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Cutting-edge Solar PV Technologies and Business Models

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New solar PV business model

On March 31, Seven & i Holdings Co. and Nippon Telegraph and Telephone Corp. (NTT) announced that they would partner to launch a new solar photovoltaics (PV) business scheme in April. Electricity from a solar photovoltaic (PV) plant built by NTT Anode Energy Corp. will be supplied via its electricity retail subsidiary to some stores of the Seven & i group.

This has been described to be the first offsite corporate power purchase agreement (PPA) in Japan. An offsite corporate PPA is a long-term contract where a power generator delivers electricity from a remote renewable energy power plant to the offtaker through the grid. This model does not use the feed-in tariff (FIT) scheme that requires power utilities to purchase electricity from renewable energy at a price fixed by the government over a pre-set period of time.

To date, corporate PPAs have mainly been realized onsite, where the power generator directly supplies the consumer with electricity generated by a facility built on the roof or idle land located on the property of the consumer. Offsite corporate PPAs are currently permitted only within corporate groups. At a meeting of the Subcommittee on Mass Introduction of Renewable Energy and Next-Generation Electricity Networks on March 22, the Ministry of Economy, Trade and Industry implied the possibility of interpreting the Electricity Business Act in a way that would allow offsite corporate PPAs between companies of different corporate groups. Offsite corporate PPAs would facilitate the procurement of 100% renewable electricity.

Another emerging trend is "solar sharing," or agrivoltaic systems, which allow the dual use of land for agriculture and solar power generation. This scheme contributes to the deployment of renewable energy and local consumption of locally produced energy. According to the Ministry of Agriculture, Forestry and Fisheries, in Japan, 1,992 cases (covering 560 hectares) of cropland conversion have been permitted for the purpose of installing solar sharing facilities as of FY2018 in Japan. Various crops, including vegetables, houseplants, fruits, rice and wheat, are produced below elevated solar PV panels.

In France, Germany, Italy and other countries, utility-scale solar sharing facilities are being installed in greenhouses, vineyards, olive orchards and the like. There is ongoing research on optimal solar array tilt angles and spacing with regard to insolation levels.

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Movable solar panel systems are also being explored. In an auction for innovative solar PV technologies implemented by the French Energy Regulatory Commission in January this year, agrivoltaic projects accounted for 31 (with total capacity of 80MW) of 47 successful bids (146.2MW). In February, Enel Green Power, a subsidiary of Italian energy giant Enel, launched a series of agrivoltaic pilot projects to retrofit nine existing solar PV arrays in Spain, Italy and Greece for integration with agriculture.

Solar PV technologies embrace the potential for use in a diversity of contexts, not limited to agriculture. In December 2020, the New Energy and Industrial Technology Development Organization (NEDO) released “NEDO PV Challenges 2020” as a technology development guideline, identifying six areas for further solar PV technology development: (1) building facades; (2) roofs with load limits; (3) vehicles (vehicle-integrated photovoltaics); (4) stand-alone houses; (5) water surfaces (floating solar PV); and (6) agricultural lands.

Technological advancements in next-generation solar cells and future challenges

Next-generation solar cell technologies hold promise for emerging solar PV applications (see table). Solar cells can be categorized into three types: silicon, compound and organic semiconductor solar cells. At present, crystalline silicon cells account for around 90% of the solar cell market.

Compound semiconductor solar cell technologies include existing technologies such as CIS (copper/indium/selenium) and CdTe (cadmium telluride) photovoltaics. Promising next-generation PV technologies using gallium arsenide (GaAs) have potential for innovative applications. For instance, Sharp Corporation has realized the world’s highest PV conversion efficiency of 30-32% for GaAs cells, which were originally developed mainly for use in satellites. Having developed a 0.03-millimeter GaAs solar battery cell for electric vehicles, Sharp launched public road trials for vehicles equipped with these solar batteries in partnership with automakers in 2019.

Dye-sensitized solar cells (DSSCs) belong to a group of PV technologies that uses organic materials. They can stably generate electricity even at low light levels, and thus have been adopted as independent power sources for telecommunication devices and sensors. Its applications are expected to increase with the spread of Internet of Things technologies. Conventional liquid electrolytes based DSSCs embraced safety and durability issues associated with the leakage of electrolytes and corrosion. However, last year, Ricoh Company launched the world’s first solid-state dye-sensitized solar cell modules, which have been applied for commercial use in wireless mouses.

Organic thin-film PV (OPV) cells are promising next-generation solutions that feature low-cost manufacturing and Earth-abundance. These cells can be fabricated by printing raw materials onto thin films. Colorful and semitransparent OPVs are becoming increasing used for building-integrated photovoltaics (BIPV) applications overseas. Lightweight and flexible, their low PV conversion efficiency of less than 20% remains a bottleneck.

Perovskite solar cells (PSC), a type of organic-inorganic hybrid solar cell technology, are gaining increased attention as a breakthrough alternative to silicon solar cells. PSCs were invented in Japan in 2009. PSCs can be fabricated by coating the substrate with a perovskite solution, thus resulting in low production costs. Film substrates can be used to fabricate lightweight and flexible PSCs. Printed PSCs promise to be used in various applications, such as glass and building facades.

According to the U.S. National Renewable Energy Laboratory (NREL), the PV conversion efficiency for PSCs have reached around 25%, which is comparable to that of mono-crystalline silicon solar cells. The use of lead, which is toxic, in PSCs remains an issue to be overcome; and therefore, other potential materials are being explored. On March 25, the U.S. Biden administration announced an ambitious goal of cutting solar energy technology costs by 60% by 2030 to accelerate the deployment of PV technologies, earmarking a quarter of the $128 million in total funding for PSC research and development.

As progress is made in large-scale PV deployment, a massive amount of waste PV modules will be decommissioned. NEDO estimates that in Japan, waste PV modules would peak at 17 to 27 tons per year from around 2035 through 2037. Given the multi-layered structure of PV modules, which are made of cells, sealants and glass for higher durability in long-term outdoor use, we are also faced with the challenge of developing recycling technologies to cost-efficiently separate the components.

[Table] Cutting-edge next-generation solar cell technologies

Technology	Characteristics	PV conversion efficiency (%)
Gallium arsenide (GaAs) solar cells	High. PV conversion efficiency. High expectations for the application of GaAs cells on vehicles	30-32
Dye-sensitized solar cells	Stable power generation at low light levels indoors. Used in stand-alone power sources for telecommunication devices and sensors.	13
Organic thin-film solar cells	Printable, low-cost, lightweight and flexible. Can be fabricated in various colors. Low PV conversion efficiency needs improvement. Often used as building-integrated photovoltaic cells (BIPV).	18
Perovskite solar cells	Printable, low-cost, lightweight and flexible. Can be fabricated in various colors Use of lead remains an unresolved issue. Promising application in glass and buildings.	25

(Source) Prepared by the author from NREL studies, Sharp website, etc.