Combined Mechanical & Electrical POD

Efficiency Vermont R&D Project: Equity

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Executive Summary

Repeated flooding in Vermont has increased the urgency of identifying residential recovery strategies that do more than restore damaged equipment. This report evaluates whether an exterior mechanical and electrical pod, designed to relocate critical systems above anticipated flood levels, could serve as a practical resilience measure for flood-prone homes. This analysis considers Vermont's flood recovery experience, national experience implementing pod technologies, and pod technology design concepts to assess whether this approach could improve recovery outcomes while supporting long-term resilience.

The findings of this report suggest that pods are not ready to function as a fully standardized solution for Vermont homes. Vermont-specific flood recovery projects remain highly variable, and homeowners often face significant costs for straightforward equipment replacement, with added costs when systems are relocated above flood levels or converted to different technologies. At the same time, pod-based approaches offer the potential to reduce installation complexity by consolidating equipment and shifting more work off-site. For Vermont, the most promising opportunity appears to be a semi-standardized model that uses repeatable core enclosure, attachment, and weatherproofing details while allowing flexibility in equipment selection, connections, and site-specific design.

Based on the findings from this report, if this measure were to be pursued further, Efficiency Vermont's next step would be to move from exploratory research to prototype development and pilot testing. A Vermont pilot program would help validate constructability, code compliance, serviceability, homeowner acceptance, and total installed cost under real-world conditions. It would also generate the Vermont-specific performance and cost data needed to determine when pod installations are most practical, which design features can be standardized, and whether the approach can support broader flood recovery and resilience goals over time. This path would allow Efficiency Vermont to test the concept in a disciplined way before considering broader deployment.

Introduction

Vermont has experienced an increase in the frequency of extreme weather events, with flooding emerging as the state's most common and damaging hazard. Over the past 15 years, Vermont has endured multiple major floods, including Hurricane Irene (2011) and the widespread flooding events of July 2023 and 2024. These floods caused extensive damage to infrastructure, agriculture, housing, and businesses and required repeated, resource-intensive recovery. In some cases, homes were damaged in consecutive years, underscoring the need for more resilient residential systems.

As climate change increases the likelihood of recurrent flooding, it is increasingly important to identify strategies that reduce damage and support faster recovery. The concept of "building back better" has gained national attention as a framework for post-disaster reconstruction that decreases vulnerability to future events. In practice, however, implementation can be constrained by available space, access to technical expertise, and the costs borne by homeowners and contractors.

This study examines recent flood impacts in Vermont, reviews approaches used in other jurisdictions and evaluates an emerging resilience opportunity: the residential "pod." In this context, a pod is a compact, externally attached enclosure that consolidates a home's mechanical and electrical service equipment (e.g., space conditioning, domestic hot water, ventilation, and electrical panels) and relocates it above anticipated flood levels, reducing reliance on flood-prone basements. Existing pod solutions suggest that maintaining the functionality of mechanical and electrical systems during flood events can improve recovery efficiency. Although current pod concepts typically require customization to individual homes, opportunities for partial standardization may improve scalability and cost-effectiveness. By assessing design feasibility, relevant precedents, and potential cost implications, this research evaluates whether residential pods represent a practical resilience measure for flood-prone households.

Methods

The research team used a mixed-methods approach that combined quantitative and qualitative analysis. First, a desk review was conducted of Vermont and national efforts to relocate mechanical and electrical service equipment out of flood-prone basements in cost-effective ways. This review assessed whether exterior pod designs have been implemented successfully and documented key challenges and enabling factors. Next, industry stakeholders were interviewed to explore potential benefits, including cost savings, labor efficiencies, and non-energy impacts such as preserving interior square footage. Finally, the broader economic implications of faster post-flood recovery were considered, including how quicker re-occupancy may reduce costs for homeowners and communities.

