Barrier Film for Perovskite Solar Cells: Leading Technology from Japan

Achieving high durability through advanced film-forming technology

November 25th, 2025

Giving Shape to Ideas

Speakers

- **Naoya Kato**
  Representative Director and President,
  Operating Officer and Chief Executive Officer
  EneCoat Technologies Co., Ltd.

- **Yusuke Nakajima**
  Development Department
  Device Technology Development Center
  Technology Development Headquarters
  Konica Minolta Inc.

- **Keiichi Kishi**
  Corporate Vice President, General Manager, Corporate Technology Development Headquarters
  Konica Minolta, Inc.

Biography

Naoya Kato

Representative Director and President,
Operating Officer and Chief Executive Officer
EneCoat Technologies Co., Ltd.

Engaged in a number of investment projects in real estate and business restructuring at a foreign investment bank.
As a founding member of an independent PE fund, he experienced buyout investment.
In November 2016, he joined Kyoto University's Incubation Program as the promotion manager.
In January 2018, he co-founded EneCoat Technologies and assumed the representative director.

Tamotsu Horiuchi

Director/Operating Officer and Chief Technology Officer
EneCoat Technologies Co.,Ltd.

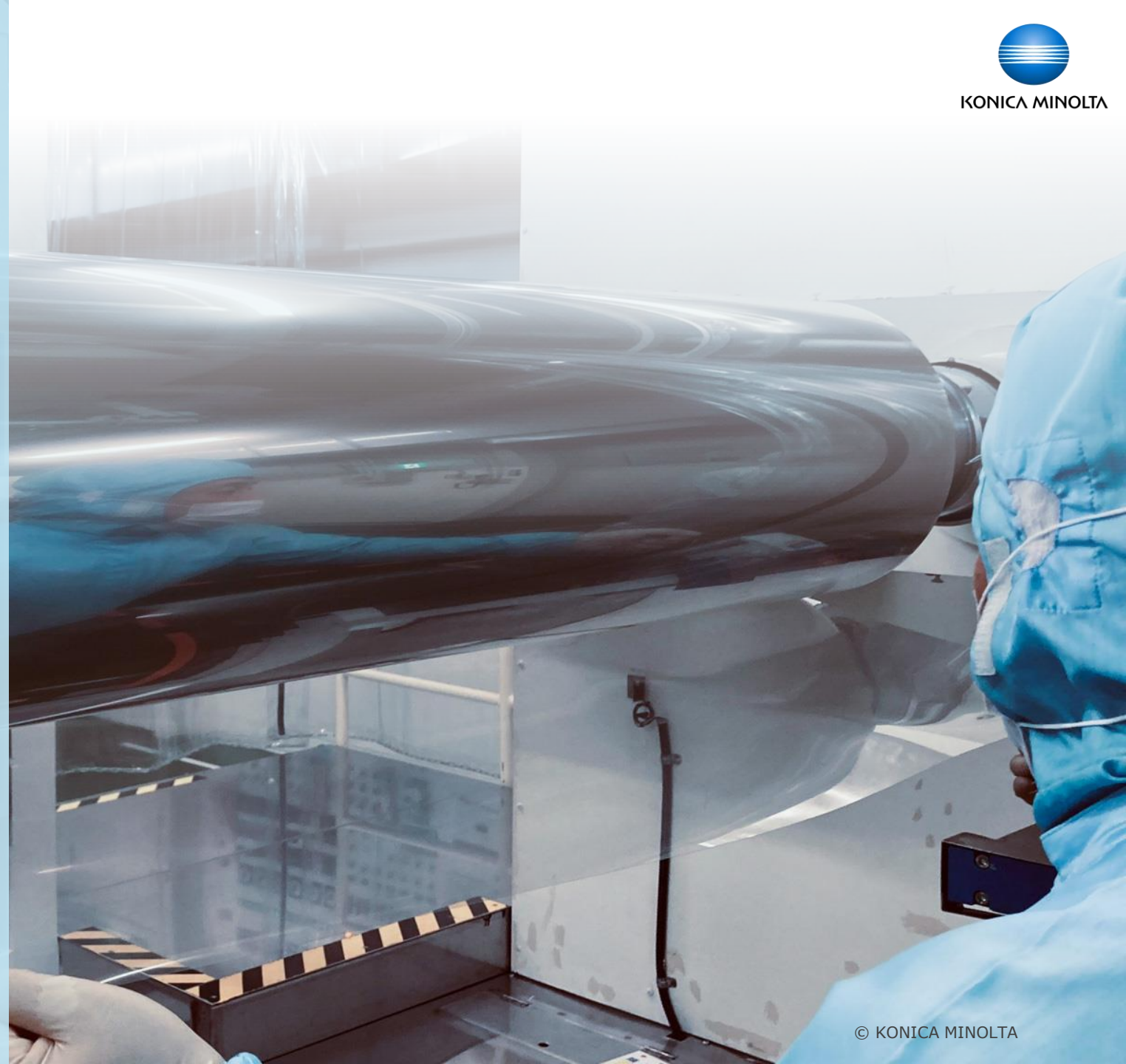
Engaged in material development at a paper manufacturer and material and device development at an electrical equipment manufacturer. Specializes in organic synthetic chemistry and organic device development. He has published 8 peer-reviewed papers, one of which has been cited more than 1,300 times. He has obtained more than 120 patents in Japan and abroad.
In March 2022, he assumed the director of EneCoat Technologies.

Significance of perovskite solar cells

Why Konica Minolta can make this possible

Path to practical application of barrier film

Naoya Kato
Representative Director and President,
Operating Officer and Chief Executive Officer
EneCoat Technologies Co., Ltd.



Our Business Strategies and Need for Barrier Film

Naoya Kato

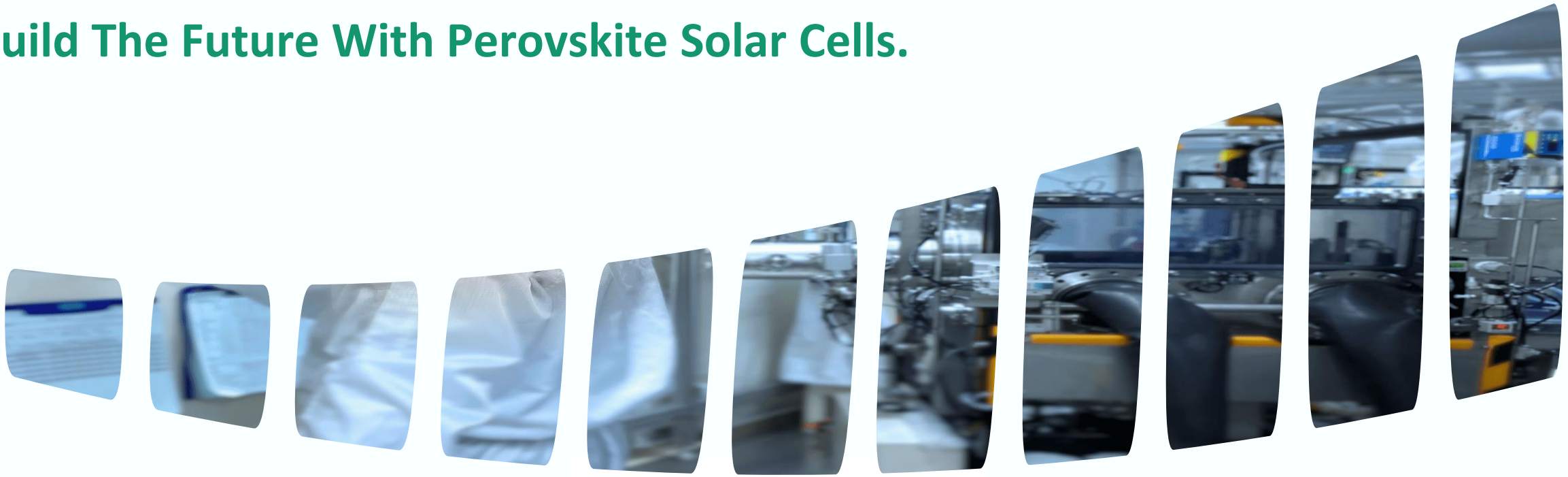
Representative Director, EneCoat Technologies Co., Ltd.

