Comparative Analysis of Fixed versus Tracking Solar panels: Efficiency, Cost and Sustainability

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This study compares fixed and tracking solar panel systems in terms of energy efficiency, cost-effectiveness and sustainability. The study uses Levelized Cost of Energy (LCOE) as the primary metric to assess the economic performance of both systems. It is a widely accepted measure for assessing the cost-effectiveness of energy generation technologies, providing a standardized way to compare costs across different setups. Among the systems studied, one-axis tracking systems offer the best balance of cost and efficiency, especially for large-scale projects in terms of LCOE.

The aim of this study is to conduct an economic comparative analysis of photovoltaic energy production across four European countries. This study uses LCOE, that accounts for the total lifetime costs of solar systems (installation, maintenance, and operation) relative to the energy they generate. It evaluates the economic performance of the system, with a lower LCOE indicating cheaper, more competitive solar energy generation. This study presents various methodologies for assessing profitability, alongside key economic parameters, and compares four distinct PV configurations using the widely accepted formula:

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_O + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \quad (1)$$

where I_0: investment expenditures in the year t; M_t: operations and maintenance expenditures; F_t: fuel expenditures in the year t; E_t: electricity generation in the year t; r: discount rate and n: economic life of the system.

The results demonstrate that while fixed solar panels are simpler and cheaper, tracking systems considerably boost energy output. This study focuses on calculating the LCOE for each location and identifying the most cost-effective tracking system. In terms of energy production costs based on the assumed investment and maintenance expenses in Figure 1, the most optimal configurations are one-axis tracking systems for large-scale solar projects. While in energy output as shown in Figure 2, two-axis tracker has the highest output among the others. They come with a significantly higher LCOE making them less attractive from an investment standpoint.

This study also denotes that future research should address the long-term degradation of photovoltaic (PV) modules, explore the integration of battery storage and hybrid systems to further improve the sustainability and economic viability of solar energy solutions.

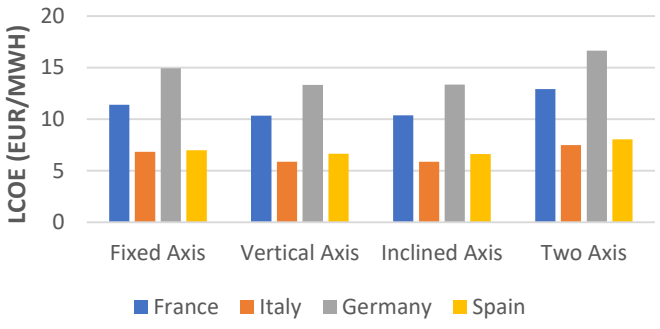

Figure 1. Detailed breakdown of LCOE by country.

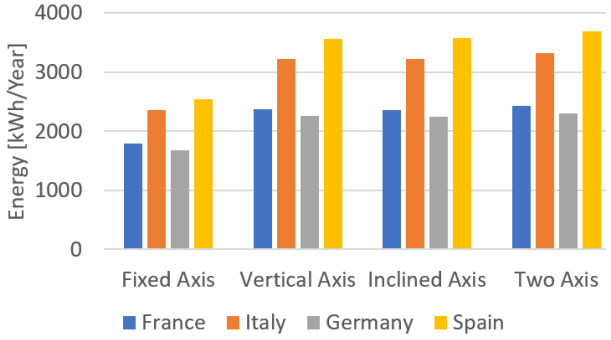

Figure 2. Detailed breakdown of yearly energy output by country.

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