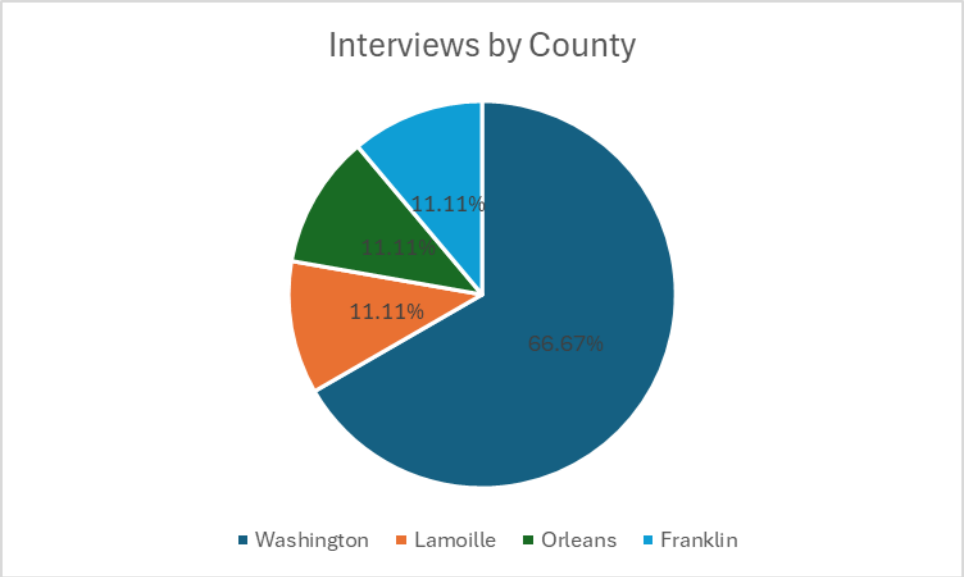
Findings

Vermont Flood Recovery Experience

Before conducting interviews, the research team reviewed local flood hazard regulations to understand city requirements. Using the city of Barre, VT as an example, its ordinance was first adopted in 1974 and most recently amended in November 2024, with the goal of outlining straightforward procedures while aligning with broader municipal policies. Homeowners should always confirm compliance with their local authority having jurisdiction to ensure they meet all applicable city regulations.

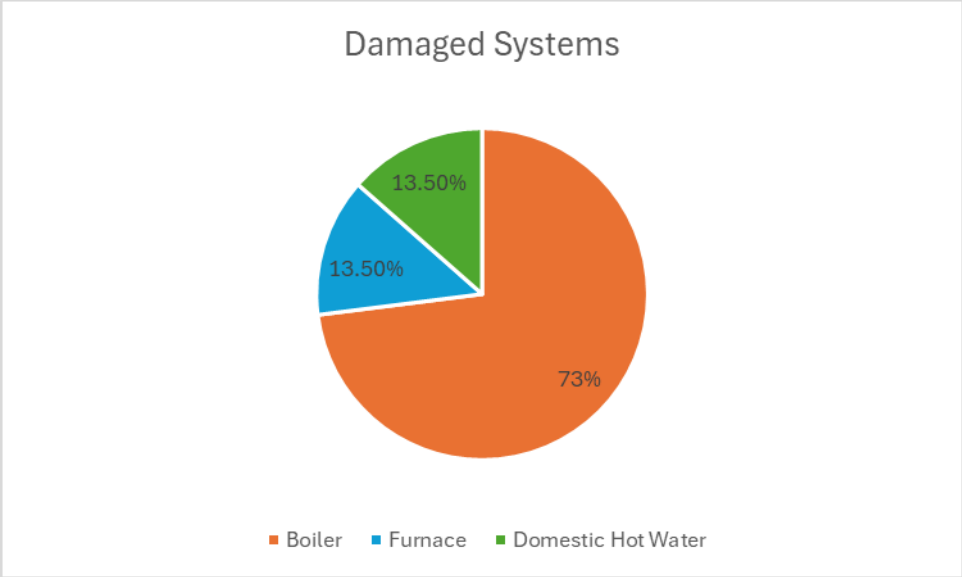
Interview participants responded to the questions in Appendix A. Participants were identified internally by reviewing completed flood recovery projects in Tracker and then narrowing the list based on measures implemented (e.g., boilers, furnaces, and water heaters). This process resulted in 10 interviewees; most located in Washington County. The county-level distribution of interviews is shown in Figure 1.

