ASIA CLEAN ENERGY FORUM 2026

Beyond Transition: Building Secure, Resilient, Inclusive, and Intelligent Energy Systems

8–11 June | ADB Headquarters, Metro Manila, Philippines

ADB

One Land, Triple Value : How AI- Enabled Agrivoltaics Create Sustainable Rural Income in Asia

Sung Yoon | CEO of Envelops Co., Ltd.

9 June 2026 | 2–3:30 p.m. (GMT+8)

In cooperation with

KOREA ENERGY AGENCY

KOPIA
KOREA PLANT INDUSTRIES ASSOCIATION


One Land, One Value


One Land, One Value
Food Security at Crisis


ENVELOPS
One Land, Double Values
Energy & Agriculture


ENVELOPS
VANILLA

ENVELOPS

Farm-Optimized Smart APV Structure

Optimal structural design considering machinery paths, work safety, and shading balance

Learn More →

SAMS Climate-Adaptive Operation

Real-time monitoring, automatic panel control, AI harvest prediction

Learn More →

Smart Farming Service

From seeding to harvest, permit maintenance, settlement reports

Learn More →

PROJECTS KLES & ENVELOPS Agrivoltaic References

ENVELOPS

FIJI

INDONESIA

VIETNAM

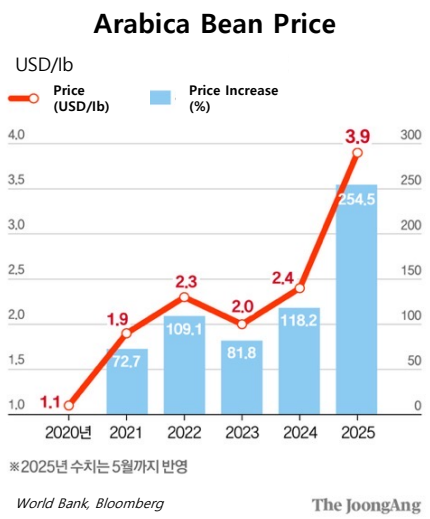
JAMAICA

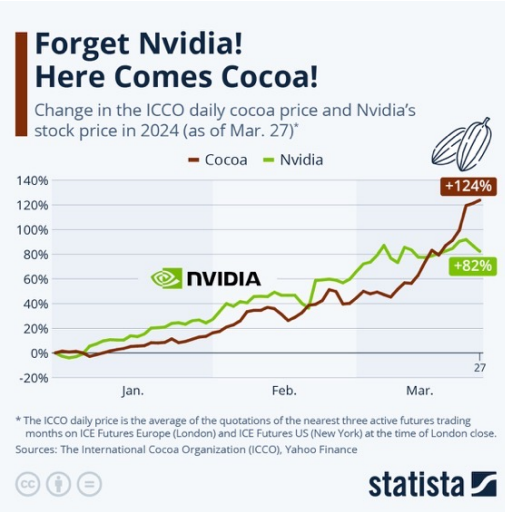
KOREA (21 sites, 2.2 MW)

PROBLEM Agriculture Crisis from Climate Change

ENVELOPS

More Price Increase than NVDIA Stock?





Southeast Asia in particular is a powerhouse in the global coffee market, with Vietnam and Indonesia being the world's second and fourth biggest coffee producers respectively. In 2023, Vietnam produced 29.1 million 60 kilogram bags of coffee while Indonesia contributed 11.85 million. Other countries in the region such as Thailand, Laos and the Philippines are also increasing their output.

But rising temperatures, erratic rainfall and prolonged droughts are taking a toll on coffee crops. Coffee plants are highly sensitive to climatic changes and the increasing heat can impair their growth, reduce yields and lower the quality of the beans. Pests like the coffee berry borer, which thrive in warmer conditions, are further exacerbating the situation, leading to significant crop losses. By 2050, up to 50 per cent of land suitable for coffee cultivation may be lost due to climate change. *Eastasiaforum, 2024*

Temperature
Heat Damage due to Climate Change

Water
Water Shortage for Agriculture Due to El Nino

Energy
Heavily Depending on Fossil Fuel For Agro Activities (Pump, Processing)

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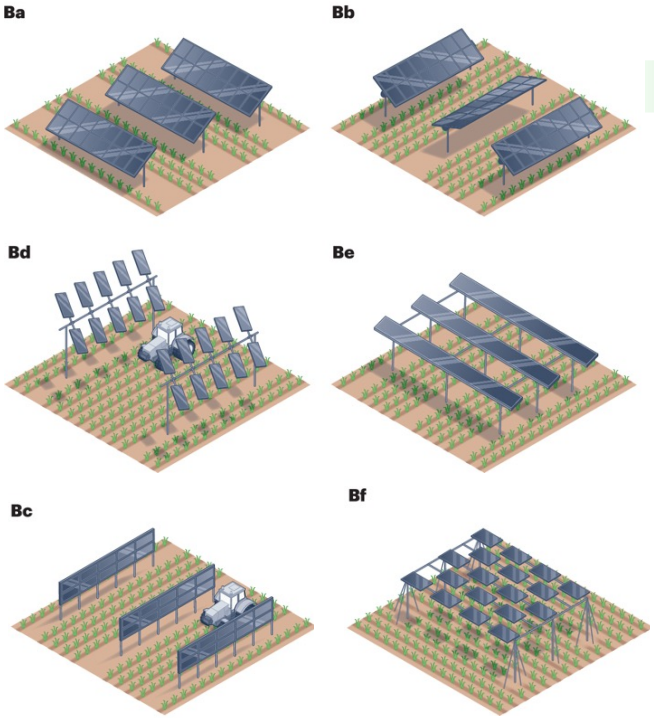
Agrivoltaics ▸ Climate Smart Agriculture



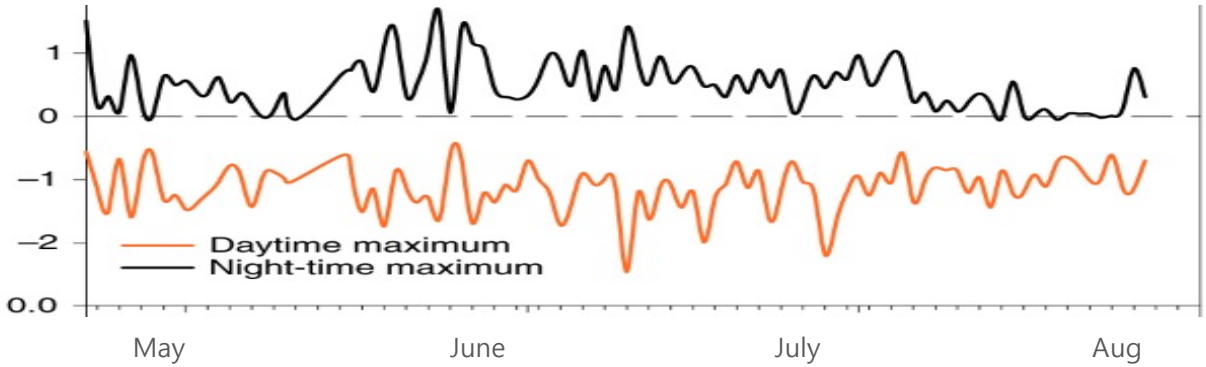
APV Relative Daytime Temp. from Open Field
0.5~2 ℃ ▼

Heat Damage Decrease

APV Relative Nighttime Temp. from Open Field
0~1.5 ℃ ▲

Cold Damage Decrease

Under APV Relative Temperature Compared to Open Field



Protecting Crops from Temperature Damage.

ENVELOPS

Case Study: Climate Damage Reduction

Evaporation Decrease → Drought Damage Reduction

ARIZONA UNIVERSITY

- Water use efficiency 153% ↑
- Chile Pepper Yield 3x ↑
- Temperature Decrease ↓

출처: www.nrel.gov

Temperature Decrease → Heat Damage Reduction

Baywa R.E.