November 25th, 2025

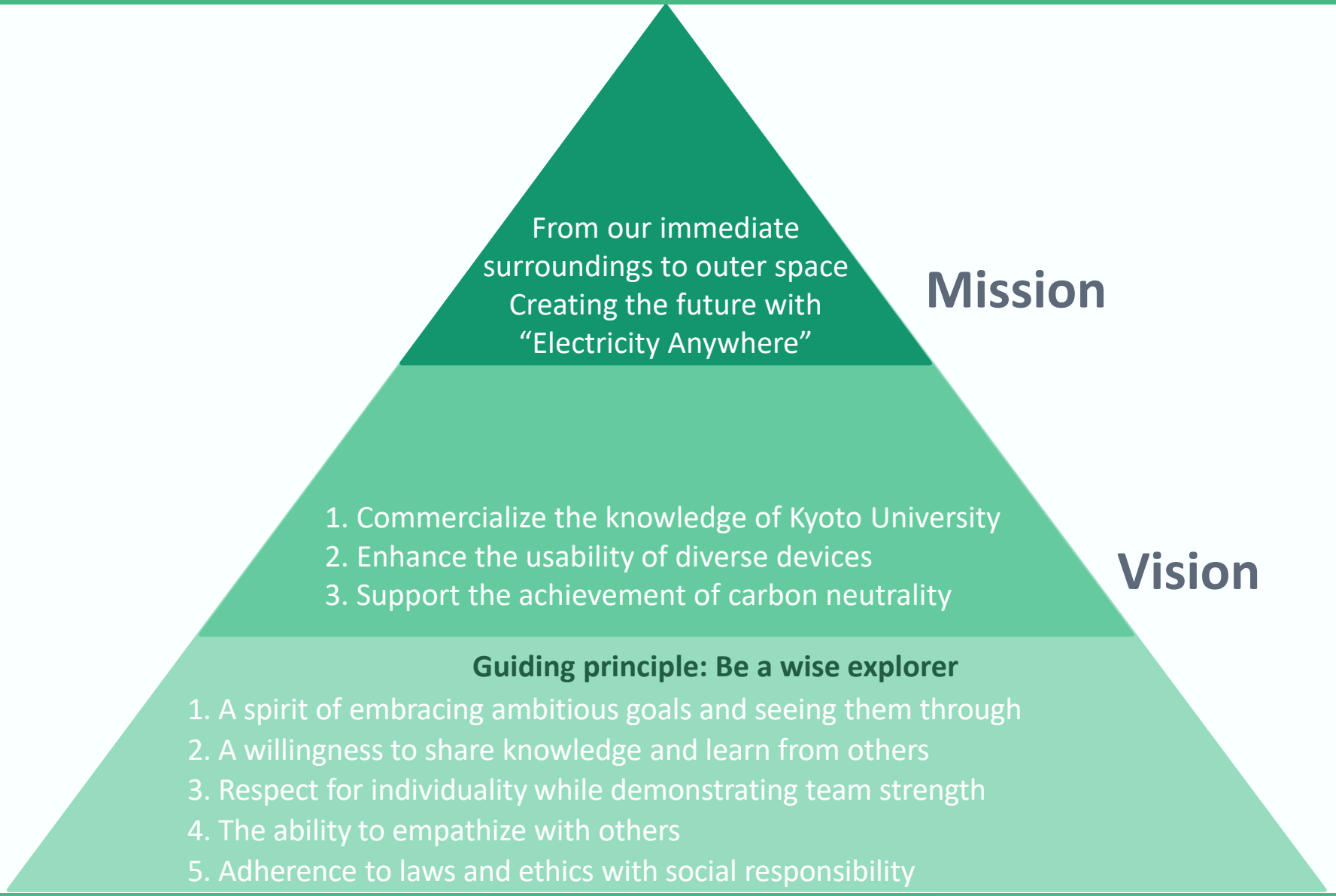
Who we are

Founded	Origin	People	Shareholders	Equity	Grant
2018	Kyoto Univ.	100+	40+	JPY8.7B	JPY10B+

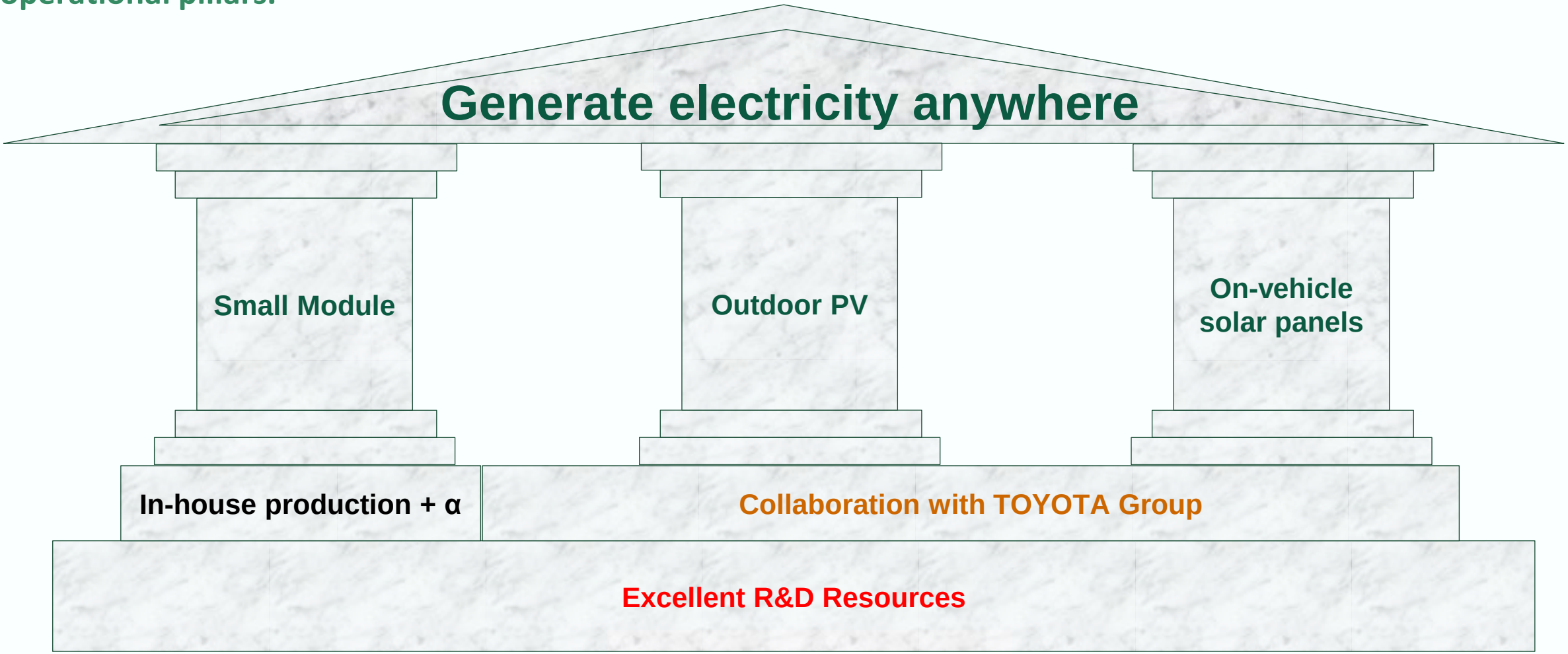
Build The Future With Perovskite Solar Cells.



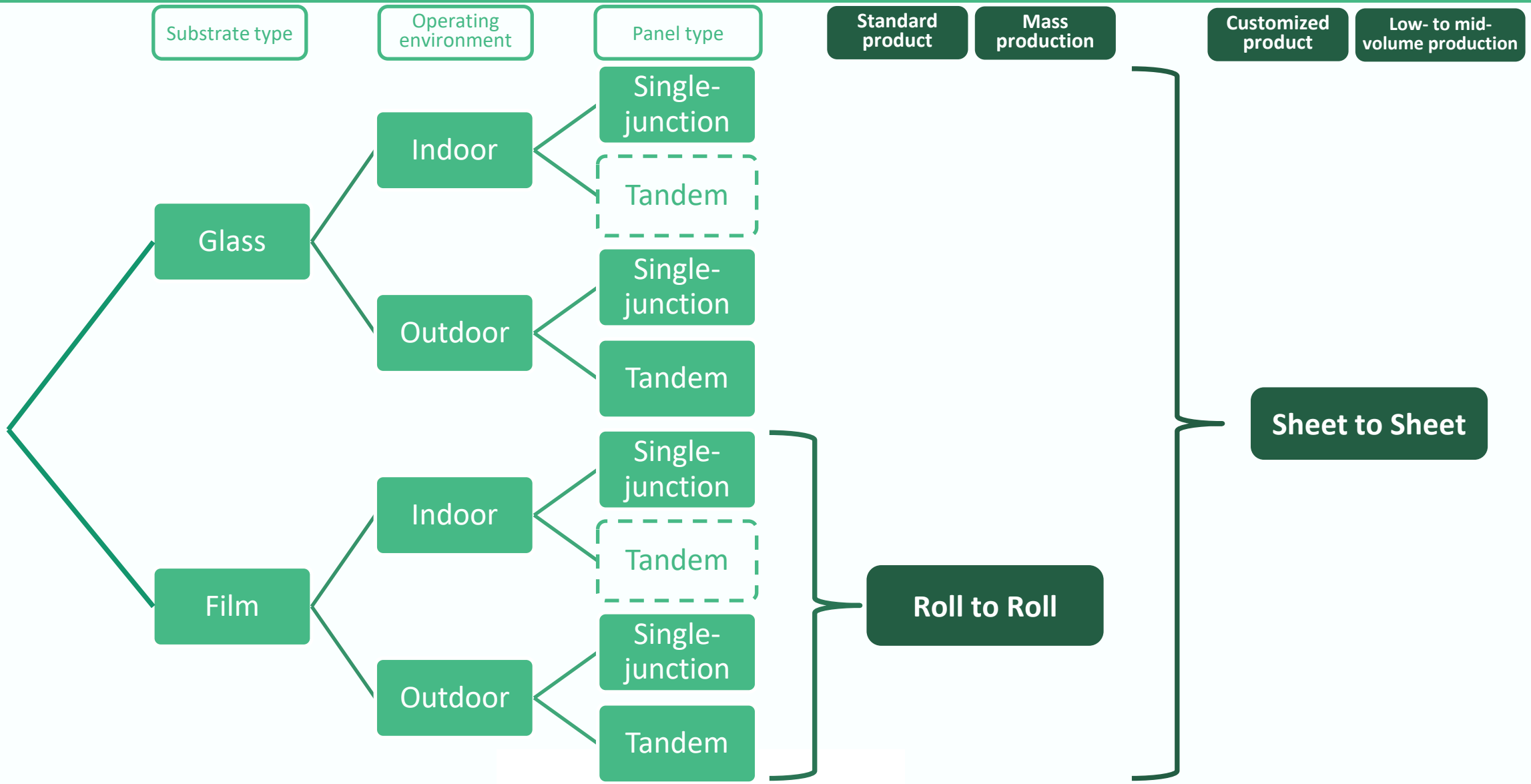
MVV



EneCoat's strength lies in its technology development capabilities, which are rooted in Kyoto University. We aim to provide foundational support for the production phases of three applications that we consider operational pillars.