Figure 1: Vermont Flood-Impacted Interviewees by County



Of those 10 homeowners interviewed, the overwhelming majority had a damaged boiler that required replacement. Some homeowners reported having multiple system failures. Figure 2 displays that most damaged systems which required replacement were heating systems, with a few water heating systems requiring replacement.

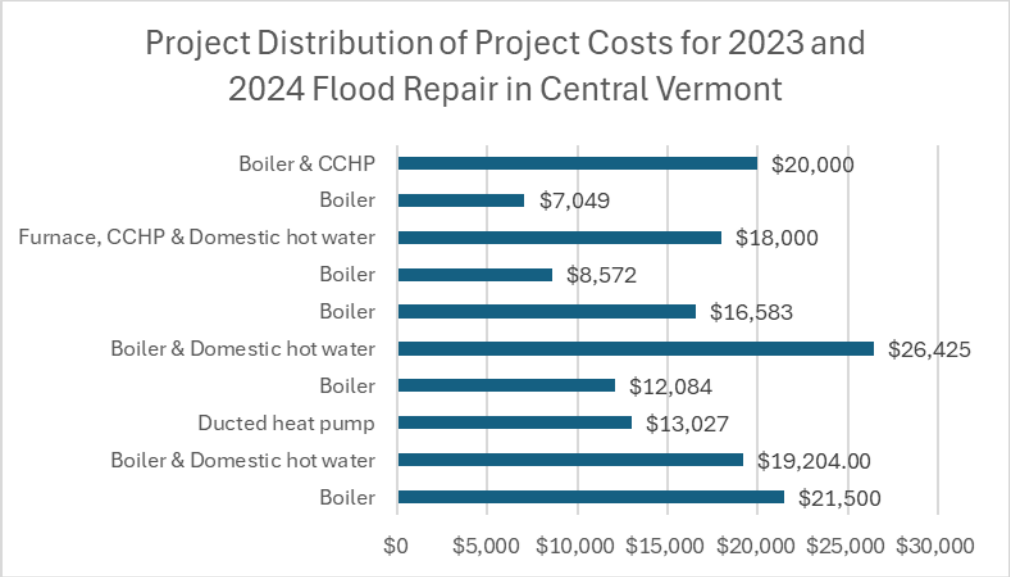
Figure 2: Overview of Systems Damaged in Homes of Interviewees



In nearly every case of system failure, homeowners chose to replace equipment with similar models—for example, replacing a failed boiler with a new boiler. There were two instances where heat pumps were added as supplemental systems, and one case where a homeowner opted to replace a damaged furnace with a ducted heat pump.

Project costs were significantly offset by rebates from American Rescue Plan Act flood recovery funding. Without this financial assistance, the expense would have posed a substantial burden for most homeowners. It is important to note that rebates were capped at $10,000 per household, while the average project cost exceeded $16,000. Figure 3 displays total project costs depending on the replaced equipment. *Project costs are varied as each project is unique.*

Figure 3: Distribution of Repair Project Costs of Interviewees



National Design and Implementation Experience

The project team reviewed recent national research and identified two notable approaches to modular solutions that address the Vermont flood recovery needs described above, the LifeWall's product and a research initiative from the University of Central Florida (UCF). Both focus on "pod" systems that consolidate a home's mechanical equipment into a single unit designed for broad deployment and significant energy savings. A central feature of these solutions is the integration of renewable energy, particularly through solar panel installations.

