

Perovskite Solar Cells

Market Scenario and Competitive Landscape

A CURA DI

Ufficio Valorizzazione della Ricerca

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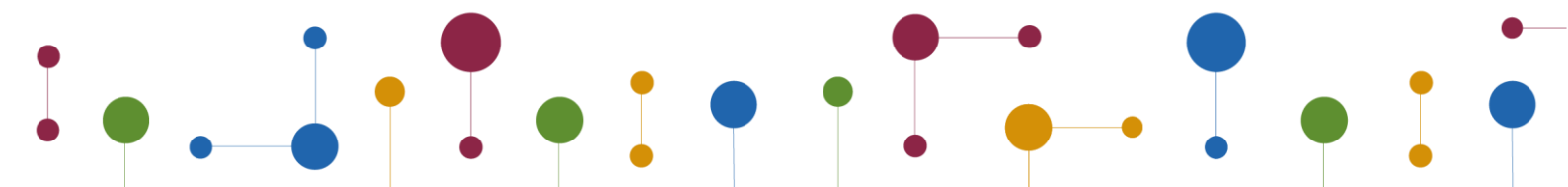


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Introduction and Methodology

“Market Scenario” is a customized and organized analysis to gather information about target markets and competitive landscape in a particular sector.

“Market Scenario” provides relevant information to identify and analyzes market needs, market size and competition in the fields of interest of the customer. A technology or a product developed by the customer can be characterized according to the sectors and potentiality of application, target market, competitive advantages and potential partners of the technology. The analysis is performed with the application of technology and business intelligence tools. The research in the information providers is usually based on the use of keywords or by thematic area, according to the specific topic of interest.

The results of the assessment are data about the target or global market potential, market value and applicability of the technologies or products developed by the customer, the trends of the market of interest, the segmentation of the market (e.g., by application, geography or indication), the supply chain and the competitive advantages of products or technologies, the key players active in the market of interest and the possible direct or indirect competitors of the customer.

Context

This report provides an overview of the global **perovskite solar cell market**, starting with market definition and global market data and dynamics. Moreover, a segmentation of the market by structure type, product, vertical, application, technology and region is provided. The report includes finally the competitive landscape for the market of interest.

1 Perovskite Solar Cell Market

1.1 Market definition

Perovskite solar cell is a type of solar cell that includes a **perovskite structured compound**, most commonly a hybrid organic-inorganic lead or tin halide-based material, as the light-harvesting active layer. Perovskite materials such as methylammonium lead halides are **economical and relatively simple to manufacture**. Perovskites offer intrinsic properties such as a broad absorption spectrum, fast charge separation, long transport distance of electrons and holes, and long carrier separation lifetime, making them promising materials for solid-state solar cells. Moreover, it exhibits properties such as **superconductivity** and **magnetoresistance**. The material is expected to be the **future of solar cells** because of its distinctive structure, which makes it perfect for developing economical, efficient photovoltaics.

