وزارة التغير المناخي والبيئة

MINISTRY OF CLIMATE CHANGE & ENVIRONMENT

ICARDA

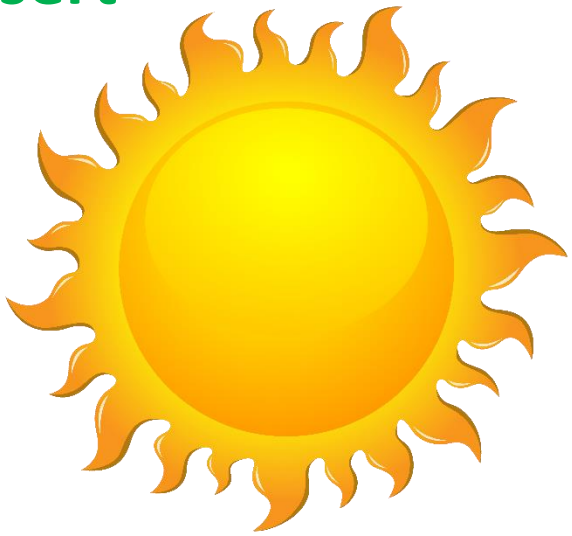
Science for resilient livelihoods in dry areas

Net House Powered by Solar Energy

Arash Nejatian

Abdul Aziz Niane

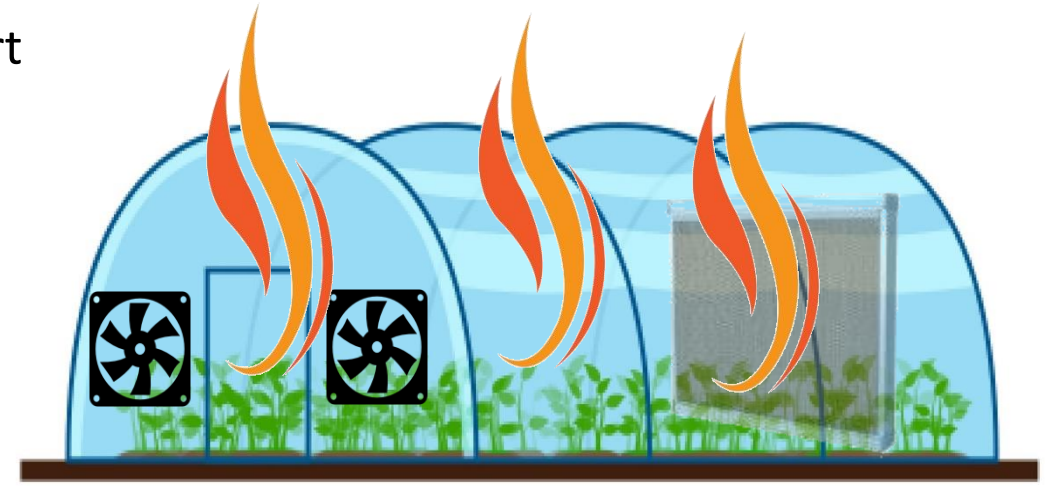
Control environment agriculture is the main pillar of desert farming



Protecting crops from the harsh environment and enhancing and managing crop production throughout the year.

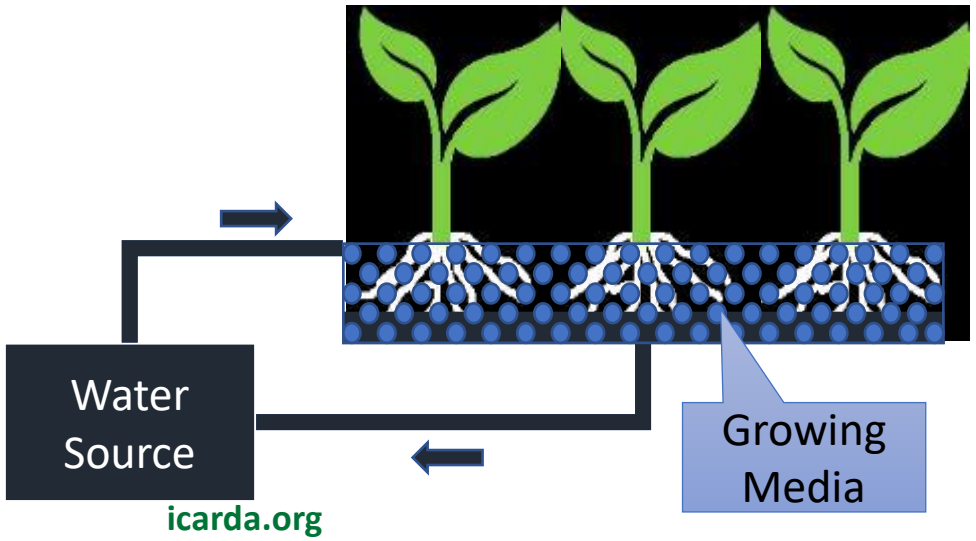
The main technical problem of using conventional greenhouses:

- maintaining the inside air temperatures and relative humidity favorable for plant growth under a desert farming system (Abdel-Ghany & Al-Helal, 2020)
- High water and energy consumption for plant production and cooling system



Simplified Closed Soilless Production System

Reduce irrigation water by more than 50%



The advantages of soilless culture over conventional soil bed systems include:

1. Provide very efficient use of water by reclaiming and reusing;
2. Shorter cropping cycle allows for more crops within the season;
3. Top quality crops grown out of the depleted or contaminated soil;
4. Increased production per unit area;
5. Reduction in labor requirement by more than 50%;
6. Increased job satisfaction among workers;
7. Better control of water and nutrients;
8. Elimination of costly operations such as sterilization, soil cultivation, base fertilizers, and weed control

