National Renewable Energy Laboratory
Innovation for Our Energy Future

PERFORMANCE COMPARISON OF A BIPV ROOFING TILE SYSTEM IN TWO MOUNTING CONFIGURATIONS

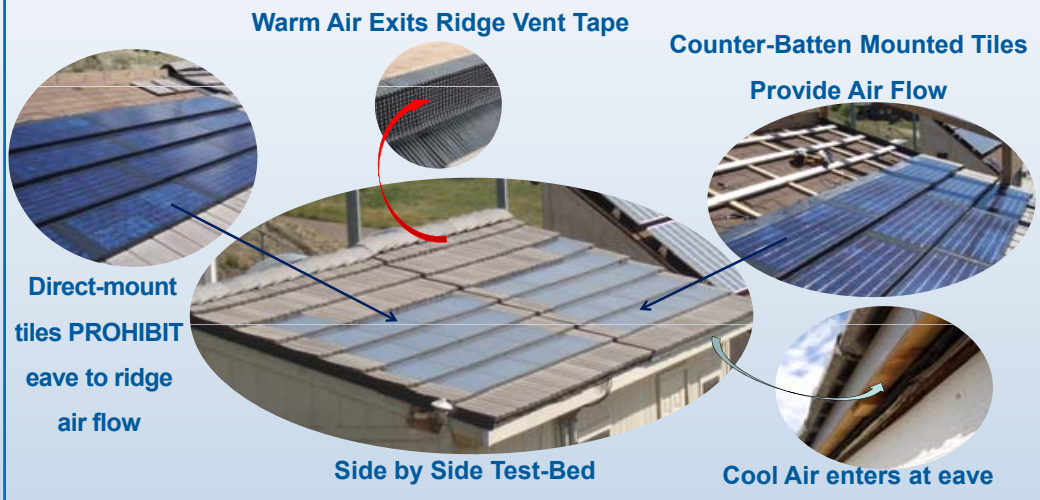
Matthew Muller, Jose Rodriguez, Bill Marion
National Renewable Energy Laboratory • Golden, CO 80401

OBJECTIVES

- Acquire data for typical hot months in Golden, Colorado
- Examine the thermal and power characteristics of a BIPV roofing system using two installation techniques, counter-batten and direct-mount.
- Compare thermal characteristics of the BIPV installation against a similar free-standing, rack-mounted module

SYSTEM DESIGN

- 17 Polycrystalline Silicon PV roofing tiles (34 W each) wired in series per installation method.
- Direct-mount and Counter-batten strings are wired for individual voltage measurements.
- The complete system is grid-tied and peak power tracked as a single string of 34 modules held at the same current.
- South facing roof with tiles tilted at 15 degrees.
- Both systems are mounted over an existing asphalt shingle roof



DAS

- 5 second sampling
- 15 minute averaging
- DC current entire system string
- DC voltage per installation method
- AC current
- AC voltage
- 2 module temperatures per installation method
- Attic temperature
- Ambient temperature
- Wind speed
- Plane of Array Irradiance (POA)

PERFORMANCE COMPARISON

Table 1
July-August data averaged for given irradiance ranges

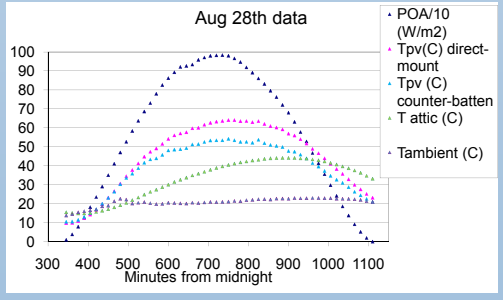
		> 100 W/m²	> 900 W/m²
T_ambient	(°C)	27.5	28.6
POA	(W/m²)	577.7	996.8
Wind	(m/s)	2.07	2.49
T_pv_battens	(°C)	44.0	59.0
T_pv_direct	(°C)	48.9	67.4
V_mp_battens	(V)	72.4	66.6
V_mp_direct	(V)	70.7	63.5
DC_Watts_batten	(W)	288.9	468.5
DC_Watts_direct	(W)	279.5	446.7

$$T_{rise\_coeff} = \frac{\sum (T_{pv} - T_{amb})}{\sum E}$$

$$T_{weighted} = \frac{\sum T_{pv} \cdot E}{\sum E} \qquad where \quad E = POA$$

Table 2 Irradiance-weighted temperatures

	August	July12-Aug31
$T_{weighted}$ (counter-batten)	48.16 °C	49.34 °C
$T_{weighted}$ (direct-mount)	53.9°C	55.37 °C
T_{rise_coeff} (PERT rack)	21.3°C/kW/m²	
T_{rise_coeff} (counter-batten)	28.7°C/kW/m²	27.7°C/kW/m²
T_{rise_coeff} (direct-mount)	37.1°C/kW/m²	36.3°C/kW/m²



CONCLUSIONS

- In early morning and late evening the two systems operated at near equal temperatures.
- At peak irradiances and elevated attic temperatures the counter-batten system operated ~10 °C cooler.
- The counter-batten system had a temperature rise coefficient that was 7.4 °C/kW/m² higher than a similar free-standing, rack-mounted module.
- The direct-mount system had a temperature rise coefficient that was 15.8 °C/kW/m² higher than a similar free-standing, rack-mounted module..
- Temperature rise coefficients were 5-6 °C/kW/m² lower than expected from the PVFORM model. (Further research is needed to explain this difference)
- For the entire data set the counter-batten system produced 3.4% more DC power than the direct-mount system.
- For irradiances above 900 W/m² the counter-batten system produced 4.9% more DC power than the direct-mount system

Acknowledgements

Appreciation is extended to Open Energy Corporation (renamed Applied Solar) and Eagle Roofing for supplying materials and expertise for completing this project. This work was supported by the U.S. Department of Energy under Contract No. DOE-AC36-08GO28308 with the National Renewable Energy Laboratory

2009 34th IEEE Photovoltaic Specialists Conference • Philadelphia, PA • June 7-12, 2009 • NREL/PO-520-46073