LifeWall can reduce household energy consumption by combining on-site solar generation, battery storage, high-efficiency heating and cooling equipment, and integrated controls that optimize when energy is produced, stored, and used throughout the home. LifeWall exemplifies this concept with its all-in-one renewable energy device that combines solar energy production, lithium-ion energy storage, space heating and cooling, water heating, energy monitoring, home automation, and fresh air exchange. Engineered for simplicity and efficiency, LifeWall offers 7 kW–10 kW of solar PV capacity, a 13.5 kWh battery, and 4G LTE connectivity for monitoring. By replacing multiple contractors with a single installation, LifeWall reduces costs by approximately 30% while delivering advanced features such as circuit-level monitoring and HEPA filtration. Image1 shows a photograph of the LifeWall system, a comprehensive, integrated approach to housing a home's mechanical and electrical service equipment.



Image 1: LifeWall System

Similarly, UCF's initiative aims to retrofit existing homes to achieve a 75% reduction in energy consumption. Their research highlights challenges such as limited innovation within the construction industry and delays in meeting climate mitigation goals. The next phase of UCF's project, scheduled for February 2026, will involve installing demonstration systems and collecting one year of performance data to validate their approach.

While these pod-based solutions show promise for cost savings and streamlined deployment, they are not currently practical for disaster relief scenarios in Vermont, where homeowners have diverse needs and aesthetic preferences. Nonetheless, lessons from these models can inform future designs, with flexibility remaining essential to address varying requirements and ensure resilience under different conditions.

Pod Approach and Examples for Vermont Applications

To date, this research has not produced enough Vermont-specific data to quantify net cost savings from pod installations compared with conventional in-home replacement or relocation strategies. National research suggests pods may deliver energy savings that could translate into lower costs over time; however, additional analysis is needed to quantify these impacts. Several key questions shape the investigation of applicability for Vermont:

- How do rapid reinstallation and quicker homeowner re-entry after natural disaster translate into cost benefits?
- What potential cost savings can be achieved through pod installation?
- Are there measurable reductions in mechanical and electrical labor costs?

- What non-energy advantages or disadvantages exist, for example, avoiding the loss of interior square footage?

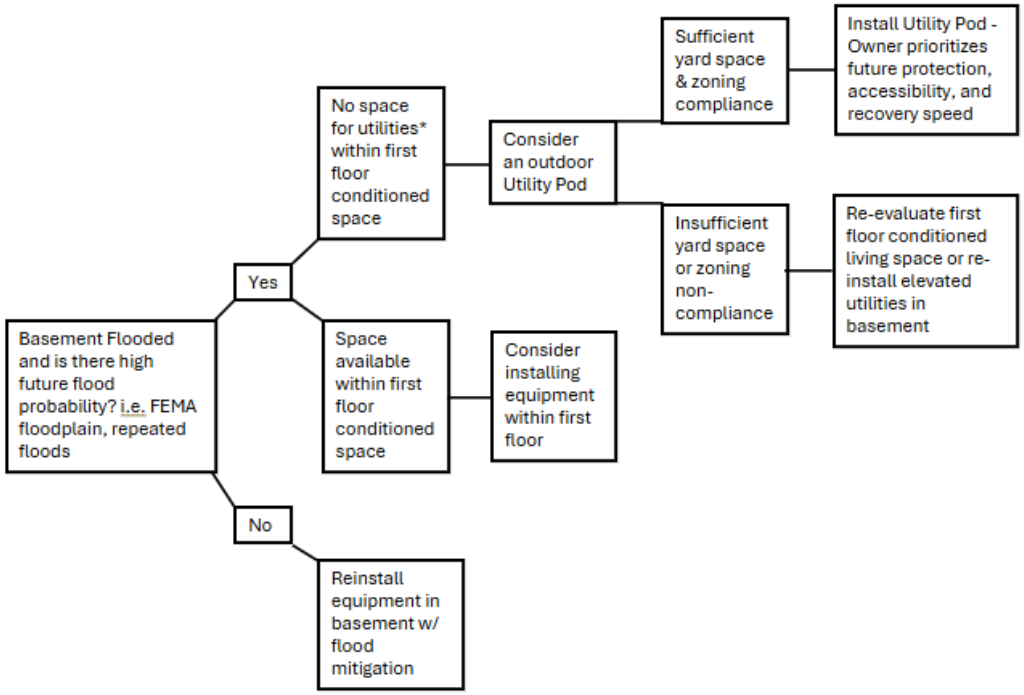
One early window into those questions comes from a contractor perspective. To help illustrate the range of post-flood mechanical decisions and the cost implications of relocating equipment out of basements, On the Dot (Barre, VT) shared side-by-side cost information from four recent sites. Together, these examples show how projects that "build back better" (for example, moving equipment to the first floor or changing system type) can quickly add scope beyond a straightforward in-kind replacement, particularly when distribution systems (ductwork or piping) must be reconfigured.

