Agrivoltaics – Roadmap to Scale up Installation of Solar PV in Farms in India

Tobias Winter, Director, Indo-German Energy Forum SO

Setting the Scene - What is Agriphotovoltaics?

Co-location of Agriculture and Solar Photovoltaics

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AgriPV increases yields!

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nature sustainability

Articles

https://doi.org/10.1038/s41893-019-0364-5

Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands

Greg A. Barron-Gafford[1,2*], Mitchell A. Pavao-Zuckerman[3], Rebecca L. Minor[1,2], Leland F. Sutter[1,2], Isaiah Barnett-Moreno[1,2], Daniel T. Blackett[1,2], Moses Thompson[1,4], Kirk Dimond[5], Andrea K. Gerlak[1], Gary P. Nabhan[6] and Jordan E. Macknick[7]

The vulnerabilities of our food, energy and water systems to projected climatic change make building resilience in renewable energy and food production a fundamental challenge. We investigate a novel approach to solve this problem by creating a hybrid of colocated agriculture and solar photovoltaic (PV) infrastructure. We take an integrative approach—monitoring micro-climatic conditions, PV panel temperature, soil moisture and irrigation water use, plant ecophysiological function and plant biomass production within this 'agrivoltaics' ecosystem and in traditional PV installations and agricultural settings to quantify trade-offs. We find that shading by the PV panels provides multiple additive and synergistic benefits, including reduced plant drought stress, greater food production and reduced PV panel heat stress. The results presented here provide a foundation and motivation for future explorations towards the resilience of food and energy systems under the future projected increased environmental stress involving heat and drought.

A key challenge to building resilience under a changing and uncertain climate is maintaining and improving both energy and food production security. Such efforts are hampered, in part, by conventional understanding of land use that asserts an year[18], as the lack of water was making agriculture non-economically viable. Many areas across the globe, including North, Central, and South America, the Middle East and North Africa, have seen a shift to increased aridity and are projected to see continued aridity

nature research

"tomato yield was twice as high"

"pepper 3 times higher"

https://www.researchgate.net/publication/335583033_Agrivoltaics_provide_mutual_benefits_across_the_food-energy-water_nexus_in_drylands