- (Day) **5 °C Decrease** - Heat Damage Prevention ↓
- (Night) Temp. Increase - Cold Damage Prevention ↓
- Temperature Management Improved for Berries

출처: pv magazine

Weather Event Protection → Frost / Heavy Rain Damage Reduction

Jeonnam Agricultural Research Center

- Leaf Area Increase ↑
- Cold and Frost Damage Reductio by 20% ↓
- Green Tea Yield Increase by 21~90% ↑

출처: 농민신문

Effectively Reducing Temperature and Drought Damage

AGRIVOLTAICS

Jack's Solar Garden – Colorado, USA

- System Design: 1.6 hectares, 3,200 panels installed
- Target Crops: Carrots, tomatoes, lettuce, etc.

Agrivoltaic Park– Fontanellato, Italy

- System Design: 2 hectares, panels installed at a height of 5 m
- Target Crops: Tomatoes

Vignes Solaires – Bordeaux, France

- System Design: 2,000 sq. meter, panels installed at a height of 6 m
- Target Crops: Grapes for wine production

Goji Berry Solar Park – Ningxia, China

- System Design: 4,000 hectares site, panels installed at a height of 2.9 m
- Target Crops: Goji berry (Wolfberry)

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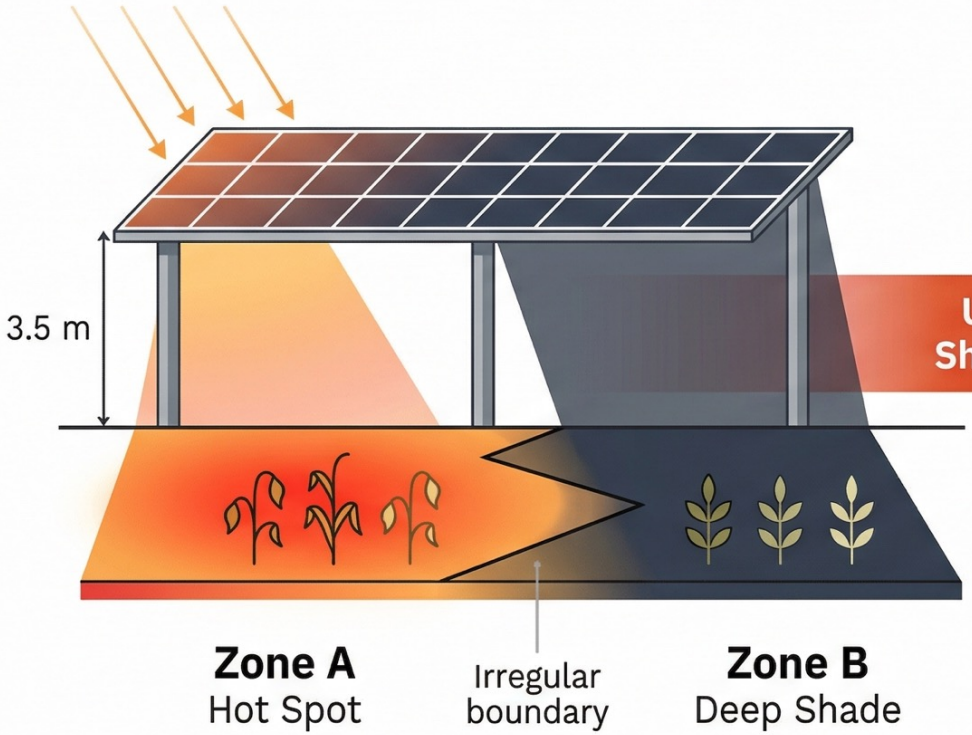
Static panels create irregular shading that damages crops



CAUSE: Static Panels

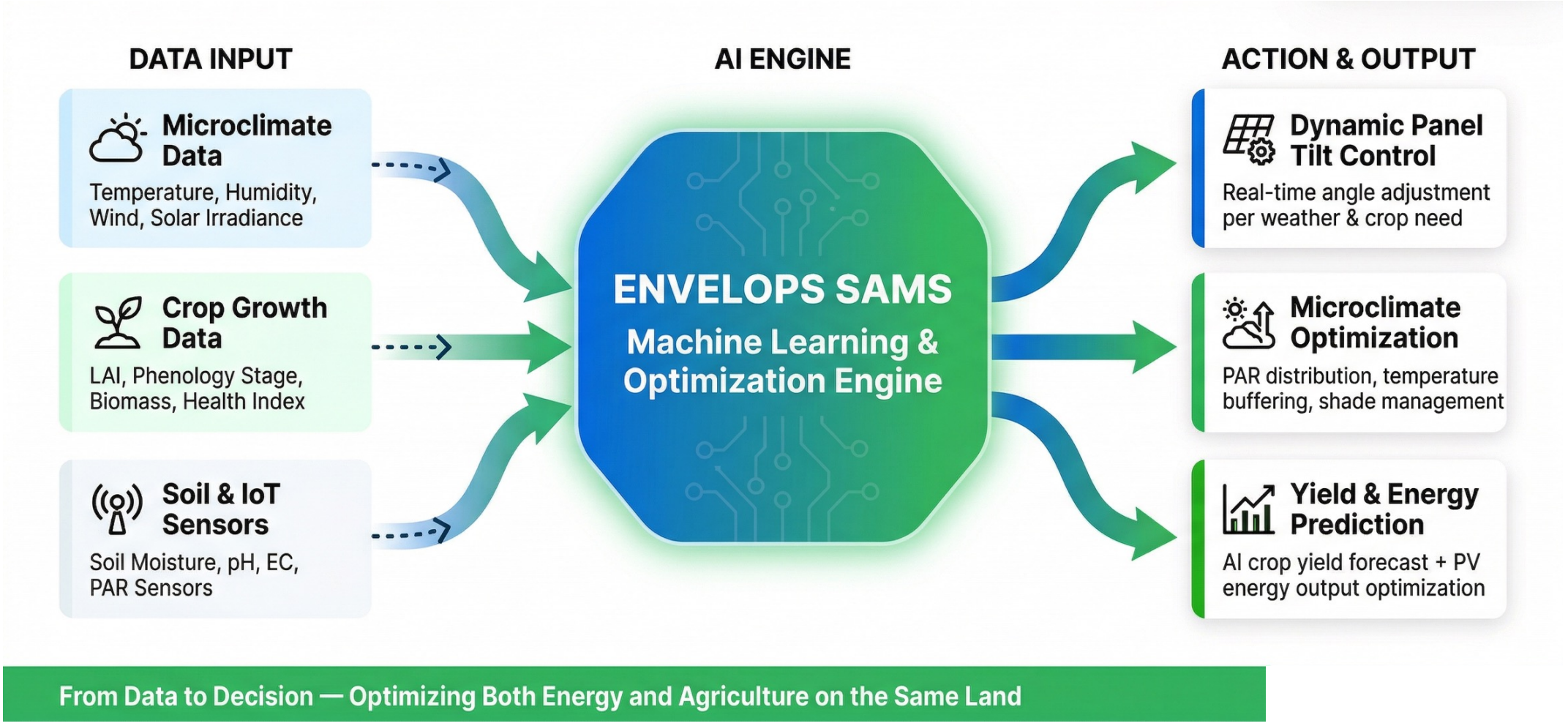
Uncontrolled Shading Pattern

EFFECT: Crop Stress & Loss

Heat Stress
Excessive temperature in exposed zones

Lack of Photosynthesis
Insufficient PAR in deep shade zones

Yield Decrease up to 30-50%
Uneven microclimate → crop failure



From Data to Decision — Optimizing Both Energy and Agriculture on the Same Land

ENVELOPS Smart Agrivoltaic Management System (SAMS, Patented)