1. In Montpelier, VT (single-family), an oil furnace in the basement was replaced with a propane furnace relocated to the first floor. Total cost was $13,000. This was approximately double the cost of a simple basement replacement, due largely to ductwork reconfiguration.
2. In Barre, VT (single-family), a propane furnace and water heater were replaced with a ductless heat pump, two Rinnai propane heaters, and a tankless water heater. Total cost was $15,700.
3. In Barre, VT (four-unit), an oil boiler was replaced with four ductless heat pumps (one per unit). Total cost was $29,400. The owner prioritized resilience over an insurance-covered boiler replacement and was aided by Efficiency Vermont rebates; the owner reports higher heating costs with heat pumps compared to oil.
4. In Barre, VT (single-family, 2023 flood), a basement propane furnace was replaced and a heat pump water heater was added for a total of $7,800. Insurance did not cover relocating equipment to the first floor.
    - In a repeat flood at the same Barre, VT site (2024), two Rinnai propane heaters were installed on the first floor after the second event. Total cost was $5.9K (heating only), while the water heater remained in the basement.

Taken together, these contractor-reported examples reinforce two key findings relevant to pod feasibility: (1) flood recovery work is often expensive even when homeowners pursue like-for-like replacement, and (2) costs can increase quickly when projects include relocation above flood levels or a shift in system type. Developing Vermont-specific cost assumptions for pod installations, including how pods might reduce on-site coordination and distribution rework—will be essential to estimate incremental cost and to identify the situations where a pod approach is most likely to be practical.

Given the variety of mechanical strategies used to restore homes following severe weather events, the next phase will focus on determining when the pod approach is an optimal solution. The decision tree will outline the circumstances under which the utility pod should be considered. Utilities provided in the pod include heating, cooling, hot water and electrical service equipment. Figure 4 presents a step-by-step decision tree that guides whether a utility pod is an appropriate recovery strategy for a flood-impacted home.

Figure 4: Decision Tree to Determine Applicability of Utility Pod



The diagram starts with an initial screening question about whether the home has experienced flooding (or is expected to experience flooding again) and then walks the reader through a series of practical considerations that affect feasibility. These considerations include whether critical mechanical and electrical equipment is currently located in a basement or other flood-prone location, whether the homeowner is planning to replace or substantially upgrade damaged equipment as part of recovery, and whether there is a clear need or desire to relocate equipment above anticipated flood levels. The decision tree also highlights site and design constraints that can prevent a pod from being a good fit in some cases, such as limited exterior space for an attached enclosure, challenges routing connections from an exterior pod back into the home, and the need to coordinate foundations/anchorage and weatherproofing at the house interface. At each branch, the figure directs the reader either toward "pod may be appropriate" pathways (when relocation and consolidation provide resilience benefits and the site can support an exterior enclosure) or toward "pod may not be appropriate" pathways (when equipment can be protected in place, when the scope of work is minimal, or when physical/site constraints make an exterior enclosure impractical). Overall, the figure is intended as a first-pass tool to frame discussion with homeowners and contractors and to identify the situations where additional technical review is warranted.