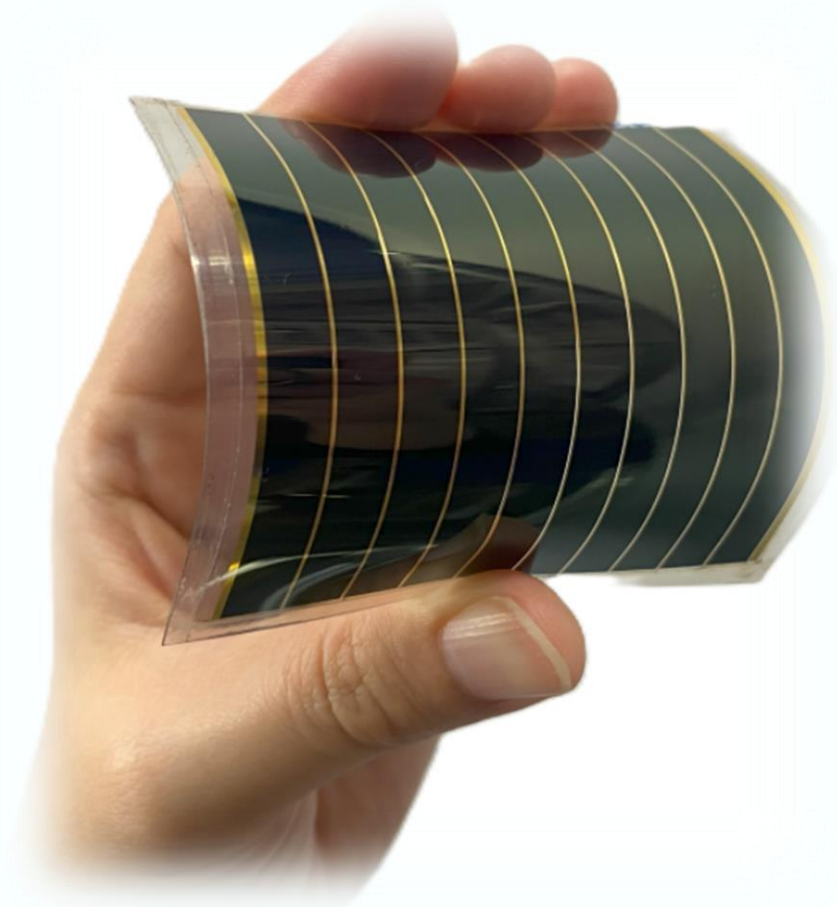


Our Strategy Market Entry Modes



What is Perovskite

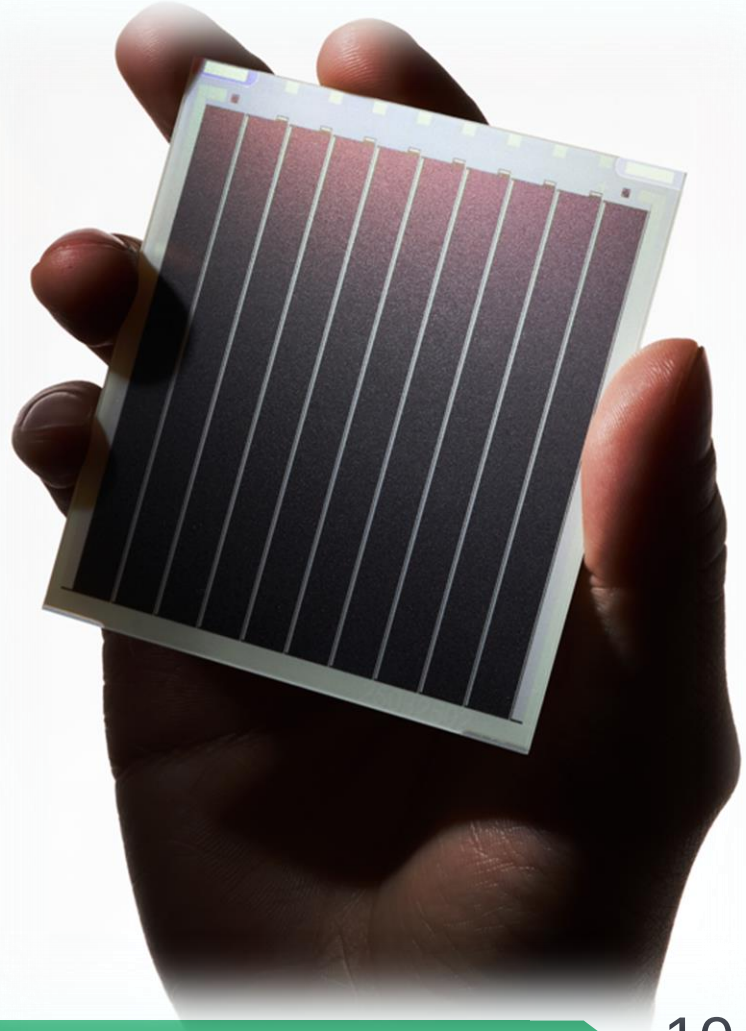
High power generation performance



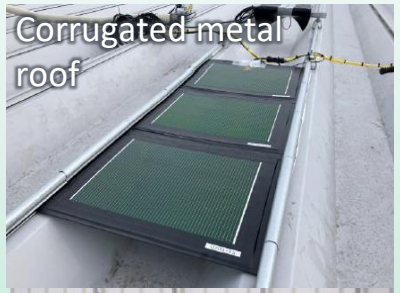
Flexible

Thin & Light

Versatile



Application



Low ← Light Intensity → High

Small ← Installation area → Large

Supplying electricity in all situations

Promotion of IoT Improvement of convenience in everyday life

Promotion of locally produced and locally consumed energy

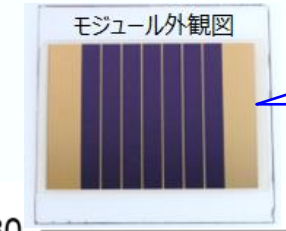
Electricity Anywhere

Comparison

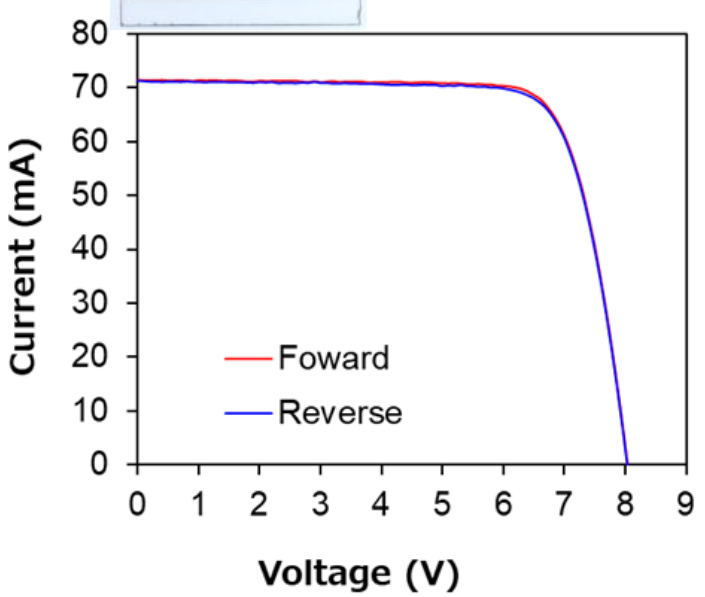
	c-Silicon	Perovskite	a-Silicon
Efficiency @ Sun light	✓	✓	△
Efficiency @ Indoor light	✗	✓	△
Weight	✗	✓	✓
Thinness	△	✓	✓
Flexibility	✗	✓	✓
Module cost	✓	△～✓	△
System cost	✓	✓	△
Durability	✓	△	△～✓

