundation 97. Foundation "tie-down" 98. Potential unit elevated foundation 101. Typical unit foundation used 52. Moisture and mold resistance 104. Flood-resistant materials TB2 105. Moisture resistance 106. Wind-driven rain resistance 107. Insect damage resistance 108. Types of insulation materials 112. Exterior siding materials 113. Exterior door materials 114. Window materials	A weight of 1.25x is applied to questions 25, 104 and 106, concerning respectively a housing unit's compliance with ASCE standards, flood and mold resistant envelope, and wind-driven rain resistant envelope. Questions 91 to 93 concerning the unit's framing system are assigned a weight of 1.25x for Q91 and Q92, and 2.0x for Q93.

	Description	Number of Questions	Questions Included in Score	Notes
Flood Resilience (continued) ***Core Output**			118. Unit including garage 123. Roof vent composition 124, 125. Roof overhang 46. Electrical units height above floor 47. Location of HVAC air handler 48. Location of HVAC ducts	
Livability ***Core Output**	General comfort and provision of amenities	21	11. Previously utilized post-disaster 76. "Temporary-to-permanent" 40. UFAS 58. Measurements of the unit 59. Max occupants 60. Bedroom features, by bedroom 62. Bathroom features, by bathroom 64. Capacity of water heater 135. HVAC interior space capacity 65. Possibility of installing specific appliances in the unit 66. Kitchen or kitchenette 67. Appliances and Wares 70. Existence of living room 71. Living room amenities included 73. "Architectural flexibility" of unit 74. Customizable interior design 78. Unit modification capabilities 118. Unit including garage 120. Garage size 121. Customizable garage size 126. Size of porch or deck	Weights applied to questions relating to the ability to customize the interior, exterior, and overall unit size.
Range of Use ***Core Output**	Ability of unit to fill resident needs	15	12. Minimum target unit lifespan 13. Unit category description 14. Single or multi-family 58. Unit dimensions 59. Maximum number of occupants 60. Number, size of bedrooms 62. Number, size of bathrooms 66. Kitchen or kitchenette 70. Living room 40. "As-is" unit UFAS compliant	No weights applied.

	Description	Number of Questions	Questions Included in Score	Notes
Range of Use (continued) ***Core Output**			73. "Architectural flexibility" of unit 74. Interior design customizable 75. Stackable/connectable units 76. "Temporary-to-permanent" 78. Unit modification capabilities	
Ability to Customize Size	Ability to customize the unit size	10	58. Unit dimensions 59. Maximum number of occupants 60. Number, size of bedrooms 62. Number, size of bathrooms 66. Kitchen or kitchenette 69. Living room 73. "Architectural flexibility" of unit 75. Stackable/connectable units 76. "Temporary-to-permanent" 78. Unit modification capabilities	No weights applied
Timeliness ***Core Output**	Factors impacting the total amount of time from procurement to occupancy	27	9. Stage of dev. / product. / deploy. 11. Previously utilized post-disaster 39. ADA compliance 40. UFAS compliance 41. UFAS conversion in the field 96. Come with its own foundation 140. Water system hook-ups 141. Sewage system hook-ups 148. Ease of transport 149. Method(s) of transport to site 150. Minimum class of vehicle 151. Movement permit needed 152. Ability to reduce in size 153. Dimensions for size reduction 155. # towed / transported per load 156. Days needed to install unit 157. Number of workers needed 158. Specifically trained crew need 159. Number and type of tools need 160. Designed for disassembly 161. Disassembled unit dimensions 162. Number and type of tools 165. Max units produced	Weights applied to units with production capabilities in the U.S., with additional benefit to those in Texas specifically.

