Net House Powered by Solar Energy

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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
How **EVAPORATIVE COOLING** works

- Water Distributor
- Evaporative Pad
- Water Reservoir
- Blower

**HOT DRY AIR**

**COOL REFRESHING AIR**
Pad and fan challenges and constrains
Expensive and required maintenance and replacement
High water consumption

Average in GCC countries 8 liter/day/m² of greenhouse (collected from different ICARDA studies)
High cost of electricity
In Dhaid, more than 30,000 kWh for a single 8x40m GH per year
**Scenario 1:** The cost of electricity is 4.5 fils/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)
• **Scenario 1:** The cost of electricity is 4.5 fils/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
To cover the cost of production (Running and Establishment) Economic Break Even

11.3 Kg/m²
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)
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;
- Diaz-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 Solar hydroponics production system with Automatic Fertigation controller

6x300W Solar Panel
80% of total energy

Grid
20% of total energy
Grid needed all the time
New technology
24 Volt AC/DC
off-grid
Hybrid System

24v Solar hydroponics production system with Automatic Fertigation controller

24V Root Zone Cooling

6x300W Solar Panel
85% of total energy

15% of total energy
The grid can be disconnected
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
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
Solar irrigation setup and wiring chart for Closed Hydroponics System

Recommended irrigation time: 5 min/h
Greenhouse size: 8x30 meter
Irrigation lines: 4 lines

Solar Charge Controller
30Amp
Recommended:
FOXSUR
12V/24V
30A

Irrigation controller (output 24VAC)

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

Pump
DC (solar), 450Watt
1½ inch outlet

SOLAR PANEL 310-330
WATTS MONOCRYSTALLINE

UPS/SOLAR Battery
12V 20AH

UPS/SOLAR Battery
12V 20AH
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
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.

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

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

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 40m³ of water for crop irrigation and fertigation.
- The cooled GH consumed an extra 176.85m³ of water for the cooling system.
## Economic analysis

### Machinery and depreciation

#### Estimated cost of establishment and equipment

<table>
<thead>
<tr>
<th>Establishment cost</th>
<th>Economic life (year)</th>
<th>Annual cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>cooled GH</td>
<td>NH-RZAC</td>
<td></td>
</tr>
<tr>
<td>Greenhouse structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40000</td>
<td>25000</td>
<td>10</td>
</tr>
<tr>
<td>Irrigation system</td>
<td>2930</td>
<td>2015</td>
</tr>
<tr>
<td>5</td>
<td>586</td>
<td>403</td>
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<tr>
<td>Root Zone Cooling</td>
<td>0</td>
<td>7000</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>1400</td>
</tr>
<tr>
<td>cooling system</td>
<td>10000</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2000</td>
<td>0</td>
</tr>
<tr>
<td>Hydroponics system</td>
<td>3000</td>
<td>3000</td>
</tr>
<tr>
<td>5</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Total</td>
<td>55930</td>
<td>37015</td>
</tr>
<tr>
<td>Cost per season (4 seasons for cooled GH and 3 seasons for the net house)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Net house with RZAC and solar energy reduce establishment cost and depreciation with about 10%
### Partial budget analysis

<table>
<thead>
<tr>
<th></th>
<th>Cooled GH</th>
<th>NH-RZAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeds</td>
<td>180</td>
<td>180</td>
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<tr>
<td>Total fertilizer</td>
<td>225</td>
<td>225</td>
</tr>
<tr>
<td>Total pesticides</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Labor</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Energy</td>
<td>302</td>
<td>14</td>
</tr>
<tr>
<td>Machinery (including depreciation)</td>
<td>1797</td>
<td>1634</td>
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<tr>
<td>Water</td>
<td>680</td>
<td>126</td>
</tr>
<tr>
<td>Total Cost</td>
<td>3733</td>
<td>2729</td>
</tr>
<tr>
<td>Total revenue</td>
<td>6614</td>
<td>6019</td>
</tr>
<tr>
<td>Net return</td>
<td>2881</td>
<td>3290</td>
</tr>
</tbody>
</table>

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

![Bar chart showing electricity consumption (kWh)]

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

Week1 (23-May) 48.0
Week2 48.0
Week3 51.3
Week4 52.3
Week5 49.9
Week6 (20-June) 52.3
Week7 50.4
Week8 137.5
Week9 43.9
Week10 48.6
Week11 53.1
Week12 (10-Aug) 52.3
Week12 (10-Aug) 52.7

Yield (Kg)

Temp (C)

Average Max Temp (C) Records inside Net house
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)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Establishment cost (US$)</th>
<th>Annual depreciation (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CGH</td>
<td>NH-RZAC 24V Hybrid</td>
</tr>
<tr>
<td>Greenhouse frame &amp; cover</td>
<td>10,870</td>
<td>6,793</td>
</tr>
<tr>
<td>Irrigation system</td>
<td>796</td>
<td>548</td>
</tr>
<tr>
<td>Root Zone Cooling</td>
<td>0</td>
<td>1,902</td>
</tr>
<tr>
<td>Evaporative cooling system</td>
<td>2,717</td>
<td>0</td>
</tr>
<tr>
<td>Hydroponics system</td>
<td>815</td>
<td>815</td>
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<tr>
<td>Total Establishment</td>
<td>15,198</td>
<td>10,058</td>
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