1 hectare

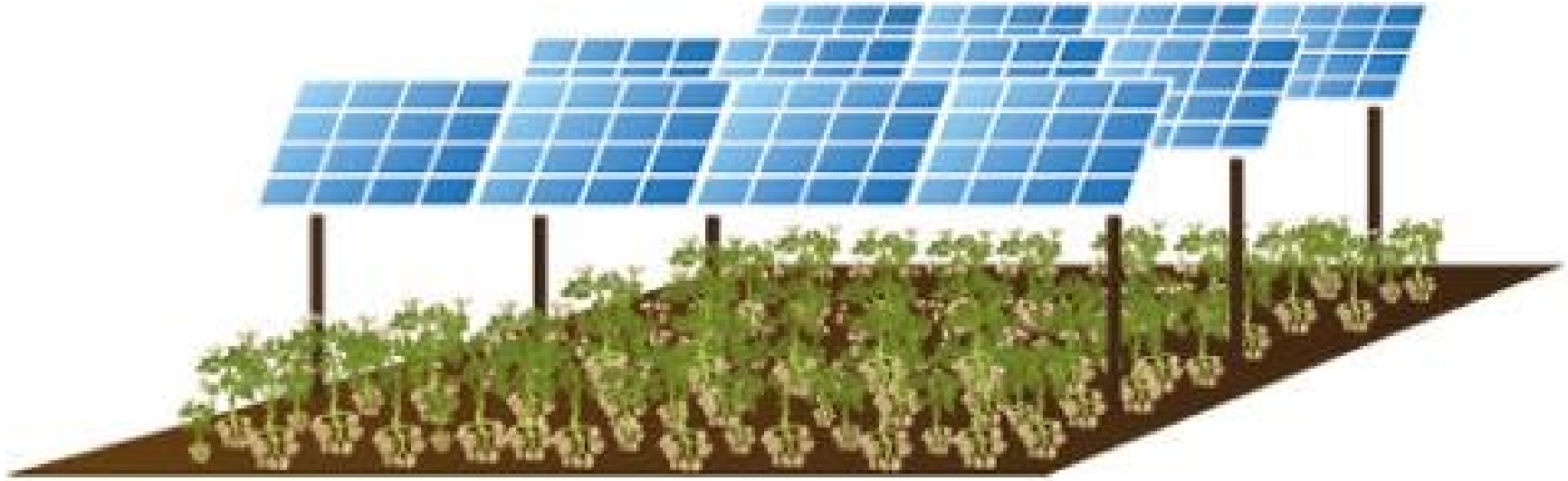
100% potatoes

© Fraunhofer ISE

1 hectare

100% solar electricity

© Fraunhofer ISE



1 hectare

103% potatoes

83% solar electricity

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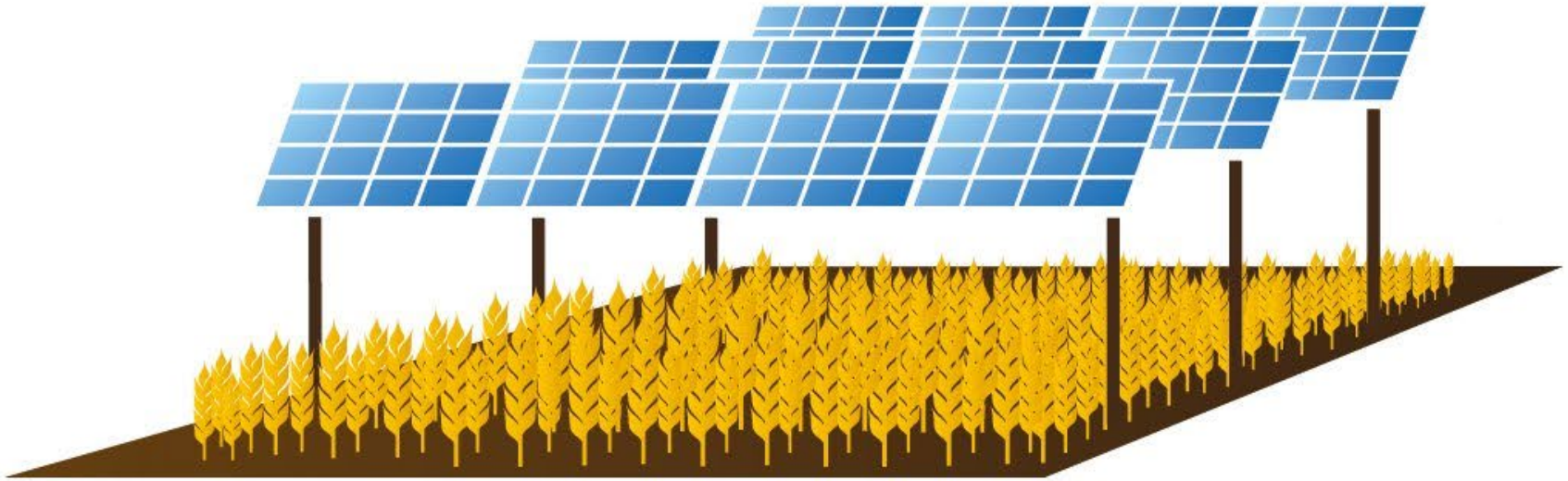


1 hectare

80% wheat
80% solar electricity

© Fraunhofer ISE

2,15 MWp Agrovoltiacs with dynamic dual axis tracker, Italy

© REM TEC, 2011

Tree crop and dynamic agrovoltaics in France

source: https://sunagri.fr/en/agrivoltaics/tree-crop/

Source: https://scontent-atl3-1.cdninstagram.com/vp/befd8eff72894765f9fca80e7e633ec1/5D084BA7/t51.2885-15/e35/40172849_2185838381660321_5570315784998889287_n.jpg?_nc_ht=scontent-atl3-1.cdninstagram.com

Agrovoltaics system with rice cultivation in Japan

Source: https://twitter.com/agrivoltaique

Source: Institute for Sustainable Energy Policies ISEP

Global players startet investing in AgriPV

700 MW AgriPV by Huawei

Indo-German Energy Forum

TOTAL Quadran

BayWa r.e.