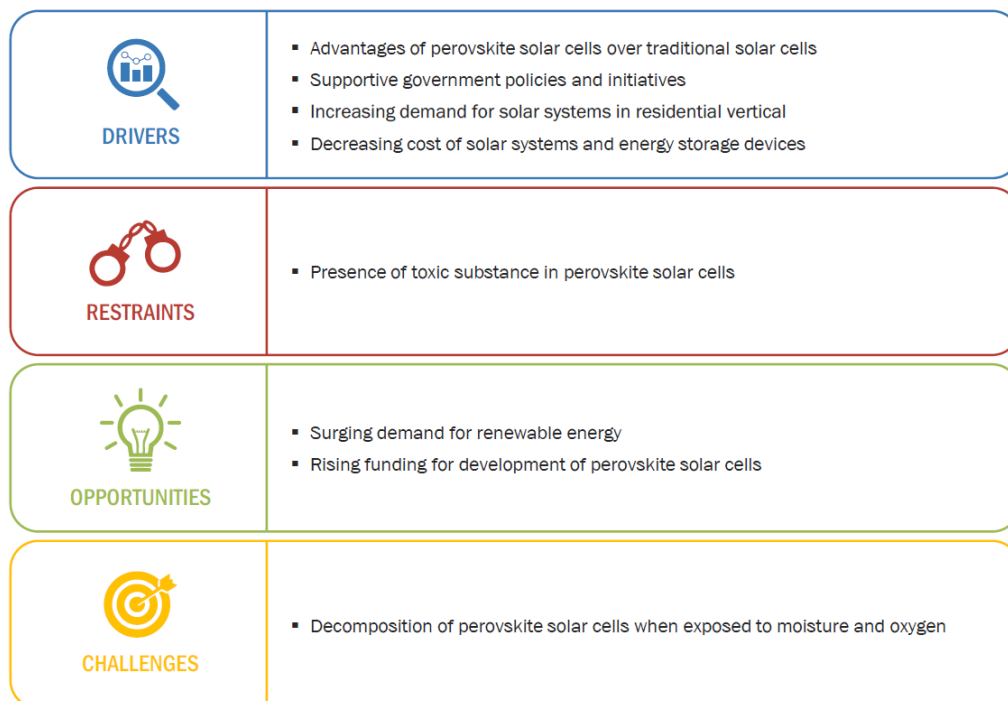
1.2 Global Market and Dynamics

The perovskite solar cell market is expected to grow from USD 271 million in 2024 to **USD 2,268 million by 2028**.

The perovskite solar cell market has been in **constant research and development phase**. The rising demand for renewable energy, the support extended by governments of multiple countries to increase the installation of solar panels, and growing concerns regarding environmental safety are **driving the growth** of the solar cell market, which is expected to fuel the demand for perovskite solar cells.

Figure 1 describes the drivers, restraints, opportunities, and challenges influencing the market’s growth.

Figure 1. Perovskite Solar Cell Market: Drivers, Restraints, Opportunities, and Challenges



The following paragraph further investigates one of the drivers of the market, which are of particular interest for the purposes of this analysis.

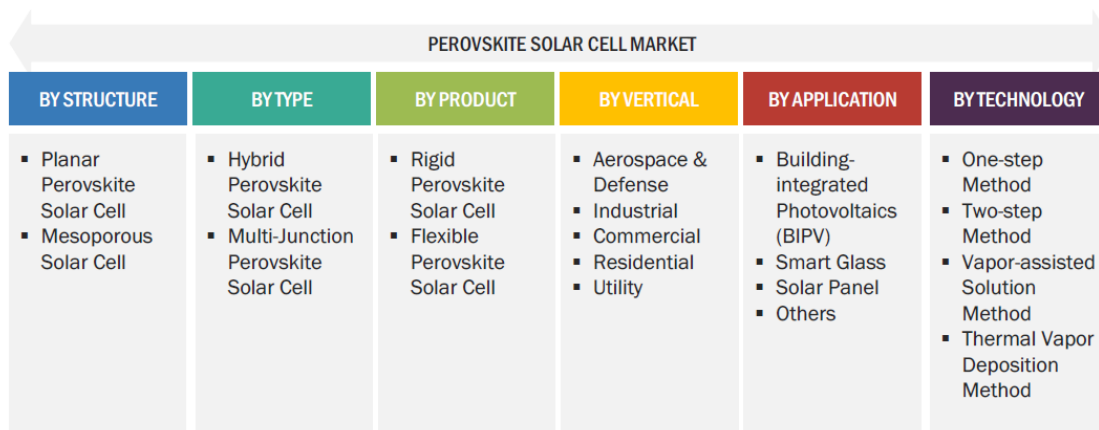
1.2.1 Advantages of perovskite solar cells over traditional solar cells

Perovskite solar cells have competitive power conversion efficiencies (PCE) with the potential for **higher performance** than traditional solar cells. Perovskite solar cells can convert sunlight into electricity even if the **sunlight is indoors, outdoors, or the light is artificial**. A few of the benefits of perovskite solar cells are they are much cheaper to fabricate and thinner than traditional solar cells. Besides, perovskite solar cells offer better efficiency in low and variable lights and have high spectral absorption.

1.3 Ecosystem Analysis

Figure 2 reports the ecosystem analysis of the perovskite solar cell market.

