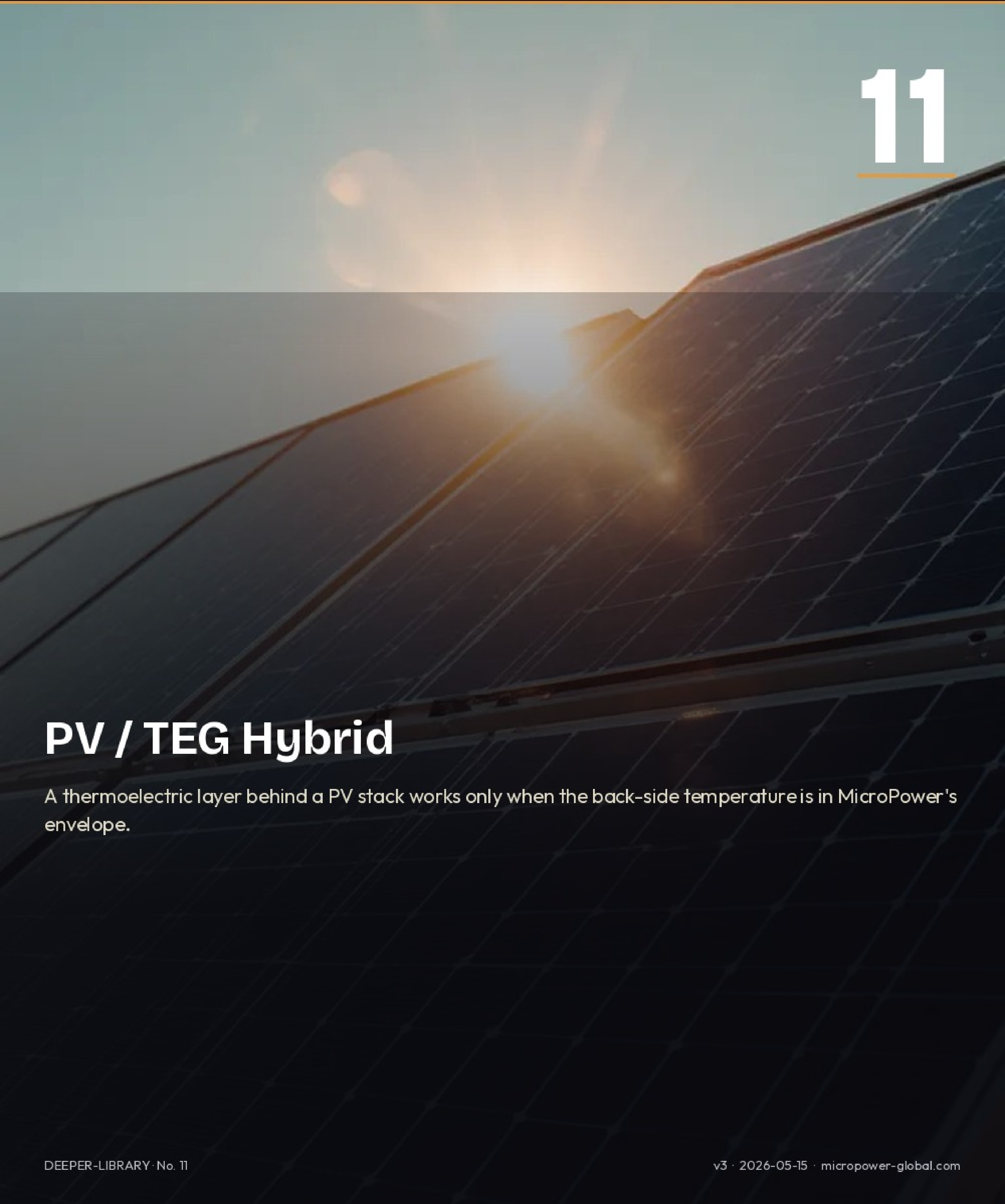
MicroPower
DEEPER LIBRARY · A MICROPOWER PUBLICATION



11

PV / TEG Hybrid

A thermoelectric layer behind a PV stack works only when the back-side temperature is in MicroPower's envelope.