HUAWEI

ENGIE

700 MWp largest tracking system worldwide, Hongdunzi, Ningxia, China © Huawei

10th Feb. 2022

„We expect up to 200 Gigawatts of additional photovoltaic capacity to be installed on agricultural land.“

Dr. Robert Habeck

Federal Minister for Economic Affairs and Climate Action
Government of Germany

GroenLeven
zonne-energie

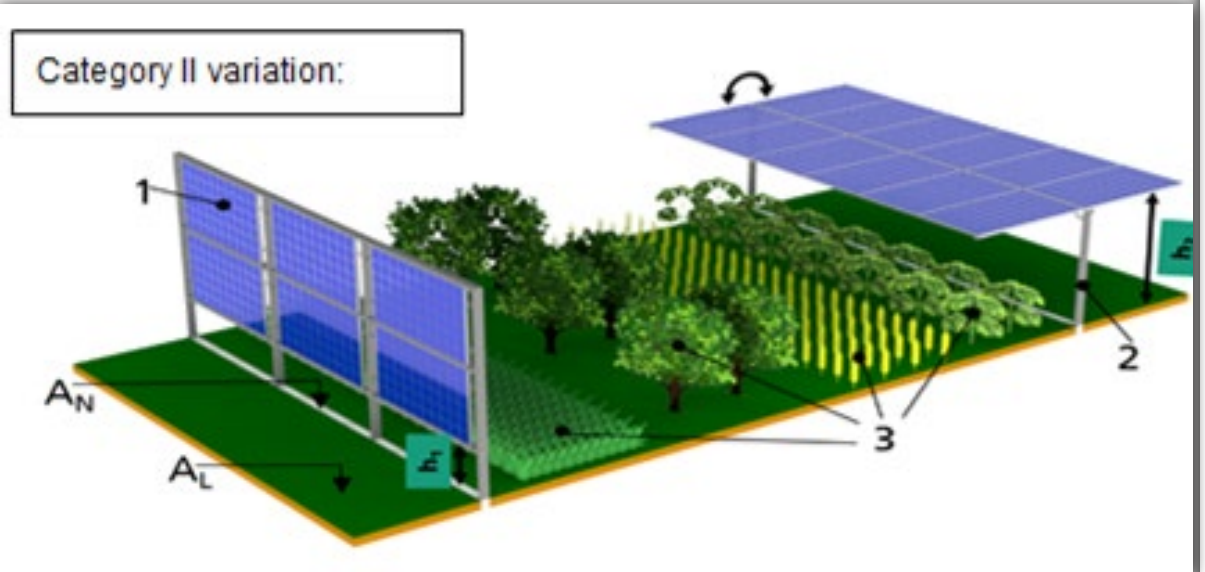
BayWa r.e.