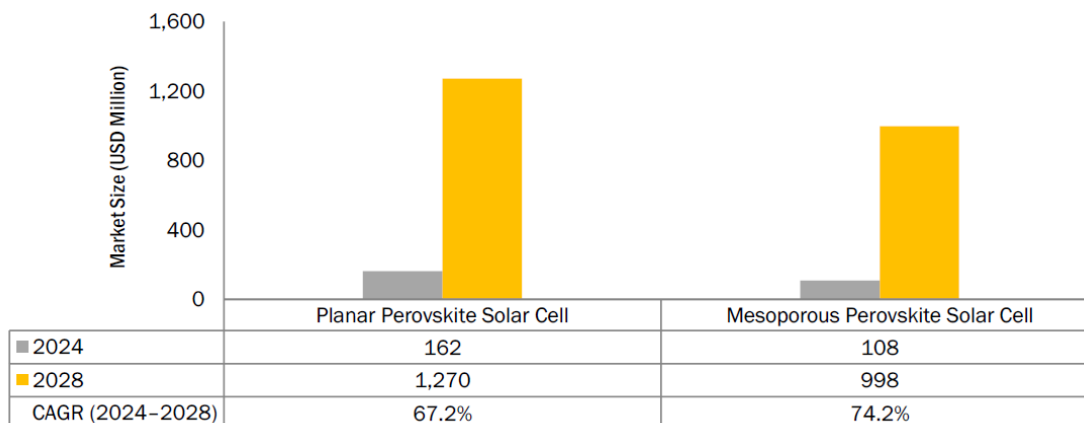
Figure 2. Perovskite Solar Cell Market: Ecosystem Analysis



1.4 Market by Structure Type

Based on structure type, the perovskite solar cell market has been segmented into **planar perovskite solar cell** and **mesoporous perovskite solar cell**. In terms of market size, the planar perovskite cell segment is expected to dominate the market, while mesoporous perovskite solar cell is expected to be the fastest growing segment during the forecast period (Figure 3).

Figure 3. Perovskite Solar Cell Market, by Structure Type, 2024–2028 (USD Million)



Constant research and development related to **planar perovskite solar cells** have increased their efficiency from 4% to 19%, fueling their adoption in various verticals. Moreover, the planar perovskite solar cell has a p–i–n structure that uses hole-transport layers (HTL) and electron-transport layers (ETL) to collect photogenerated holes and electrons and feature high performance.

1.5 Market by Type

The perovskite solar cell market based on type has been segmented into **single-junction perovskite solar cell** and **multi-junction perovskite solar cell**. In general, single-junction solar cells have one p–n junction to direct the flow of electricity created when sunlight hits a semiconducting material, while in multi-junction solar cells, multiple p–n junctions can induce a flow of electricity. The multi-junction perovskite solar cell market is expected to witness the fastest growth during the forecast period (Table 1), as it offers higher efficiency than a single-junction perovskite solar cell and is cost-effective.

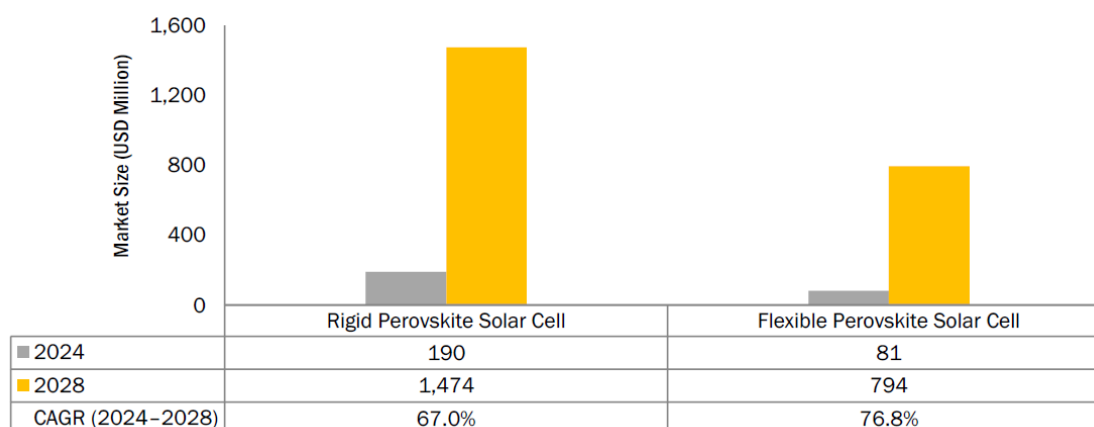
Table 1. Perovskite Solar Cell Market, by Type, 2024–2028 (USD Million)