Achievements

Achieved world-class conversion efficiency exceeding 21 % with a film module

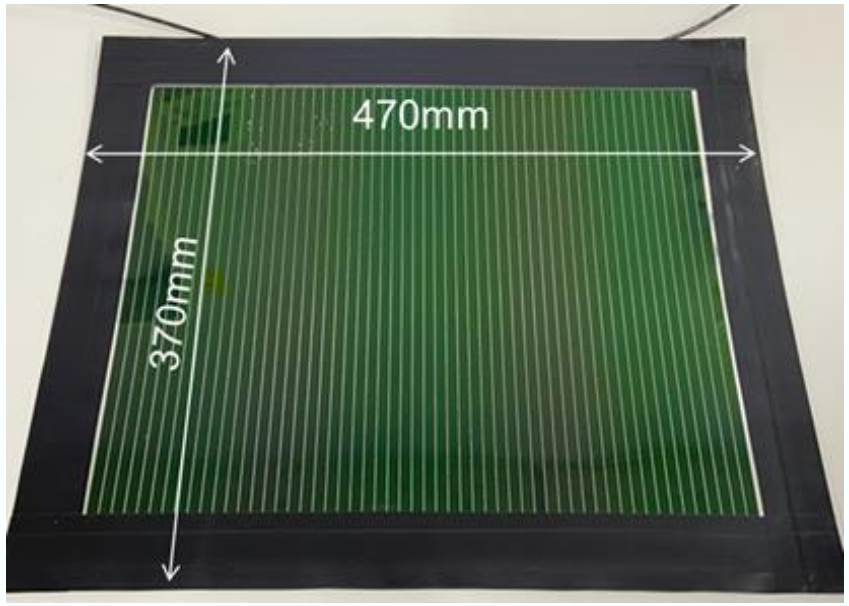


Size
75 mm × 75 mm



	Voc (V)	Isc (mA)	FF	PCE (%)
Forward	8.04	71.5	0.780	**21.2**
Reverse	8.04	71.2	0.775	21.0

Successfully produced a film module of practical size using a pilot line



	Voc(V)	Isc(mA)	FF	PCE(%)
Forward	53.9	383.8	0.71	**15.0**
Reverse	53.8	386.0	0.71	**15.2**

Achieved conversion efficiency exceeding 30 % with a perovskite/silicon four-terminal tandem solar cell

Results of the joint development project with Toyota Motor on automotive solar cells

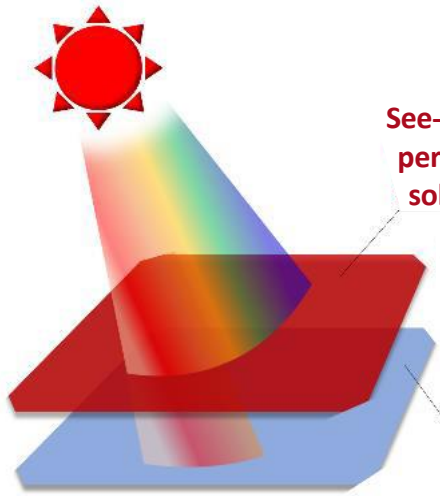
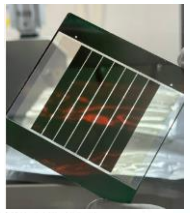


Illustration of a tandem solar cell

See-through perovskite solar cell



Generates electricity efficiently mainly from visible light

Conventional silicon solar cell

Generates electricity efficiently mainly from infrared light

	Area (cm²)	Jsc (mA/cm²)	Voc (V)	FF	PCE (%)
See-through perovskite solar cell	0.1	23.1	1.18	0.82	22.40
Silicon solar cell (when light passes through the perovskite solar cell)	4	16.3	0.69	0.71	8.0
Performance of four-terminal tandem solar cells					**30.4**
*Silicon solar cell alone	4	37.7	0.71	0.67	17.7

Demonstration Leveraging Low-Illuminance Characteristics

Functions and design leveraging the characteristics of perovskite, aiming for social implementation of “Electricity Anywhere” –generating electricity even under low indoor illumination

IoT sensor

Application to IoT sensors and measurement instruments
Air quality CO_2 sensor

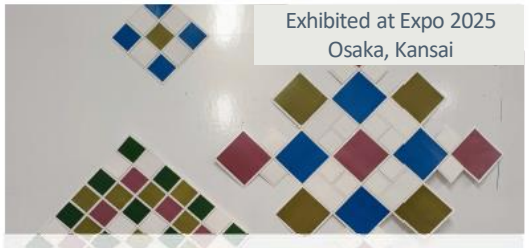
Macnica

Aroma diffuser

Function × Design
Design that enriches daily life

Mitsui Fudosan Residential

Color mosaic wall



Solar cells that do not look like batteries
Highlighting interior aesthetics and design qualities

LoRa wireless communication module

Displays sensor data on a PC

Autonomously operates the temperature and humidity sensor and the communication module

Electronic shelf label system

Autonomously communicates with host PC and displays shelf labels

Demonstration Leveraging High-Illuminance Characteristics

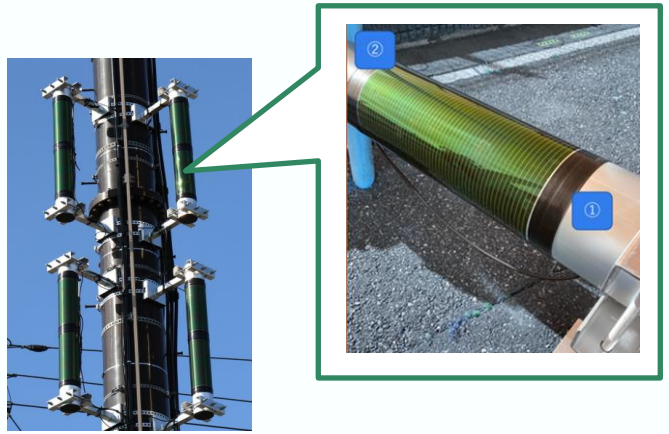
Toyota Motor

Began testing the installation of perovskite solar cells on vehicle **roofs** to extend the driving range of EVs and similar vehicles

JGC

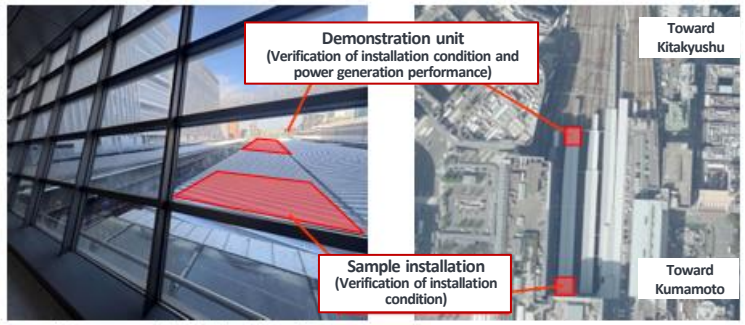
Conducts **outdoor demonstration experiment** in the bay area. Provides perovskite solar cells for installation on corrugated metal roofs

KDDI



Installed perovskite solar cells on mobile base station towers to use them as **standalone base stations**

JR Kyushu/JGC



Rendering from the station concourse　　Aerial rendering*

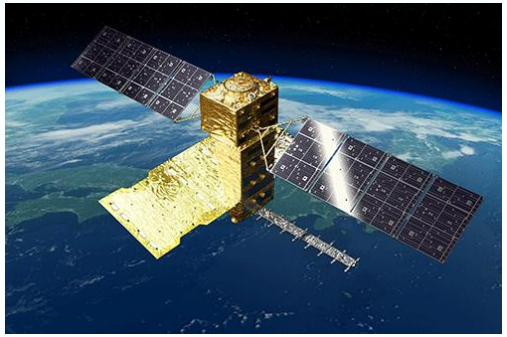
Installed perovskite on the **platform roof** of JR Hakata Station using a sheet construction method

Toyoda Gosei

Uses four 75 mm square units as a power source

Examined incorporating perovskite solar cells as the power source for air-conditioned clothing worn by Expo staff

JAXA



Jointly conducting durability tests that are more demanding than those performed on the ground, such as **radiation-resistance testing, high-temperature testing, and UV testing**

Topics

Press release on the NEDO website dated September 10, 2025

NEDO has adopted three new projects under the Green Innovation Fund Projects: "Development of Next-Generation Solar Cells/Next-Generation Solar Cell Demonstration Project." The projects aim to cultivate the market for perovskite solar cells through the development of mass-production technology and field demonstrations.

