Sustainability Analysis of Solar Power Projects

Maneesh Reddy Thipparthi, Prasad Pokkunuri

Introduction:

- The solar energy sector is going to play a vital role in the world moving towards a sustainable future. Owing to the high capital-intensive nature of these power plants, a sustainability analysis would be a necessary task before they set these up so that they can sustain for a longer time without facing any major trouble.
- Multi-criteria Decision Making (MCDM) methods are a class of methods that have proven very useful in solving decision making problems that have conflicting criteria.
- These methods rank available alternatives by applying specific algorithms to multiple criteria values after assigning suitable weights (relative importance) to every individual criterion.

Previous Work:

- MCDM methods such as Weighted Sum Method (WSM), Weighted Product Method (WPM), Weighted Aggregated Sum Product Assessment (WASPAS), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) have been previously used to rank 5 solar power projects in India and China for their sustainability.
- 3 different weighting methods were used for a total of 10 sustainability criteria that included technical, economic, environmental, and social factors.
- The mode of ranks obtained by different methods gives the final ranking for each power plant.

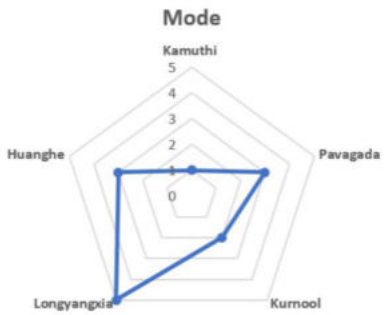

Figure 1. Final Ranking

Objective:

- To study the effect of changes in criteria weights on the final rankings of the alternatives by performing a Sensitivity Analysis.
- To perform a Trade-Off ranking, to deal with multiple conflicting factors.

Methodology:

- Sensitivity Analysis:
  1. Apply MCDM methods to rank the alternatives.
  2. Determine the most critical/important criteria.
  3. Weight of the most important criterion is varied within a feasible range and all other criteria weights are adjusted equally.
  4. New rankings are computed for these changing criteria weights using the MCDM methods.
  5. Local and global weight stability intervals are computed.
- The local weight stability interval indicates the range of weights within which the rank of the best alternative remains unaltered, whereas, the global weight stability interval indicates the range of weights within which the overall rank order of all the alternatives remains unaffected.
- Trade-Off Ranking:
  1. Calculate the distance from one point to all other points in the objective space.
  2. Sum the distances of points of one alternative to all the other alternatives and is considered as the degree of trade-off (DT).
- The trade-off ranking of each alternative is determined by the value of DT with respect to the others. The least value of DT holds the highest ranking.

Results:

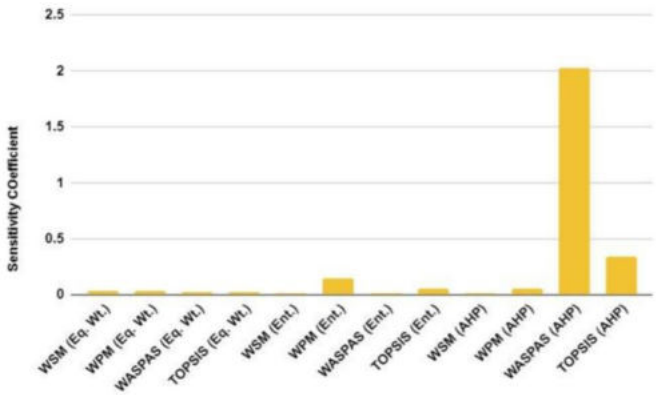

Figure 2. Distribution of sensitivity coefficient for critical criteria

- Order of Robustness:
  1. Equal Wt.: TOPSIS > WSM = WASPAS > WPM
  2. Entropy Wt.: TOPSIS > WSM > WASPAS = WPM
  3. AHP Wt.: WPM > TOPSIS = WSM > WASPAS

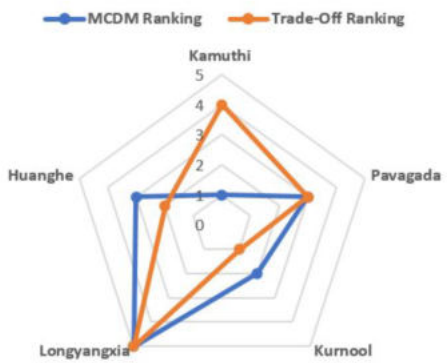

Figure 3. Comparison of MCDM and Trade-Off Ranking

Conclusions:

- Studied the robustness of these MCDM methods.
- The optimal solution obtained from Trade-Off ranking is different from the best solution obtained from MCDM methods and has the least compromise.

Important References:

- Triantaphyllou, E. and Sánchez, A. (1997), A Sensitivity Analysis Approach for Some Deterministic Multi-Criteria Decision-Making Methods. Decision Sciences, 28: 151-194
- Jaini, N, Utyuzhnikov, S. Trade-off ranking method for multi-criteria decision analysis. J Multi-Crit Decis Anal. 2017; 24: 121– 132

maneeshreddy160355@mechyd.ac.in
prasad.pokkunuri@mahindrauniversity.edu.in

Research carried at Mahindra University