Type	2024	2025	2026	2027	2028	CAGR (2024–2028)
Single-junction Perovskite Solar Cell	149	338	601	812	907	57.1%
Multi-junction Perovskite Solar Cell	122	321	664	1,044	1,361	82.8%
Total	271	659	1,264	1,855	2,268	70.1%

1.6 Market by Product

Based on product, the perovskite solar cell market has been segmented into **rigid perovskite solar cell** and **flexible perovskite solar cell**. Rigid perovskite solar cells are more efficient than flexible perovskite solar cells; however, flexible perovskite solar cell is expected to be the fastest-growing segment during the forecast period (**Figure 4**). Scientists are constantly working on **research and development** of perovskite solar cells. They have developed flexible perovskite solar cells that use sunlight and generate electrons with an efficiency of 20.7%. As the efficiency of flexible perovskite solar cells is increasing with time, their adoption is expected to rise significantly during the forecast period.

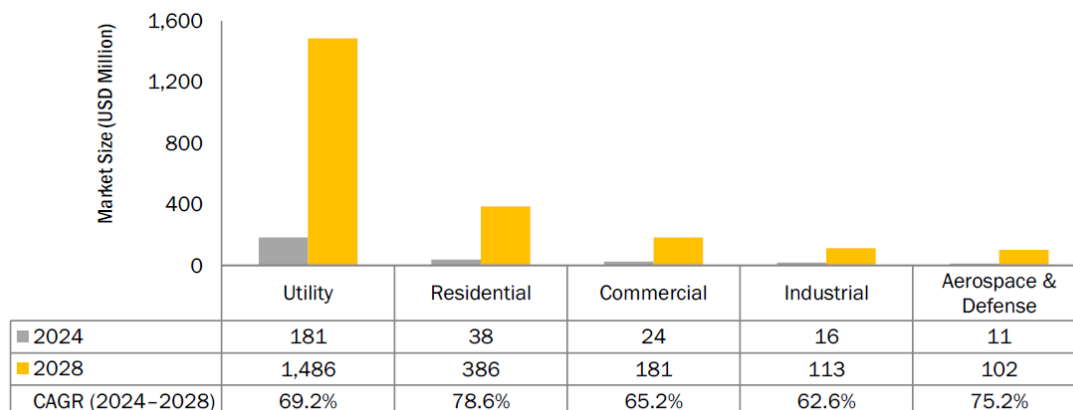
Figure 4. Perovskite Solar Cell Market, by Product, 2024–2028 (USD Million)



1.7 Market by Vertical

Solar cells are being increasingly used across various verticals. Market trends in different verticals variably impact the demand for solar cells. The perovskite solar cell market based on vertical has been segmented into **aerospace & defense, industrial, residential, commercial, and utility**. The **utility segment** is projected to hold the largest share of the overall market during the forecast period (**Figure 5**). The scope of this segment includes solar power plants based on perovskite solar cell photovoltaic (PV) systems. These solar power plants are environmentally friendly; therefore, governments across many countries are promoting their installation. Governments' special schemes and financial support for installing solar power projects are expected to boost the demand for perovskite solar cell-based PV systems during the forecast period.

Figure 5. Perovskite Solar Cell Market, by Vertical, 2024–2028 (USD Million)



Given the purposes of this analysis, the **residential segment** will be further explored in the following paragraph.