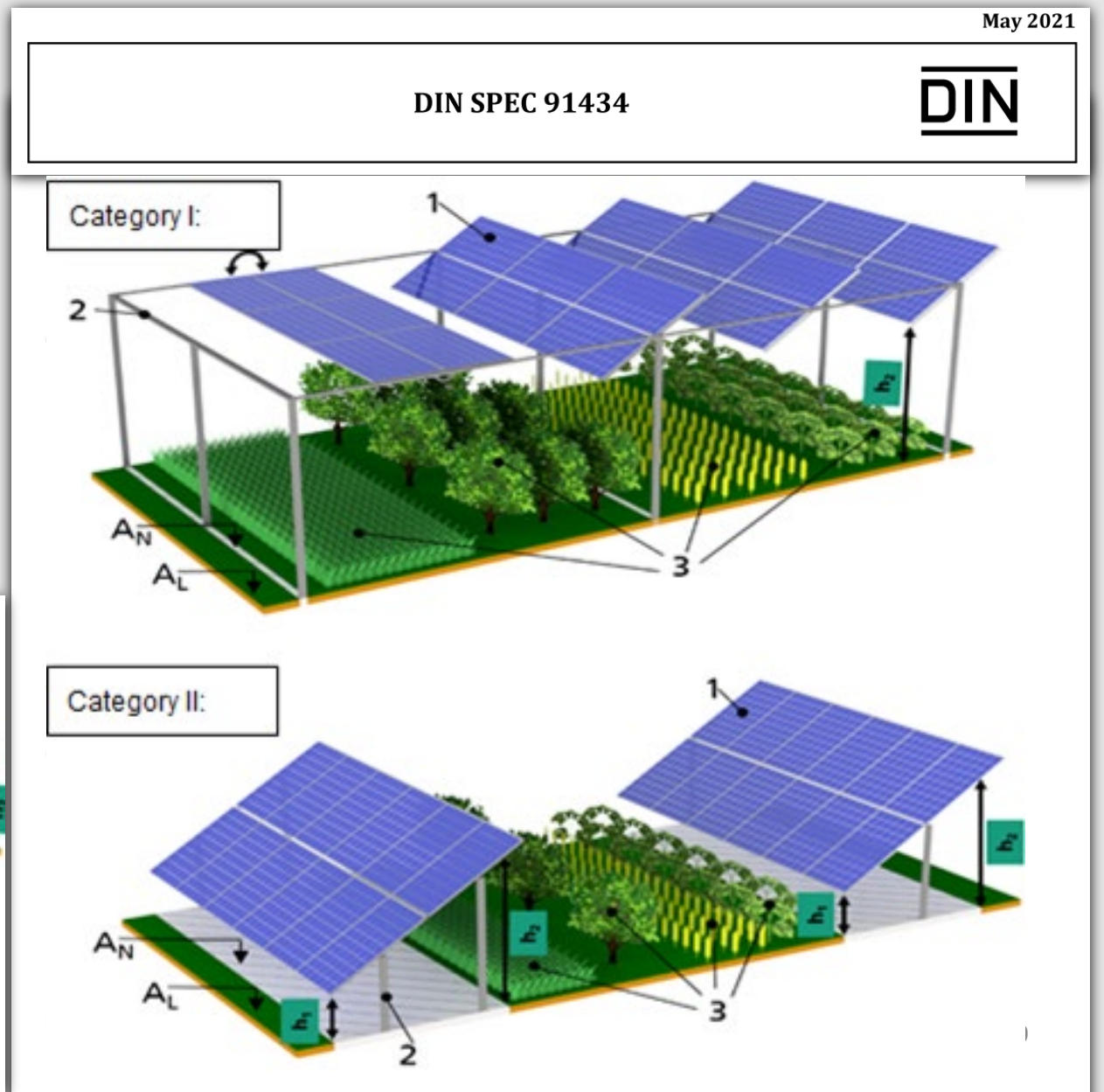
Source: Öko-Haus GmbH

Pre-Norm „DIN SPEC 91434:2021-05“

Key requirements and criteria

- **Agricultural primary land use** must be proven
- **Land loss** due to PV installation set to **max. 10% for category 1 and 15 % for category 2.**





