



February 5, 2021

Power Home Solar and Roofing  
919 North Main Street  
Mooreville, NC 28115

**Design Criteria:**

Design Wind Speed (ASD)- 120 mph  
Ground Snow Load- 10 psf  
Risk Category- II  
Exposure category- C

**RE: Structural Roof Evaluation for the *Erwin Residence: 1121 Warren Road, Erwin, North Carolina***

As per your request, we have evaluated the roof structure under the proposed solar panel array. The information used to evaluate this structure was gathered during a field visit by Power Home Solar and Roofing on behalf of Right Angle Engineering. The roof structure consists of 2x4 rafters spaced at 16" on center. The roof material consists of asphalt shingles. The design criteria used to analyze this structure are listed above and included with this letter. The adopted building codes in this jurisdiction are: *the 2018 North Carolina Building Code, the 2018 North Carolina Existing Building Code, and ASCE 7-16.*

North Carolina Existing Building Code (NCEBC) 2018 section 807.4 indicates that alterations to an existing building that results in less than a 10% increase in the total stress may be performed without a structural evaluation of the existing building. As demonstrated in the attached calculations, the additional weight of the solar panels will be less than 10% increase in the gravity loading and the stress on the existing roof framing.

Based on our assessment we have determined that the existing roof framing will safely and adequately support the additional loads imposed by the solar panels without reinforcement. In order for the loads to be evenly distributed, the roof attachments should be staggered and spread evenly throughout the panel array. Attachment points should be spaced at a maximum of 48" on center. The racking system should be installed per the manufacture's specifications. There should be a minimum of 38 L-foot attachment points to the roof. Each attachment should have a 5/16" or 18/8 SS lag screw with 2.5" minimum penetration centered on each truss top chord. Waterproofing around the roof penetrations is the responsibility of others. Right Angle Engineering assumes no responsibility for improper installation of the solar panels.

Regards,



2/5/21

Robert D Smythe, P.E.  
Right Angle Engineering

### Design Criteria:

|                                   |            |     |
|-----------------------------------|------------|-----|
| Design Wind Speed (3 second gust) | 120        | mph |
| Exposure Category                 | C          |     |
| Risk Category                     | 2          |     |
| Mean Roof Height                  | 30         | ft  |
| Roof Type                         | Gable Roof |     |
| Building Type                     | enclosed   |     |

### Roof Dead Load- ASCE Table C3-1

|                             |    |     |
|-----------------------------|----|-----|
| Asphalt Shingles            | 2  | psf |
| 5/8" Plywood Sheathing      | 2  | psf |
| Roof Framing                | 4  | psf |
| Insulation                  | 0  | psf |
| Gypsum sheathing            | 0  | psf |
| Solar Panel Array           | 3  | psf |
| Dead Load Without Panels    | 8  | psf |
| Dead Load With Solar panels | 11 | psf |

### Roof Live Load

|                                  |    |     |                       |
|----------------------------------|----|-----|-----------------------|
| Existing Roof Live Load          | 20 | psf | ASCE 7-16 Table 4.3-1 |
| Roof Live Load with Solar Panels | 0  | psf | 2018 NCBC 1607.12.5   |

### Roof Snow Load-ASCE 7-16

|                                           |     |     |                |
|-------------------------------------------|-----|-----|----------------|
| Ground Snow Load (pg)                     | 10  | psf | Section 7.2    |
| Exposure Factor (Ce)                      | 0.9 |     | Table 7.3-1    |
| Thermal Factor (Ct)                       | 1.1 |     | Table 7.3-2    |
| Importance Factor (Is)                    | 1   |     | Table 1.5-2    |
| Flat Roof Snow Load (Pf)                  | 7   |     | Equation 7.3-1 |
| Slippery surface Slope Factor (Cs)        | 0.6 |     | Figure 7-2     |
| Nonslippery Surface Slope Factor (Cs)     | 1   |     | Figure 7-2     |
| Roof Snow Load                            | 7   | psf | Equation 7.4-1 |
| Reduced Roof Snow Load (Slippery Surface) | 4   | psf | Equation 7.4-1 |

### Load Combinations - ASCE 7-16 Section 2.4.1

|        | Without Solar Panels | With Solar panels |
|--------|----------------------|-------------------|
| D + Lr | 28 psf               | 11 psf            |
| D + S  | 14.9 psf             | 15.2 psf          |

## Solar Array 1-

|                  |       |                 |
|------------------|-------|-----------------|
| Roof Slope       | 34    | degrees         |
| Number of panels | 23    |                 |
| Panel Area       | 402.5 | ft <sup>2</sup> |

## Wind Calculations- ASCE 7-16

|                                     |       |     |                     |
|-------------------------------------|-------|-----|---------------------|
| GC <sub>p</sub> Zone 1              | -1    |     | Figure 30.3-(2A-5B) |
| GC <sub>p</sub> Zone 2              | -1.2  |     | Figure 30.3-(2A-5B) |
| GC <sub>p</sub> Zone 3              | -1.2  |     | Figure 30.3-(2A-5B) |
| G <sub>cp</sub> i                   | 0.18  |     | Table 26.13-1       |
| Velocity Pressure (q <sub>h</sub> ) | 30.7  | psf |                     |
| $q_h = .00256K_hK_{ht}K_dV^2$       |       |     | Equation 26.10-1    |
| K <sub>h</sub>                      | 0.98  |     | Table 26.10-1       |
| K <sub>ht</sub>                     | 1     |     | Equation 26.8-1     |
| K <sub>d</sub>                      | 0.85  |     | Table 26.6-1        |
| Designed wind pressure (P)          |       | psf | Equation 30.8-1     |
| $P = q_h(GC_h) - (GC_{hi})$         |       |     |                     |
| Zone 1 Pressure (P)                 | -36.2 | psf |                     |
| Zone 2 Pressure (P)                 | -42.4 | psf |                     |
| Zone 3 Pressure (P)                 | -42.4 | psf |                     |

## Roof Connection

|                               |           |                 |                      |
|-------------------------------|-----------|-----------------|----------------------|
| Shear Capacity                | 190       | lbs             | NDS 2015 Table 12K   |
| Shear tributary area          | 47.5      | ft <sup>2</sup> |                      |
| Pullout Capacity              | 266       | lbs/in          |                      |
| Lag screw embedment           | 2.5       | in              |                      |
| Total pullout capacity        | 665       | lbs             | NDS 2015 Table 12.2A |
| Pullout max tributary area    | 15.7      | ft <sup>2</sup> |                      |
| Factor of Safety              | 1.91      |                 |                      |
| Minimum number of connections | <b>38</b> |                 |                      |

## Beam Stress NCEBC 2018 Section 806.2

|                             |                      |                   |                  |                |
|-----------------------------|----------------------|-------------------|------------------|----------------|
| Beam Span                   | 19                   | ft                |                  |                |
| Spacing                     | 1.33                 | ft                |                  |                |
| Roof Framing type           | 2x4 rafters          |                   |                  |                |
| Panel Orientation           | portrait             |                   |                  |                |
| Number of Panels per rafter | 3                    |                   |                  |                |
| Panel distance from eave    | 2                    |                   |                  |                |
|                             | Without Solar Panels | With Solar Panels | Percent Increase |                |
| Bending Moment              | 1680.5 ft-lbs        | 1141.9 ft-lbs     | 68%              | Less than 105% |
| Vertical Reaction (V1)      | 353.8 lbs            | 243.8 lbs         | 68.9%            | Less than 105% |
| Vertical Reaction (V2)      | 353.8 lbs            | 208.31 lbs        | 58.9%            | Less than 105% |