	Description	Number of Questions	Questions Included in Score	Notes
Timeliness (continued) ***Core Output**			167. Units in production 168. Units in stock (#) 169. Unit inventories by state 170. Manufacturing points	
Unit Type	Type of alternative housing provided	3	12. Minimum target unit lifespan 13. Unit category description 14. Single of multi-family	No weights applied.
Vendor Credibility	Factors indicating the overall credibility of the vendor to support government contracts	7	1. Vendor's organization 2. Year founded 3. Website address 4. Contact person 5. Secondary contact 6. Vendor is manufacturer? 7. U.S. registered business	No weights applied.
Wind Resilience ***Core Output**	Ability of a unit to withstand damage from wind events	31	19. Approved standards 21. HUD and related compliance 24. IRC 2015 compliant residence 25. ASCE 7-10 and 24-14 compliant 26. TWIA wind-resistant unit 27. Other I-Codes, NEC, ASHRAE 56. Code plus feasibility for wind 79. Primary wall framing structure 82, 84, 87, 89. Framing connectors 91-93. Framing system details 94. Secondary roof barrier 97. Foundation "tie-down" 101. Typical unit foundation used 106. Wind-driven rain resistance 112. Exterior siding materials 113. Exterior door materials 114. Window materials 115. Shutters for windows 116. Type of shutters used 118. Unit including garage 120. Garage size 123. Roof vent composition 124, 125. Roof overhang 47, 48. Location of HVAC	A weight of 1.25x is applied to questions 25, 106, and 115, concerning respectively a housing unit's possession of or compliance with ASCE standards, wind-driven rain resistant envelope, and window shutters. Questions 91 to 93 concerning the unit's framing system are assigned a weight of 1.25x for Q91 and Q92, and 2.0x for Q93.

The total score in each category was translated to a 10-point scale for evaluation both separately and individually and to inform a reader-friendly layout in the vendor profiles. Based on the scores across all categories, the Study identified an average score for the unit to inform the total score. Scores are reflected in ***Table 20*** (see below) and each individual vendor profile.

Table 20: Score Summary

	Total Score	Range of Use	Livability	Timeliness	Cost	Flood	Wind	Fire	Energy	Overall Resilience	Codes and Standards	CredFeas	UnitType	SizeCust	Vendor Credibility
Haus.me	9.3	7.3	6.3	6.7	6.4	6.4	4.7	6.6	9.4	6.4	6.5	7.7	7.0	7.6	7.8
Boxabl	9.3	7.9	7.2	7.0	7.6	6.1	4.7	7.9	7.3	6.1	5.0	7.1	7.0	8.0	7.3
Kiro Action	8.8	7.4	4.9	7.3	8.1	7.1	4.5	6.0	5.5	5.8	5.5	7.6	7.0	7.2	7.6
LiV-Connected	8.4	7.6	7.1	6.2	5.1	4.6	5.3	4.8	5.3	5.0	5.0	7.1	10.0	7.1	8.0
ICON	8.2	7.7	7.4	7.7	4.4	3.5	5.7	4.5	2.7	4.2	6.5	7.7	9.4	7.5	7.8
IndieDwell	8.2	7.0	6.1	5.9	5.7	6.1	5.7	3.7	3.9	5.2	6.5	7.9	9.4	6.0	7.8
Connect Homes	8.0	5.9	3.9	6.2	8.1	4.5	3.4	6.9	7.5	5.0	5.0	7.9	6.7	6.2	7.0
Sunshine Home Kits	8.0	7.7	5.5	4.4	4.2	3.6	6.0	2.3	9.0	5.1	6.5	6.7	8.7	7.2	6.8
Falcon Structures	7.9	7.0	4.4	6.1	7.8	6.1	6.2	4.0	3.5	5.4	5.5	6.4	9.4	7.0	7.0
A-FOLD Houses	7.6	7.4	5.3	5.2	7.3	3.6	5.9	2.7	3.5	4.2	4.5	7.2	10.0	7.3	6.8
Hex House	7.5	7.7	5.9	4.1	7.4	5.9	5.3	3.3	4.1	5.0	6.0	7.1	10.0	7.3	5.9
RAPIDO	7.1	7.0	7.2	4.2	3.3	5.9	5.9	3.6	3.4	5.1	4.5	7.1	8.7	7.2	5.9
Horizon North	6.9	7.3	5.0	5.8	5.2	3.6	3.7	1.6	1.6	3.0	4.0	7.4	10.0	5.2	7.0
AbleNook	6.7	5.1	4.4	6.0	5.4	3.6	5.9	6.7	3.8	4.9	4.0	8.1	2.0	6.5	8.3
Dweller	5.9	5.2	4.2	4.6	2.9	3.8	3.3	3.4	2.7	3.4	4.5	7.3	10.0	3.2	6.2
Urban Rigger	5.7	5.3	4.6	3.6	2.8	1.6	3.4	4.1	3.9	3.0	4.5	7.3	8.7	4.8	6.2
M-Rad	5.6	6.0	5.1	5.2	2.6	2.3	0.6	1.7	5.0	2.1	2.5	6.6	7.4	5.2	5.9
Gravity Architects	5.1	5.8	6.6	2.3	0.2	2.8	2.8	2.8	3.3	2.9	3.5	6.6	8.2	5.7	5.9
Allwood Industrials	4.6	4.8	2.8	4.4	4.0	2.9	1.9	0.5	0.7	1.8	1.0	6.6	8.7	5.0	5.9
SO?	3.7	3.6	2.5	4.3	3.7	1.6	0.5	1.4	1.5	1.2	2.0	5.6	4.8	2.5	4.5