The research team worked with partners to understand how core components of the pod approach could be deployed in Vermont. The first example detailed below is a conceptual schematic that illustrates one potential exterior HVAC/utility pod configuration. The second example details an exterior pod that was deployed in a home in Barre, VT. Together, these examples show what a pod can look like in concept and how an exterior enclosure has been implemented in practice.

Alger Brook Design Build (Thetford Center, VT) developed the schematic FEMA HVAC Pod concept shown in Figure 5 below. This figure should be interpreted as an early design study rather than a construction-ready detail set. The schematic conveys the overall intent of consolidating mechanical equipment in an exterior enclosure while locating it above anticipated flood levels. In this example they replaced an exterior. uninsulated electric furnace with a high efficiency ducted heat pump housed in an insulated pod. Many key items need to be customized to site specific requirements, including final equipment selection, connection details to the existing home, structural attachment/anchorage, weatherproofing, penetrations, code clearances, and service access.

Figure 5: Schematic Design of FEMA HVAC Pod by Alger Brook Design Build

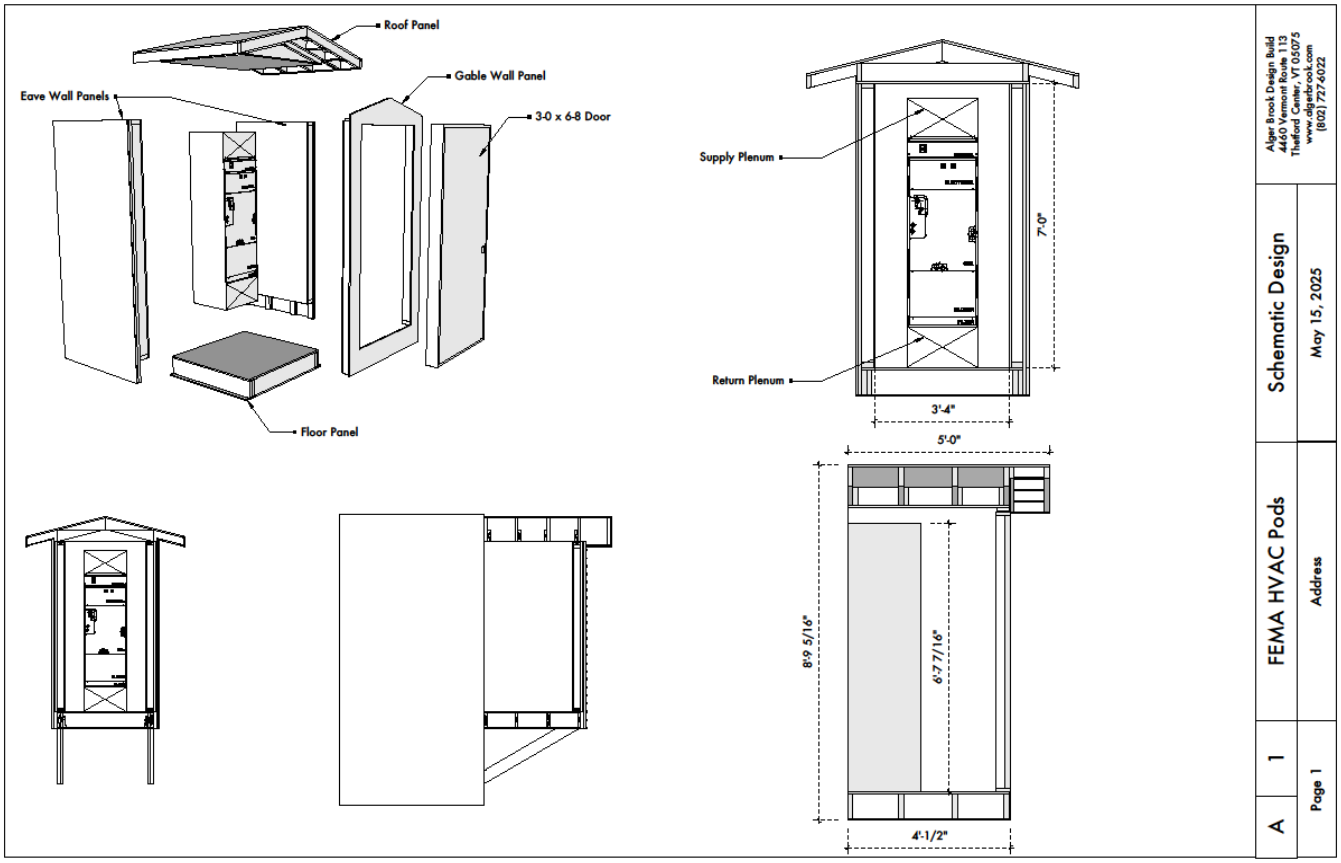


Figure 6 shows photographs of an exterior pod that was built and attached to a home in Barre, VT. Unlike the schematic above in Figure 5, this example demonstrates real-world constructability and siting on an existing home, including enclosure configuration, placement relative to the house, and how the pod presents aesthetically. This installation helps ground future design development by highlighting practical considerations that any repeatable pod approach would need to address. These factors include foundations/anchorage, water management at the roof/wall interfaces, routing of mechanical/electrical connections, maintenance access, and integration with varying existing conditions.

Figure 6: Photographs of Installation in Barre, VT



Discussion and Next Steps