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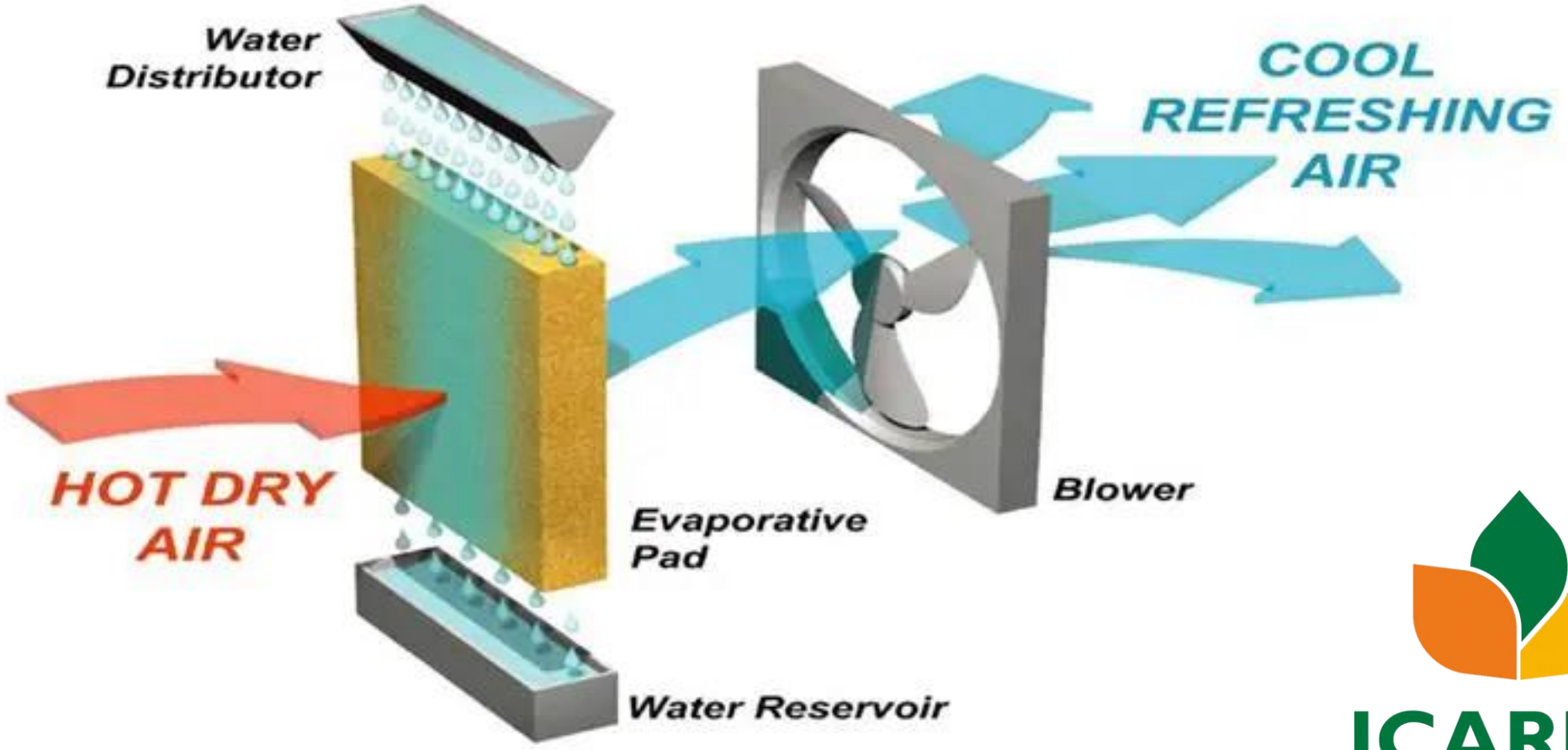
How **EVAPORATIVE COOLING** works



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Pad and fan challenges and constrains

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Expensive and required maintenance and replacement

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High water consumption

Average in GCC countries 8 liter/day/m2 of greenhouse (collected from different ICARDA studies)

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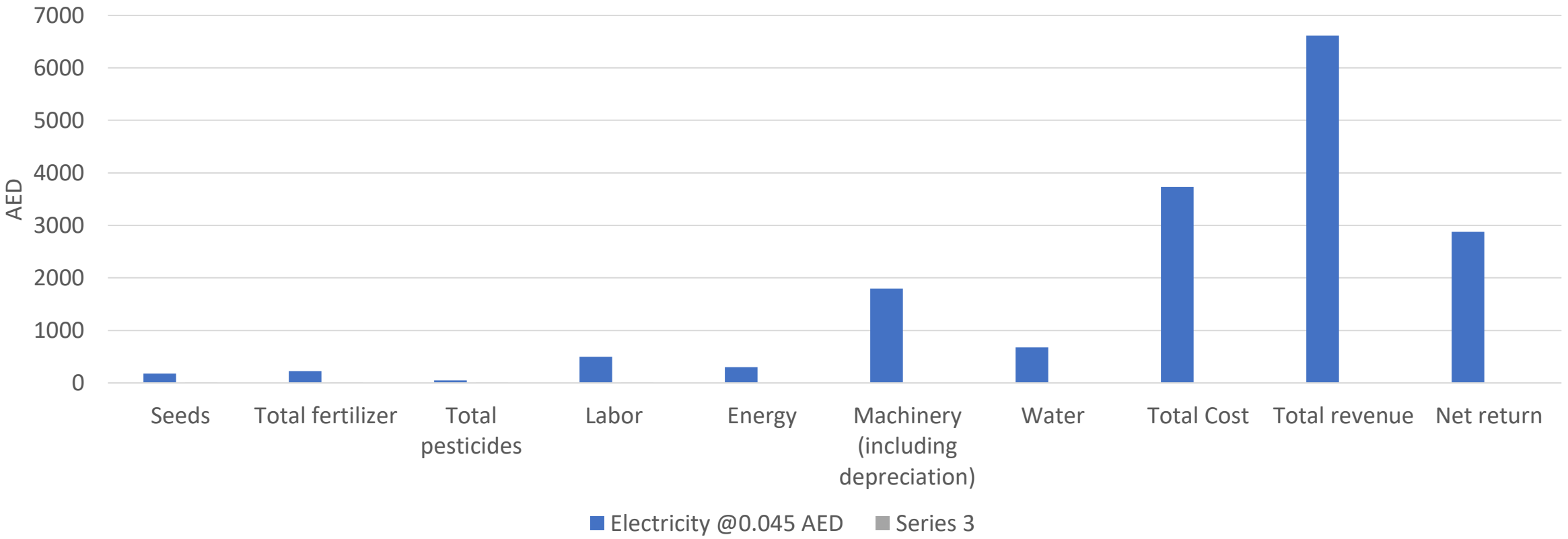
High cost of electricity

In Dhaid, more than 30,000 kWh for a single 8x40m GH per year

Net Return for Cucumber crop in cooled GH in UAE (25 March – 15 June) with two Scenario for Energy cost



- **Scenario 1:** The cost of electricity is 4.5 fills/kWh based on agricultural electricity tariff (Abu Dhabi Distribution Company, 2017)
- Scenario 2: average business electricity price worldwide in March 2021 was reported at 0.135US$ or 0.5AED per kWh (Electricity prices, 2021)Average