APPENDIX D: OVERSIGHT COMMITTEE HAT SURVEY MEETING NOTES

March 3, 2020 | 10:30 a.m. – 12:00 p.m. | Virtual (Skype) and Texas GLO-CDR Harvey Meeting Room

Purpose of Meeting	Oversight Committee Meeting #1
Primary Facilitators	Shonda Mace, GLO-CDR James Ariail, Hagerty Ashley Wargo, Hagerty
Notetaker	Adrienne Lefevre, Hagerty

ATTENDEES

- **Texas General Land Office – Community Development and Revitalization (GLO-CDR)**
    - Shonda Mace
    - Colleen Jones
    - Sarah Douglas
    - Jet Hays
    - Ellen Kinsey
- **Oversight Committee Members**
    - Jim Reed (in-person)
    - Emily Martinez (in-person)
    - Michelle Meyer (virtual – Skype)
    - Lonnie Hunt (virtual – Skype)
    - Joshua Bryant (virtual – conference line)
    - Shanna Burke (virtual – conference line)
- **Hagerty**
    - James Ariail
    - Ashley Wargo
    - Adrienne Lefevre
    - Ashley Saulcy

KEY POINTS

- GLO-CDR provided an overview of Phase I of the Disaster Recovery Alternative Housing Study, which is a platform to explore opportunities for interim and permanent housing solutions in disaster-affected communities. Phase I is currently in progress, and the

Housing Assessment Tool (HAT) survey will gather information from alternative housing vendors to evaluate potential solutions.

- The Oversight Committee was introduced, and its purpose established, to provide expertise and feedback on the needs that alternative housing should address. Throughout the course of meeting, the Committee emphasized the importance of unit flexibility, cost effectiveness, and feasibility under jurisdictional regulations.
- The long-term vision for the Study is to host the HAT on the Texas Disaster Information System (TDIS), providing a tool for ongoing evaluation of housing solutions as technologies evolve and as specific disaster recovery needs emerge.

MEETING NOTES

INTRODUCTIONS AND OVERVIEW

- GLO-CDR, Hagerty, and Oversight Committee members provided brief introductions.
- GLO-CDR provided an overview of the Disaster Recovery Alternative Housing Study, and outlined its objective, to gather, analyze, and evaluate data related to alternative housing options and inform approaches that can better serve Texas citizens in the wake of disasters.
    - The Study will be conducted in two phases. The current project is Phase I. Phase II will focus on testing housing prototypes to evaluate feasibility for use in Texas.
    - GLO-CDR is seeking to identify solutions that are more cost effective than the interim housing units traditionally used by FEMA (i.e., manufactured housing units and travel trailers). While cost effectiveness is achievable, building codes and other community standards may present obstacles.
- Hagerty outlined the meeting objectives and the purpose of the Oversight Committee. As representatives of communities and other stakeholders, the Oversight Committee is intended to help shape the study by sharing the expertise and perspectives of its members.
- The timeline for Phase I of the Disaster Recovery Alternative Housing Study will involve three meetings with the Oversight Committee to 1) discuss feedback regarding HAT survey metrics (today's meeting); 2) review the Community Outreach Plan; and 3) review the draft findings from Phase I.