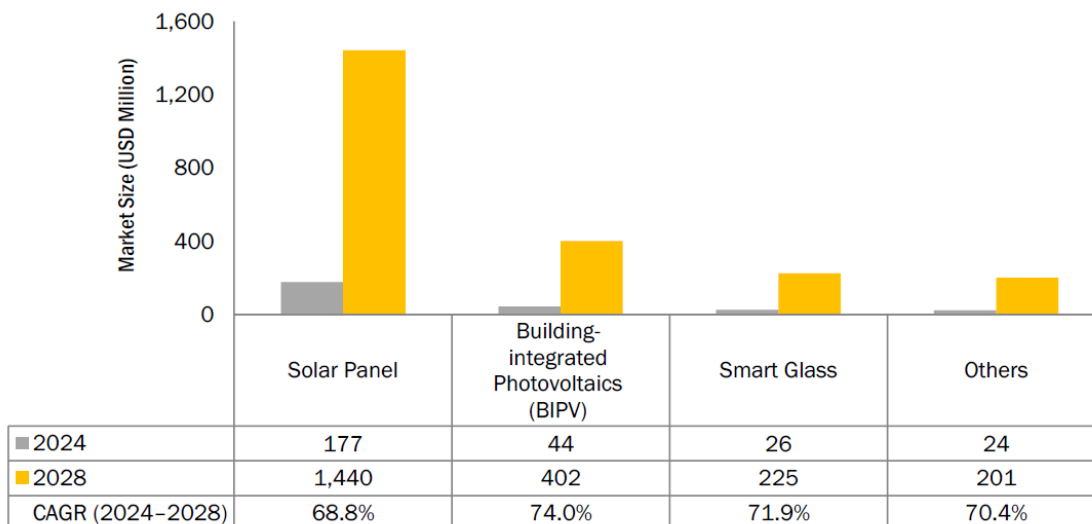
1.7.1 Residential

The perovskite solar cell market for the residential vertical is expected to register the **highest CAGR of 78.6%** during the forecast period. In residential applications, perovskite solar cell-based PV systems are expected to be installed on the **rooftop** or at locations where adequate sunlight is available to **fulfill the home's electricity needs**. Electricity is required for **in-home lighting and ventilation solutions** and several **other consumer electronics and appliances**, such as water pumping systems, lanterns, radios, televisions, flashlights, outdoor lights, security systems, gate openers, and fans. These PV systems need **batteries** to store electricity; charged batteries can be used when needed. The excess electricity (if generated) can be sold by transferring it to the national or local electricity grid (depending on the system feasibility, availability, and policies of governments and electricity providers). Perovskite solar cells for PV systems can be useful in **remote areas and faraway villages** where electricity grids are unavailable. Apart from PV systems, perovskite solar cells are also expected to be used in **Building-integrated Photovoltaics (BIPVs)** in the residential segment. The use of perovskite solar cells for **powering consumer electronics** in residential buildings is expected to boost the growth of the residential segment.

1.8 Market by Application

This paragraph discusses various applications of perovskite solar cells, **including building-integrated photovoltaics (BIPV), smart glass, solar panel, and others** (other applications include portable devices, solar blinds, charging stations, electronic shelf labels, drones, and satellites). The solar panel segment is expected to hold the largest market share during the forecast period, while the BIPV segment is expected to experience the highest growth (**Figure 6**). The growing use of perovskite solar cells to **charge portable devices in residential buildings** is one of the key factors driving the growth of the "others" segment during the forecast period.

Figure 6. Perovskite Solar Cell Market, by Application, 2024–2028 (USD Million)



1.9 Market by Technology

The perovskite solar cell market based on technology has been segmented into **one-step method, two-step method, vapor-assisted solution method, and thermal vapor deposition method**. In one-step solution processing, a lead halide and a methylammonium halide are dissolved in a solvent and spin coating onto the substrate. In the two-step method, to form the PbI₂ nanostructure, a new approach to the use of high CH₃NH₃I concentration is being adopted. Vapor-assisted solution method can be used to form multi-junction perovskite solar cells. The thermal vapor deposition method consists of two categories, i.e., chemical vapor deposition (CVD) and plasma-enhanced CVD. No market data are available for the segmentation by technology.

1.10 Market by Region

The perovskite solar cell market based on region has been segmented into **North America, Europe, Asia Pacific, and Rest of the World (RoW)**. **Asia Pacific** is expected to hold the largest share of the perovskite solar cell market during the forecast period, followed by Europe and North America (**Table 2**). China, Japan, South Korea, Taiwan, and India are expected to be the major contributors to the Asia Pacific perovskite solar cell market growth. The **North American** market is witnessing considerable growth owing to the increasing deployment of solar cells and PV modules in the residential and commercial verticals. Regarding **Europe**, Germany and Italy are expected to be the major contributors to the European perovskite solar cell market.