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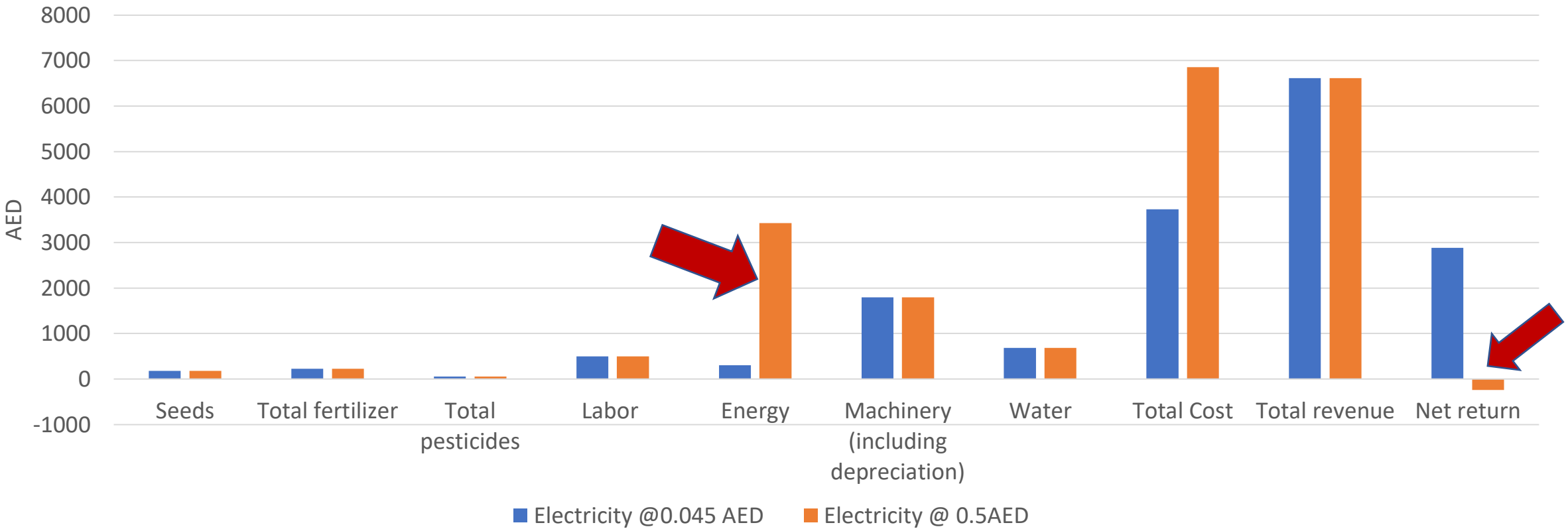

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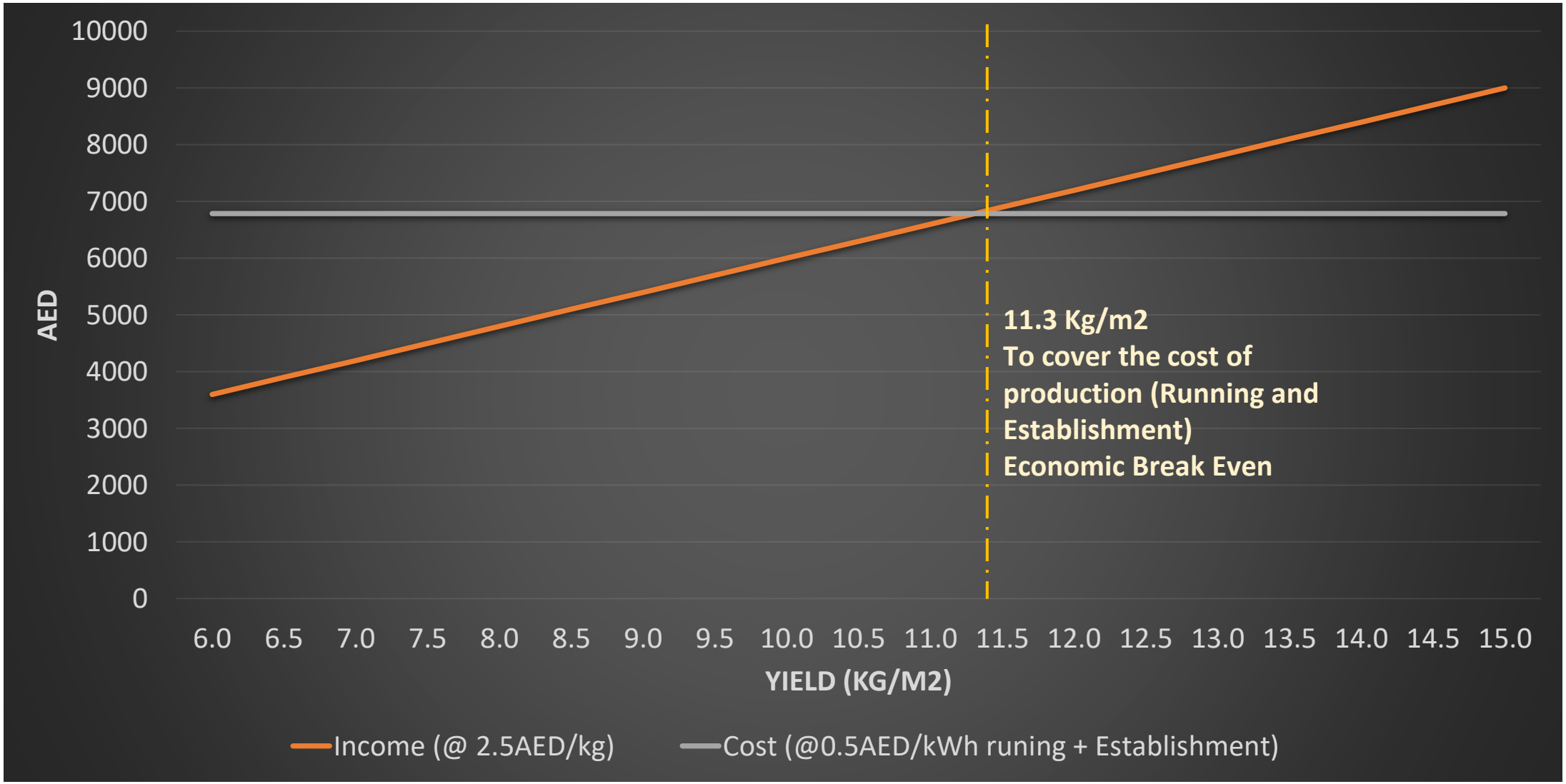
10000
9000
8000
7000
6000
5000
4000
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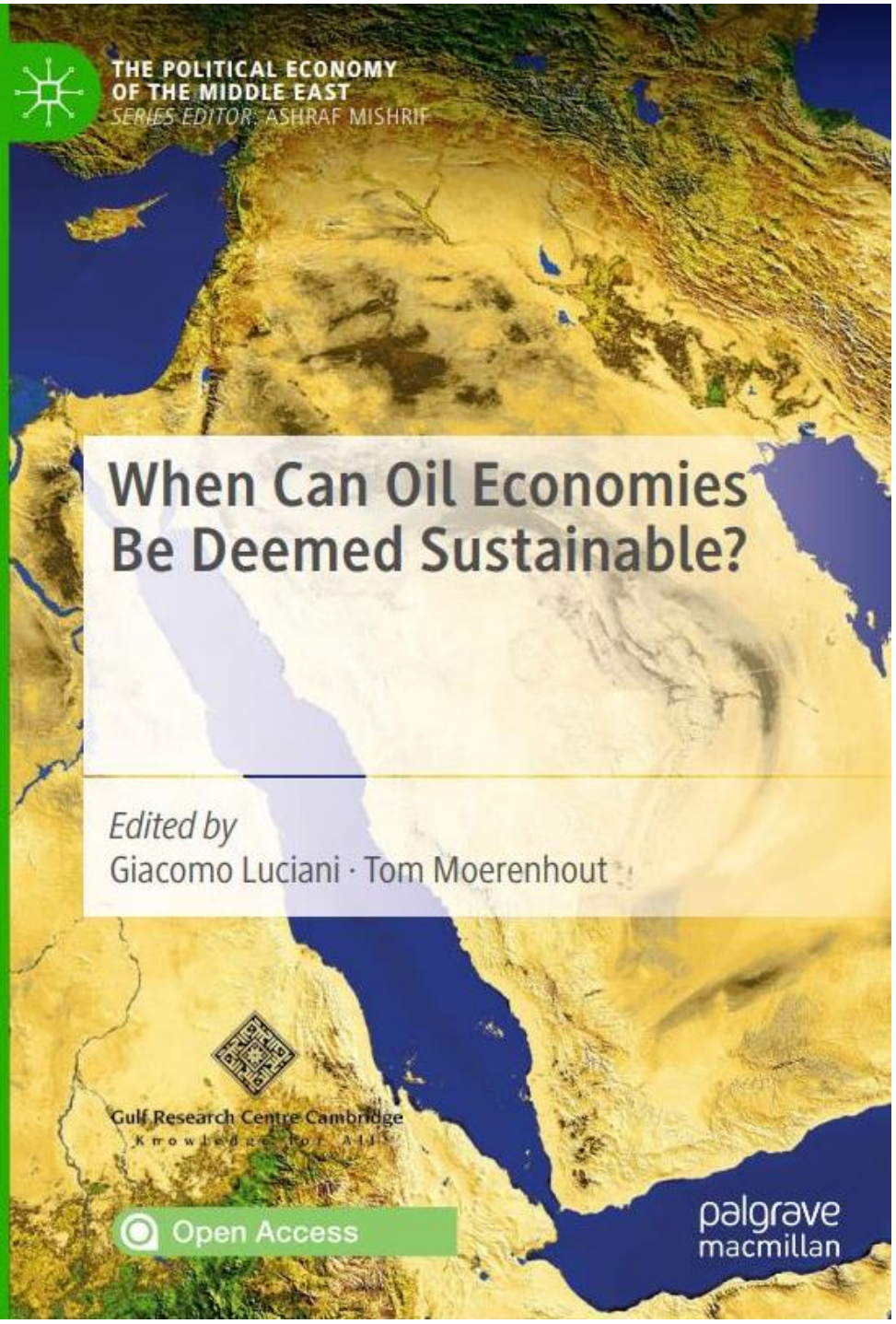
2000
1000
0
AED
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
YIELD (KG/M2)
11.3 Kg/m2
To cover the cost of production (Running and Establishment)
Economic Break Even
Income (@ 2.5AED/kg)
Cost (@0.5AED/kWh runing + Establishment)



