Matchmaking in the Field: Raspberry Bush Meets Solar Panel

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Which solar panel works best with which crop? The answer to that question is being sought in hundreds of farms around the world.

The fusion of agriculture and solar – where elevated panels shelter crops beneath – can be seen in two ways: it makes the same piece of land doubly productive, or it slices away performance from both. There is something to be said for both arguments, as more and more so-called agroPV projects are being rolled out globally.

German company Baywa r.e. recently completed construction of a 2.7MW solar installation above raspberry plants in Netherlands using specially designed semi-transparent modules, "allowing sufficient sunlight for the plants to pass through while at the same time protecting the crop from hail, heavy rain and direct sunlight."

It is now working with different varieties of fruit: strawberries, blue berries, red berries and black berries. It is also trying out coupling of solar with apples (in Germany) and pears (in Netherlands).

"We are planning further fruit trials in Germany. In several other European countries, we are researching the possibility of developing agroPV projects with local partners," Stephan Schindele, AgriPV product manager at Baywa r.e. told BloombergNEF.

The company wants to show that its agroPV projects "actually improve the quality of the fruit and reduce the cost of its production."

Raspberry under solar

Picture credit: BayWa r.e.

It is estimated that there are between 2GW and 4GW of agroPV installations globally already. Projects are expected to multiply in markets such as India, U.S. and France but, intriguingly, the argument is likely to continue over whether such projects really make economic sense.

In the article below, we look at some of the characteristics of agro-PV, focussing particularly on one of its busiest markets – India. But first, some general concepts.

Going vertical

Combining PV with farming often means raising the panels a few meters higher than would be the case in a solar-only installation. There may be other unusual aspects to the positioning of the panels.

Germany's Next2sun has been working with vertical solar installations on farms using bifacial panels. Their east-west solar installations (instead of typical tilted panels facing in the direction of the equator) generate

power closer to the morning and evening peak times, when the sun is rising and when it is setting, enabling a better price to be secured for power generated.

“Our system is robust and we are competitive on pricing. We are getting a lot of questions from developers around the world,” said Sascha Krause-Tunker, commercial manager at the firm.

Next2Sun has recently completed construction of a 4.1MW installation at Donaueschingen in Germany, which adds to a 2MW plant built earlier in the European country. The first bifacial solar “fence” has been installed in Austria. Ireland, Poland and South Korea also have installations.

The pandemic has slowed the next set of projects in the pipeline, but the company is looking for partners around the world.

“It is all about precision. At the German farm, the space between panels is 10 meters, and we are able to use a 9.2-meter machine equipped with GPS [geographical positioning system] there,” Tunker said.

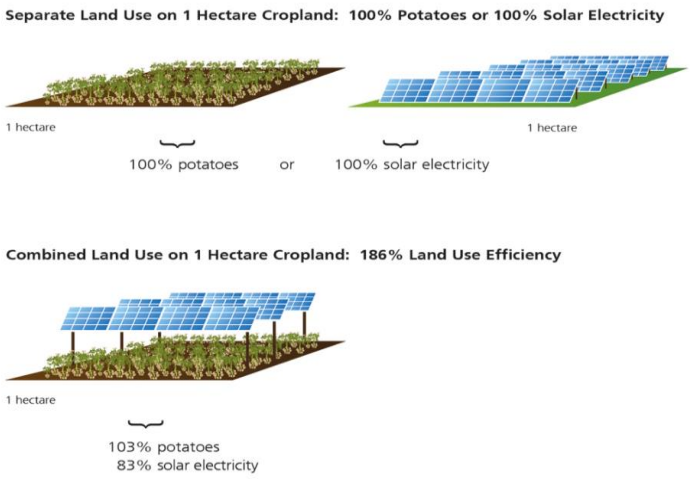
Agri-machinery and solar

Picture credit: Next2Sun

Next step: automated farming

Fraunhofer Institute for Solar Energy Systems has been conducting research on multiple agroPV projects. A frequently cited study by the Institute of a farm in Heggelbach, Germany showed that the agricultural productivity of the land almost doubled after panels were installed at a height of 5 meters.

AgroPV and land use efficiency



Picture credit: Fraunhofer ISE

“We are seeing the pace of agroPV installations accelerating globally. Policy support is being discussed in many jurisdictions,” said Maximilian Vorast, an agroPV researcher at the Institute.

In parallel, agroPV itself is evolving.

“The next step in agroPV is automated farming: integration of land, agricultural machinery, robotics, automation and artificial intelligence. We are planning a pilot project on these lines at a small test garden in Germany next year,” said Vorast.

AgroPV installations can improve agricultural yield by reducing heat-stress in certain arid regions. They can help reduce water use at the farm, make possible rural-specific applications and increase farmer income. However, there is an additional cost of installing panels at a height.

The big five

The five markets ahead in agroPV installations – China, Japan, France, South Korea and Massachusetts (U.S.) – are also those that were ahead in formulating policy and offering incentives, though the drivers varied.

In France, China, and Massachusetts, financial support schemes were introduced to preserve cropland, while in South Korea and Japan, “diversifying farmers’

income sources and counteracting the exodus from rural areas" were the main objectives, according to a recent study on the subject.

Leading regions

Country	Details
Japan	Japanese Ministry of Agriculture, Forestry and Fisheries allowed agroPV in 2013, post the Fukushima disaster. 150MW installed (1,650 projects).
South Korea	Target of 10GW of small (100kW) agroPV plants by 2030. Government finances farmer training. 2MW installed (18 projects)*.
China	Large plants such as Ningxia (700MW) constructed on the back of incentives available. 4GW installed from 2014-18, including 2.3GW of solar greenhouses.
France	Offers financial support for agroPV since 2017. Plans for tendering 45MW announced.
Massach-usetts	AgroPV systems qualify for a generation incentive.