https://www.beuth.de/en/technical-rule/din-spec-91434/337886742

1 % of India‘s agricultural land

can hold 630 GWp AgriPV …a scenario for 450 kWp/ha

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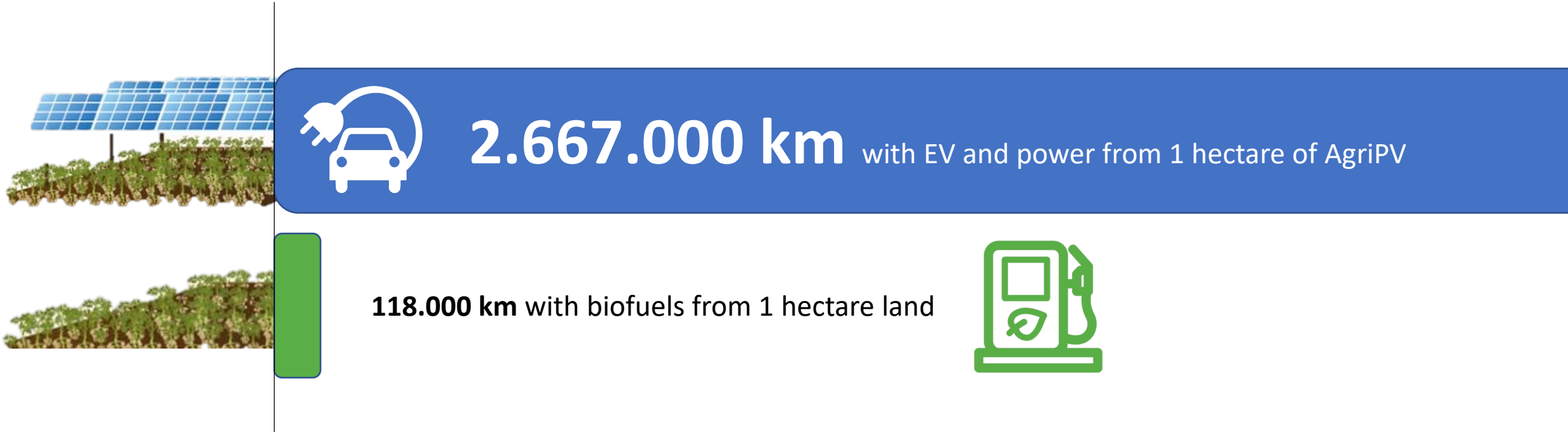
Agrivoltaics Scenario	Remarks	Capacity (GWp)	Land Requirement (km^2)
Agrivoltaics technical potential	1% of net sown area of 140 million hectare	630	14,000
Add. Agrivoltaics on fallow land	1% of fallow land of 26 million hectare (current fallows and fallow land)	117	2,600
Optimal Generation Mix for 2029-30 by Central Electricity Authority, Ministry of Power	Cumulated PV capacity (GWp), 2030	300	6,666 (if all with agrivoltaics)
Agrivoltaics economic potential	5% of total PV capacity (300 GWp), 2030	15	333

How far can we drive an EV with 1 hectare of AgriPV?

Compared to an internal combustion engine car fueled with biofuels produced on 1 hectare in a year



First countries study EV super charger infrastructure combined with AgriPV

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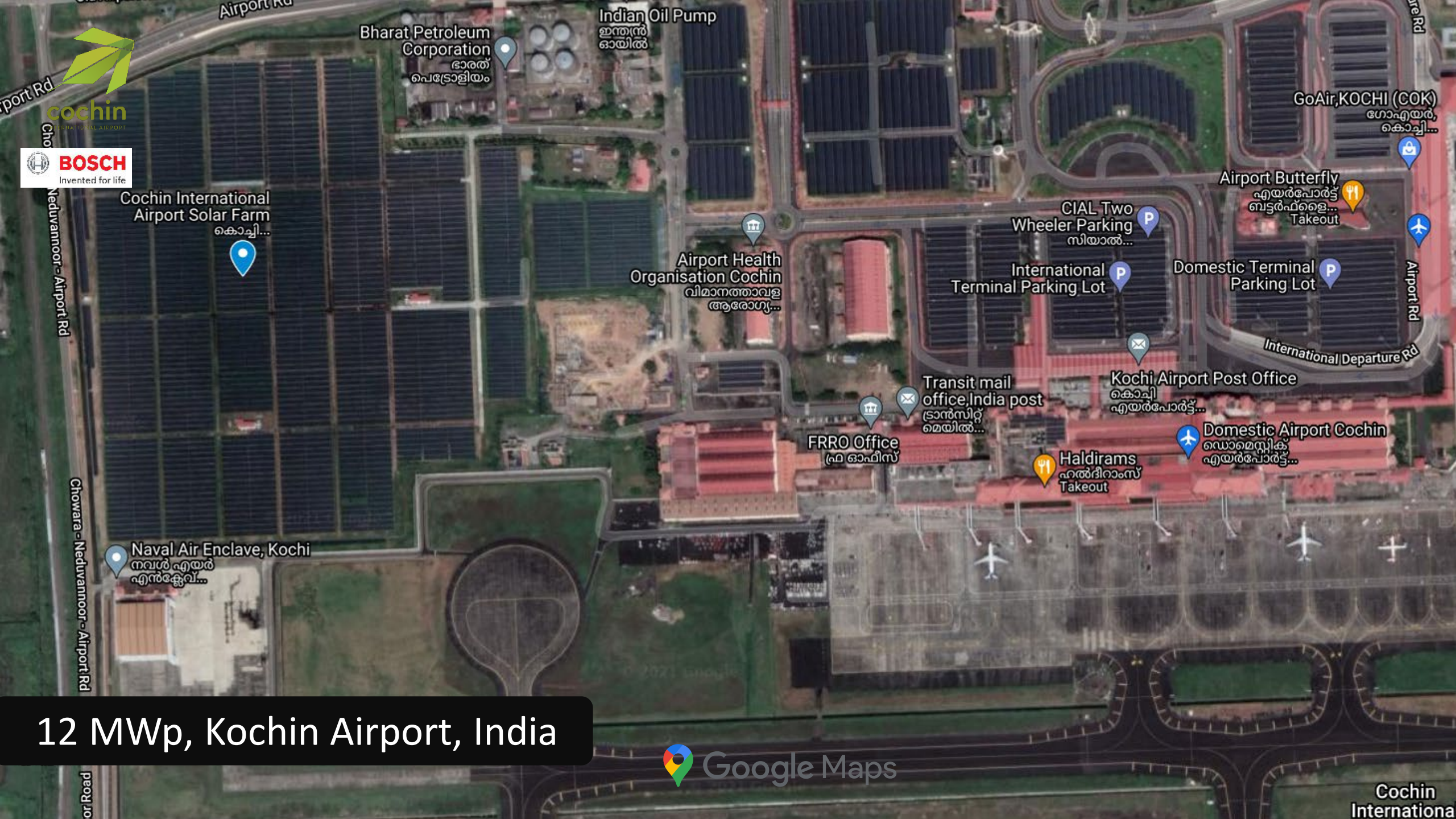
Several Indian delegations visited Heggelbach, Germany