Most GCC countries have increased electricity prices over the past few years.

Tom Moerenhout 2021

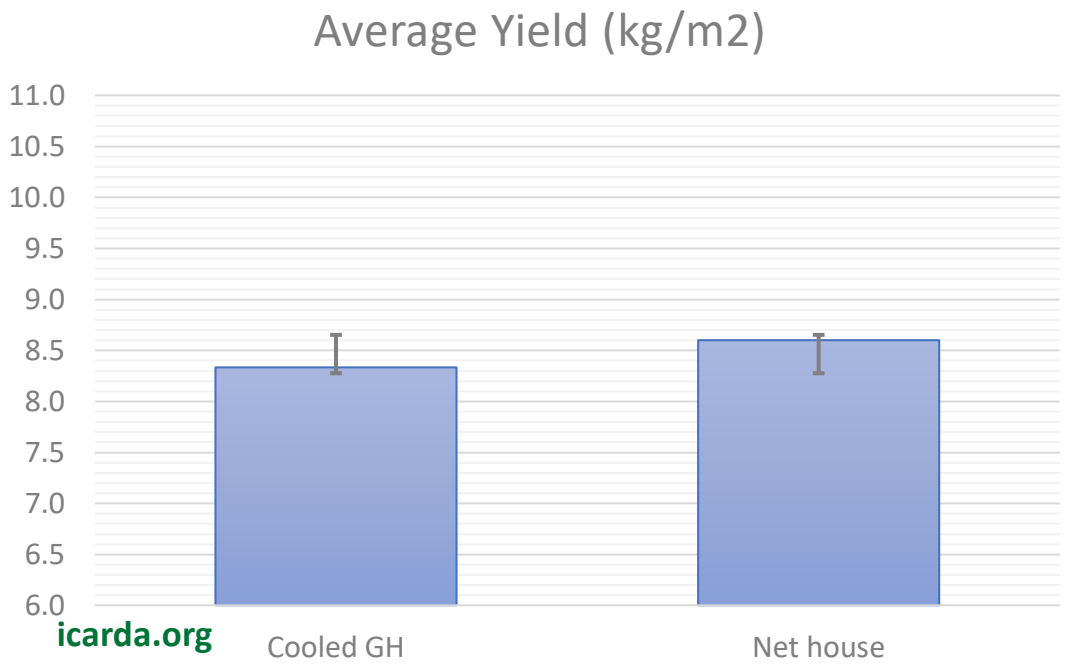
Columbia University, School of International and Public Affairs, New York, NY, USA

- Active
  - Fan-and-pad cooling
  - Fog
- Passive
  - Ventilators
  - Net house

Net-house using insect-proof net

Considering the average monthly temperature, the production of cash crops could be successfully adopted in net-house for 7-8 months/year.

Comparing cucumber production in Net-house VS. Cooled GH in UAE (September to December 2012)



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Root zone area cooling (RZAC)

The air temperature inside the greenhouse tends to be very high during the daytime.

The root zone cooling system has been used as an energy-efficient cooling system for GH to overcome this problem

- Niam & Suhardiyanto, 2018;
- Lyr & Garbe, 1995;
- Lahti et al., 2005;
- Solfjeld & Johnsen, 2006;
- Dıaz-Perez et al., 2007;
- Nxawe et al., 2009

Ultra-low-energy drip irrigation and Utilizing Hybrid Solar Energy

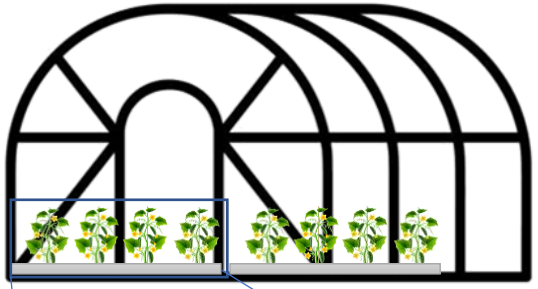
The new emitters studied through ICARDA-MIT research activities