Indonesia APV Site

C34W-VJF 발전소

국가 지역 Fiji, Nailuva

면적 1,178m²

누적수익 ₩48,000,000

수익률 14.5%

실시간 센서 정보

온도 24.5°C 1시간 전 측정

습도 65% 1시간 전 측정

풍속 3.2m/s 1시간 전 측정

기본 정보 | 태양광발전 | 작물 | 기상 | 토지/인프라

실시간 모니터링

대기 온도 27.5°C ↑29.8°C ~ ↓20°C

토양 온도 25.0°C 적정 범위 내

습도 60% 적정

토양 수분 38% 관수 필요

CO2 농도 390ppm 정상

일사량 850W/m² 강함

조도 85,000lx 밝음

기압 1012hPa 안정

풍속 3.2m/s 북동풍

강수량 0mm 맑음

24시간 추이

80 60 40 20 0

00:00 03:00 06:00 09:00 12:00

알림

⚠ 토양 수분 부족: 관수 권장

실시간 센서 정보

온도 24.5°C 1시간 전 측정

습도 65% 1시간 전 측정

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기본 정보 | 태양광발전 | 작물 | 기상 | 토지/인프라

작물 정보

감자 운영중

봄감자/수미

파종일 2024.03.15

수확 예정일 2024.06.15

재배 이력

2023 하반기 감자

수확량 4.8톤

매출 2,880만원

2023 상반기 감자

수확량 5.2톤

매출 3,120만원

2022 하반기 감자

수확량 4.5톤

매출 2,700만원

ENVELOPS

생육 환경

토양 온도 18.5°C 적정 범위

토양 수분 65% 적정 범위

생육 적정 온도 18~22°C

적정 토양 산도 pH 6.0~6.5

병해충 위험도 낮음

수익성 분석

예상 수확량 5.0톤 +4% 전년 대비

예상 매출 3,000만원 +6% 전년 대비

비용 구조

종자/비료 480만원

인건비 620만원

기타 운영비 300만원

예상 순수익 1,600만원

Smart APV Sensing and Monitoring Technology

IPB University
Bogor Indonesia

First in Indonesia, IPB University Inaugurates Agrivoltaic Research Station

NEWS

November 28, 2024

IPB University has inaugurated the Agri-Photovoltaic Research Station at the Cikabayan Educational Farm, Dramaga Campus, Bogor (22/11). This unit is the first in Indonesia to integrate agriculture with solar panel-based energy.

ENVELOPS CASE 1: Indonesia Dynamic Agrivoltaic Pilot Project in Bogor

ENVELOPS

SAMS
Smart Agrivoltaic Management System

AI analysis on crop yield and power generation

Optimizing microclimate for crop by changing panel angle

ENVELOPS - INDONESIA

ENVELOPS INDONESIA AGRIVOLTAIC NEXUS

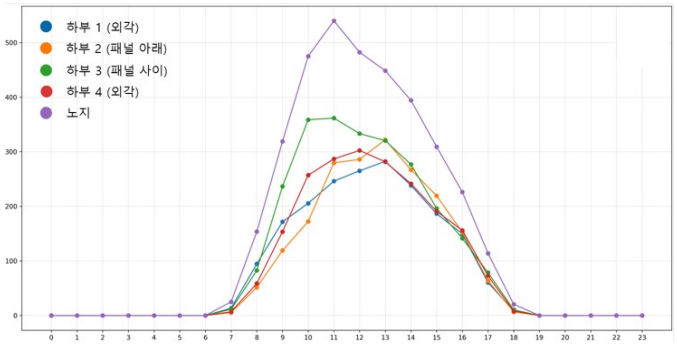
IPB University Bogor Indonesia · 한국에너지공단 KOREA ENERGY AGENCY · KLES · ENVELOPS

Max-Generation Mode for Non-farming Season, Max-Yield Mode for Farming Season

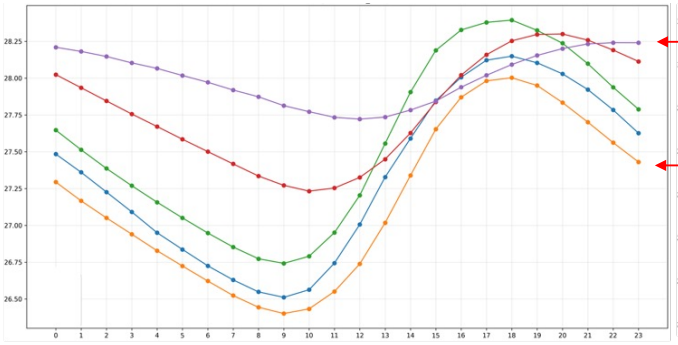
ENVELOPS CASE 1: Indonesia Dynamic Agrivoltaic Pilot Project in Bogor

ENVELOPS

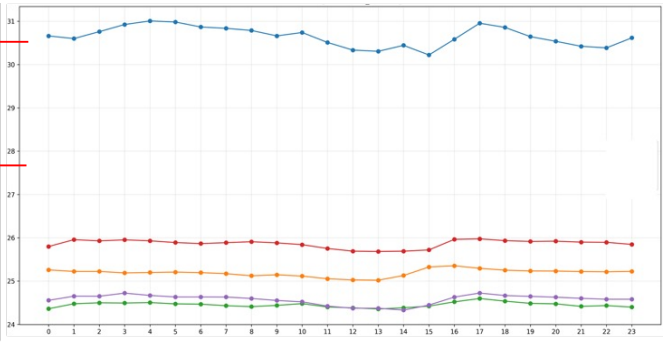
(A) Sunlight

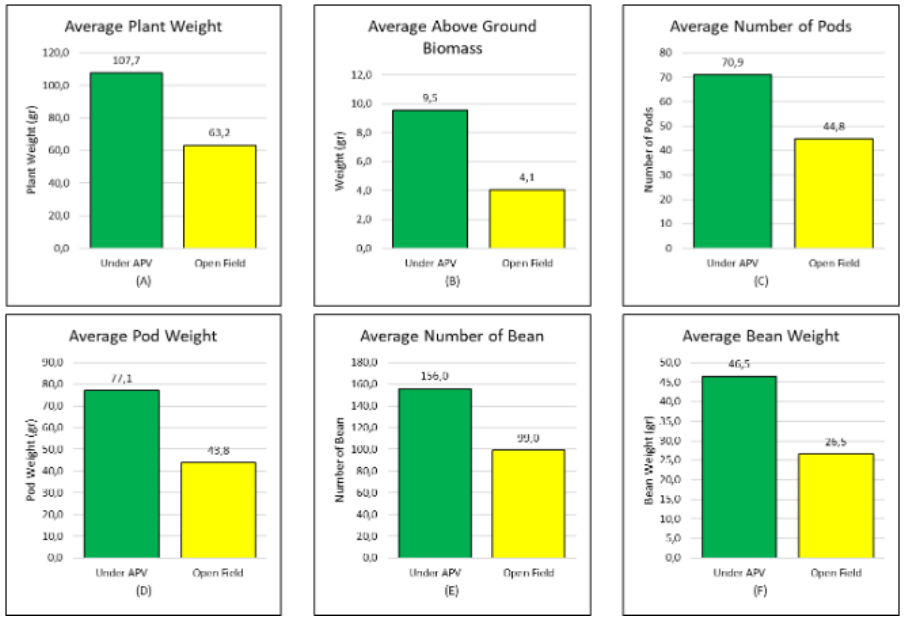


(B) Soil temperature



(C) Soil moisture





ENVELOPS CASE 2: Vietnam Agrivoltaic Pilot Project in Dalat

ENVELOPS TRƯỜNG ĐẠI HỌC ĐÀ LẠT Fraunhofer ISE giz GTC 녹색기술센터 HAEZOOM 해줌 KLES

1 Economic Validation

High Efficiency Confirmed

- **99.98% Self-Consumption Rate** achieved over 10 months.
- **VND 61.2M** in calculated electricity cost savings.
- **941 kWh/kWp** Specific Energy Yield demonstrates robust PV performance.