Table 2. Perovskite Solar Cell Market, by Region, 2024–2028 (USD Million)

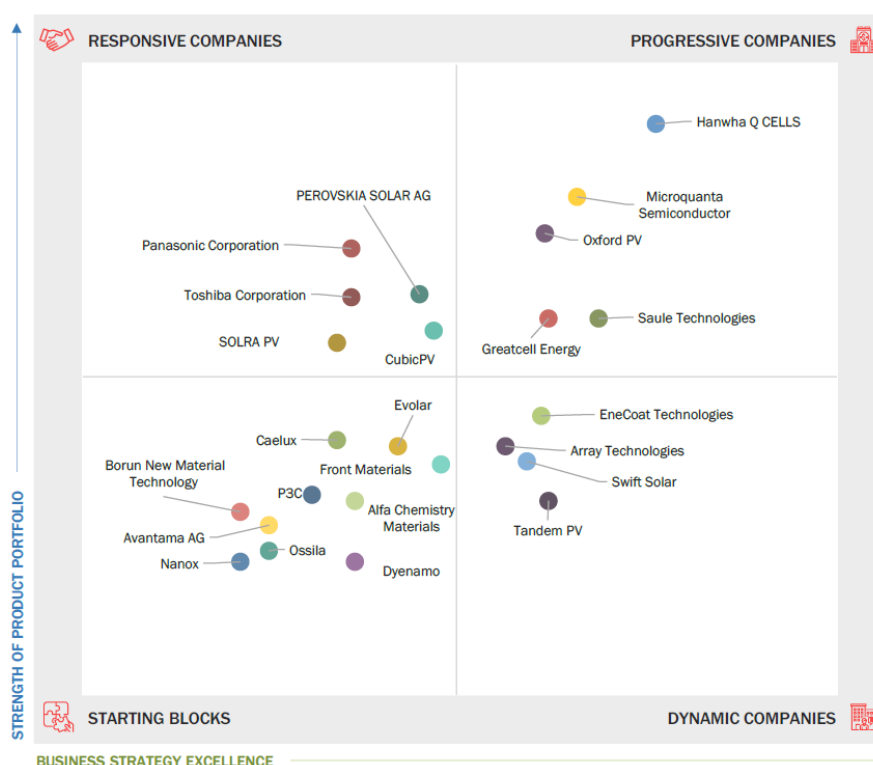
Region	2024	2025	2026	2027	2028	CAGR (2024–2028)
North America	51	123	232	335	403	67.3%
Europe	68	165	316	461	561	69.3%
Asia Pacific	133	328	638	948	1,173	72.3%
RoW	18	42	79	112	132	64.5%
Total	271	659	1,264	1,855	2,268	70.1%

1.11 Competitive Landscape

The competitive landscape provides an overview of the major players operating in the perovskite solar cell market. **Key players** in this market are Hanwha Q CELLS (South Korea), CubicPV (US), EneCoat Technologies (Japan), Microquanta Semiconductor (Chin), Greatcell Energy (Australia), Oxford PV (UK), P3C (India), PEROVSKIA SOLAR AG (Switzerland), and Saule Technologies (Poland).

The perovskite solar cell market is currently in a research and development phase. Therefore, the players profiled in the market are **SMEs and startups**. The quadrant below (**Figure 7**) gives information about the major small and medium-sized players or the players having a limited focus on research and development of perovskite solar cells. It outlines findings and analysis of how well each market vendor performs within the predefined competitive leadership mapping criteria. Vendor evaluations are based on two broad criteria—strength of product portfolio and business strategy excellence. The top 25 companies are placed into **four categories** based on their performance in each criterion: **progressive companies**, **responsive companies**, **starting blocks**, and **dynamic companies**.

Figure 7. Perovskite Solar Cell Market (Key Players): Competitive Leadership Mapping, 2022



In the next paragraph we provide an overview of the company **Saule Technologies**, which the client is interested in establishing business relations.

1.11.1 Saule Technologies

Business Overview

Saule Technologies is a high-tech Polish company that works on the **research and development of solar cells based on perovskite solar cells**. The company uses inkjet printing to develop flexible, lightweight, ultrathin, and semi-transparent

photovoltaic modules. The company aims to provide products for applications in the BIPV, residential, and commercial segments. The company has associations with organizations such as the European Funds Smart Growth, the European Union, and The National Center for Research and Development to advance research and development of solar cells. The company has been featured in publications such as Forbes, BBC, and The Economist for research and development in solar cells.