- Cut pumping energy **by 80%,**

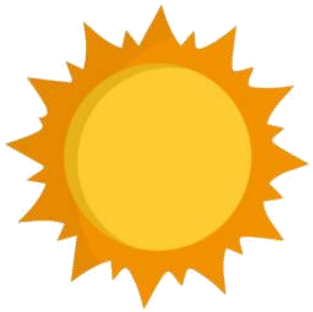
Reduce pumping time with five folds

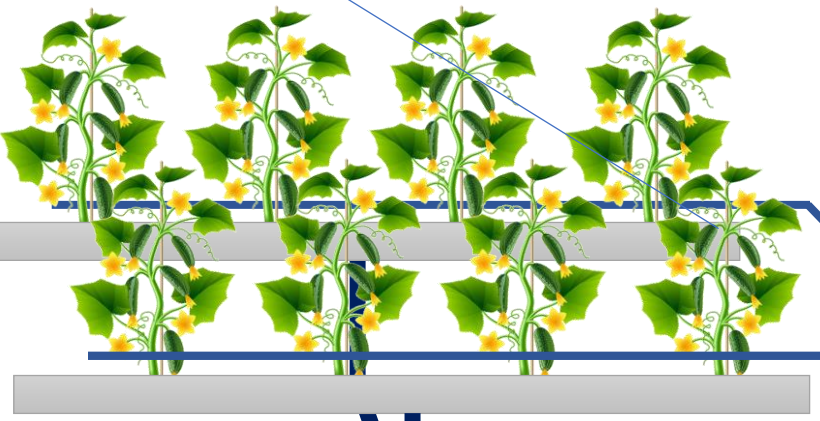
Reduce the Number of panels from three to one panel

Net house 8x30 meter

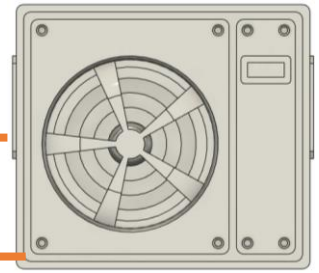


24 Volt AC/DC On-grid Hybrid System

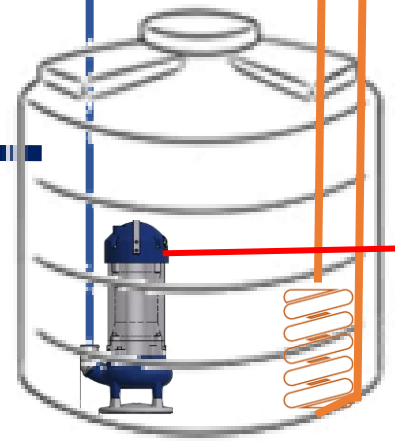


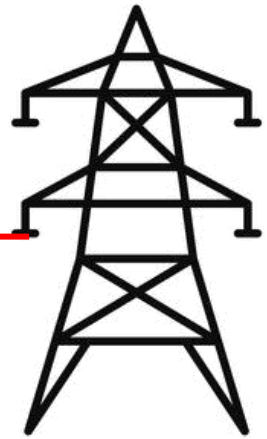


24V Root Zone Cooling



6x300W Solar Panel
80% of total energy

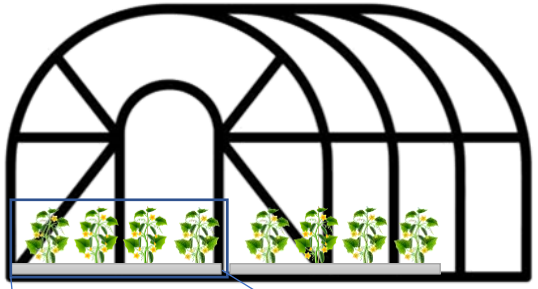




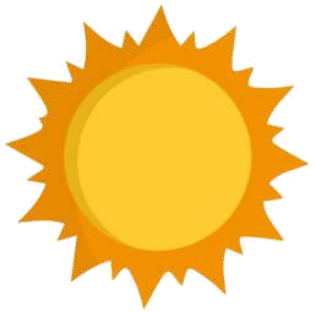
Grid
20% of total energy
Grid needed all the time

24v Solar hydroponics production system with Automatic Fertigation controller

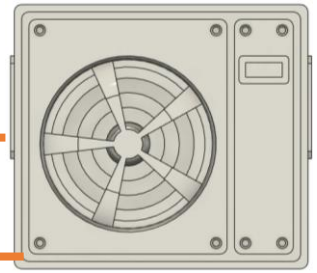
Net house 8x30 meter



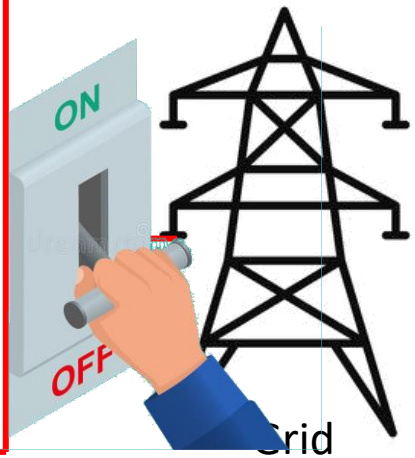
New technology
24 Volt AC/DC
off-grid
Hybrid System



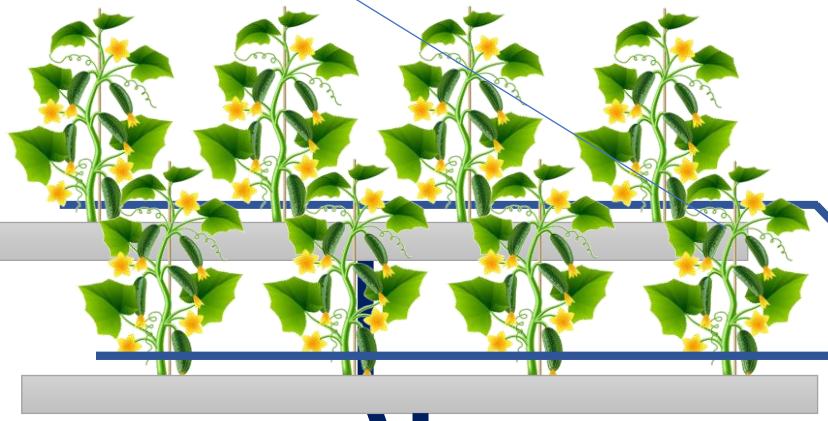
24V Root
Zone Cooling

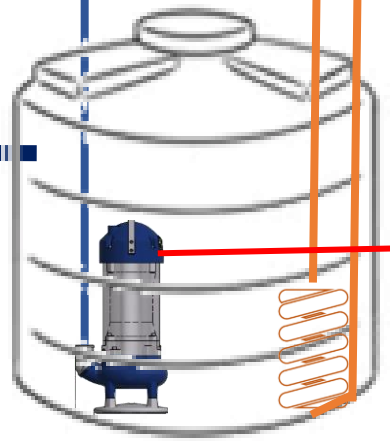


6x300W Solar Panel
85% of total energy



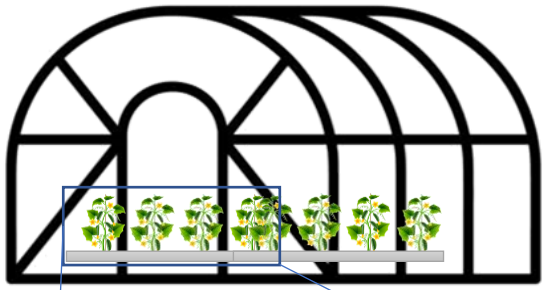
Grid
15% of total energy
The grid can be disconnected



