Benefits of Intercropping in Solar Facilities

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Solar Energy

- Lower carbon emissions than fossil fuel generation
- LCOE decreasing
- Larger land footprint
- Long-time commitment of land
- Integration with other land uses

Advantages

Disadvantages

Mitigation
Large solar installations: Land Use

13 Km² site in Mojave desert


One million ha of direct land transformation in US by 2030 target of 350 GW
India - target of 200 GW by 2050 (PV & CSP)
Large solar installations: Water Use

Water additions equivalent to 100 mm of rainfall/year in some systems
Impacts on Soil & Hydrological processes

![Diagram showing impacts on soil and hydrological processes.](image)
Solar Centric or Crop Centric
Land and water use efficiency, socio-economic & environmental co-benefits

**Key question:** Identifying suitable crops

- Ecological and physiological adaptations (e.g. CAM photosynthesis) to achieve economical yields on marginal lands
- High demand & existing markets
- Low growth stature
- Low maintenance and long crop cycle
- Tolerate shade, drought, high temperature
- Respond well to light irrigation events

*Panicum virgatum* (switchgrass), *Aloe vera*, *Agave sp*
Example 1: Solar – Agave Colocation

- Life cycle analysis of water, energy, emissions and economic feasibility
- Water inputs for solar are sufficient
- Electricity (solar) and liquid fuel (agave)
- More $ per unit of water use
- Biofuels in marginal lands

Ravi et al; Environmental Science & Technology (2014)
Example 2: Colocation of solar PV and Aloe Vera in India

The uncertainty in Net Present Value (NPV) determined by Monte Carlo analysis that varied the most important parameters, as determined by sensitivity analysis. (Ravi et al. 2016 Applied Energy)
Example 3: In the tropics

**Rural Electrification Challenges**

Over 70 million Indonesians do not have access to a consistent electricity supply.

<table>
<thead>
<tr>
<th>Region</th>
<th>Electrification Ratio (2012)</th>
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<tbody>
<tr>
<td>(PLN+ Non PLN)</td>
<td>73.7% 72.8% 79.9%</td>
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Category:
- >60%
- 41-50%
- 20-40%

Over 80% live in rural areas and over half live outside of the dominant economic centers.
Indonesia: PV - Patchouli Colocation

• Patchouli (*Pogostemon cablin*)
  • Extensively cultivated
  • Expensive essential oil
  • Physiologically viable
  • Tolerate shade

• Crop centric approaches
Environmental benefits

GHG offsets from solar PV against grid emissions

GHG offsets from solar PV against emissions from diesel generation

GHG emissions from solar PV

GHG emissions from patchouli oil production

GHG emissions and offsets (Mg CO$_{2eq}$ ha$^{-1}$ yr$^{-1}$)
Potential socioeconomic benefits

Energy flow in gigajoules (GJ)

Energy input, 345

PV energy output, 2055

Household, 678

Surplus, 1223

Productive, 116

Social, 38

Coffee mill, 63
Carpenter, 43
Restaurant, 6
Kiosk, 2
Tailor, 1
School, 22
Hospital, 14
Comm.infra, 1
Towards “life style centric” approaches to integrate renewable energy services in rural communities
Synergies of colocation

- Maximize efficiency of land and water use
- Deploying non-food crops in marginal lands
- Rural electrification & Employment generation
- Lower panel temperatures from crop cooling
- Other potential synergistic factors: rainfall concentration, reduced soil erosion, shading in extreme arid environments.

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