The findings of this research suggest that use of a Vermont pod is most promising not as a fully standardized, one-size-fits-all product, but as a semi-standardized approach that combines repeatable enclosure and attachment details with project-specific equipment selection. The case examples and national precedents both indicate that flood recovery costs are already substantial, particularly when homeowners seek to relocate equipment above flood levels or improve resilience beyond simple like-for-like replacement. In that context, a pod approach may offer its greatest value by reducing design complexity, shortening installation timelines, improving coordination across trades, and supporting faster recovery after future flood events. For Vermont, the most credible path forward is to standardize the elements that can realistically be repeated, such as enclosure form, weatherproofing strategy, structural attachment concepts, and service access, while preserving flexibility to respond to differences in home layout, site constraints, mechanical needs, and homeowner preferences.

To continue investigating the use of pods in Vermont, a next step would be to progress from exploratory research into prototype development and field validation. This should include advancing the engineering and mechanical design to a more detailed level, identifying a suitable pilot site, and testing a pod installation under real-world conditions. A prototype would help validate constructability, code compliance, weatherproofing, serviceability, homeowner acceptance, and total installed cost. Just as importantly, a pilot program would generate Vermont-specific performance and cost data to help determine where pods are most practical, quantify potential long-term cost savings, identify design features suitable for standardization, and evaluate the approach's ability to support broader flood recovery and resilience goals.

Appendix A: Questionnaire for Homeowners

Homeowners were posed with the following question set *(some declined to answer)*:

1. Any system(s) relocated?
Most homeowners chose to keep systems in the basement and chose to elevate them or hang them on the walls or ceilings.

2. Time without HVAC, how long?
Not every homeowner experienced time without HVAC, but for those that did, it typically ranged from 3-6 months.

3. Occupant displaces, how long?
No one reported the need for displacement.

4. VEIC financing used?
No reports of VEIC financing being used.

5. Was AC a factor in new equipment choice?
AC was a factor in one homeowner's situation.

6. Future flood plans?
Future flood plans included some typical procedures such as sandbagging basement windows or installing a sump pump; however, in some more rare instances the house was sold to FEMA or they worked with the federal government to put the house on a new foundation.