HAT METRICS REVIEW AND FEEDBACK

- Hagerty provided a high-level overview of the HAT survey.
    - The HAT survey is delineated into a set of categories for participant vendor usability, outlined as: alternative housing categories; codes and standards; resilience; unit size and amenities; customizability; structure elements; construction and site requirements; production capability; and cost and cost effectiveness.
    - Inputs will provide data to evaluate factors including resilience, livability, range of use, timeliness, and cost.

- The HAT survey will produce a dataset that will be used to evaluate each unit being surveyed for use as temporary, permanent, or temporary-to-permanent housing.
- The Oversight Committee provided the following feedback on ***resilience factors***.
    - Storm surge is a key hazard to account for and underscores the importance of elevation potential.
    - Permanent housing construction under the Homeowner Assistance Program requires two feet of freeboard.
    - Raising HVAC systems, including ductwork, and electrical systems, has been used successfully for flood mitigation. After Hurricanes Matthew and Florence, North Carolina residents found that moving duct work from under the house to the attic cut down on repair costs and reduced the scale of damage from severe to moderate.
    - A key factor to mold resistance is type of insulation used.
    - Fortified housing design is a strong framework for evaluating home resilience.
- The Oversight Committee provided the following feedback on ***unit size and amenity factors***.
    - Post-disaster housing unit sizes, including the number of bedrooms and bathrooms, are often dictated by HUD. These requirements have resulted in challenges for previous housing missions (e.g., Montgomery County, Houston).
    - Overall unit storage capacity is a key factor, while keeping in mind that GLO-CDR does not build garages unless mandated for an area by the local homeowner's association (HOA). To that point, some HOAs do not allow for certain personal items to be stored outside, which jurisdictions have responded to through strategies such as the use of donated shipping containers.
    - Flexibility for installation of appliances is a key factor. Temporary units may not have appliances available, but when modifying for permanent residence, homeowners may require additional appliances (e.g., dishwashers). Rural communities may have appliance needs (e.g., deep freezers) that exceed those for urban communities.
    - Residents will often take better care of units if they understand that they may have the option to purchase the unit.
    - Clear instructions for how to use the unit, such as how to hang a television, can help preserve units for re-sale or re-use.
- The Oversight Committee provided the following feedback on ***customizability factors***.
    - Exterior customizability should not be constrained by application to historical standards but should also account for the preferences and culture of the community.
    - A key factor for customizability is flexibility to modify from an individual structure to a multi-family unit that can grow in size and number (e.g., 3D printing, stacking units).
- The Oversight Committee provided the following feedback on ***construction and site requirements factors***.
    - The ability of a unit to be self-sustaining with its own generator or ability to plug into another structure should be considered. For example, Rockport took four

  - months to re-establish electrical service in some areas, which limited the capacity to support certain types of housing units.
  - Unit electrical system evaluation should remain mindful of compatibility with utility companies and the ease of hook-ups and account establishment with utility companies. For example, many families may have past due bills that must be paid off before the account is re-established.
  - A key factor to unit transportability is ability to transport on rural county roads. Post-Hurricane Harvey, there have been challenges getting homes in/out of rural locations.
  - It is important to communicate with elected officials before beginning housing operations in a community. Elected officials may also be able to expedite the permitting process. A key factor for evaluating cost and transportability is the cost of transportation for individual parcels versus multi-unit sites (e.g., commercial parks).
  - A factor to consider for multi-family units is the need to establish community centers and/or wrap-around services.
- The Oversight Committee provided the following feedback on ***cost and cost effectiveness factors***.
  - A key factor for long-term affordability is the ability of the survivor to afford property taxes. During the last legislative session, Senate Bill 812 froze the property tax at pre-storm rates for replacement structures, and temporary structures were not taxed; however, it is important to consider the timeframe in which a structure is no longer "temporary" and how designations impact affordability.
  - A key factor for resale value is how home value changes during the transition from a temporary to a permanent structure. Programmatic costs include changing legal title.
  - A key factor to cost is recertification to maintain eligibility for interim housing.
  - A key cost factor is permitting, especially if a solution is unique and unfamiliar to permitting authorities. For example, tiny houses have encountered significant permitting challenges, such as minimum square footage requirements.
  - It would be useful to have a cost effectiveness matrix to support decision-making. Cost analyses should also capture overall effectiveness and how housing solutions compare to different programming costs.