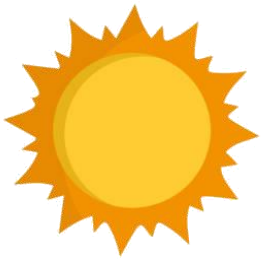


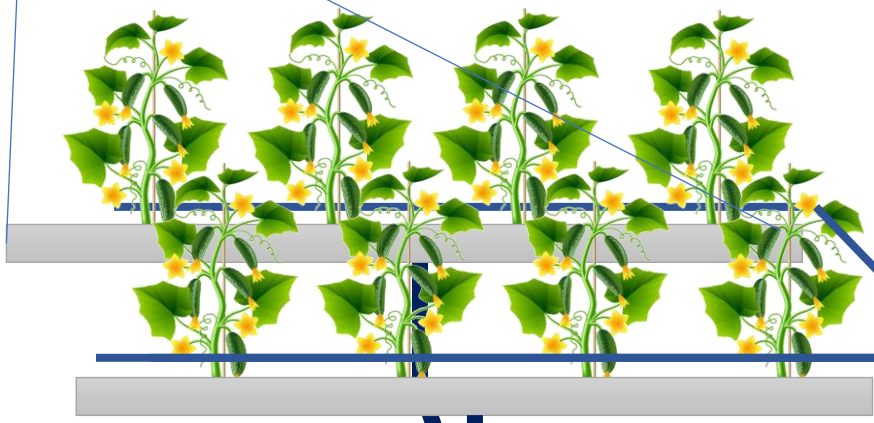
24v Solar hydroponics production system with
Automatic Fertigation controller

Net house 8x30 meter

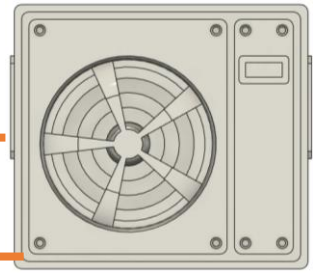


48 Volt 100% off grid

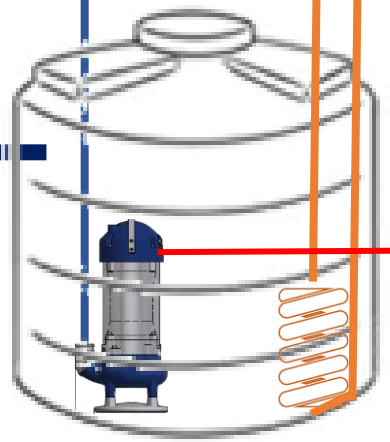


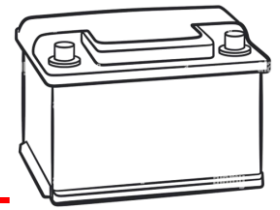


48V Root
Zone Cooling



10x300W Solar Panel
100% of total energy





6x120Ah batteries

24v Solar hydroponics production system with
Automatic Fertigation controller

Intelligent DC Brushless submersible pump

An intelligent pumping system consists of a pump, variable speed drive or controller, and instrumentation.

Brushless Motor

- Increased Efficiency
- More Reliable
- Long Lifespan
- Lower Maintenance
- Higher Speeds

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Solar irrigation setup and wiring chart for Closed Hydroponics System

Recommended irrigation time: 5min/h

Greenhouse size: 8x30 meter

Irrigation lines: 4 lines

Solar Charge Controller

30Amp

Recommended:

FOXSUR

12V/24V

30A

Irrigation controller (output 24VAC)

\+

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SOLAR PANEL 310-330 WATTS MONOCRYSTALLINE

Miniature circuit breaker

16 A –DC

Recommended:

Schneider C60H-DC

24 VAC Modular Contactor

25Amp-2 Normally Open

Recommended:

Finder 22.32.0.024.4340

2NO-25Amp-24V AD/DC

\+ \- \+ \-

UPS/SOLAR Battery 12V 20AH

UPS/SOLAR Battery 12V 20AH

Pump

DC (solar), 450Watt

1½ inch outlet


Off Grid
Solution

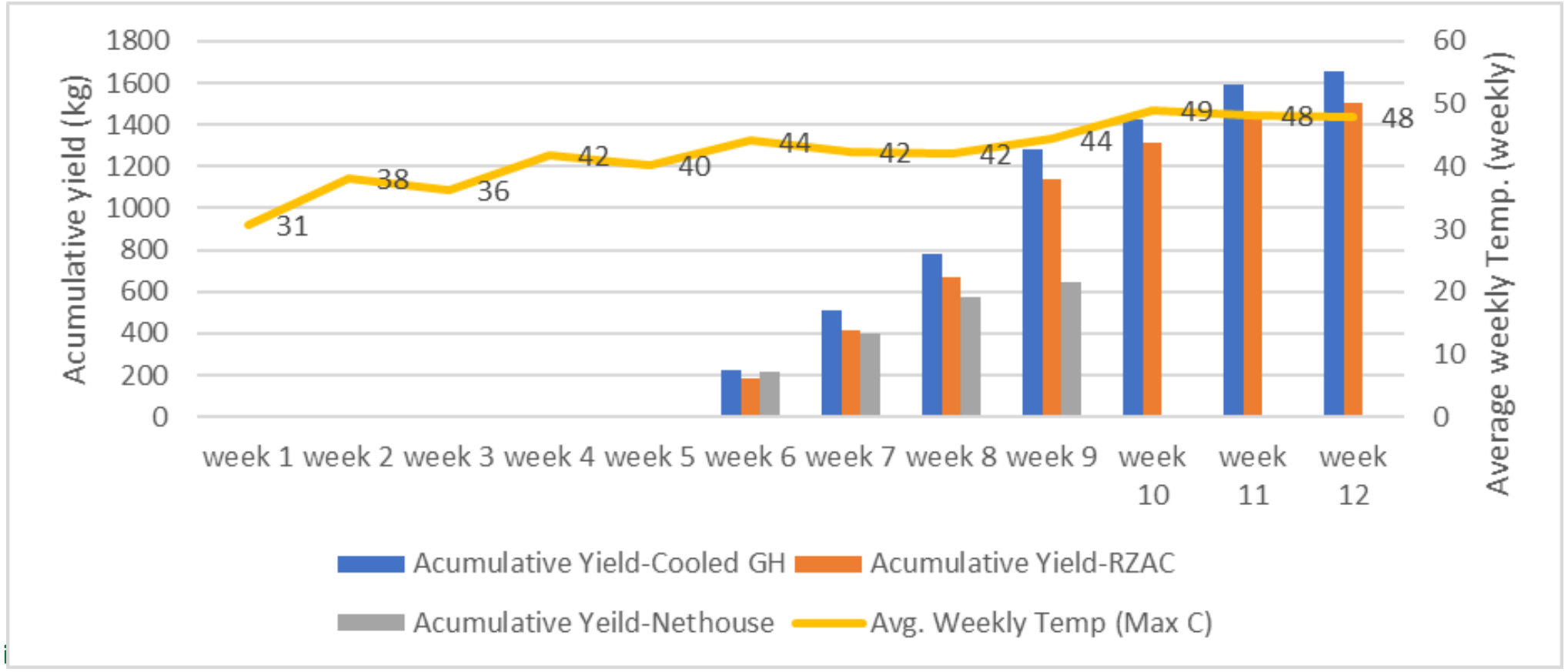
Combination of Five technology packages

For the first time, this study aimed to combine the five technologies to investigate the possibility of improving productivity and extend the production period of the net house,

- closed soilless production system,
- net house,
- ultra-low pressure irrigation system,
- root zone area cooling,
- and low-cost solar energy,.