12 MWp, Kochin Airport, India

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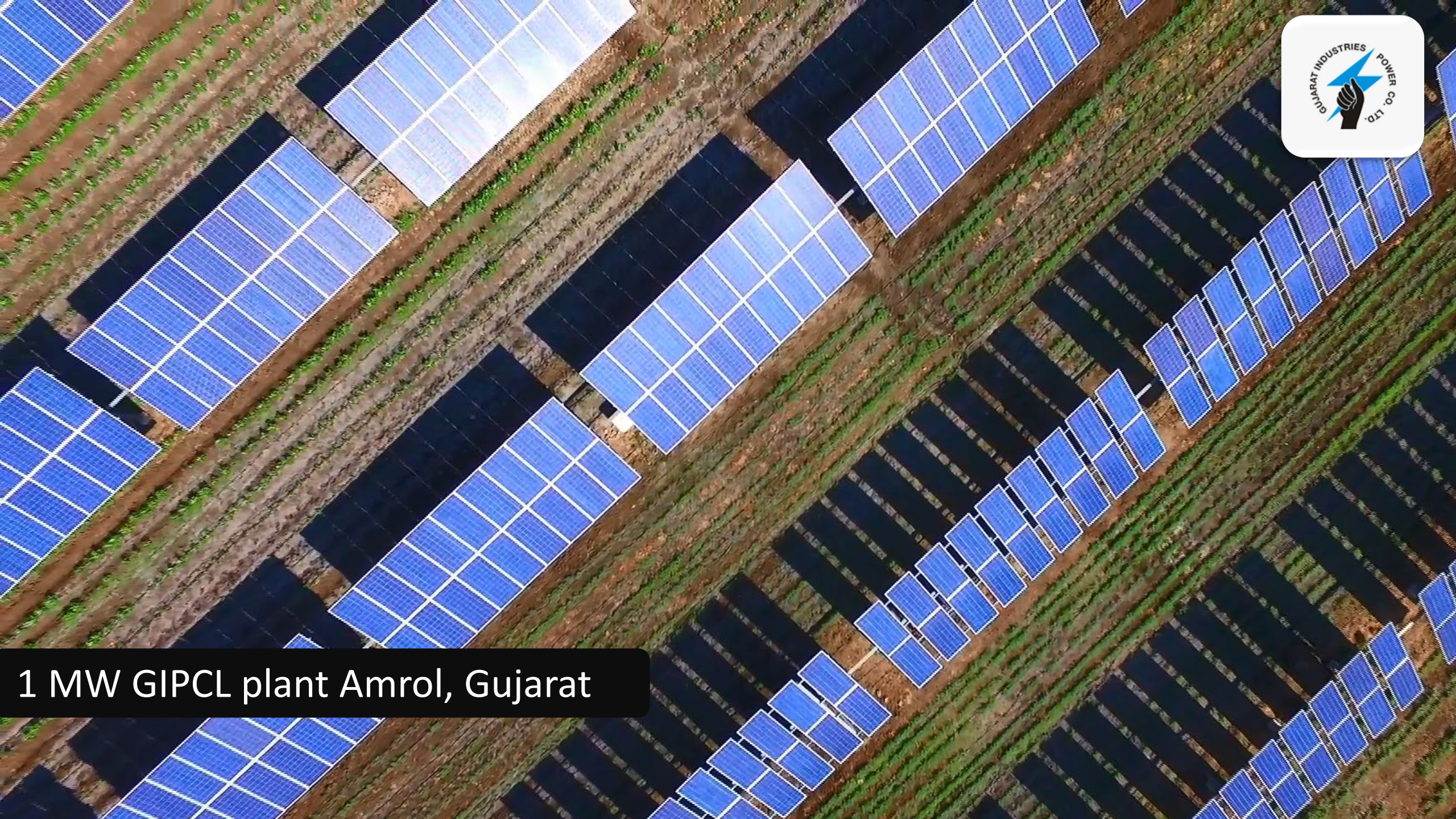
1 MW GIPCL and Anand Krishi Agricultural University, Amrol, Gujarat