2 Agricultural Success

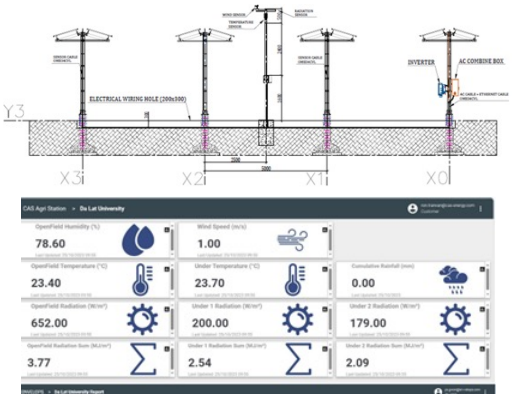
Optimized Yield & Microclimate

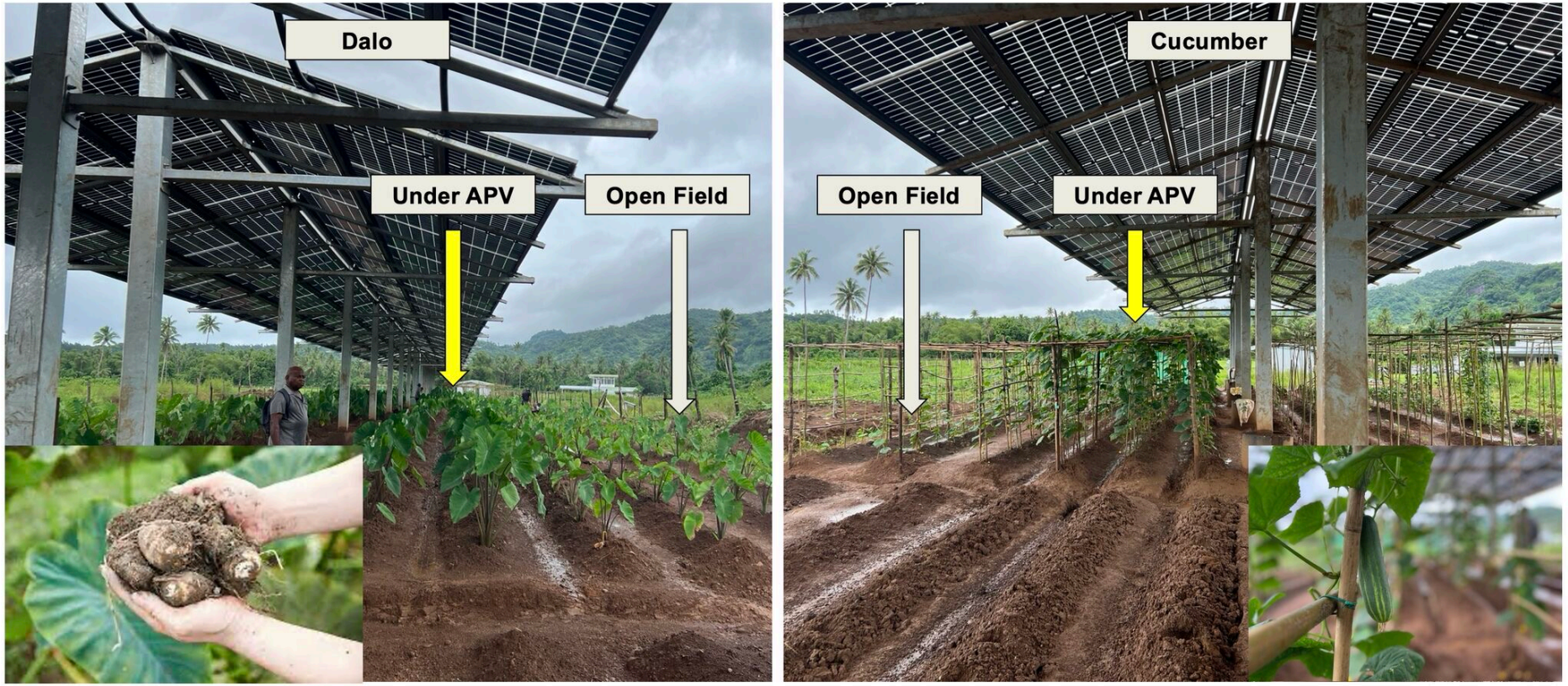
- **72.66% Survival Rate** for artichoke under APV, vs. 50% in the reference plot.
- **50-60% Radiation Reduction** created a highly beneficial, cooler microclimate.
- APV system produced **3.5X greater yield** than the unshaded reference plot.