PV / TEG Hybrid

A thermoelectric layer behind a PV stack works only when the back-side temperature is in MicroPower's envelope.

Photovoltaic cells convert visible-spectrum photons into electricity; the infrared component of solar flux raises cell temperature and degrades PV efficiency. A thermoelectric (TEG) layer behind the PV cell could in principle both extract additional electricity from that thermal flux and stabilise the PV cell's operating temperature. This note frames the architectural fit and the temperature conditions under which the hybrid is worth engineering. BiTe is the correct material choice for non-concentrated PV-TEG hybrid applications and for concentrator cells backed by a strong thermal anchor such as chilled-water circulation. Where temperatures can be held well below the PbTe/TAGS commercial floor, BiTe handles both the power-generation and Peltier-cooling modes.

1 · The hybrid concept

Crystalline silicon PV cells have a clear theoretical efficiency ceiling (Shockley-Queisser limit) and a strongly temperature-sensitive operating point. Every 1 °C rise above optimum costs roughly 0.3–0.5% of relative efficiency for silicon, with thin-film cells generally more temperature-sensitive again. A thermoelectric layer mounted to the back of a PV stack would harvest the IR-driven thermal load both as additional electrical output and as cell-temperature stabilisation.

2 · Why the hybrid has not been commercial yet

Conventional bismuth-telluride (BiTe) TEGs operate optimally at 100–250 °C hot-side temperatures. PV cell back temperatures in normal operation sit at 50–80 °C. The temperature differential available to a BiTe TEG behind a PV cell is therefore in the wrong part of the BiTe operating envelope, and the marginal electrical output does not justify the system complexity.

3 · The MicroPower position

MicroPower's PbTe / TAGS chip platform is designed to deliver useful conversion across the 300–1,000 °C hot-side range – well above PV operating temperatures. Production-spec performance is 14% module conversion efficiency at 550 °C (extrapolated from ARL's evaluation of MicroPower's standard modules; independently confirmed by NREL against datasheet). For a hybrid PV/TEG stack to be economically attractive, one of two conditions must hold:

- Concentrator photovoltaics (CPV). Optical concentration raises the cell back-side temperature substantially, into the lower end of the MicroPower envelope.
- Coupled thermal source. The back-side temperature is augmented by a separate higher-temperature thermal source (building hot-water loop, process heat, parabolic trough, building façade in a hot

climate) that holds the TEG hot side in MicroPower's operating envelope.

Where these conditions are met, MicroPower's chip platform delivers the material-level performance the hybrid analysis requires. The MBE-grown energy-sorting barrier-layer architecture multiplies chip-level power density 1.5–1.8× on top of the baseline platform; that figure is from internal MicroPower lab measurement on the prototype barrier layer and is on the post-funding production roadmap, not in production-spec modules today.

4 · Assessment

PV / TEG hybrid is a credible technical adjacency to MicroPower's core industrial waste-heat work, not an active commercial pipeline. It deserves attention from a CPV partner or a building-integrated PV specialist whose system geometry naturally lifts the back-side temperature into the MicroPower operating envelope. Outside those geometries, the engineering case is hard to close.

MicroPower engages with CPV integrators, building-integrated PV specialists, and hybrid-system developers interested in TEG-augmented stacks. Introductions and structured enquiries are welcome via the MicroPower Global contact page.

References

Skoplaki, E. and Palyvos, J. A. "On the temperature dependence of photovoltaic module electrical performance: a review of efficiency / power correlations." Solar Energy 83, 614–624 (2009).

Dubey, S., Sarvaiya, J. N. and Seshadri, B. "Temperature dependent photovoltaic (PV) efficiency and its effect on PV production in the world – a review." Energy Procedia 33, 311–321 (2013).

Kraemer, D. et al. "Concentrating solar thermoelectric generators with a peak efficiency of 7.4%." Nature Energy 1, 16153 (2016).

Champier, D. "Thermoelectric generators: a review of applications." Energy Conversion and Management 140, 167–181 (2017).