*Source: Research paper *as of April 2019.*

Vegetation control

In the case of India's Mahindra and Mahindra Group, the driver for agroPV was saving on costs to control the weeds and sundry unwanted vegetation that comes up under, or in between, rows of panels.

At a place called Tandur in the south Indian state of Telengana, the group's renewable energy asset management unit (Mahindra Teqo), which has a 3.2GW operations and maintenance portfolio, worked on a pilot project in collaboration with Kancor Mane, an Indo-French spice producer. After a successful run with organic lemongrass at a 1-acre site on the 37MW plant last year, it plans to scale up with new sites and new crops.

"We have converted a cost – weed and vegetation removal – into a profitable activity," said Sohini Gupta, sustainability lead at the company. "This model is especially useful in solar plants where the panels are already installed at a height for technical/design reasons."

Finding the right agricultural partner is one of the key challenges, however.

Lemongrass under solar

Picture credit: Mahindra Susten

Vegetation control can be a significant cost, said BNEF solar analyst Lara Hayim. In Europe, vegetation control accounts for about 10% of the operations and maintenance contract cost.

Average O&M* price break-up in Europe for a fixed-axis solar system in 2019 (euros/MW/year)

Periodic maintenance	2,650
Monitoring	600
Panel cleaning	600
Vegetation control	570
Corrective maintenance	2,280
Total	**6,700 ($7,900)**

*Source: BloombergNEF. *O&M is operations and maintenance.*

India's stretch agroPV

Government incentives can certainly help grow the market. India has a multi-billion dollar rural solar program – Kusum – which is focused on solar pumps for agriculture (3.5 million), and small-scale solar power plants (up to 2MW) at the edge of farms, adding up to an ambitious 10GW. Though Indian officials refer to it as agroPV, there is no meshing of solar panels and crops, as is typical of agroPV.

The subsidy-led scheme does require an investment by the farmer, and that was expected to limit the

uptake. Some states are showing good progress, despite the pandemic. In the desert state of Rajasthan, power purchase agreements for over 700MW of solar plants have been signed with farmers, according to the state government. It is likely that the farmers are supported by some corporate groups.

In the western state of Maharashtra, about 100MW of such rural solar installations have been put up by Energy Efficiency Services Ltd. (EESL), with the local utility offering unused barren land. Another 700MW of projects are in the pipeline.

The levelized tariff is 3 rupees ($0.04) per unit for 25 years. That still involves a saving for distribution companies since the cost of agricultural power supply is typically over 7 rupees per unit, while the collection is either nil or a nominal 1 rupee per unit.

"Solar on every farm"

"We are offering a rural development package now. We can bundle the decentralized solar plant with batteries, and also provide street lighting for a tariff of less than 4 rupees [per kWh]," said Saurabh Kumar, EESL's managing director. "That would mean solar on every Indian farm, and saving of over $2 billion in a state like Maharashtra ."

Tata Power Solar has been installing solar agricultural pumps in multiple states. The total has crossed 26,000 units, with the highest number in Maharashtra (13,000) and Rajasthan (3,800).

However, the company's outlook on agroPV is very cautious. "Who should take the lead in such installations: the power guy or the agri chap?" asked Ashish Khanna, president of all the renewable businesses of the Tata Group. "We need to create the right business and operating examples."

The scope for expanding the use of solar in agriculture is huge for a large country like India where 60% of the land area is dedicated to agriculture, and where sunshine is abundant.

"We have barely scratched the surface on what is possible on our farms. The same land can give three crops: a winter crop, a summer crop and an all-season solar crop," said Ajit Jain, joint managing director at Jain Irrigation, an agricultural technology company that supplies integrated solar water pumping systems globally.

"AgroPV is one step closer to smarter sustainable agriculture, which is what we have been promoting across India and the world," Jain added.

Banana crop at Jain Tissue Culture Park

Picture credit: Jain Irrigation

Fraunhofer Institute conducted an agroPV study in the west Indian state of Maharashtra, which showed that there was "sufficient solar irradiation to keep expected average yields of the analyzed crop (soybean, cotton, tomato, and banana) above 83% compared to conventional agriculture if bifacial glass-glass PV modules are installed at a height of 4 meters above ground. For shade-loving crops like tomato and cotton, yield increases between 16% and 32% are expected."

It also said that the "the system appears economically feasible."

Land and solar

Solar projects continue to be land-intensive, though recent projects have seen average land usage shrink. According to the latest estimates from BNEF, average land use per megawatt is currently at 1.7 hectares.

It varies depending on how scarce and costly land is. "Solar projects in Canada take up a lot of space while those in Japan are usually more compact," BNEF said in recent report that analysed land use trendsAgroPV

offers one way of land-neutral expansion of solar, as do options like floating solar or canal-top solar.

BNEF's view

"We will see more cases of PV+agriculture," said BNEF's solar technology specialist Xiaoting Wang. She was part of the team that visited a large 200MW agroPV plant in China, and analyzed it in a note earlier this year.

However, there will "be a lot of places where agroPV is done purely to collect subsidies, and does not improve output," added Jenny Chase, head of solar analysis at BNEF.

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Contact details

Client enquiries:

- Bloomberg Terminal: press <Help> key twice
- Email: support.bnef@bloomberg.net

Vandana Gombar	Editor, Global Policy	vgombar@bloomberg.net

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