3 Future Imperatives

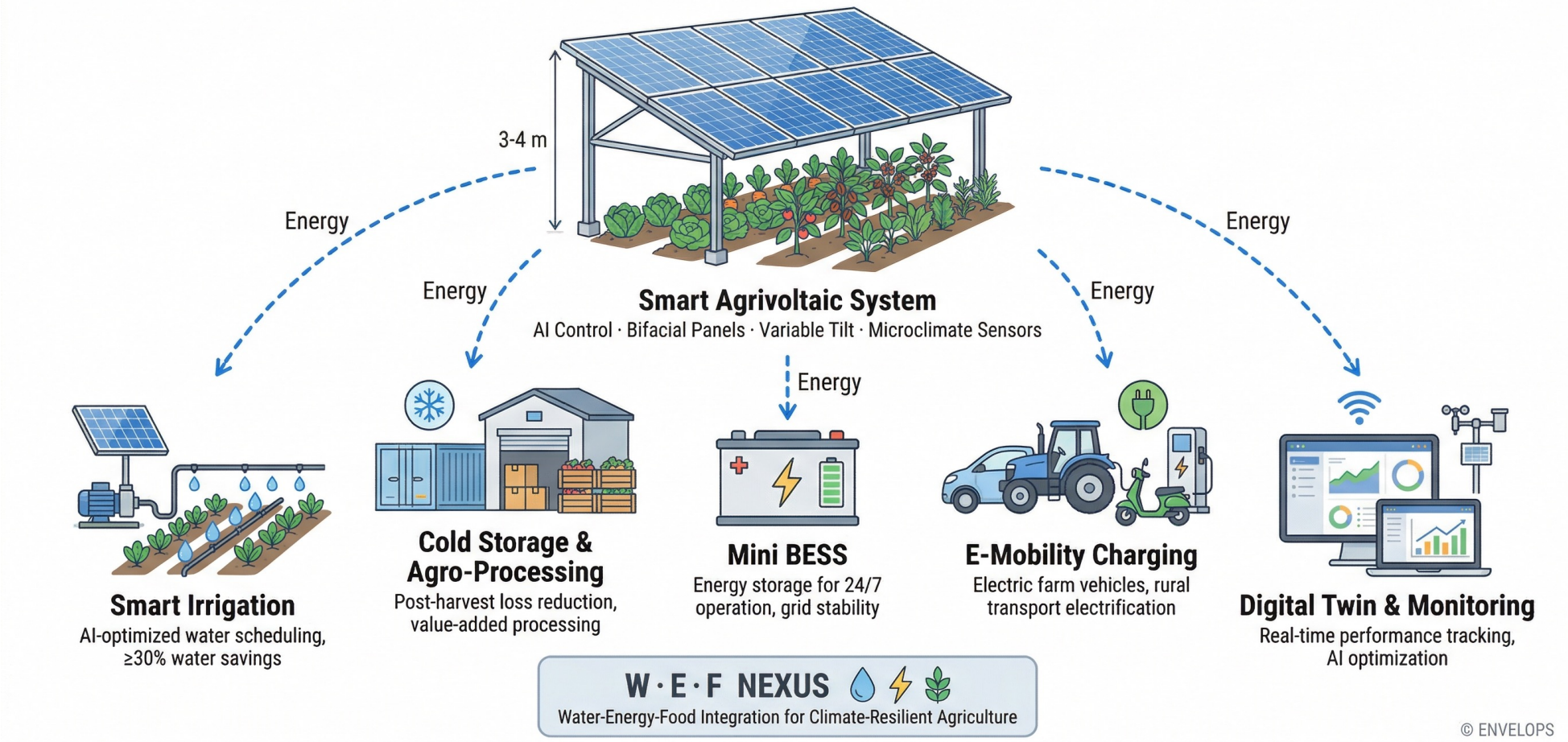
Key Areas for Next Phase R&D

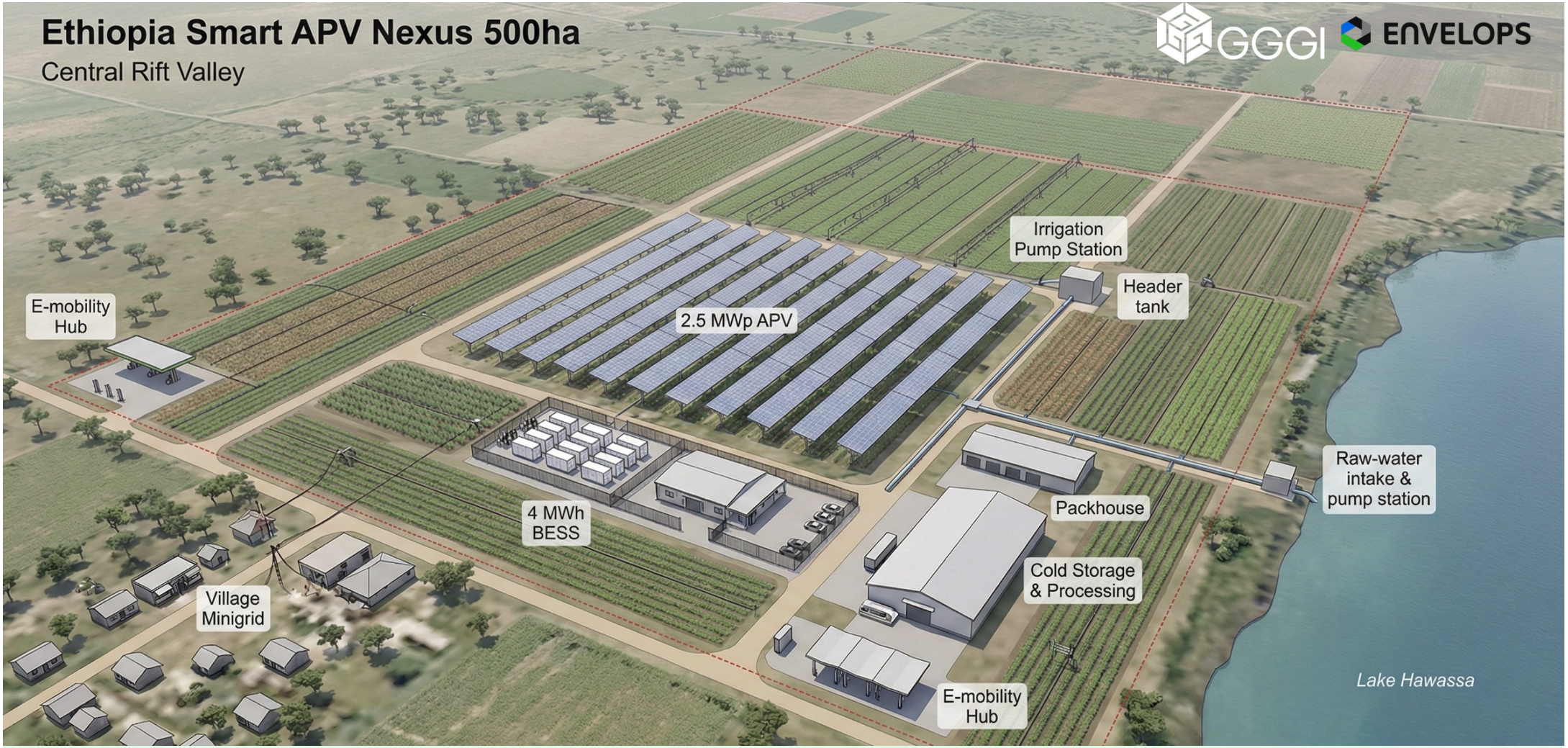
- **Incorporate Humidity/Soil Sensors** to quantify water conservation benefits.
- **Address Data Gaps** such as phenological inconsistencies for greater statistical confidence.
- **Long-Term Monitoring** to track perennial crop yield stability over multiple seasons.




Dalo
Under APV
Open Field
Cucumber
Open Field
Under APV

Tackling Multiple Problems with One Stone
- The Smart Water-Energy-Food APV Nexus Model

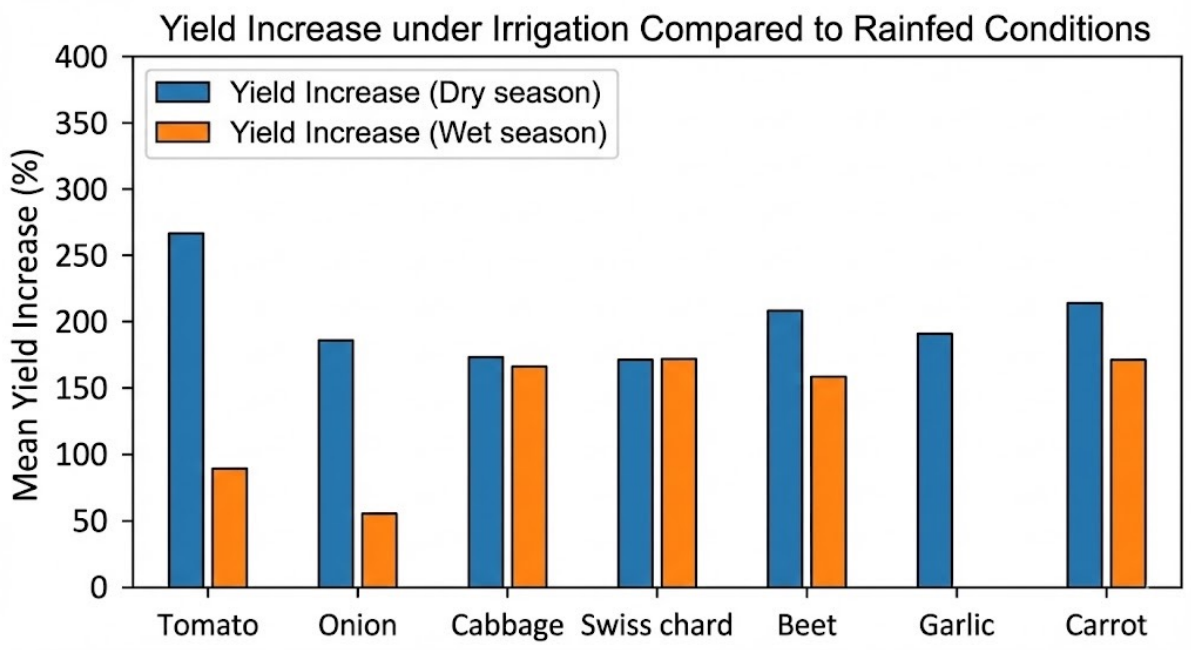




- ✔ 2.5 MWp fixed tilt APV plant
- ✔ 4 MWh Battery Energy Storage System (BESS)
- ✔ Irrigation system for ~500 ha command area
- ✔ Post harvest and value addition cluster
- ✔ Smart Nexus Operations

Irrigation Is Not Optional: A Prerequisite for Stable Agricultural Production

Across all seven crops, irrigation increases yields by 2.0–4.5 times, eliminates dry-season crop failure, and reduces inter-annual yield variability by more than 50%.



Outcome	Result under Irrigation
Mean yield	2.0–4.5× higher than rainfed
Dry-season yield	Fully restored to viable levels
Inter-annual variability	Reduced by >50%
Crop failure frequency	Reduced to near zero
Climate sensitivity	Strong buffering against rainfall variability and heat stress

Agrivoltaics as a Water-Efficiency Multiplier in Water-Limited Environments

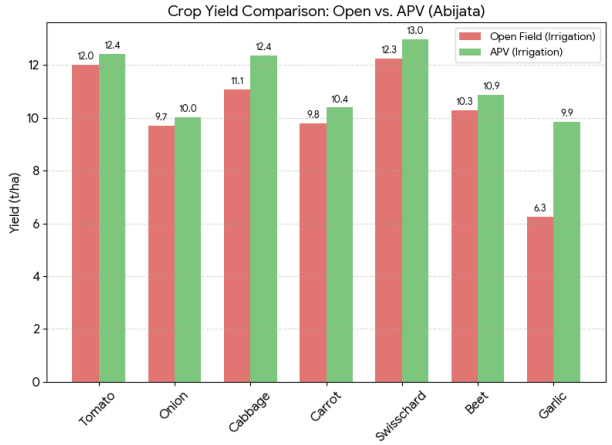
In Abijata, agrivoltaics functions primarily as a stability and water-efficiency enhancer rather than a yield-boosting technology.

