



Energy Materials Network  
U.S. Department of Energy



**HydroGEN**  
Advanced Water Splitting Materials

# All-perovskite tandem Photoelectrodes for Low-Cost Solar Hydrogen Fuel Production from Water Splitting

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# Project Overview

## **Project Partners**

EMN nodes: Todd Deutsch (NREL), Kai Zhu (NREL), Tadashi Ogitsu (LLNL).

## **Project Vision**

To research, develop, and demonstrate efficient, durable, low-cost, and large-scale all-perovskite tandem photoelectrodes for photoelectrochemical (PEC) water-splitting systems to achieve levelized cost of hydrogen approaching \$1/kg.

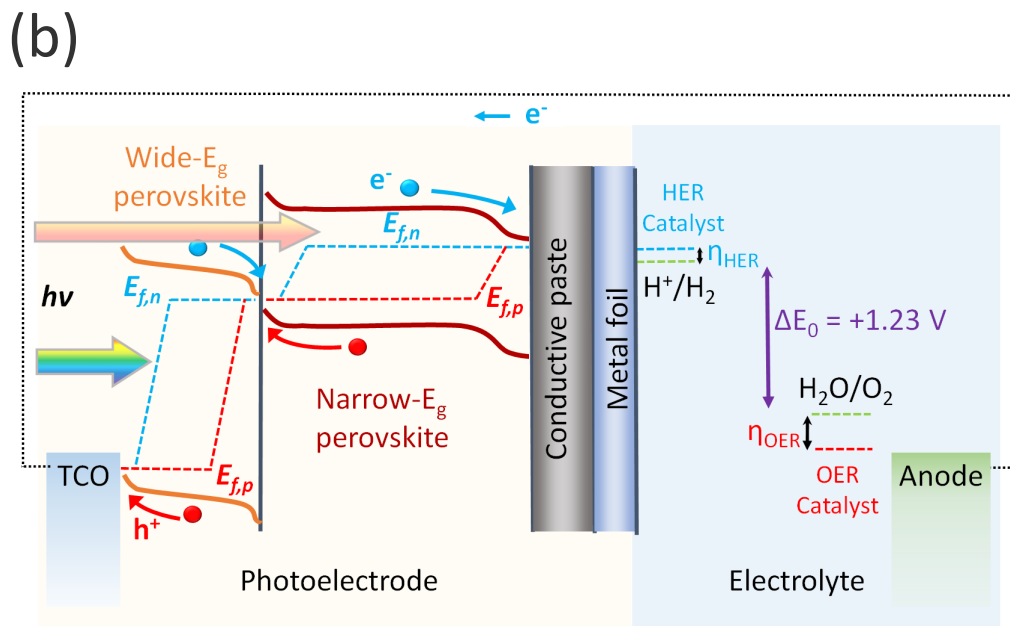
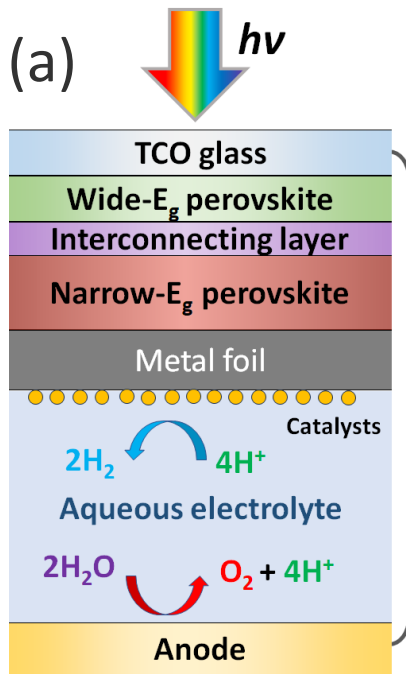
## **Project Impact**

Will help meet the DOE 2026 and 2031 cost targets and pave the way for the widespread commercialization of solar hydrogen production technologies.



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## Type 3 photocell configuration



(a) device structure and (b) working principle of the proposed all-perovskite tandem photoelectrodes



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## Project objectives/goals:

### Budget period 1:

STH: >16%; T90 lifetime: 300 hours; Active area: 0.1 cm<sup>2</sup>

### Budget period 2:

STH: >17%; T90 lifetime: 500 hours; Active area: 1 cm<sup>2</sup>

### Budget period 2:

STH: >18%; T80 lifetime: 500 hours; Active area: 25 cm<sup>2</sup>



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## **Tasks To Be Performed – BP1:**

Task 1.0: Optimize perovskite absorbers for efficient tandem photoelectrodes

Task 2.0: Demonstrate all-perovskite tandem photoelectrode baseline

Task 3.0: Improve all-perovskite tandem photoelectrode stability

Task 4.0: Further improve all-perovskite tandem photoelectrode efficiency

Task 5.0: Diversity, Equity, and Inclusion (DEI) task



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## Tasks To Be Performed – BP2:

Task 6.0: Develop scalable methods for wide-Eg and narrow-Eg perovskites

Task 7.0: Demonstrate large-area all-perovskite tandem photoelectrodes

Task 8.0: Understanding the stability of all-perovskite tandem photoelectrodes

Task 9.0: Further optimization of all-perovskite tandem photoelectrodes

Task 10.0: Diversity, Equity, and Inclusion (DEI) task



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## Tasks To Be Performed – BP3:

Task 11.0: Demonstrate all-perovskite tandem photoelectrode panels

Task 12.0: Scale up all-perovskite tandem photoelectrode panels to 25 cm<sup>2</sup>

Task 13.0: Outdoor test of photoelectrode panels

Task 14.0: Technoeconomic analysis of all-perovskite tandem photoelectrodes

Task 15.0: Diversity, Equity, and Inclusion (DEI) task



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## Brief scopes of EMN nodes

Lab	Node PI	BP1 Brief Scope	BP2 Brief Scope	BP3 Brief Scope
NREL	Todd Deutsch	NREL will perform PEC benchmarking	NREL will perform PEC benchmarking	NREL will perform PEC benchmarking
NREL	Kai Zhu	NREL will perform experimental understanding of the instability of wide-bandgap perovskites	NREL will perform experimental understanding of the instability of narrow-bandgap perovskites	NREL will perform experimental understanding the instability of perovskite tandem solar cells
LLNL	Tadashi Ogitsu	LLNL will perform theoretical understanding of instability of wide-bandgap perovskites	LLNL will perform theoretical understanding of instability of narrow-bandgap perovskites	LLNL will perform theoretical understanding of instability of photoelectrodes