1 MW GIPCL plant Amrol, Gujarat

1 MW GIPCL and Anand Krishi Agricultural University, Amrol, Gujarat

1 MW GIPCL and Anand Krishi Agricultural University, Amrol, Gujarat

1 MW GIPCL plant Amrol, Gujarat

1 MW GIPCL plant Vastan, Gujarat

105kW CAZRI plants Jodhpur, Rajasthan

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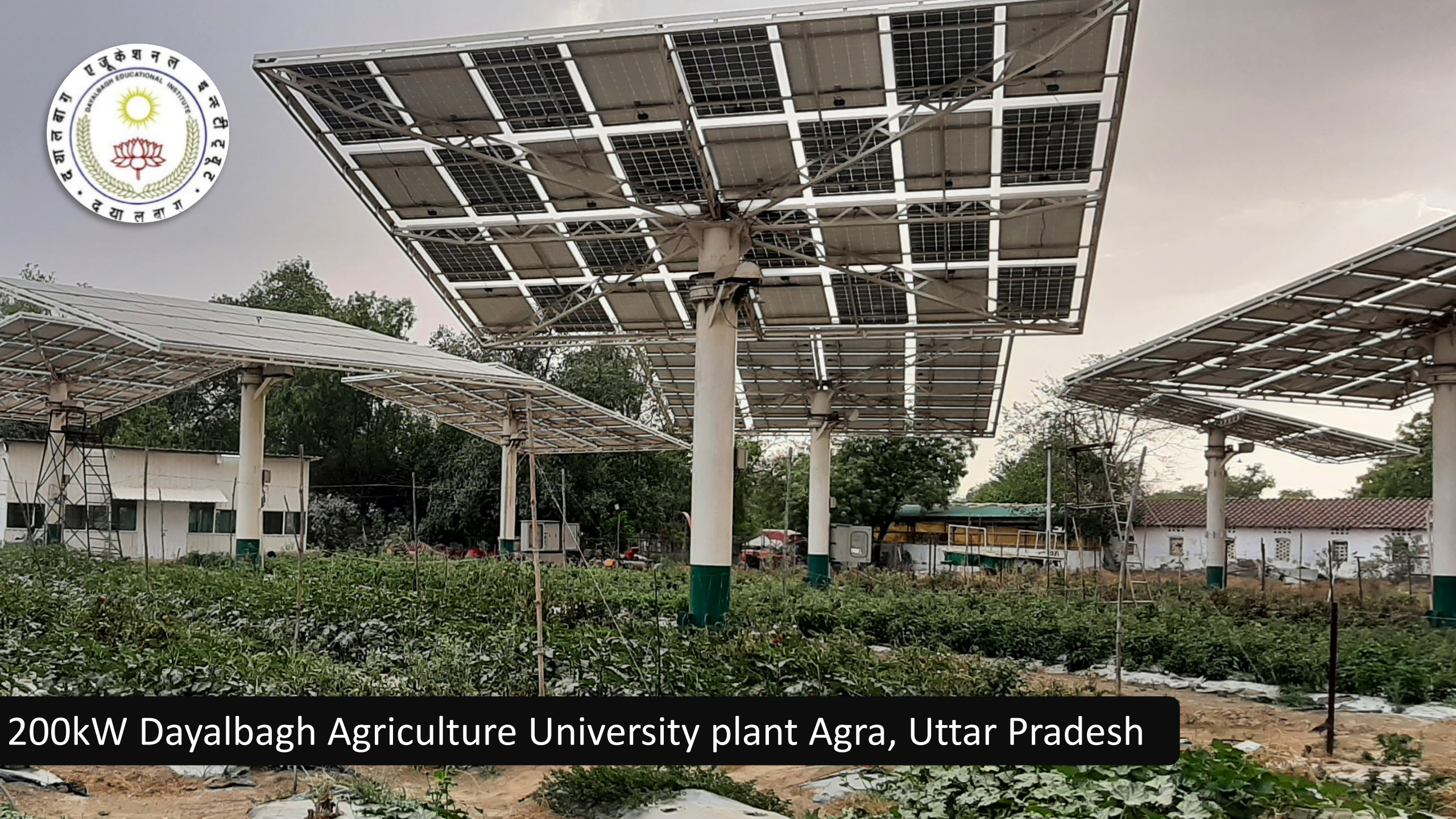
110 kW AgriPV pilot with Krishi Vigyan Kendra Ujwa, Delhi NCR