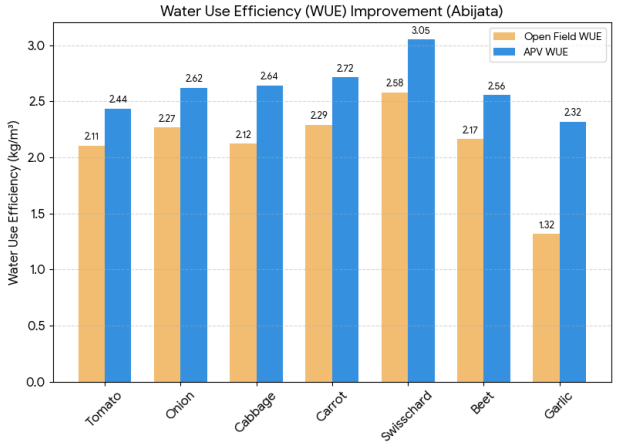
1. Risk mitigation under severe water stress

- Rainfed conditions lead to **crop failure** due to low soil water retention (**TAW ≈ 12%**).
- Example (Tomato):Rainfed yield drops to **1.74 t/ha**, indicating non-viable production.
- Under irrigation, APV mitigates vapor pressure deficit (VPD) and reduces non-productive water losses, stabilizing crop performance.

2. Improved yield and water use efficiency in stress-sensitive crops

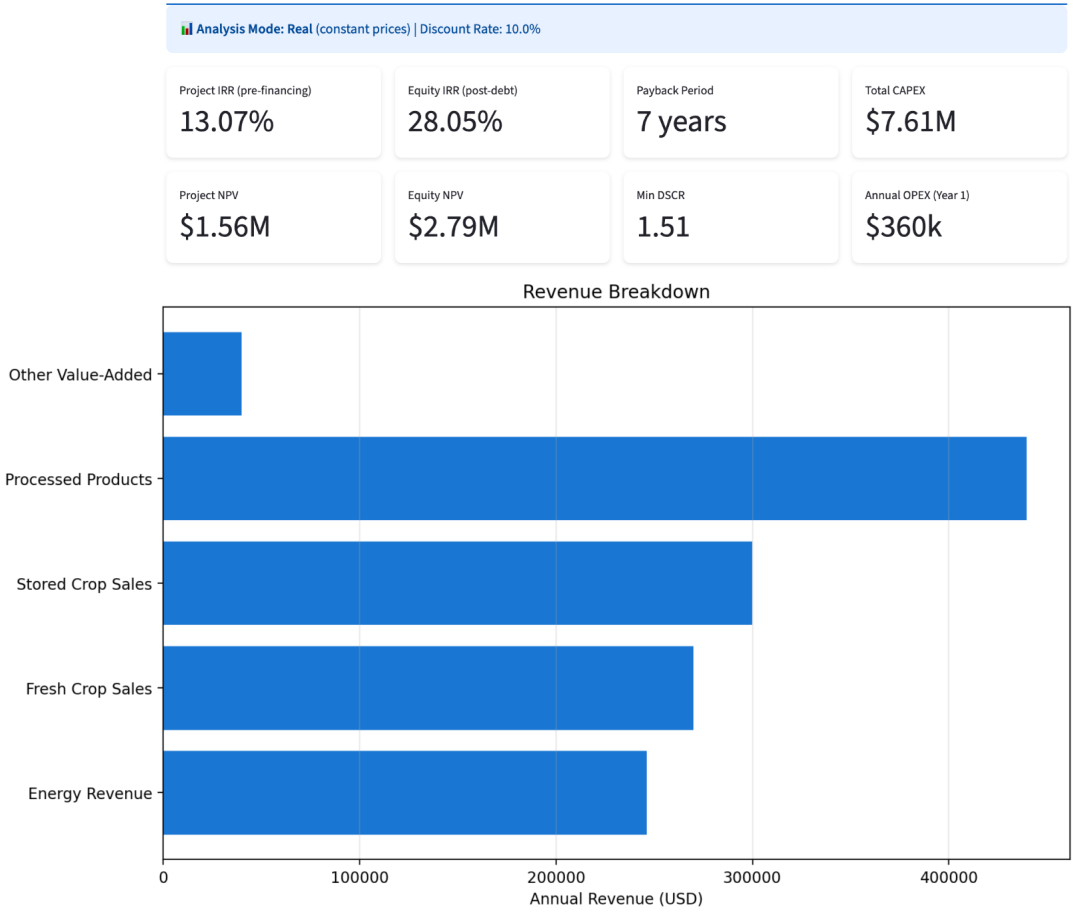
- APV increases yields in crops most vulnerable to heat and water stress: **(Cabbage) +11.5% (Garlic) +57.5%**
- Water Use Efficiency (WUE) improvement is particularly pronounced: **Garlic WUE increases from 1.32 → 2.32 kg m^{-3}**
- APV elevates water productivity to levels comparable with more resilient crops.





REVENUE STREAMS

Revenue category	Key modeling assumptions (central case)	Indicative annual revenue (USD/year, per site)
Energy services and surplus electricity sales	Average annual surplus electricity **2,461.3 MWh/year** exported to surrounding communities and external e-mobility users at **0.10 USD/kWh**. Internal APV–Nexus loads (irrigation, cold storage, processing, buildings, internal EVs) are treated as self-consumption cost savings.	**≈246,000**
Irrigated horticulture and value-added products (integrated SPC operation)	**≈405 ha** net cultivated area (within ~470 ha irrigated farmland). High-value vegetables and root crops under drip irrigation and APV microclimate; 2–3 cropping cycles per year. Marketing mix: **30 % fresh sales**, **30 % cold-stored and sold off-season**, **40 % processed on-site** (tomato paste and other products). Blended **net margin ≈2,200 USD/ha/year**, inclusive of storage and processing value-addition benefits and associated OPEX.	**≈890,000**
Total annual revenue (per site, central case)	**Steady-state operation after ramp-up; all values in real USD (no price escalation) over the 20-year evaluation period.**	**≈ 1,140,000–1,180,000**




Aral Sea
Uzbekistan

Global Environmental Disaster

The Aral Sea Tragedy: From World's 4th Largest Lake to Desert

Once a thriving 68,000 km² ecosystem, the Aral Sea has lost 90% of its volume due to intensive cotton irrigation. This is Uzbekistan's greatest water security challenge.

90%
Volume Loss

54k
km² Dried Seabed

Toxic Salt Storms
Dried seabed dust affects health across the region

ENVELOPS

The Cost of Conventional Cotton

Linking irrigation practices to environmental collapse

Extreme Water Usage

~6,000 m³/ton

Direct Cause of Desiccation

Water diverted from Amu Darya river

Economic Trap

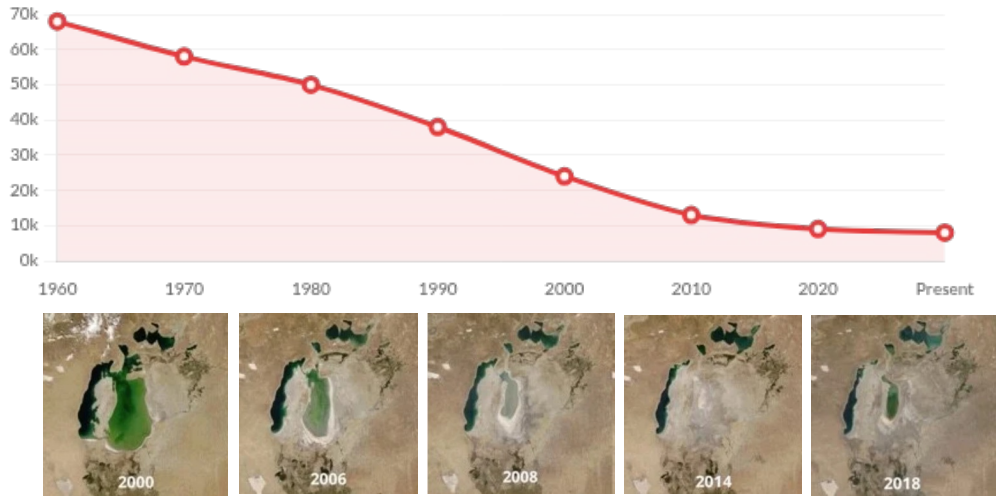
Low Value

Raw Export Dependency

Exporting water-intensive commodities

Aral Sea Surface Area Decline (1960-Present)

km²



Scope 3 Emissions: High

Fashion Brands Demand Change

Source: UN Environment Programme / World Bank Data


10 MWp | Carbon-Free Cotton

ENVELOPS

Expected Benefits of Agrivoltaics for Cotton Production

- Open field vs. smart irrigation vs. agrivoltaics: APV adds shade-based microclimate control and on-site power to smart farming

