Penn FUSION Engineering

152 S. Broad St.
Lansdale, PA 19446
(215)361-8040

September 14, 2018

PowerHome Solar
919 N. Main St
Mooresville, NC 28115

RE: Abbitt Residence
575 Highgrove Dr, Spring Lake, NC 28390
Client Project #: 575ABBI
PFE Project #: 184084

On behalf of PowerHome Solar, Penn Fusion Engineering LLC (PFE) performed a structural analysis of the roof design at the above referenced location. The purpose of our analysis was to determine if the existing design of the roof system is structurally sufficient to support the new photovoltaic modules in addition to the code required design loads. Our analysis is based on the information provided by PowerHome Solar and is isolated only to the areas where the modules are intended to be placed.

System Specifications:
Total System Size: 7.08 kW/DC
Panel Specs: (24) Mission Solar – MSE295SQ5T
Inverter Specs: (24) Enphase – IQ6+
Racking System: Iron Ridge – Flush Mount

The modules are to be located on the following roof plane:

Mounting Plane	Rafter Size	Rafter Spacing	Horizontal Span	Collar Ties	Collar Tie Spacing	Sheathing	Shingle Type	Number of Shingle Layers	Ceiling Profile
1	2x6	16"	16ft. 4in.	N/A	0"	CDX 1/2"	Asphalt Shingles	1	Flat

The roof design has been analyzed in accordance with the 2012 North Carolina Residential Code with design loads as follows:

Ground Snow (Pg): 10 psf
Wind Speed (V): 96 mph

Mounting Plane 1
The calculations for these structural members are attached. It has been determined by this office that the rafters, as specified above, exceed the allowable span for the total design loading. Attached are repair details that, when installed, will render the roof design structurally adequate to support the new PV modules in addition to the code required design loading.

Attach the module rail brackets to the roof with 5/16" lag bolts at 48 on center maximum. Provide a minimum of 2" of penetration into the wood members.

If you have any questions regarding this analysis, please feel free to contact us.

Best Regards,
Penn Fusion Engineering LLC
Firm License No. P-1848

Andrew D. Leone, P.E.
Principal

Penn FUSION Engineering

152 S. Broad St.
Lansdale, PA 19446
(267)640-2758

Client Name: PowerHome Solar
PFE Project Number: 184084
Client Project Number: 575ABBI
Project: Abbitt Residence
Address: 575 Highgrove Dr
Spring Lake, NC
28390
Description: Mounting Plane 1
Calculations By: ADL
Date: September 14, 2018

Roof Construction

2x6 Rafters at 16" on center

A=	8.25 in^2
Ix=	20.8 in^4
Sx=	7.56 in^3
Wood Species=	Doug-Fir Larch #2
Fb=	900 psi
Fv=	180 psi
E=	1600000 psi
Roof Slope=	42 °
Rafter Span=	16.35 ft
Ceiling Attached to Rafters?:	No

Design Criteria

Ground Snow (P_g):	10 psf
Design Wind Speed:	96 mph
Live Load:	20 psf
Dead Load:	5.48 psf
PV Modules:	4.04 psf

Wind Calculations

Directionality Factor (K_d):	0.85
Topographic Factor (K_{zt}):	1
Velocity Pressure Exposure Coefficient (K_z):	0.7
Importance Factor (I):	1
Velocity Pressure (q_z):	14.04 psf
Tributary Square Footage on Component:	10.83 ft^2
Component Roof Pressures:	15.11 / -19.27 psf

Snow Load Calculations

Exposure Factor (C_e):	1
Thermal Factor (C_t):	1
Importance Factor (I):	1
Flat Roof Snow Loads (P_f):	7 psf
Roof Slope Factor (C_s):	0.7
Sloped Snow Loads (P_s):	4.9 psf
Unbalanced Snow Load:	10 psf

Member Calculations

Bending

M_d:	1315.06 in*lb		
f_b:	2086.71 psi		
Load Duration Factor (C_d):	1.15		
Stability Factor (C_L):	1		
Wet Service Factor (C_M):	1		
Temperature Factor (C_T):	1		
Size Factor (C_F):	1.3		
Flat Use Factor (C_{fu}):	1		
Incising Factor (C_i):	1		
Repetitive Member Factor (C_r):	1.15		
F_b:	900 psi		
F'_b:	1547.33 psi	2086.71>1547.33	No Good in Bending

Shear

V_d:	321.74 lb		
f_v:	58.5 psi		
Load Duration Factor (C_d):	1.15		
Wet Service Factor (C_M):	1		
Temperature Factor (C_T):	1		
Size Factor (C_F):	1.3		
Flat Use Factor (C_{fu}):	1		
Incising Factor (C_i):	1		
F_v:	180 psi		
F'_v):	207 psi	58.5<=207	OK in Shear

Deflection

Live Load Deflection (Δ_L):	1.29 in	L/152	No Good in Live Load Deflection
Total Load Deflection (Δ_T):	1.9 in	L/103	No Good in Total Load Deflection

Uplift Calculation

Tributary Square Footage on Component:	10.83 ft^2
Uplift Pressure:	-19.27 psf
Uplift per Lag:	-208.81 lbs
Lag Screw Diameter:	5/16 in
Allowable Withdrawal per Inch:	490.99 lbs/in
Minimal Screw Penetration:	0.43 in

Install 5/16" diameter lag screws @ 48 on center with minimum penetration of 2" into rafter.

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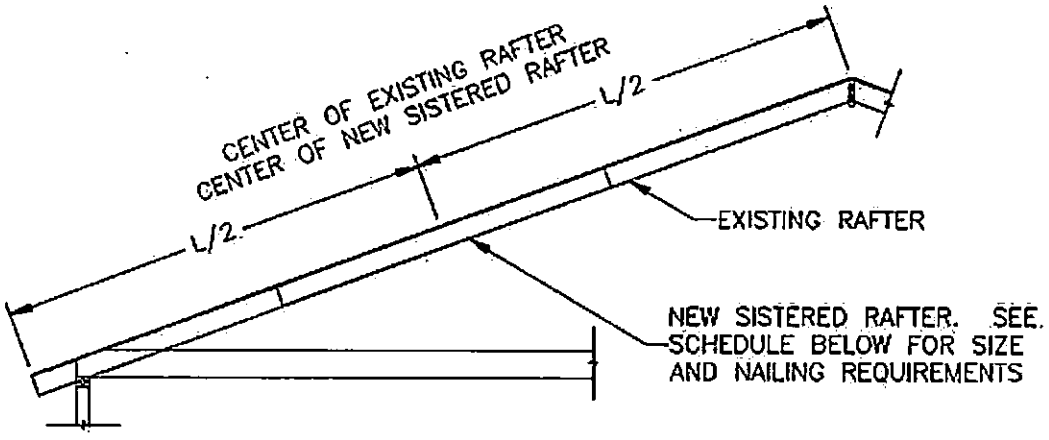

New Sistered Rafter Size: 2x6x6' Doug-Fir Larch #2 or better
Nailing Requirements: (2) 10d Nails @ 12" on center with (3) additional 10d Nails at each end

10d = .12" shank diameter x 3" long minimum

Note: Apply repair to each rafter under PV system