Solar Powered Water System and solar eco-community

Tsinghua University
Renewable Energy Promotes Ecosystem Restoration Project Team

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Drought land – Water - Irrigation-Energy

- Irrigation can increase yields of most crops by 100 to 400 percent. Farmers who switch from surface irrigation to localized irrigation can cut their water usage by 30 to 60 percent.

- It is estimated that poor drainage and irrigation practices have led to waterlogging and salinization of about 10 percent of the world’s irrigated lands, thereby reducing productivity.

- In many areas of developing countries, power grids are unavailable, and diesel pumps for irrigation are expensive and heavily polluted.
Solar pump

Solar-water-land nexus

Figure 4. Solar water pumping system. Image credit: Energy and Development Group.
Factors affecting irrigation area:
1. The underground water level;
2. Types of crops;
3. Pump capacity;
4. Water-saving irrigation technology;
5. Photovoltaic power potential

Data: the calculation is based on the parameter of Tianyuan Co., LTD.
### Potential Benefits for Different Crops

The calculation is subject to the condition:
- Water head = 30 Meter
- Irradiation = 1500KWh
- Pump utilization rate = 33%

<table>
<thead>
<tr>
<th>Crops</th>
<th>Yield (ton/ha)</th>
<th>Water (m³/ton)</th>
<th>Water (m³/ha/year)</th>
<th>Total Water (m³/KM²)</th>
<th>PVs (KW)/ha</th>
<th>PVs (KW)/KM²</th>
</tr>
</thead>
<tbody>
<tr>
<td>One KM² Rice</td>
<td>3.90</td>
<td>1673</td>
<td>6524</td>
<td>652400</td>
<td>2.88</td>
<td>288</td>
</tr>
<tr>
<td>One KM² Maize</td>
<td>4.47</td>
<td>1222</td>
<td>5462</td>
<td>546200</td>
<td>2.4</td>
<td>240</td>
</tr>
<tr>
<td>One KM² Wheat</td>
<td>2.74</td>
<td>1828</td>
<td>5008</td>
<td>500800</td>
<td>2.16</td>
<td>216</td>
</tr>
<tr>
<td>One KM² Soybean</td>
<td>2.24</td>
<td>2145</td>
<td>4804</td>
<td>480400</td>
<td>2.16</td>
<td>216</td>
</tr>
<tr>
<td>One KM² Potato</td>
<td>59</td>
<td>59</td>
<td>3500</td>
<td>350000</td>
<td>1.56</td>
<td>156</td>
</tr>
</tbody>
</table>

Note: The parameter (Yield, water per ha) in the calculation is based on the report of FAO.
Pumping systems typically have a 20-year lifespan, higher initial investment (barrier)  
- Solar pump will be paid back within 3 years.  
- Additionally, solar pumping is more attractive than diesel pump in terms of the environmental costs from carbon dioxide (CO2) emissions and lost production costs from system downtime.
Case 1: Solar Pump for Restoration in Ordos Desert

Remarkable transition achieved in 2016

● Solar pumping system was proved to be very suitable in the desert region, it can be used for planting vegetable, fruit, grasses, herbs and other economic crops, which can produce ecological and economical benefits.

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar Panels (kW)</th>
<th>Head (m)</th>
<th>Water (ton/day)</th>
<th>Crops</th>
<th>Size (ha)</th>
<th>Survival Rate</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>3</td>
<td>30</td>
<td>85</td>
<td>watermelon</td>
<td>42.5</td>
<td>92%</td>
<td>micro-spray and drip irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>camphor pine</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>controlled group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(more than 2 times of water)</td>
<td>62%</td>
<td>traditional pumping and broad irrigation</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>7.5</td>
<td>30</td>
<td>220</td>
<td>vegetable</td>
<td>809</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>alfalfa and corn</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Shenzhen Tianyuan technology co., LTD.
Case 2: Solar Water Pump and Agriculture in Zimbabwe

- The system generates 2,628 KWh annually.
- The photovoltaic irrigation project directly created 11 jobs for the town and was also beneficial to the local vegetable vendors working in downstream industries.

Source: Shenzhen Tianyuan technology co., LTD.

