# Testing Energy Storage Systems (ESS) in Residential Properties

In the IAFF's effort to improve our members' work environment, the International Association of Fire Fighters and UL Solutions initiated a joint project in 2022 under an agreement with the United States Department of Energy (U.S. DOE). This project has focused on two separate and important initiatives related to energy efficiency in residential buildings.

## Initiative 1 — Fire Performance on Energy Efficient Exterior Walls

The first initiative of the project addresses concerns surrounding new technologies with enhanced, energy-efficient exterior walls installed on residential properties.

The concerns of fire travel extending vertically or laterally were examined. In the United States, testing to the exterior wall standard NFPA 285 is required for commercial buildings only, while exterior walls of residential constructions are not typically mandated to undergo fire testing in the same manner.

The initiative and its concerns were a natural evolution, stemming from the efforts of Pacific Northwest National Laboratories (PNNL), who had partnered with the DOE in researching existing and innovative retrofitted exterior wall systems. This meant wall systems had to be able to be applied to existing structures that would enhance the insulative performances of these buildings. However, fire performance did not factor into the research.

To initiate the project, the IAFF and UL Solutions team established a Project Advisory Panel and held several virtual meetings to present information on previous fire testing conducted by the UL Solutions Fire Research & Development team and the Fire Safety Research Institute of UL Research Institutes. The panel discussed the development and goals of the earlier PNNL project, and then they developed a test plan.

The test plan incorporated a modified version of an American Society for Testing and Materials (ASTM) test method, ASTM E2707, Standard Test Method for Determining Fire Penetration of Exterior Wall Assemblies Using a Direct Flame Impingement Exposure, as the foundation of the research.

The original ASTM E2707 assesses fire penetration into a wall assembly (horizontal burning into the wall, through the layers). This modified method is under development at ASTM and addresses fire propagation (vertical burning up the exterior face of the wall), not fire penetration.

The modified method is strictly a draft currently, so using it for this research work served as suitable proof of some of the concepts. The test method involved a wall structure that is 16' high by 8' wide. The sheathing was 1"x6" spruce/pine boards to represent retrofit construction, with no insulation in the stud cavities and an interior 5/8" gypsum wallboard.

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The objective was to consider various energy-efficient new and retrofitted designs and evaluate how they spread fire vertically or laterally. Through past research initiatives, it was known that fires that extend up the wall and into attic spaces are problematic for first responders. To date, 11 of these tests have been conducted, and the results of the full analysis will be in a future report.

## Initiative 2 — Firefighting Tactics in Residential Properties with Building Energy Storage Systems

The second aspect of the UL-IAFF Project focuses on the fire service response to Residential Battery Energy Storage System (RBESS) incidents. Again, the IAFF and UL established a Project Advisory Panel with several fire fighters who have responded to BESS incidents, representatives from the battery industry, and engineers involved in designing commercial BESS fire and explosion protection solutions.

Through a series of planning meetings, the panel developed a matrix for tests to be conducted within a structure that represents a typical residential two-car garage. The two-car garage was selected after a review of RBESS installation practices identified the garage as the preferred installation location. A review of U.S. Census data identified the attached two-car garage as the most common garage type.

These simulation tests were constructed in the large-scale fire test facility at UL Solutions' Northbrook, Ill., campus. A baseline test was conducted that involved a test structure with no batteries and shelving units populated with standardized commodities, representing a typical garage with cellulosic and plastic contents.

Three additional tests have been conducted to generate data with the contribution of energy storage system (ESS) batteries to compare fire and explosion hazards against the baseline test.

Through this work, fire service tactical considerations can be explored. To date, from the data, the team can determine 1) the visual indicators of a residential fire that has involved an RBESS (or, potentially, other large batteries), and 2) the impact of fire service-initiated ventilation of the structure on the fire conditions and explosion risks.

## Next Steps for UL Solutions, IAFF, and DOE

With this milestone of testing complete for Projects 1 and 2, the advisory teams continue to analyze results and determine what next phase of tests will take place. Ultimately, a report of this work will be released to the DOE and made available through IAFF and UL Solutions platforms. The IAFF will focus the third year of the project on generating educational materials to disseminate the information.

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## Summary of Test Results:

| Test # | Cladding | Additional Layer | Additional Layer | WRB | Sheathing | Insulation | Interior | Fire Size | Flame Propagation @ 16' Time, mm:ss | Flame Propagation @ Side Time, mm:ss | Test Terminated Early? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 inch Wood Composite Lap Siding | | | Asphalt-impregnated building paper | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 17:30 | 19:08 | No |
| 2 | 8 inch Wood Composite Lap Siding | | | Asphalt-impregnated building paper | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 50 kW | Did Not Reach | Did Not Reach | No |
| 3 | 5 inch Vinyl Lap Siding | | | Asphalt-impregnated building paper | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 3:08 | 4:03 | Yes 4:36 |
| 4 | 8 ¼ inch Fiber Cement Lap Siding | | | Asphalt-impregnated building paper | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | Did Not Reach | Did Not Reach | No |
| 5 | 8 inch Wood Composite Lap Siding | Two layers 2.5-in. EPS panels with cable chases and drainage channels | House wrap, 1 inch mineral wool | None | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 7:25 (interior foam) 7:42 (exterior siding) | 7:51 (interior foam) | Yes 7:55 |
| 6 | 5 inch Vinyl Lap Siding | Two layers 2.5-in. EPS panels with cable chases and drainage channels | House wrap, 1 inch mineral wool | None | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 4:22 | 4:22 | Yes 4:42 |

Note: Red cells indicate layers that burned away exposing the layer underneath.

| Test # | Cladding | Additional Layer | Additional Layer | WRB | Sheathing | Insulation | Interior | Fire Size | Flame Propagation @ 16' Time, mm:ss | Flame Propagation @ Side Time, mm:ss | Test Terminated Early? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7* | 8 ¼ inch Fiber* Cement Lap Siding | Two layers 2.5-in.* EPS panels with cable chases and drainage channels | House wrap*, 1 inch mineral wool | None* | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | Did Not Reach* | Did Not Reach* | No* |
| 8 | 5 inch Vinyl Lap Siding | 1x4 furring strips with XPS infill | 2 in. XPS | House wrap | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 4:20 | 4:16 | Yes 5:56 |
| 9 | 5 inch Vinyl Lap Siding | 1x4 furring strips | 1-in. foil-faced polyiso foam board | Drainage wrap weather resistant barrier | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 2:58 | Did Not Reach | Yes 9:51 |
| 10 | 8 inch Wood Composite Lap Siding | 1x4 furring strips | 1-in. foil-faced polyiso foam board | Drainage wrap weather resistant barrier | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | 9:34 (fuel rich gases above) 10:01 (exterior siding) | Did Not Reach | Yes 18:40 |
| 11 | 5 inch Vinyl Lap Siding | 1x4 furring strips | Drainage wrap weather resistant barrier over 2 in. high compressive (80) mineral wool over | Asphalt-impregnated building paper | 1x6 Spruce/Pine boards | None | 5/8 inch Gypsum wall board | 75 kW | Did Not Reach | Did Not Reach | No |