	Open Field	Smart Farm (sensor + drip)	Agrivoltaics (APV + smart irrigation)
Yield / productivity	Baseline index 100 	**+10–19% yield increase** 	**+33% potential 3,750 → 5,002 kg/ha** 
Water effect	Baseline conventional irrigation	**18–42% less irrigation water WUE +35–103%**	**20–47% WUE gain +14.4% water availability via rain harvesting**
Heat stress mitigation	Exposed to high radiation & VPD	**Better irrigation timing, limited shade**	**1–4°C lower air/soil temperature potential**
Power & land value	External grid / diesel exposure	**Sensors and pumps still need power**	**On-site PV for pumps + sensors Land efficiency +94%**

Sources: Fraunhofer ISE Paras Horticulture PV Study (2019); Uzbekistan drip irrigation and WFD cotton trials (Ibragimov et al., 2007/2021); agrivoltaics WUE/microclimate review studies

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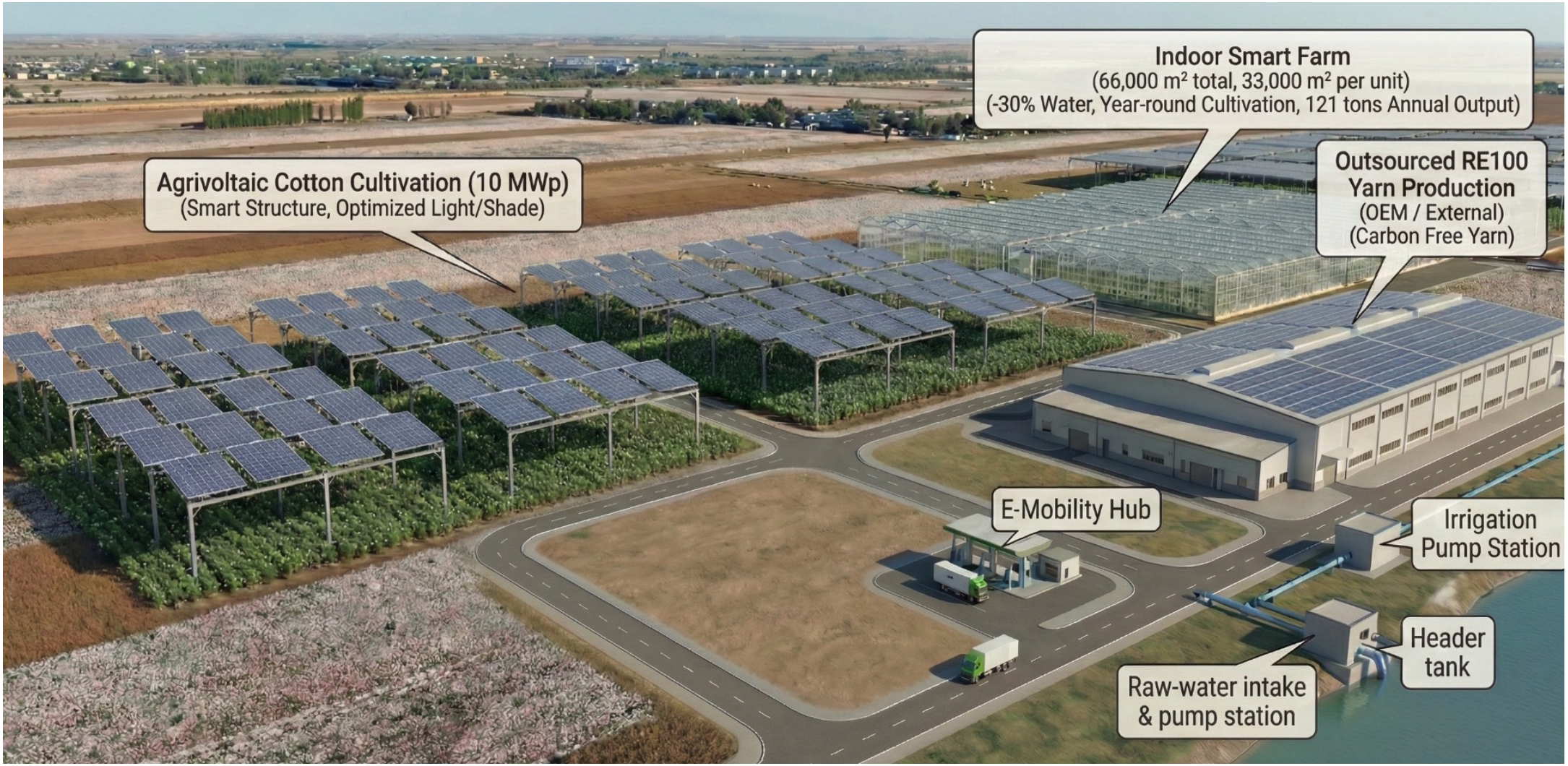

Indoor Smart Farm
(66,000 m² total, 33,000 m² per unit)
(-30% Water, Year-round Cultivation, 121 tons Annual Output)
Agrivoltaic Cotton Cultivation (10 MWp)
(Smart Structure, Optimized Light/Shade)
Outsourced RE100
Yarn Production
(OEM / External)
(Carbon Free Yarn)
E-Mobility Hub
Irrigation
Pump Station
Header
tank
Raw-water intake
& pump station

ENVELOPS

GREEN COTTON AGRIVOLTAIC NEXUS — National Scaling Strategy

Korea-Uzbekistan Climate Cooperation under Paris Agreement Article 6

ODA Pre-Feasibility

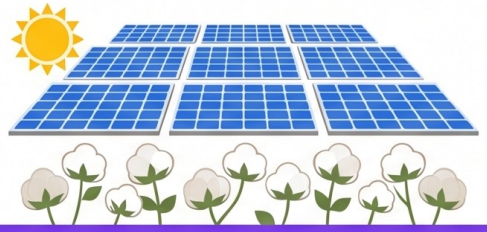
ODA Pre-Feasibility

2026-2027

MCEE Energy ODA
Technology & Economic Validation
Site: TSAU Campus, Tashkent

1 MW
Pilot Design

ITMO Commercial Project



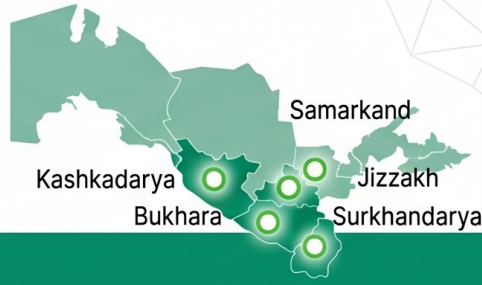
ITMO Commercial Project

2028-2031

Blended Finance: MDB + Private Equity
ITMO Transfer: Korea 80% / Uzbekistan 20%
Carbon Free Cotton: GOTS + RE100 + OEKO-TEX

10-20	$22-43M	6,700-13,400
MW	Investment	tCO_2/yr

Cotton Belt Replication



2031+

10 MW Standard Module × **5-10** Sites
Full Commercial Finance + Impact PE
Programme of Activities (PoA) Registration

50-100	$110-220M	Up to 67,000
MW		tCO_2/yr

But who owns it?