### Table: Solar Water Pump and Agriculture in Zimbabwe

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar Panels (kW)</th>
<th>Head (m)</th>
<th>Water (ton/day)</th>
<th>Crops/Livestock</th>
<th>Size</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3.2</td>
<td>25</td>
<td>30 m$^3$/day</td>
<td>green peppers,</td>
<td>4.5 acres</td>
<td>drip irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>canola, kale,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>spinach, tomatoes,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>beans, other</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>vegetables.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>broiler chickens</td>
<td>4000</td>
<td></td>
</tr>
</tbody>
</table>
Challenges in No-electricity Communities

- Limited access to healthcare services and medicine
- Riskily exposed to malaria, tuberculosis and other diseases
- Lack of public health awareness and medical knowledge

- Lacking access to safely managed sanitation facilities
- Lacking access to safely managed drinking water services
- Lacking access to basic sanitation services, such as toilets or latrines

- Backward education facilities, e.g. no electricity
- Low-effective learning environments

Goal 3: Good Health and Well-being
Goal 4: Quality Education
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy

* 900 million people lack access to clean cooking. (Africa Energy Outlook 2019, IEA.)
* Two most commonly used fuels for cooking are wood (deforestation) and farm residue, representing 74% and 12% respectively. (Adkins, 2012)
* Use of polluting fuels such as coal, wood for cooking and indoor space heating cause severe Household Air Pollution which negatively affects human health. (Buthelezi, 2019)
13% of the global population lacks access to modern electricity, especially in Sub-Saharan Africa, 50% of the people live in the dark. (Source: https://www.un.org/sustainabledevelopment/energy/)

Power grid is expensive and unavailable.

Solar energy is affordable, clean, sustainable and easily available!
Solar Empowers Family

1. Lighting
2. Reading lamp
3. TV
4. Phone
5. Radio
6. Fan
7. Anti-mosquito lamp
8. Computer
9. Refrigerator
10. Electric bicycles
11. Motorcycles
12. Cooking

Basic Model: Daily Electricity Consumption (Wh/day)

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Lighting</th>
<th>Reading Lamp</th>
<th>TV</th>
<th>Phone</th>
<th>Radio</th>
<th>Fan</th>
<th>Anti-mosquito Lamp</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>2.5 W</td>
<td>5 W</td>
<td>12 W</td>
<td>10 W</td>
<td>5 W</td>
<td>10 W</td>
<td>5 W</td>
<td>45 Wh</td>
</tr>
<tr>
<td>Duration</td>
<td>6h</td>
<td>4h</td>
<td>6h</td>
<td>6h</td>
<td>6h</td>
<td>6h</td>
<td>6h</td>
<td>337 Wh</td>
</tr>
</tbody>
</table>

Basic Model: 337 Wh/day

One Family: 400 Wp; 600 kWh/year

Two solar panels can support a family’s daily life! ($336)

Solar Battery

Two solar panels can support a family’s daily life!
Upgraded Model:  Family with Modern and Convenient Household Appliances

One Family: 400 Wp; 600 kWh/year

Eight solar panels guarantee a family’s modern life!
“Solar +” and Sanitation & Public Health

- Anti-mosquito Lamp
  - Reducing the transmission of malaria, tuberculosis and other diseases

- Solar Water Purification
  - Accessing to safely managed / health drinking water services

- Solar Vaccine Refrigerator
  - Accessing to medical resources and services, such as vaccine

- Electric Bicycle with Medicine Cabinet
  - Accessing to clean and modern medical facilities

- Solar Clinic

Limited Access to Healthcare Services and Medicine

No Clean Drinking Water

Outdated Medical Facilities

Accessing to safely managed / health drinking water services

Accessing to medical resources and services, such as vaccine

Accessing to clean and modern medical facilities
The use of solar energy in agricultural production, agricultural product processing and storage has increased the agricultural value chain.

The e-commerce of agricultural products further extends the value chain which goes beyond space constraint.
The cost of PV has dropped significantly compared to the last decade.

The cost of SPIS system has been thus greatly reduced and its cost-effectiveness has been significantly improved.

The percentage of the grant will drop down, making access to finance easier.

Establish a measurable market mechanism for the ecological public goods.
Business Model for Deployment of SPIS

The introduction of financial leasing companies makes access to finance easier.

1) Financial leasing companies buy SPIS from the vendors in bulk and access loans from the banks.

2) SPIS are leased to cooperatives with several farmers or individual farmers by FLC.

3) Farmers pay small monthly instalments during the growing season and more after the harvest.

4) Government subsidizes to farmers and FLC.

5) Government can optimize policy to manage water and soil, according to the information provided by the monitoring system integrated in SPIS.
Thank you

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