Production period

24 March → 13 June

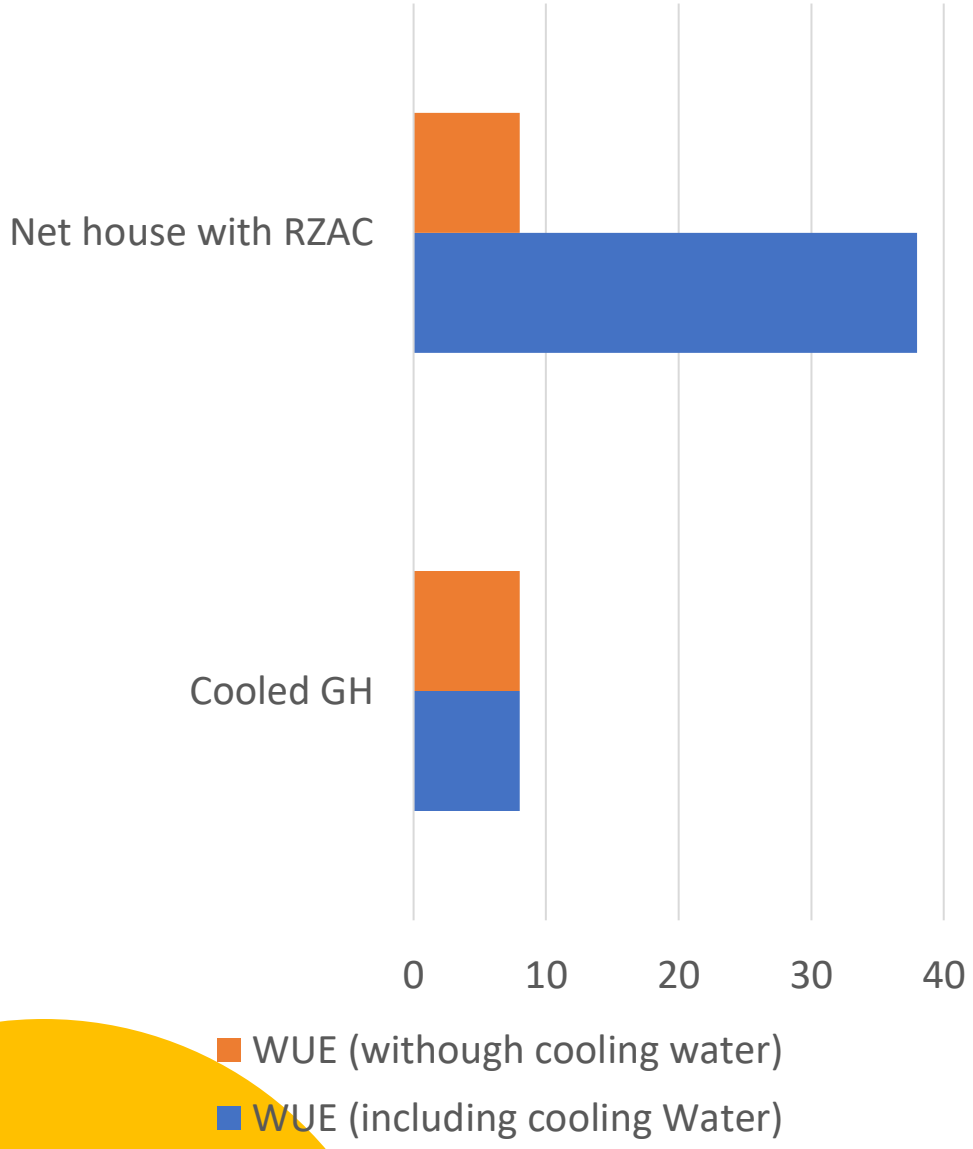


Comparison of cucumber yield under Net house with RZAC and Cooled GH

- Each of the structures was divided into seven sections in length.
- Each section had 70 pots and 140 plants.
- The production records of each section were collected separately and used as different samples to compare each structure's average yield and water productivity using independent samples t-test.

	Net-house with RZAC production (kg/m2)	Cooled Greenhouse production (kg/m2)
Section 1	7.13	6.18
Section 2	6.49	7.24
Section 3	6.14	7.94
Section 4	6.07	7.41
Section 5	5.82	7.24
Section 6	6.46	6.42
Section 7	6.14	6.21
Total	**6.32**	**6.95**

The independent two-tail t-test for equal variance proved no significant yield between cooled-GH and NH-RZAC



Water Use Efficiency (kg/m3) in the net house with RZAC and conventional cooled greenhouse

- Both structures used about 40m^3 of water for crop irrigation and fertigation
- The cooled GH consumed an extra 176.85m^3 of water for the cooling system.

Economic analysis

Machinery and depreciation

Estimated cost of establishment and equipment

	Establishment cost		Economic life (year)	Annual cost	
	cooled GH	NH-RZAC		cooled GH	NH-RZAC
Greenhouse structure	40000	25000	10	4000	2500
Irrigation system	2930	2015	5	586	403
Root Zone Cooling	0	7000	5	0	1400
cooling system	10000	0	5	2000	0
Hydroponics system	3000	3000	5	600	600
Total	55930	37015		7186	4903
Cost per season (4 seasons for cooled GH and 3 seasons for the net house)				1797	1634

Net house with RZAC and solar energy reduce establishment cost and depreciation with about 10%