ODA PROJECT IN TUVALU

But who owns it?

ODA PROJECT IN TUVALU


Korea’s Solar Income Village Model
한국농정

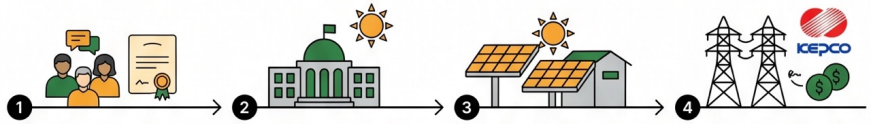
Project Sustainability Issue, Mostly from lack of Profit and Ownership – Solution : Solar Income Village Model

The Village That Cooks With Sunshine

70 households, 120 people — a community-owned solar power plant funding free meals and transport

Guyangri, Yeoju City, Gyeonggi Province, South Korea

How a tiny village built its own power plant



1. **Village cooperative formed**
   60+ members, no individual investment required
2. **Selected for Korea's "Sunshine Village" government program (2022)**
3. **Installed 1 MW solar across 6 community-owned sites**
   rooftops, warehouses, sports facilities
4. **Connected to national grid — started selling electricity to KEPCO**
   Korea Electric Power Corp.

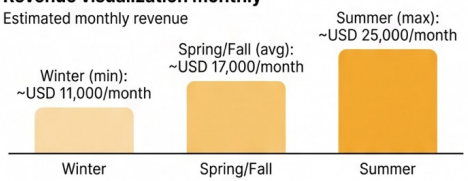
Capacity:	Total investment:	Resident investment:	REC bonus:
1 MW	**USD 1.2M**	**$0**	**+0.2 weight**
997.92 kW	government low-interest loan	zero out-of-pocket cost	community-owned projects

How the money flows

Sunlight → 6 Solar Sites → Electricity → Sold to Grid (KEPCO)

Revenue visualization monthly

Estimated monthly revenue

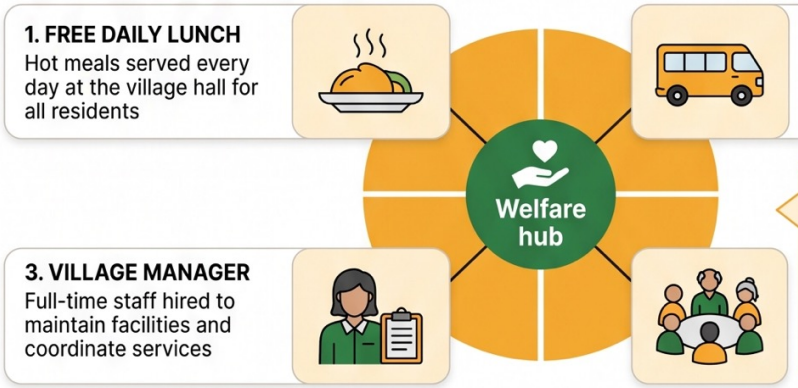


Annual gross revenue:
~USD 90,000

Loan repayment + insurance + maintenance:
~USD 8,000/month

Net profit:
~USD 7,500/month

Where the profits go



1. FREE DAILY LUNCH
Hot meals served every day at the village hall for all residents

2. FREE VILLAGE BUS
'Happiness Bus' runs daily routes to hospital, market, town center

3. VILLAGE MANAGER
Full-time staff hired to maintain facilities and coordinate services

NO individual cash dividends — 100% reinvested in community welfare
Even residents who initially opposed the project receive equal benefits

Why Guyangri matters

100% community-owned
— No outside developer
The cooperative runs everything

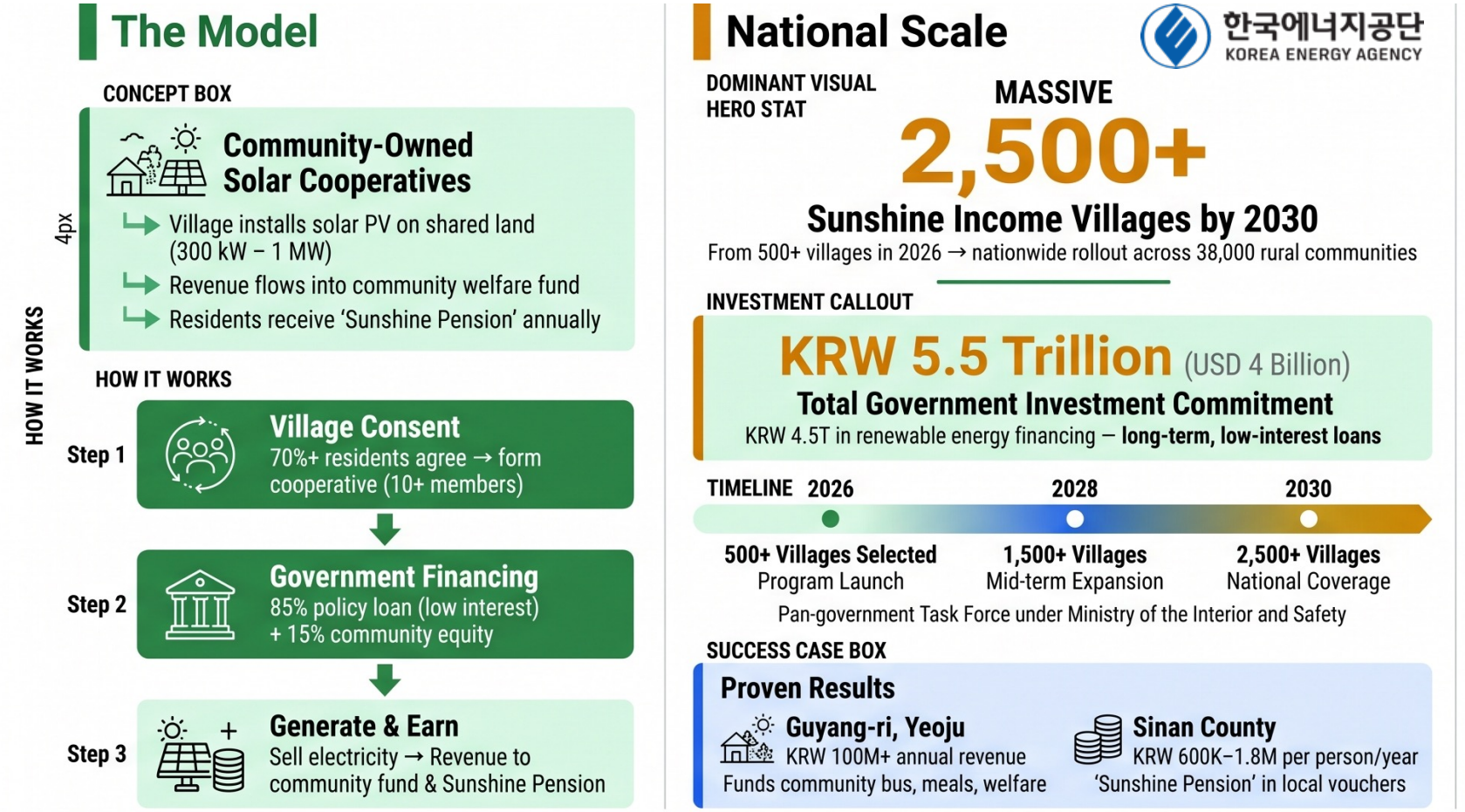
Zero financial risk for residents
— Government loan, no personal investment needed

20+ year income stream
— Revenue continues for the full life of the solar installation

"We sell electricity to cook meals and run buses — that's our village business model."

Guyangri is now South Korea's flagship model for the national 'Sunshine Income Village' program targeting 2,500 villages by 2030.

Project Sustainability Issue, Mostly from lack of Profit – Solution : Solar Income Village Model



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