

## Technical Assistance Request for the project entitled:

### Factory Installed Solar Solutions for Manufactured Homes *Cleverly Designed Power Integration for a New Wave of American Home Buyers*

#### Abstract

Manufactured and modular homes have roughly 8% of the US population living in them and make up 11% of the new, single-family home starts each year. The industry reported a compound annual growth rate (CAGR) of 7.86% in 2018<sup>1</sup>. And yet, solar penetration in this market is negligible, mostly for financing qualification factors. Phase3 Photovoltaics is currently establishing partnerships with 2-3 manufactured home industry players in order to provide solar installation solutions that can be integrated directly into the roofs of their home products, assembled in their factories, and shipped directly to home sites ready for utility hookup. Currently, factory-based home builders have no offerings for solar roofs. Therefore, this concept, if funded, will customize PV system design packages for high-volume, pre-manufactured homes. The aim is to use mass-production practices in a centralized facility to dramatically lower the installation, permitting, and interconnection costs in lieu of assembling the solar systems on-site. The turnkey systems envisioned are wholly inclusive of the entire balance of system components and dovetail into the energy efficient appliances through an intelligent power management hub located in the home's control center. The goal is to expedite return on investment by maximizing self-generated power consumption at peak pricing times, such as by offsetting air conditioning loads in the summer months. An added benefit of this approach is that it provides solar power to even the most underserved portion of the US market, so that they too can have access to renewable energy and reap the benefits of lower net monthly bills. It is through leveraging the construction expertise of pre-fabricated home builders, that an estimated reduction of installation, operational, and balance-of-system costs at close to 60% of on-site, retrofit solar installations. This translates to a conservative projection of \$1.60/Wp installed systems, and possibly even more on smaller systems sited in rural and tribal lands (See Figure 1). Several economical, engineering, and technical challenges exist that Phase3 Photovoltaics hopes to address in this area: (1) The roofing construction methods of prefabricated houses differ from those of site-built structures and modification to the racking, mounting and module frames may be necessary to address static and dynamic loading requirements; (2) transportation of completely assembled solar arrays affixed to prefabricated roofs has never been attempted, and adaptation of mounting hardware capable of withstanding interstate truck and rail shipment is needed; (3) hiring, training and tooling a workforce that is to assemble, wiring and test PV systems within a factory environment is new to everyone in the industry and new quality inspections systems will need to be created. The first step in this project will be to assess the market, and conduct a rigorous economic validation of modeled costs. Because no data exists for this segment of consumer, the ability to gauge viability requires prototyping and in-depth analysis at manufacturing and customer sites.

<sup>1</sup> <https://www.manufacturedhousing.org/wp-content/uploads/2018/06/2018-MHI-Quick-Facts-updated-6-2018.pdf>

## Request Summary:

1. Finite Element Analysis of Residual and Dynamic Loading Conditions Experienced by Solar Arrays Mounted on Manufactured Home Roofs
  - Partner with Sandia National Lab having Extensive Structural Simulation Abilities to Include Dynamic and Oscillatory Loading Conditions of a Complex 3D Truss/Roof/Array Model => Sandia has responded affirmatively, CRADA Pending
  - Tasks to Include Building at Mesh from Design Drawings and Simulating Various Loading Conditions to Inspect Comparative Differences with Site-Built Homes
  - Desire a FEA Model of Stress States of at least (5) Roof/System Configurations During (3) Characteristic Loading States
  - Envisioned Work Package Can be Delivered for ~25 kUSD  
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2. Wind Loading and Vibrational Mode Testing in Simulation of Transport Loading Conditions
  - Desired Laboratory to have Comprehensive Wind Tunnel and Vibrational Table Capabilities that can be Applied to a Prototype Structure => no response as of yet
  - Tasks Likely Include High Resolution Imaging and Data Acquisition that Mimic Structural Simulations, High Speed Imaging, Stress Mapping and Comparisons to Models
  - Desire at least (5) Wind Load and Vibrational Conditions of ~ (3) Prototype Structures
  - Envisioned Work Package Can be Delivered for ~35 kUSD
3. EL/PL/IV Spatial Mapping of Fix-Mounted Modules  
Pre & Post Transport in Aims of Mitigating Power Loss Mechanisms via Shielded Placement Strategies
  - NREL Module Characterization and Reliability Teams Can Easily Conduct Work Package => no response as of yet
  - Plan is to Characterize Modules before and after various Factory-Handling, Road-Transportation, and Final Installation Scenarios Unique to Manufactured Homes
  - Desire a Full Characterization Report of Supplied Modules (~ 20) before and after being subjected to Field Testing in Non-Standard Applications
  - Envisioned Work Package Can be Delivered for ~20 kUSD
4. Load and Generation Profile Optimization of a Smart-Manufactured Home Pre-Wired with Tunable Appliances, HVAC, and Electric Vehicle Charging Station to Enable 100% Self-Consumption of Harnessed Incident Energy
  - Target Laboratory to have Background Knowledge of Smart Homes, Appliances, Energy Usage Models and Apply Them to PV Generation Models => no response as of yet
  - Work Includes Building a Comprehensive Model that Reflects a Typical Manufactured Home Owner's Usage Portfolio and Adapting an Optimization Scheme for Appliance Activation and Habit Formation
  - Desire a Model Capable of Address at Least (3) User Profiles in (3) Characteristic Markets
  - Envisioned Work Package Can be Delivered for ~35 kUSD
5. Mortgage-based Cost Deferment Analysis of Original-Equipment-Manufacturer Solar Arrays Situated in Variable Insolation Areas
  - NREL's Solar Cost Modeling Group Should be able to Create a Series of Estimates that Reflect the Basis of Inspection => NREL has expressed interest to collaborate, but wishes to modify scope, CRADA pending
  - Project to Reflect the Benefits (and Detractors) of Building a Solar Array During Home Construction and Thereby Including it with the Original Home Mortgage
  - Desire a Cost Model Capable of Generating Scenarios Across Lender Terms and Conditions and Scalable to Various Installation Costs and Able to Offset a Time of Use Local Utility Rate Structure
  - Envisioned Work Package Can be Delivered for ~20 kUSD  
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