ADDITIONAL CONSIDERATIONS DISCUSSED BY THE COMMITTEE

- Code flexibility is important. Every municipality has an emergency management plan that could potentially include an emergency code to be implemented following a disaster. An alternative to housing missions is direct cash payments for survivors to purchase or rent post-disaster housing. There are varying reviews regarding the past success of these programs.
  - There is sentiment among Emergency Management Coordinators and county judges to figure out how to enable individual survivor decision-making through financial support.

    - After Hurricane Katrina, FEMA implemented a cash-based program and found that it did not serve housing needs, but resulted in misspending in some cases (e.g., gambling).
    - A cash-based program implemented in Texas allowed homeowners to rent houses based on a series of options that could fit their needs. The system enabled an intake center with case managers to operate the system and worked effectively.
- HUD Community Development Block Grant – Disaster Recovery funding carries limits due to its restrictions surrounding "duplication of benefits." This is especially challenging when residents use FEMA housing assistance for non-housing needs.
- HAT survey data will eventually be wrapped into the larger TDIS interface that will be made available to the public to serve as an iterative platform for decision-making.

ADJOURNED AT 11:45 A.M.

DECISIONS/NEXT STEPS

- Factors relating to local jurisdiction taxation and permitting will be included as considerations in the findings report from Phase I but will not be collected directly as survey data from vendors.
- If you have further insights, please reach out to James Ariail or Shonda Mace. The GLO-CDR Intergovernmental Relations representative, Sarah Douglas, will also be involved in the community outreach process.
- Next month, we will hold the second Oversight Committee meeting, to focus on the Community Outreach Plan. The Disaster Recovery Alternative Housing Study team will be in touch later this month to identify a date for this meeting (likely to be held at approximately the same time as this first meeting).
    - During the next meeting, we will review the outreach strategy, identify key community members whose perspective would provide useful insight to the Study, and discuss the methodology for engagement.
- Thank you for your participation in the Oversight Committee—we look forward to continuing the conversation to identify stronger housing solutions for Texas.

APPENDIX E: OVERSIGHT COMMITTEE FINDINGS REPORT MEETING NOTES

September 25, 2020 | 12:00 p.m. CDT | Teleconference (Zoom)

Purpose of Meeting	Oversight Committee Meeting #3
Primary Facilitators	Shonda Mace, GLO-CDR James Ariail, Hagerty Ashley Saulcy, Hagerty
Notetaker	Rachel Rosmarin, Hagerty

ATTENDEES

- **Texas General Land Office – Community Development and Revitalization (GLO-CDR)**
  - Sarah Douglas
  - Shonda Mace
- **Oversight Committee Members**
  - Lonnie Hunt
  - Michelle Meyer
  - Damian Morales
  - Shannon Van Zandt
- **Hagerty**
  - James Ariail
  - Rachel Rosmarin
  - Ashley Saulcy
  - Ashley Wargo

KEY POINTS

- Hagerty provided an overview of the Study approach and findings for the literature review, community outreach strategy and the Housing Assessment Tool (HAT) survey.
- Hagerty presented key takeaways from the community outreach as well as the analysis of the alternative housing findings.

- The Oversight Committee provided feedback on the solutions identified, with emphasis on the affordability of alternative solutions and the usefulness of a RAPIDO-like model that incorporates add-ons to support temporary-to-permanent housing.

MEETING NOTES

INTRODUCTIONS AND OVERVIEW

- GLO-CDR, Hagerty, and Oversight Committee members provided brief introductions.
- GLO-CDR provided an overview of the agenda.