次世代型太陽電池の開発

別紙２

次世代型太陽電池実証事業

事業の目的・概要

- フィルム型・建材一体ガラス型のペロブスカイト太陽電池の実用化へ向けて一定条件下での発電コスト14円／kWh以下を達成するため、品質を安定させつつ大量生産可能な量産技術の確立に向け、一連の生産プロセスとして高いスループットや高い歩留まりを実現する技術開発を行う。
- 量産技術の確立と並行して、ペロブスカイト太陽電池の特徴を活かした設置方法や施工方法などを含めた性能検証のため、国内外の市場を想定した建築物などの実用箇所への施工、運用試験といったフィールド実証を行い、必要に応じて検証結果を踏まえた改良を行うことで、ペロブスカイト太陽電池の実用化を促進させる。

今回新規採択したテーマの規模等

- 事業期間　：2025年度～2029年度（5年間）
- 事業規模　：約335億円
- 支援規模*：約246億円
  *インセンティブ額を含む。
  採択予定額であり、契約などの手続により変更の可能性あり。
- 補助率：助成2/3、1/2

事業イメージ

実施体制

テーマ名（●は今回の新規採択テーマ）	事業者名　※太字は幹事企業
○軽量フレキシブルペロブスカイト太陽電池の量産実証	**・積水化学工業株式会社**、東京電力ホールディングス株式会社
●インクジェット印刷ペロブスカイト太陽電池生産技術開発および社会実装に向けた設置施工技術・電装技術開発	**・株式会社リコー**
●ガラス型ペロブスカイト太陽電池の量産技術開発とフィールド実証	**・パナソニック ホールディングス株式会社**
●設置自由度の高いペロブスカイト太陽電池の社会実装に向けた量産技術開発と実証	**・株式会社エネコートテクノロジーズ**

Nikkei dated September 10, 2025

京大発エネコート、曲がる太陽電池で産学連合　豊田合成や青学も

スタートアップ　✓フォロー済み

2025年9月10日 12:26

保存

京都大学発スタートアップエネコートテクノロジーズ（京都府久御山町）は10日、薄くて曲がる「ペロブスカイト型太陽電池」の開発に向けて産学連合をつくると発表した。トヨタ自動車や日揮、豊田合成など9社のほか、京大や青山学院大学が参加する。建物の屋根や壁に設置しやすい太陽電池の開発を急ぐ。

エネコートの事業がこのほど国の「グリーンイノベーション（GI）基金」に採択された。同基金からの補助と自己資金を合わせて100億円規模を投じるとみられる。素材や実証の技術を持つ大企業と組んで開発する。

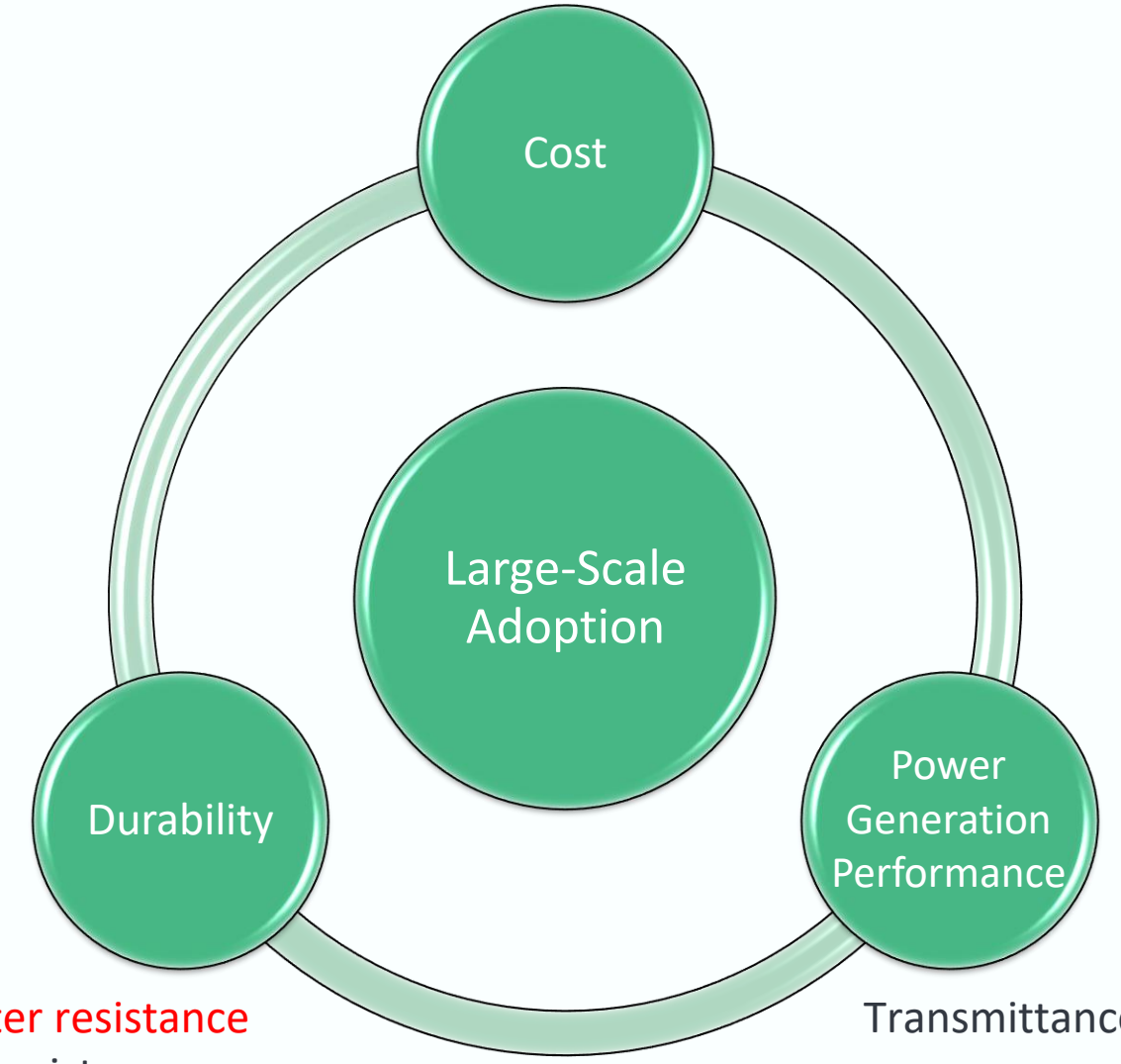
エネコートを幹事としてコンソーシアムをつくる。トヨタ自動車、日揮、KDDI、豊田合成、YKKAP、京大、青山学院大などの企業や大学が加わる。2030年までの研究開発と実証で協力する。

ペロブスカイト型は次世代の太陽電池として今後の普及が期待されている。エネコートは23年からトヨタと車載用を共同開発してきた。今回の資金で建物の屋根や壁に設置する用途に参入する。

New factory

2027
Mass production

Importance of Barrier Films

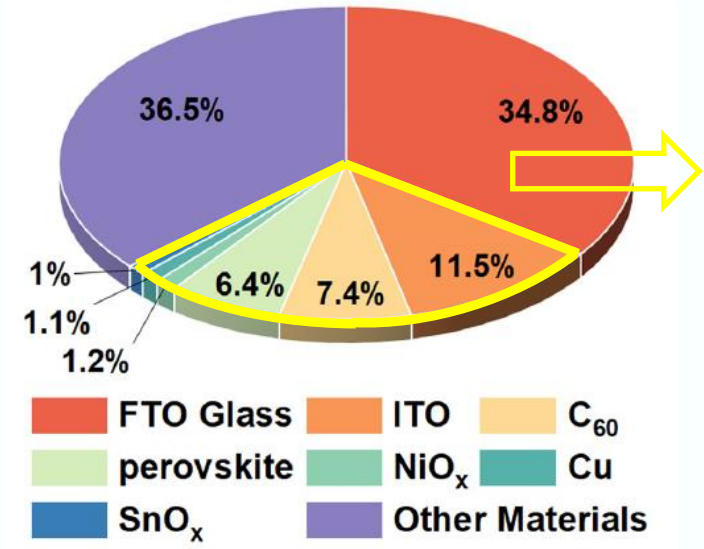


Water resistance
UV resistance

Transmittance

-Cost structure of a typical inverted glass perovskite solar module-

Reference: Y. Liu.et al., *Nano-Micro Letters,* **2025**, vol.17 219



Photoactive layer materials account for less than 30 %

Photoactive-layer materials in perovskite solar cells are relatively low-cost, while substrate and other components represent a larger portion of the cost.

In film-based PSCs, the barrier film (including the substrate) is the primary cost contributor among non–photoactive-layer materials..

Our Expectations to Konica Minolta's Barrier Film

- Achievements (technologies and expertise) in high-barrier films developed through OLED and related applications
- Exceptional water resistance (low water vapor transmission rate, WVTR)
- Device compatibility (thin film and curvature conformance)

We look forward to products that offer both high functionality and low cost

ペロブスカイト太陽電池で未来を創ります。

Build The Future With Perovskite Solar Cells.

ENECOAT

株式会社エネコートテクノロジーズ

EneCoat Technologies Co., Ltd.

