

# Perovskite Tandems Enter The Scale-Up Race

Perovskite solar cells are moving from record efficiency to commercial modules, cost targets, and GW-scale production readiness.





## 34.85%

RECORD CELL EFFICIENCY



## 30%

RECORD MODULE EFFICIENCY



## 0.29

USD/W  
PROJECTED MANUFACTURING COST

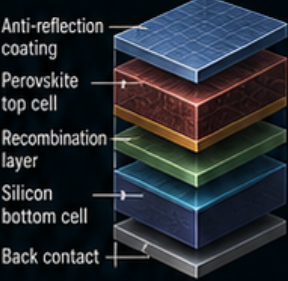


## GW SCALE

PRODUCTION CAPACITY


## FROM LAB RECORDS TO MARKET-READY MODULES

**1 TANDEM STACK**




- Perovskite + silicon tandem architecture
- High open-circuit voltage and current matching
- Path to >30% efficiency

**2 EFFICIENCY BREAKTHROUGH**




- Rapid efficiency gains
- Interface engineering boosts performance
- >30% module efficiency within reach

**3 LIFETIME & ENCAPSULATION**




- Stable encapsulation and moisture barriers
- Interface defect control and ion migration mitigation
- Target: 15–30 year lifetime and UL/IEC certification

**4 MODULE PRODUCTION READINESS**



- Large-area coating and high-throughput lines
- Process control, uniformity, and yield improvement
- Cost targets for bankable commercial modules

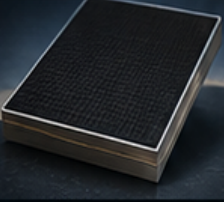
**5 DEPLOYMENT & INTEGRATION**



- BIPV, rooftops, and utility-throplations
- Lightweight, flexible, and semi-transparent
- Policy support and market pull drive scale


## THREE KEY SIGNALS THIS WEEK

**1 OXFORD PV & FRAUNHOFER ISE REPORT 25.6% TILE-SHAPED TANDEM MODULE PERFORMANCE**



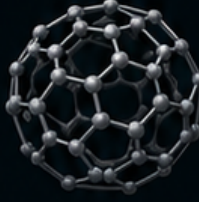
- 25.6% certified efficiency on tile-shaped module
- Improved uniformity and scale-up relevance
- Commercial form factors accelerate BIPV adoption

**2 OXFORD PV GEN-3 TARGETS 26% EFFICIENCY AND LONGER LIFETIME**



- Gen-3 platform aims for 26% module efficiency
- Enhanced stability and 15+ year target lifetime
- Path toward bankable performance warranties

**3 HIGH-PURITY C60 AND INTERFACE MATERIALS CRUCIAL FOR DURABILITY**




- High-purity C60 improves charge extraction
- Interface layers reduce non-radiative recombination
- Better moisture stability and operational lifetime

### ENGINEERING RELEVANCE

Interface defects	Passivation and defect control at perovskite/transport layers
Encapsulation & barriers	Moisture, oxygen, and UV protection for long life
Lifetime testing	Accelerated aging, damp heat, thermal cycling, and UV
Lead management	Containment, recycling, and environmental compliance
Module integration	BIPV design, aesthetics, and structural integration
Yield & uniformity	Large-area coating, in-line metrology, and quality control


### BUSINESS RELEVANCE

Module warranty	Bankable warranties drive project financing
BIPV applications	High-value building integration expands TAM
Supply chain readiness	Materials, precursor, glass, and encapsulant scale-up
Policy support	Incentives, standards, and procurement drive adoption
Cost competitiveness	Cost per watt targets enable market penetration
Time to market	Execution speed determines leadership



**VERDICT**  
**READING PRIORITY: HIGH**

The field is shifting from lab records to bankable product metrics.



HIGH EFFICIENCY

LONGER LIFETIME

LOWER COST

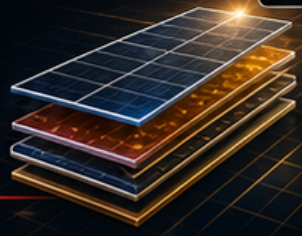
SCALE-UP READINESS

BIPV & MARKET ADOPTION

POLICY & INDUSTRY ALIGNMENT

# OPPORTUNITIES, RISKS, AND NEXT ACTIONS

Turning perovskite breakthroughs into reliable, scalable, and profitable solar solutions.



TANDEM EFFICIENCY  
**34.85%**  
Best in Class



## OPPORTUNITIES

**1 Tandem modules above 30%**

- Perovskite-silicon tandems exceed 30%
- Rapid efficiency gains continue
- Commercialization entering pilot stage

**2 BIPV and tile-shaped modules**

- New architectural and aesthetic markets
- Lightweight, semi-transparent options
- Strong policy push for building decarbonization

**3 Low projected manufacturing cost**

- Estimated cost as low as 0.29 USD/W
- Solution-process printing reduces CAPEX
- Path to grid parity in many regions

**4 Component and materials upside**

- High-purity C60 and transport layers
- Encapsulants, barrier films, and electrodes
- Critical materials drive performance and lifetime

## RISKS

**1 Lifetime gap to bankable warranties**

- Current target 15 years vs. 25-30 year bankability
- Degradation mechanisms not fully resolved
- Field reliability data still limited

**2 Lead and recycling requirements**

- Lead content faces regulatory pressure
- Recycling infrastructure still immature
- Compliance cost and public perception risks

**3 Large-area uniformity challenges**

- Coating pinholes and thickness variation
- Interfacial defects reduce yield
- Scale-up requires new process windows

**4 GW-scale yield and qualification**

- Process stability at high throughput
- Module-to-module variance
- Bankability demands rigorous qualification

## THREE MANAGEMENT DECISIONS

**1 Market focus**  
Decide where to play first.

- Roof-top residential & commercial
- BIPV and architectural applications
- Utility-scale power plants

**2 Reliability plan**  
Define tests and warranty path.

- Damp heat, UV, thermal cycling
- Light-soaking and bias tests
- Field pilots and bankable metrics

**3 Partner map**  
Build the right ecosystem.

- Module manufacturers
- Materials and component suppliers
- Coating equipment and encapsulation
- Certification and testing labs

## WHO SHOULD READ

Solar cell developers

Materials and component suppliers

BIPV and building planners

Power developers and EPCs

Policy and government teams

Manufacturing investment leads

## KEY PLAYERS TO WATCH

**OXFORD PV**

**Oxford PV**  
Perovskite-silicon tandem module innovator

**Fraunhofer ISE**

**Fraunhofer ISE**  
Leading research on tandem and module reliability

**High-Purity C60 Suppliers**  
Critical electron transport material for high efficiency

**Tandem Module Manufacturers**  
Scaling pilot lines toward commercial production

**BIPV Developers**  
Building-integrated PV solutions and system integration

## ACTION TIMELINE

Map competitors by efficiency, lifetime, cost, and production timing.

- Benchmark tandems and modules
- Track pilot and GW announcements
- Identify technology gaps

### WITHIN 30 DAYS

Shortlist materials and process supply options.

- Encapsulation and barrier materials
- Charge transport layers and electrodes
- Evaluate suppliers and lead times

### THIS QUARTER AND BEYOND

Design a demonstration plan with reliability metrics.

- Define BIPV or high-efficiency module pilot
- Set lifetime and performance targets
- Plan certification, field tests, and scale-up

## TOP PRIORITY

Convert record efficiency into bankable lifetime, yield, and warranty evidence.



High Efficiency Tandems

Long-Term Reliability

Low Cost Manufacturing

Regulatory Compliance

Supply Chain Resilience

Bankable Warranties

Sustainability and Recycling