STUDY APPROACH AND FINDINGS

- Hagerty reviewed the Study approach and findings in the three areas of the report, including the literature review, community outreach, and the Housing Assessment Tool (HAT) survey.
    - The literature review captured the best practices from prior disasters to inform the Study.
    - Community outreach involved stakeholders at many levels to understand what is necessary for a successful alternative housing strategy.
    - The HAT survey was a technical review of the options that were evaluated.
- Literature review found that while there has been interest at all levels of government to pursue alternative housing options, the technology and scale of production available in the marketplace has historically limited these solutions. However, the Study found that the marketplace has significantly expanded its production and innovation to meet these needs.
- Hagerty presented key takeaways from the community stakeholder outreach approach and specific quotes that informed those takeaways. The key takeaways included:
    - Efforts like temporary-to-permanent housing that focus on expediting the long-term recovery process can better serve the well-being of survivors and their communities;
    - When evaluating cost, it is critical to consider the broader cost implications of a housing program, as well as the long-term affordability of the home for the survivor;
    - Alternative housing solutions that serve permanent needs can better keep survivors safe by meeting or exceeding code, as well as by identifying their long-term purpose at the front-end of the program;
    - State agencies should increase coordination with long-term recovery groups and philanthropic groups to better leverage the information and resources available; and
    - Education about alternative housing units—particularly modular ones—is necessary to facilitate understanding and buy-in and should be implemented through clear and simple communication.

- Hagerty provided an overview of the HAT survey approach and levels of participation. A total of 34 surveys were completed from 24 participating vendors.

ALTERNATIVE HOUSING FINDINGS

- Hagerty provided an overview of the vendors and types of alternative housing identified by the Study.
- Hagerty presented how the alternative housing types align with key capabilities and needs identified for the State of Texas. Additionally, noted the strong performers for different categories (e.g., flood resilience, wind resilience, fire resilience, livability, and cost).
- The Study used a hybrid quantitative and qualitative approach that operated under two objectives:
    - Provide a consistent scoring approach across various questions and answer choices; and
    - Facilitate comparison of housing units and ranking between units based on the user's criteria (e.g., resilience).
- Hagerty conducted a cost effectiveness analysis. In addition to developing an overall cost score for each of the units, the Study identified the estimated resilience benefit-cost ratio (BCR) that reviewed units based on their total cost range per year, their estimated life expectancy, and their overall resilience scores.
- The Study identified four vendors that presented the most viable solutions for use in the State of Texas:
    - Boxabl
    - ICON
    - indieDwell
    - LiV-Connected

OVERSIGHT COMMITTEE FEEDBACK AND DISCUSSION

- The Oversight Committee provided the following feedback on the ***four solutions recommended for Phase II***.
    - As a point of clarification for those last four models that were shown – it looked like perhaps three of the four were designed so that when the temporary housing ended they could be repurposed. Which of these are designed to be reused versus deployed for permanent use?
        - Hagerty explained that the four solutions recommended for Phase II all have temporary to permanent capabilities. Boxabl, indieDwell, and LiV-Connected could be disassembled and reused in a different location if needed. Because so much of the community outreach on the long-term viability of rapidly deployable solutions, the Study focused on those units that could be

        installed, meet and exceed code requirements, and be added onto for permanent use.
        - Hagerty noted that the RAPIDO model has been successful in deploying core units and then adding on top of them with traditional construction, a model that can be replicated with the units recommended for Phase II of the Study.
        - (*Additional stakeholder response*) All of these are designed to stay and be a permanent solution?
            - Hagerty responded in the affirmative.
    - I think the most intriguing of them is probably the 3D printing model, ICON. Are there examples of those that have been in place for a period of time? I'm curious how long that would hold up.
        - Hagerty explained that each of the units identified has a total of thirty year plus lifespan, if not longer for their durability. This is a good point of clarification, that these are all relatively new companies.
        - Hagerty noted that ICON has constructed units in Austin, TX, but they're new within the last 10 years. Similarly, indieDwell is similarly relatively new and establishing manufacturing points across the United States—including a recent deployment to Santa Cruz, CA to address the needs emerging from wildfires.
        - Hagerty noted that the analysis of units was able to capture that the way they are engineered holds up to what would be expected durability for the long-term but there are not tangible examples of that having been implemented yet.
    - Based on what I see, all four of these solutions appear to be preferable and more desirable permanent solutions than what is currently used in rural Texas, which is generally a manufactured home or mobile home or recreational vehicle.
    - (*Additional stakeholder response*) Those that have been in place for a while, but the RAPIDO program does have homes that have been in place since 2014, so 6 years. They have at least 20 homes on the ground in the lower Rio Grande valley and they have about the same number in the Houston area and those homes have held up really well and blend well into the neighborhood. Appreciate that the study looked into neighborhood characteristics. Of the four shown, the indieDwell is the one that looks most like it would blend in to a neighborhood for a period of time.
- The Oversight Committee provided feedback on ***temporary-to-permanent alternative housing options***.
    - One concern, particularly for ICON, if it is not portable and it is a unit that is intended to be permanent, is that the look of it could potentially cause some issues depending on the neighborhood in which it is placed. It does have kind of the cool factor, having been 3D printed, but the overall look of the home doesn't blend well with most existing neighborhoods. That would also be a concern for the Boxabl.