Products Offered

Table 3. Saule Technologies: Products/Solutions/Services Offered

Product	Description	Product Type	Vertical
Perovskite Electronic Shelf Label	The company provides Perovskite Electronic Shelf Label. Electronic labels have an inexhaustible power source and do not require costly and time-consuming battery replacement.	Solar Cell	<ul style="list-style-type: none"> • Residential • Commercial • Others
Solar Sun Blinds	The company provides solar sun blinds, a kinetic façade where the amount of light entering can be dynamically regulated. The solar sun blinds are equipped with lightweight and flexible perovskite solar modules. These solar blinds can be operated manually and automatically to optimize room temperature.	Solar Blinds	<ul style="list-style-type: none"> • Residential • Commercial • Others
Smart Glass	The company offers smart glass semi-transparent perovskite foil, sealed between glass shields, and seamlessly integrated into the façade.	Smart Glass	<ul style="list-style-type: none"> • Residential • Commercial • Others

Recent Developments

Table 4. Saule Technologies: Product Launches

Month & Year	Approach	Product Type	Product Name	Description
August 2021	Product Launch	Photovoltaic Blinds	Solar Sun Blinds	Saule Technologies launched photovoltaic blinds and announced the first installation of photovoltaic blinds - sun breakers with perovskite solar cells. This commercial implementation of perovskite solar cell technology was in collaboration with a client, Aliplast.
May 2021	Product Launch	Production Line	-	Saule Technologies launched a production line of perovskite photovoltaics - printed, flexible, ultra-thin, and ultra-light.

Table 5. Saule Technologies: Deals

Month & Year	Deal Type	Company Name 1	Company Name 2	Description	Deal Size
May 2022	Partnership	Saule Technologies, Columbus Energy (Poland)	Google Cloud (US)	Saule Technologies and Columbus Energy have partnered with Google Cloud by signing a strategic cooperation agreement to develop new products using perovskite solar cells and solutions in the field of distributed energy and IoT.	NA

March 2022	Agreement	Saule Technologies	Columbus Energy (Poland) and Somfy Polska (Poland)	Saule Technologies has signed a strategic agreement with Columbus Energy and Somfy Polska to develop innovative solutions for building projects using perovskite solar cells.	NA
September 2020	Acquisition	Saule Technologies	Columbus Energy (Poland)	Columbus Energy, one of Poland's leading providers of services in the modern energy market, invested in Saule Technologies and acquired 20% of the company's shares.	~USD 10 Million
April 2020	Funding	Saule Technologies	Polish National Centre for Research and Development (NCBR) (Poland)	Saule Technologies received funding from Polish National Centre for Research and Development (NCBR) to work on the mass production of flexible perovskite solar modules for IoT applications.	~USD 4 Million

Key Strengths/Right to Win

Saule Technologies is **one of the leading companies** working in the **research and development of perovskite solar cells**. The company's key strength is its **team**, which consists of Ph.D. students and scientists from the solar cell industry. The company enhances its business by investing and developing perovskite solar cells for **different applications**, including smart glasses, solar panels, and BIPV. In May 2021, the company launched a production line of perovskite photovoltaics - printed, flexible, ultra-thin, and ultra-light.

Strategic Choices Made

Saule Technologies focuses on partnerships, acquisitions, and funding to develop perovskite solar cells. For instance, in May 2022, Saule Technologies and Columbus Energy **partnered with Google Cloud**, signing a strategic cooperation agreement to develop new products using perovskite solar cells and solutions for distributed energy and IoT (Internet of Things). Similarly, the company has received funding of USD 4 million from Polish National Centre for Research and Development (NCBR) to work on the mass production of flexible perovskite solar modules for **IoT applications**. All these developments are expected to strengthen the company's position in the perovskite solar cell market.

Weaknesses/Competitive Threats

Saule Technologies has a strong presence in terms of the development of perovskite solar cells. The company has a **presence in Europe**. However, it can leverage its strong position in the perovskite solar cell market to expand in emerging regions.

2 Conclusions

The perovskite solar cell market is expected to grow from USD 271 million in 2024 to **USD 2,268 million by 2028**: it is in a constant research and development phase, as its use is very promising in the next future. The rising demand for renewable energy, the support extended by governments of multiple countries to increase the installation of solar panels, and growing concerns regarding environmental safety are **driving the growth** of the solar cell market, which is expected to fuel the demand for perovskite solar cells.

