Abstract

The levelized cost of energy (LCOE) is widely used to compare the cost of energy generation across technologies. In a utility-scale concentrating photovoltaic (CPV) system, spacing dual-axis trackers must be balanced with total energy harvested from modules to minimize LCOE. In this paper, a spacing method of dual-axis trackers in a CPV system is presented. Based on definition of LCOE, a cost function is defined and optimized in terms of spacing related parameters. Various methods to estimate hourly direct normal irradiance (DNI) are investigated and array configuration to minimize the cost function are discussed.

Motivation

- Model CPV systems with dual-axis trackers
- Model accurate direct normal irradiation
- Model self-shading loss
- Find the function to reach the optimum solution
- Find optimal spacing of a tracker array
- Expend modeling to m-by-n tracker array

Cost Function

- Defined as
  
  \[ CF = \frac{\int_{t_1}^{t_2} P(t)dt}{(t_2 - t_1)P_{max}} \]

  \[ GCR = \frac{\sum A_{Module}}{A_{land}} \]

  \[ LCOE = \frac{1 + k/GCR}{CF} \]

Direct Normal Irradiance (DNI)

- Highly concentrating PV systems accepts only direct normal irradiation due to their narrow acceptance angle
- Method to estimate DNI
   - \( I_0(n) \): extraterrestrial radiation
   - \( W(n) \): weather function
   - \( AM \): air mass, \( \theta \): elevation angle

\[ I_0(n, \alpha) = I_0(n)W(n)0.7AM(\alpha)^{0.4/\theta} \]

Shadow by a Tracker Array

- m-by-n tracker array
  - Control: \( \Delta X \) and \( \Delta Y \)
  - Mapping: m-by-n by 3-by-3 array
- Mapping method

Simulation Results

- Shading by a tracker array
  - Darker color indicates more frequent shading
- Minimum cost function according to k

Dual-axis Tracker

- Geometry
  - \( h = 4.22 \text{m} \)
  - \( w = 4.72 \text{m} \)
  - \( P = 2.50 \text{m} \)

- Shadow by a dual-axis tracker

Variables of a tracker array

- North-south spacing: \( \Delta X \)
- East-west spacing: \( \Delta Y \)
- Geometry of trackers
- Geometry of CPV modules