        The LiV-Connected looks aesthetic, has some really nice aesthetic qualities, but it wouldn't blend necessarily well unless it was able to be modified to take on some of the architectural characteristics of the surrounding neighborhood.

        - Hagerty noted that is an important point and that the aesthetic shown in the pictures is not representative of the full range of what is possible. For Boxabl, the exterior finish can be completely customized, the roof can be customized. LiV-Connected can come in lots of different configurations. What is shown is just one possible configuration. With ICON and indieDwell, lots of different possibilities in terms of the ultimate aesthetic in the final product.

- The Oversight Committee provided feedback on the ***cost effectiveness of solutions for long-term use by survivors***.
    - As it pertains to cost and cost effectiveness, we're seeing in this presentation a lot of perspective from the vendors and from the General Land Office, but what is the cost effectiveness for the survivors themselves, for the individuals? Oftentimes, some of these temporary to long-term housing may look aesthetically pleasing, may be affordable for the taxpayer, but it is not an affordable long-term solution for the actual survivor and/or survivors that are within the home. I'm just wondering if that aspect was looked at, at all.
        - Hagerty noted that one of the factors that was looked at was cost.
        - (*Additional stakeholder response*) Did not see it in the PowerPoint, is it possible just overlooking it?
        - Hagerty noted that in terms of affordability, range of use to select specific HVAC, electrical, and plumbing systems was available, depending on what the particular preference was to the end user. The vendors emphasized the flexibility of their solutions to specifically use whatever systems would be requested of them, and from that perspective, one of the benefits is their flexibility to adapt. These aren't necessarily heavily prescribed systems that have to keep a certain type of proprietary system to be operated. For the Boxabl unit in particular, and across the board, the fact that you can also marry it with the traditional construction needs, means that you can have this modified solution that can replicate some of the key successes of the RAPIDO program.
        - Hagerty noted that in terms of overall durability, vendors are thinking about durable affordable housing. The ICON team—which is based in Texas—provided an anecdote about their experiences with flooding in the Beaumont area.
- The Oversight Committee provided feedback regarding the ***cost of alternative units***, as compared to providing survivors traditional home reconstruction.
    - The team discussed cost and cost effectiveness, but what I wanted to know is what the bottom line is, not just compared to traditional solutions of hotel vouchers and FEMA trailers, etc., but what is the cost of these houses and how does that compare to just putting people in a regular home?