Significance of perovskite solar cells

Why Konica Minolta can make this possible

Path to practical application of barrier film

Yusuke Nakajima
Development Department
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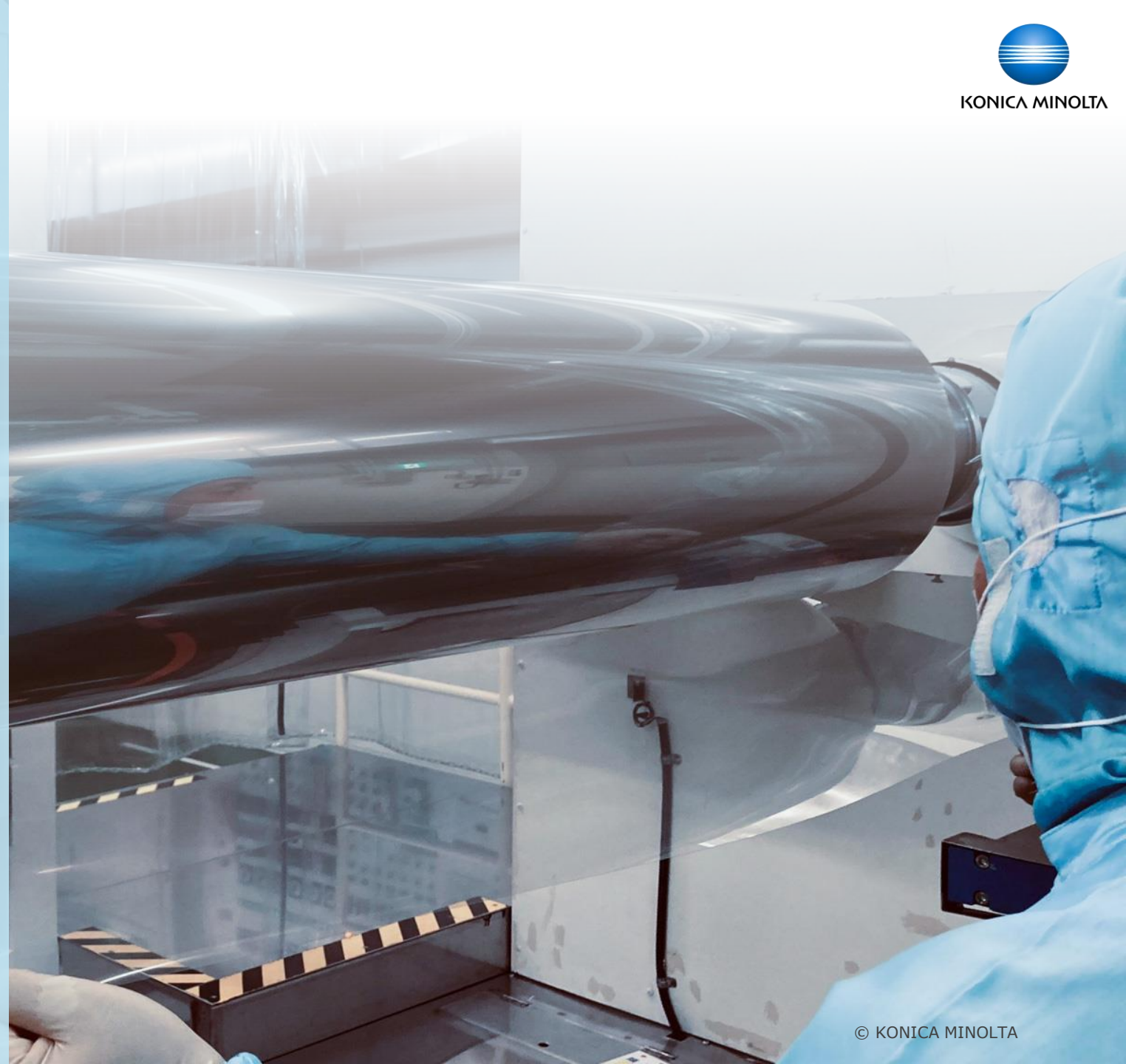
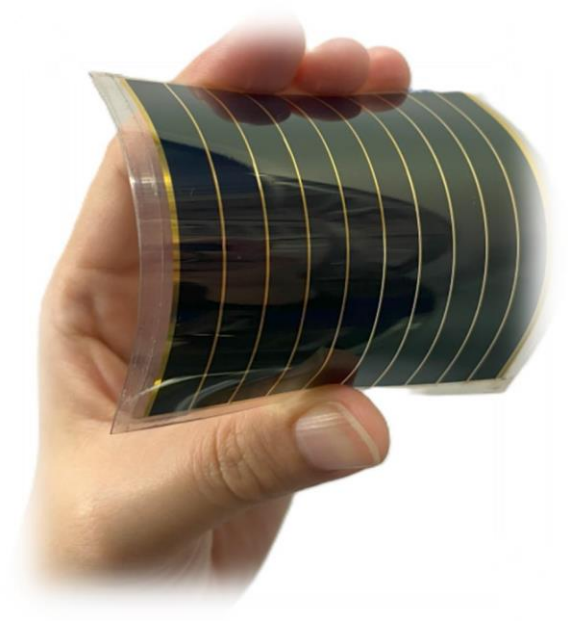


Durability and Water Resistance Required for the Widespread Use of Perovskite Solar Cells



Challenge

Water intrusion degrades the photoactive layer

Scaling up to mass production can lead to a quality decline

Konica Minolta's barrier film

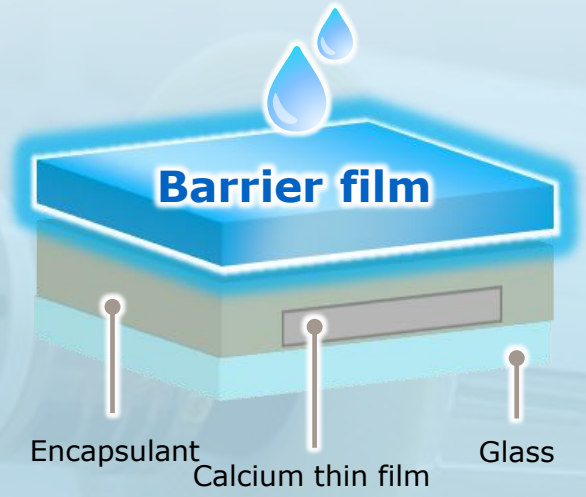
Formation of a high-barrier layer to suppress water intrusion

Production technology cultivated in the functional film business

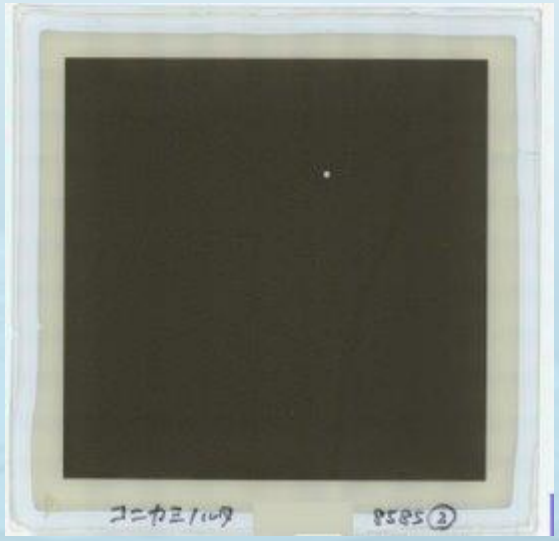
Becoming the Leading Company in High Water-Resistant Barrier Film Originating in Japan

Through the calcium test, which is used to evaluate the water vapor transmission rate (WVTR) of barrier films, it was verified that the film provides sufficient quality for outdoor applications of perovskite solar cells

Calcium test sample configuration



Evaluation status



* Calcium test sample created by EneCoat Technologies (after 3,507 hours)

The degradation of the moisture-sensitive calcium layer is observed to evaluate the barrier film quality, i.e., its resistance to water vapor transmission

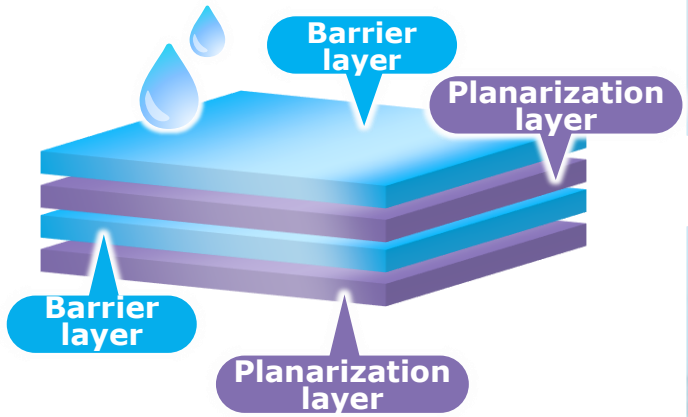
In the calcium test conducted by EneCoat Technologies, the existing barrier film product demonstrated durability exceeding **3,500 hours**

Note: A duration of 2,000 hours is considered sufficient for outdoor applications

