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Allâ€‘Perovskiteâ€ƒTandemâ€ƒModules Madeâ€‘inâ€‘California

Additional submitted attachment is included below.

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Proposal to the California Energy Commission

FY 2026-2030 EPIC Research Initiative

"All-Perovskite Tandem Modules Made-in-California"

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1 | Executive Summary

Today's high-efficiency "tandem" solar panels pair a U.S.-made perovskite top cell with a silicon bottom cell that is today dominated by 95 % of the supply chain imported from China. The dependency collides head-on with emerging *foreign-entity-of-concern* (FEOC) rules in the federal 45 X and 48E tax credits, and it leaves California without a home-grown supply chain for the most promising next-gen PV technology.

Tandem PV proposes that the CEC launch a targeted 2026-2030 R&D program to develop—and pilot-manufacture in California—the first commercially durable *all-perovskite* tandem module (perovskite top *and* low-band-gap perovskite bottom). Recent lab results already top 31 % cell efficiency, but the narrow-band-gap sub-cell still faces intrinsic stability limits. CEC leadership can close that gap, capture domestic IP, and de-risk local manufacturing.

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2 | Problem Statement & Opportunity

Issue	Current State	Opportunity for CEC
Supply-chain exposure	>90 % of crystalline-Si ingots & wafers originate in FEOC jurisdictions.	All-perovskite tandems use low-cost salts/metals available in CA & U.S., friendly nations. Enable continued target focus of SB100 in the event that the US solar market becomes substantially supply-constrained.

Cost & material intensity	Si bottom cell adds 10-25 ¢/W.	Replacing Si with thin-film perovskite cuts cost, energy use, and material use by ~90 %. Reduces energy payback time.
Land-use pressure	Utility PV needs ever-higher efficiency to cap acreage.	Target ≥30 % module efficiency, reduces levelized cost of electricity
Durability gap (narrow-band-gap Pb-Sn perovskite)	1 000 h damp-heat T_{90} shown; ≥10 000 h required for bankability.	Fund chemistry & encapsulation work to push T_{90} beyond 10 000 h and IEC 61215.

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3 | Proposed R&D Scope (2026-2030)

Phase	Key Objectives	Lead Tasks	Milestones
I – Materials & Interfaces (FY 26-27)	Stabilize 1.15 eV Sn-rich perovskite absorber	• Alloy engineering (Br-Cl / cation mixing)• Ionic additive passivation• Accelerated DH/UV ageing loop	• 28 % 2-T mini-module (≥100 cm²)• 5 000 h 85 °C/85 % RH T_{90}
II – Device & Encapsulation (FY 27-28)	Integrate wide-/narrow-gap stack with barrier films	• Flexible SiN_x/Al_2O_x laminates• Thermo-plastic edge-seal• Slot-die & R2R scale-up	• 30 % rigid & flexible modules (≥400 cm²)• IEC 61215 & PID pass
III – Pilot Line & Field Demo (FY 29-30)	Stand-up 10 MW yr^{-1} pilot in Bay Area	• Tooling (slot-die coaters, R2R anneal)• UL 61730 certification• 1 MW CEC testbed (Agua-Caliente, West LA harbor roof)	• <5 ¢ /W incremental cost vs Si tandem• 12-month outdoor degradation <2 %

Total direct CEC request: $28 M (matched 1:1 by private + federal cost share).

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4 | Participants

- **At least 5 companies in California could respond competitively to such a solicitation:** Tandem PV, Caelux, Peronova, Swift Solar, First Solar (R&D center in CA)

- **Multiple universities and National Labs could add to the R&D effort:** UC San Diego, UC Merced, Stanford, UC Berkeley, and LBNL all have perovskite R&D efforts.

- **Utility partners and local test labs in CA can help with testing and validation**: PG&E, SCE**,** PVEL, and RETC.

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5 | Expected Benefits for California

- **Local manufacturing & jobs** – ≥200 high-skilled positions by 2031

- **Energy sovereignty** – removes nearly 100 % FEOC content from next-gen modules, aligning with federal 45 X compliance pathways.

- **Cost & carbon** – projected LCOE ↓ 13 % vs best Si-tandem, embodied energy ↓ 50 %.

- **Resilience & deployment** – multiple new applications like agrivoltaics, space/defence, low load commercial buildings, and others that California has a commercial leadership position

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6 | Alignment with CEC Goals

EPIC/CEC Priority	Proposal Alignment
Decarbonize electric sector	>30 % efficiency reduces land & grid integration cost. Further's the Strategic Coal of Achieving 100 Percent Net-Zero, particularly in the face of solar supply chain risk.
Grow CA clean-tech economy	Builds end-to-end perovskite supply chain located in CA
Equity & workforce	Tandem PV pilot line sited in Fremont, CA; apprenticeship program with San Jose State.
First-of-a-kind manufacturing	Complements 2019-2025 CEC perovskite top-cell grants; next logical leapfrog.

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7 | Risks & Mitigations

Risk	Mitigation

Long-term stability of Sn-rich absorber	Parallel encapsulation + composition tracks; go/no-go after Phase I.
Lead safety	Adopt self-containment & recycling protocols
Market timing vs Si tandem cost drop	Potential for flexible form factor and FEOC-free premium carve niche for initial scale

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8 | Conclusion & Next Steps

All-perovskite tandems are the most California-centric path to >30 % module efficiency, FEOC-free supply chains and novel lightweight applications. A focused 2026-2030 CEC program can vault the technology from lab to pilot-scale production, securing IP and manufacturing jobs for the state while supporting California's 100 % clean-electricity mandate.

We respectfully request that the CEC include "All-Perovskite Tandem Modules" as a flagship research thrust in its forthcoming EPIC investment plan and invite Tandem PV to submit an application.

Submitted on behalf of Tandem PV, Inc.
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