200kW Dayalbagh Agriculture University plant Agra, Uttar Pradesh

10kW Amity University plant, Noida, Uttar Pradesh

14.4 kW Jain Irrigation private research plant, Jalgaon, Maharashtra

9.6 kW Jain Irrigation private research plant, Jalgaon, Maharashtra

Jain Irrigation large scale PV greenhouse, Jalgaon, Maharashtra

Jain Irrigation large scale PV greenhouse, Jalgaon, Maharashtra

7 kWp, Junagadh Agricultural University, Junagadh

1st bifacial and vertical PV pilot of India by NISE

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105kW CAZRI plants Jodhpur, Rajasthan

105 kW CAZRI plants Jodhpur, Rajasthan

CAZRI™
Enhancing resilience of arid lands

CAZRI
Enhancing resilience of arid lands
सौर पैनल वर्षा जल संचयन टाँका
क्षमता - 100000 लीटर
Solar Panel Rainwater Harvesting Tanka
Capacity - 100000 Litre

18,6 KWp out of 1 MW is with fish pond in Bhaloji, Rajasthan (KUSUM A)

1.5 MW Plant close to Delhi

1MW GSECL plant Panandharo, Gujarat

400 kwp Mahindra Susten’s Agro Photovoltaic Model, Tandur, Telangana

Higher elevation, single axis tracking and simple robotic cleaning may be a solution for India (here California plant without APV)

How about your own roof?
HINREN
3 kW Hinren Agri-PV Rooftop (APVRT) System, Bangalore

Overview of operational projects in India

https://buff.ly/3tNHxsc

Some Findings

- Very little awareness and experience with co-location of solar panels and commercial crops in India
- Current policy framework does not provide sufficient regulatory clarity
- Farmer was usually not involved before the construction of the plant
- Cleaning a challenge

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10 predictions for 2022 by Bloomberg New Energy Finance

for solar PV

BloombergNEF

"Agrivoltaics will start to be properly understood for commercial purposes in 2022"

https://about.bnef.com/blog/solar-10-predictions-for-2022/

GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

Indo-German Energy Forum

Shri Bhagwant Khuba,
Honourable Minister of State,
Chemicals and Fertilizers and New and Renewable Energy

"Solar-PV and Agriculture together will transform the lives of farmers and their livelihood."

Get in touch

…with the National Solar Energy Federation of India or Indo-German Energy Forum Support Office

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