Barrier Film | Konica Minolta's Proprietary High-Barrier Technology

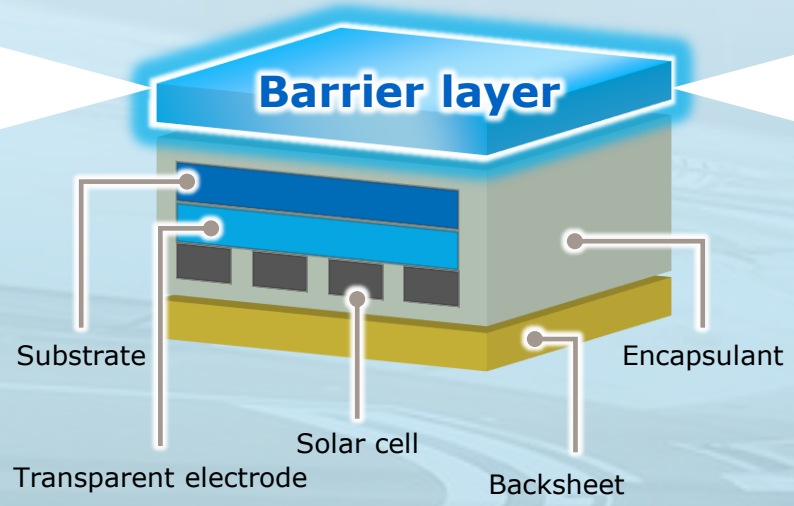
Water resistance is generally achieved by multilayer stacking of barrier layers and planarization layers filling substrate irregularities and voids
High barrier performance in thin films is achieved through Konica Minolta's proprietary technology, which enables both planarization and barrier function

Conventional barrier film

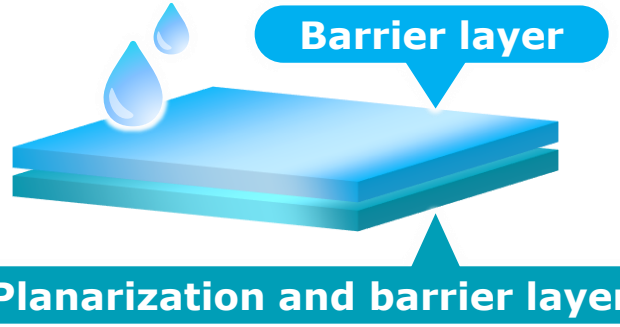


Alternating stacking of planarization layers and barrier layers

Structure of a perovskite solar cell



Konica Minolta's barrier film



Stacking two types of layers: one that provides both planarization and barrier functions, and the other that provides only barrier functions

Multilayering
required for
high barrier performance

Fewer layers
achieving
high barrier performance

Barrier Film | Stable Mass Production is Achieved Through Technology Cultivated in Film Manufacturing

Stable mass production is achieved through the production technology cultivated over many years in the roll-to-roll film business and through the use of existing equipment

1976

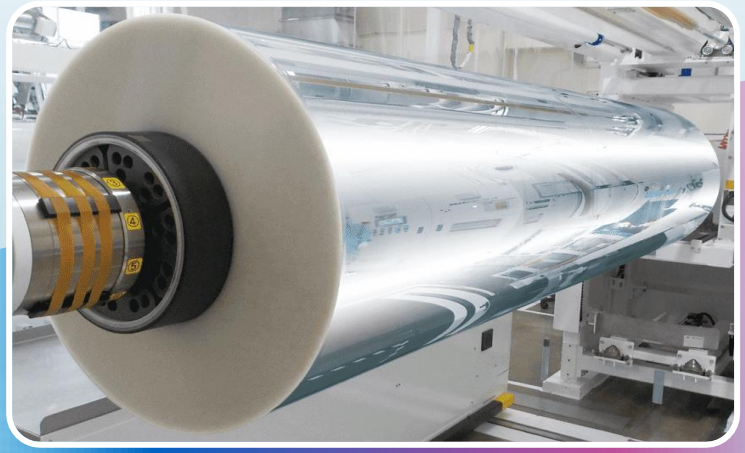
Sakura Color, a photographic film, marketed

2000

TAC films for LCD polarizers fully launched

2015

Barrier film for OLED marketed



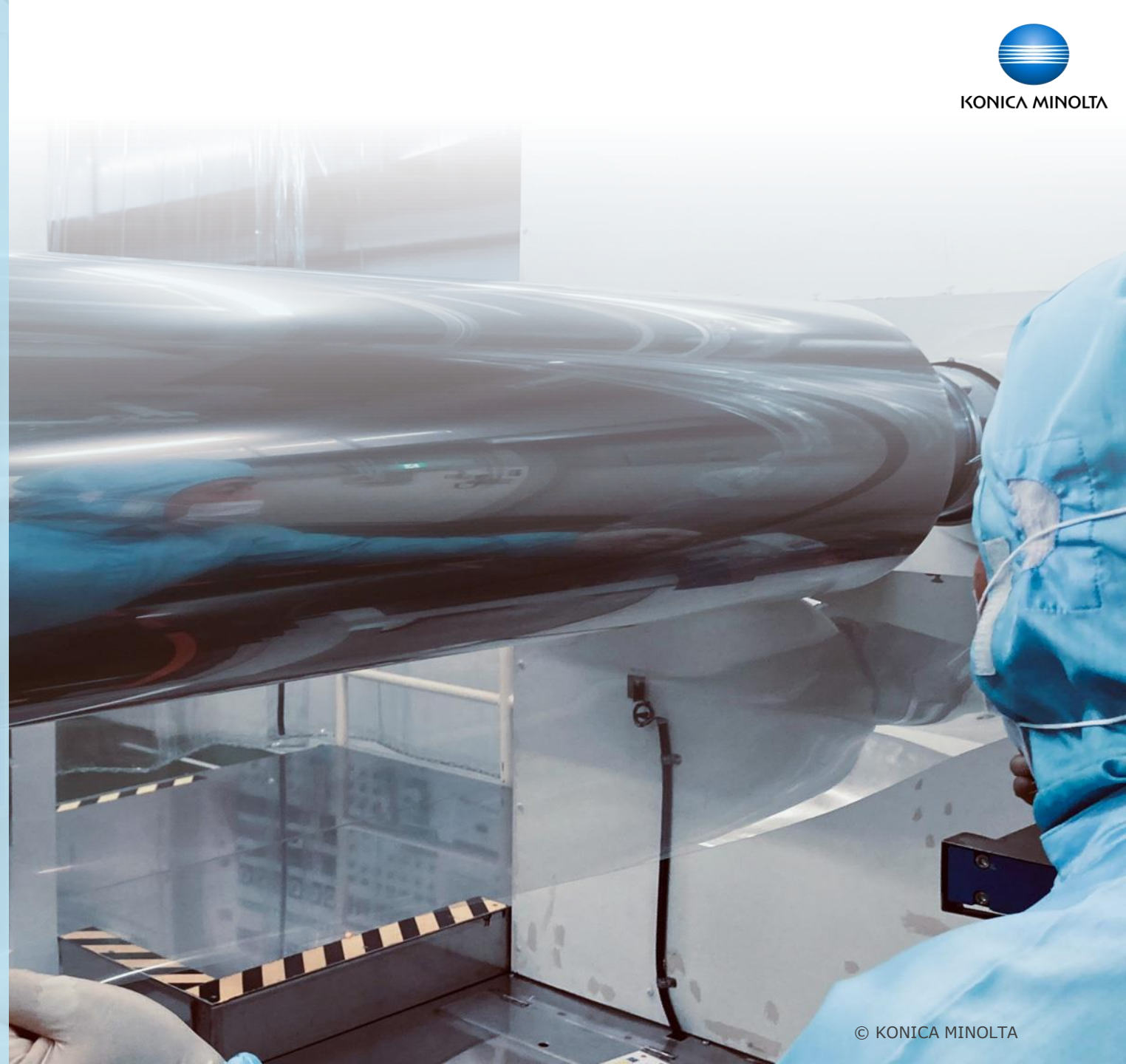
Barrier film for perovskite solar cells

Significance of perovskite solar cells

Path to practical application of barrier film

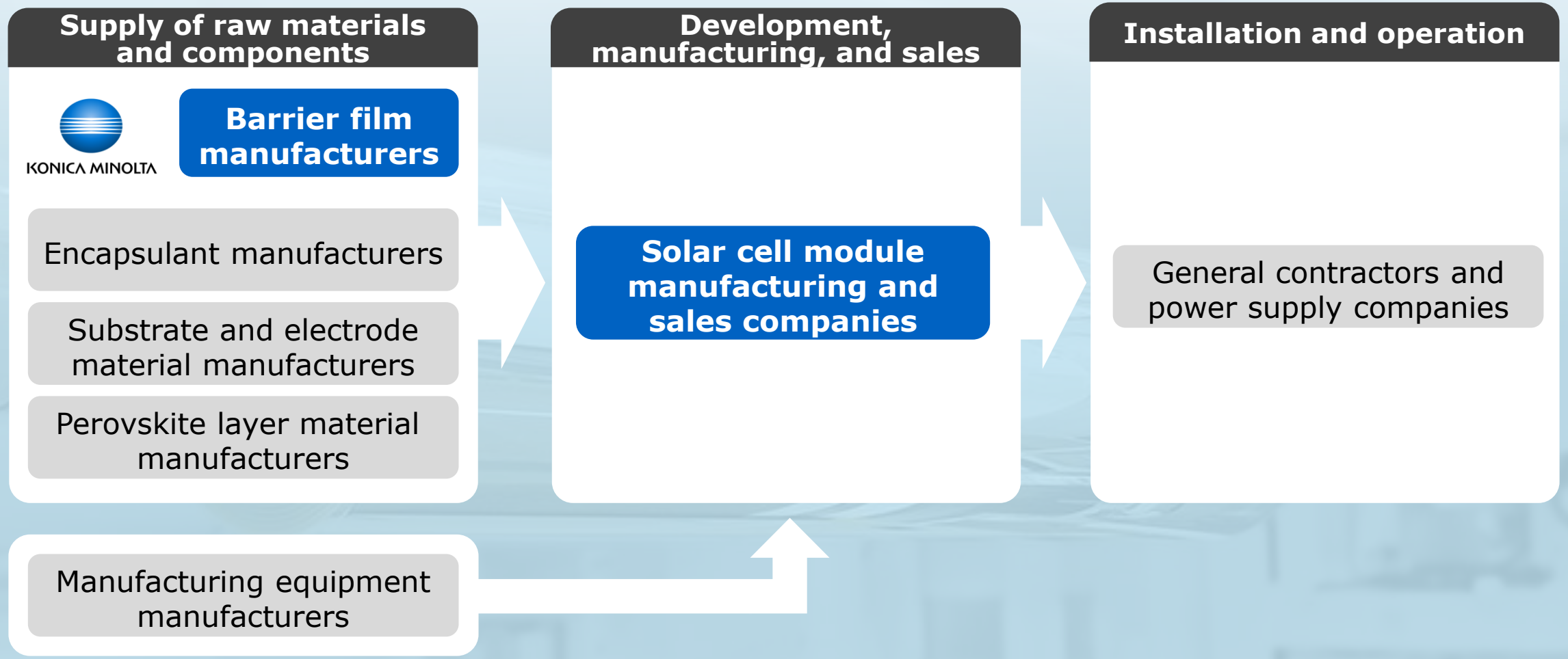
Path to practical application of barrier film