    - Hagerty noted that for the purpose of direct comparison given that different unit sizes incur different amounts of cost, so the Findings Report focuses on the cost per square footage and the cost per occupant per year. Need to keep in mind that the Boxabl unit provides a base kind of 400-500 sq ft core unit for about $50,000, so to get a full-size house it is similar to a full home construction of about $100,000.
    - Hagerty noted that all of the vendors were cost competitive overall when compared to the full life cycle cost of the FEMA MHU or a stick-built home.
    - Hagerty provided the costs per square foot for each home, including $124/sq ft for Boxabl unit and $170/sq ft for LiV-Connected unit. ICON costs $200/sq ft, but total cost per sq ft would decrease for a large-scale housing mission.
  - Those right there, that price per square foot is way more expensive than buying a home in a lot of Texas communities. I'm currently shopping here in College Station and for $200/sq ft can get a high-end home with granite countertop and a variety of very nice things. I'm stuck on why we would spend this amount of money on something that is tiny, potentially doesn't fit into the community itself, and might not hold up in their value. As the other stakeholder brought up, what is the value to the survivor? If the survivor lives in it for 10 years, are they going to be able to sell it at that point? A normal house seems to beat all of these and is dramatically lower in terms of price.
  - (*Additional stakeholder response*) I agree with that line of thinking. We are all in agreement that the current model of temporary housing units and MHUs is broken, it's expensive, it's not a good return on investment for the taxpayer or for the survivor, but I agree that these are pretty costly solutions. We know that non-profits are just part of the solution, and we generally can do a stick-built house for far less than this cost, generally speaking. It's important to look at a variety of solutions.
    - Hagerty explained that you are also getting speed with those figures as well, with the ability to deploy these modular units and add on later.
    - (*Additional stakeholder response*) I agree that you do get speed, but I want to make sure if we get speed that people are actually going to stay in them for a longer period of time and with my experience researching this worldwide, speed doesn't always mean that people will stay in a house. Sometimes these units are left empty and then it ends up being a waste of money, whereas ones that took longer to build, and might even cost less, people stay in for longer, so you actually solved the more broad housing problem rather than just a general, "We have to hurry up and get people into houses post-disaster."
    - (*Additional stakeholder response*) I know the scope of this project was to look at these kinds of temporary-to-permanent solutions, but there isn't a one-size-fits-all and I think GLO recognizes that there are going to be a variety of needed solutions. These types of temporary-to-permanent homes will be appropriate in certain settings for certain households, but they are

        not going to be a solution for all homeowners of single-family homes or in all types of settings. These might not work for the family that has an uninhabitable home, where they need to be portable as they plan what they're going to do for long-term housing.
        - Ideally, these alternative units might be able to add to the supply of affordable housing, but I think that will only be effective if it is done intentionally, if there is a location for them to go to, and if they are built as part of new affordable housing with appropriate infrastructure and as a planned part of the community. I know that is beyond the scope of what the Study was focused on and I think you've given some very good options and understandings of the strengths and weaknesses are of these different models, but it is a further step to go to be able to integrate them into a cohesive plan for how they would be used both in the near-term and the long-term.
    - (*Additional stakeholder response*) If you have ever run a program that builds homes in a long-term recovery program for disaster survivors, you can't follow the rules of traditional construction and build a home for much less than $200/sq ft. It is just the nature of these government programs and all the hoops you have to jump through, that you can't construct a home for anywhere close to what a private individual with his or her own money can just go out and hire a contractor to build.
        - (*Additional stakeholder response*) I know that is the challenge, and I just want to push us to think then, is just providing a different housing type and housing solution the best way to go for the taxpayer or is there some other version, a recovery model that we can really reduce the cost to taxpayers, while also meeting the needs of survivors? That is outside the scope of the Study per se, but I think making sure we put these costs in light of what we are paying now for our current recovery programs and housing costs in general, can help us think broadly about what we are doing with recovery.

- The Oversight Committee provided feedback regarding the ***Study approach***.
    - Has anyone thought about the approach of, as opposed to talking to existing vendors and contractors about what they are doing and what's available, about the approach of designing what we want and then finding out what it would cost to get it? Our ideal solution may be something that it's not being done out there anywhere.
    - I see a potentially great solution for rebuilding a home in its current place of just having a shell of a home with the very basics that could be moved in, that you would then build the rest of the home around that or in front of it or add on to it.
        - Hagerty emphasized that many of the vendors highlighted their capabilities to modify their designs based on the end user. The structure of the Study required a defined submission, so the concepts were provided in unified formats. Going to Phase II, it will be an important conversation, to better understand how alternative housing can meet Texas's needs.

ADJOURNED AT 1:06 P.M.

DECISIONS/NEXT STEPS

- The Disaster Recovery Alternative Housing Study is currently finalizing the Findings Report, which will be made available to the public at www.recovery.texas.gov. The Disaster Recovery Alternative Housing Study Team will share a formal notification with the Oversight Committee when the Findings Report is published.
- In October 2020, GLO-CDR will begin Phase II of its efforts in alternative housing, to physically test a set of identified high performers to evaluate their resiliency.
- Community engagement will continue alongside these efforts, to ensure that as solutions progress, they are done in hand with the communities that may be impacted by future alternative housing programs.

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