Partial budget analysis

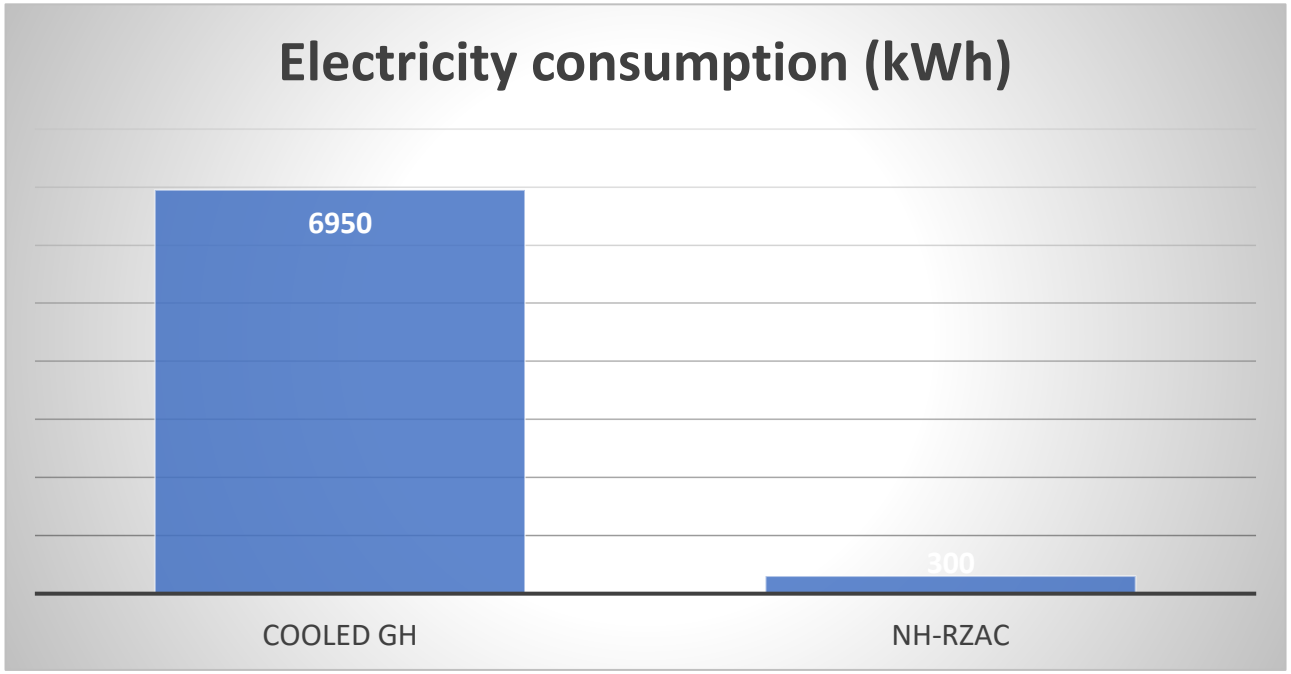
	Cooled GH	NH-RZAC
Seeds	180	180
Total fertilizer	225	225
Total pesticides	50	50
Labor	500	500
Energy	**302**	**14**
Machinery (including depreciation)	1797	1634
Water	**680**	**126**
Total Cost	3733	2729
Total revenue	6614	6019
Net return	2881	3290

compared to the conventional cooled greenhouse, utilizing net house with RZAC powered by solar energy

- reduced the total cost of production by 27%
- increased net income by about 14%

Economic analysis

Energy :

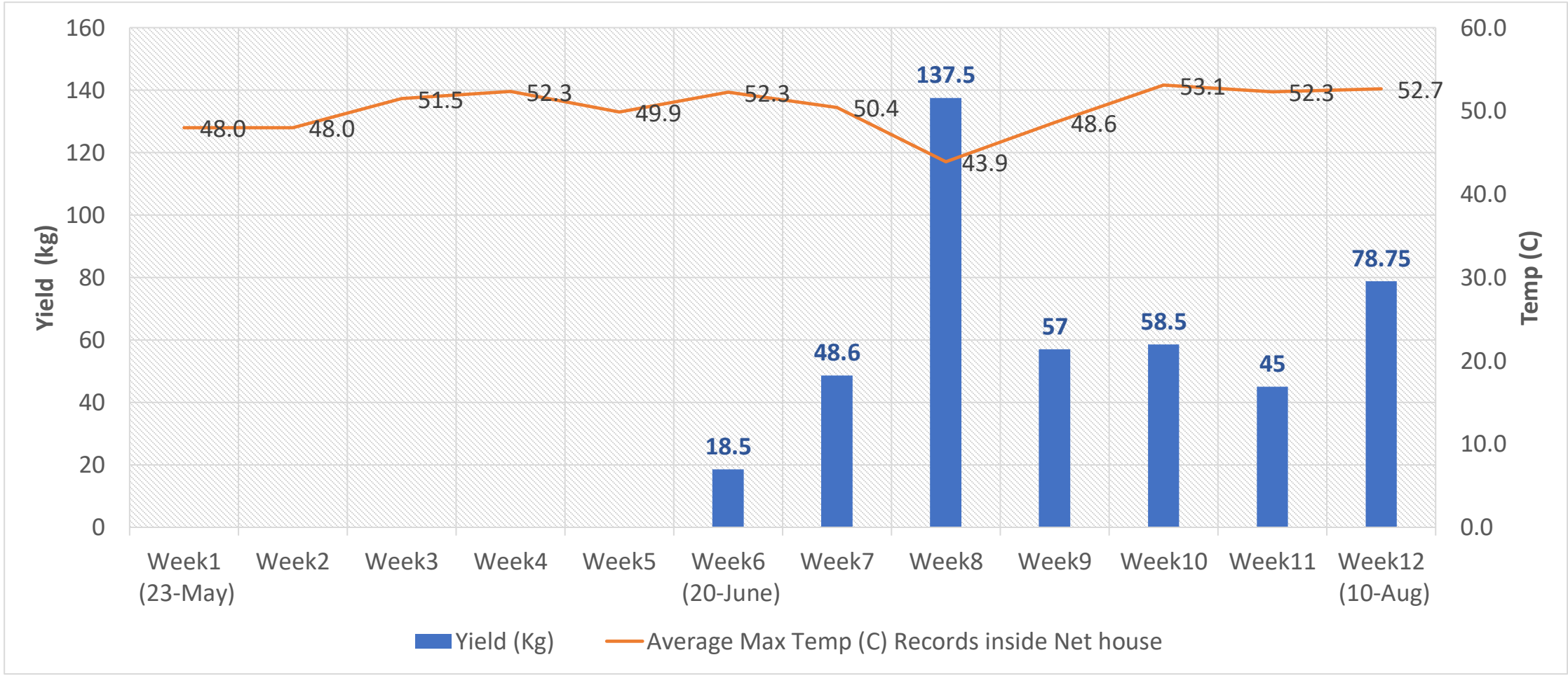


- Save more than 90% of electricity consumption

Environment: Less electricity means less carbon footprint.

The 6650-kWh saving is equivalent to 4.7 metric tons of Co2 not emitted to the atmosphere. This is equal to a co2 generated by a small car run for one year (EPA, 2020)

Cucumber production in Net house with RZC during May-Aug 2022



Conclusion

- Extend the production period
- energy consumption by up to 90%
- water by 80%, eliminating the pad and fan cooling system
- No quantitative or qualitative yield penalties were observed.

Thank you

Establishment and Annual Depreciation cost Cooled greenhouse (CGH) and Net house-RAC (8x30 meter)

Parameters	Establishment cost (US$)			Annual depreciation (US$)		
	CGH	NH-RZAC 24V Hybrid	NH-RZAC 48V off-grid	CGH	NH-RZAC 24V Hybrid	NH-RZAC 48V off-grid
Greenhouse frame & cover	10,870	6,793	6,793	1,087	679	679
Irrigation system	796	548	548	159	110	110
Root Zone Cooling	0	1,902	3,533	0	380	707
Evaporative cooling system	2,717	0	0	543	0	0
Hydroponics system	815	815	815	163	163	163
Total Establishment	15,198	10,058	11,689	1,953	1,332	1,658