Keiichi Kishi
Corporate Vice President, General Manager,
Corporate Technology Development Headquarters
Konica Minolta, Inc.



Konica Minolta As a Leader in Technology Originating in Japan

In Japan, raw material suppliers, manufacturers, construction companies, and others are entering the market
Konica Minolta provides barrier film to solar cell module manufacturers



Providing Barrier Film for Perovskite Solar Cells to Meet Customer Needs

Targeting customers engaged in the manufacturing and sales of perovskite solar cell modules
Aiming for high profitability through the Industry-type business model

Manufacturing and sales of barrier film

KONICA MINOLTA

Sales of barrier film for perovskite solar cells

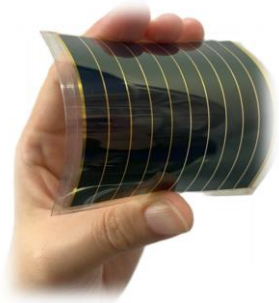
Manufacturing and sales of solar cell modules

ENECOAT

- Company A
- Company B
- Company C
- ⋮

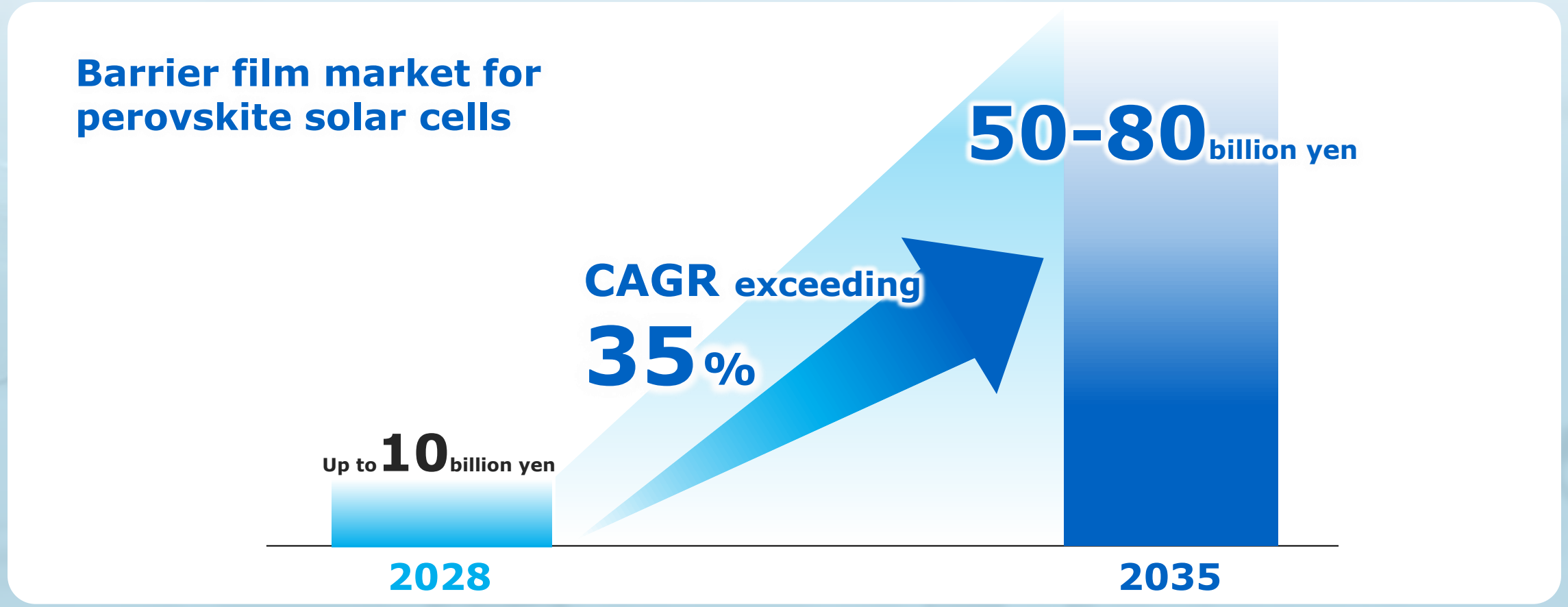
Sales of perovskite solar cell modules

Customers



Target Market for Perovskite Solar Cell Barrier Film

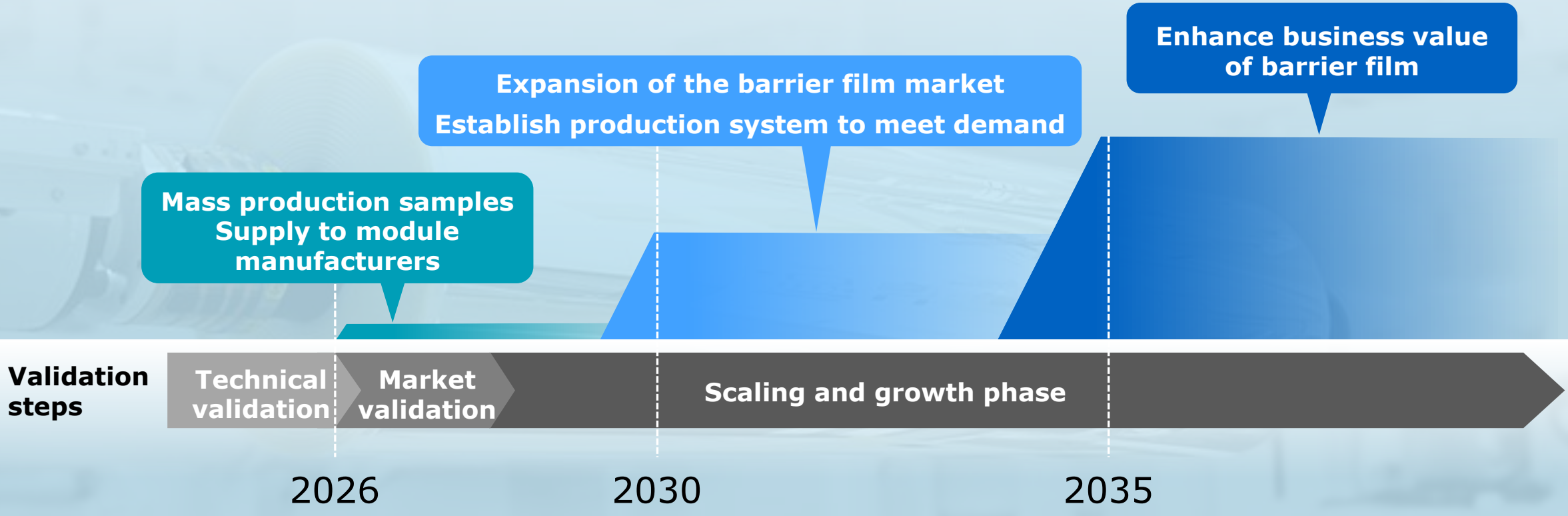
In line with the rapid growth expected for the perovskite solar cell market, the barrier film market is projected to reach 50–80 billion yen by 2035
Aiming to become the market leader by leveraging our high-performance material



* Market size and CAGR are Konica Minolta's own estimates

Business Growth Concept of Barrier Film

Leveraging our proven technology and equipment, we will begin delivery of mass production samples in 2026
Targeting market leadership in barrier film: 50 billion yen in 2035



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Cautionary Statement:
The forecasts mentioned in this material are the results of estimations based on currently available information, and accordingly, contain risks and uncertainties. The actual results of business performance may sometimes differ from those forecasts due to various factors.

Remarks:
Yen amounts are rounded to the nearest 100 million.