



Solar energy production in EU + countries using space–time forecasting

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Abstract

The need for renewable energy is underscored by the shift from fossil fuels without compromising economic growth. The European Union's strategy for resilient energy recognizes solar energy as a crucial resource. In recent years, there has been a significant focus on evaluating renewable energy production, distribution, consumption, storage, and applications. One key aspect of this evaluation is exploring production capacity trends using forecasting models. Our study proposes a space–time forecasting approach using the Curve Fit Forecast tool integrated in ArcGIS Pro 3.3, applied to solar energy in 37 European locations based on 1990–2022 data. The model tested four curved types and identified exponential growth patterns in 54% of cases, with consistent upward trends confirmed through RMSE validation. Outlier detection and 3D spatial–temporal visualization provide diagnostic insight into regional disparities and transformation regimes. This digitally enabled, geostatistical method aligns with the EU's data-driven energy transition agenda, offering a scalable and interpretable tool for policymakers and planners.

Keywords Renewable energy · Solar energy · Curve Fit Forecast · Space–Time Cube · EU resources · Digital forecasting · Energy transition · Spatial analysis

1 Introduction

European Union (EU) is at a crossroads in energy policy development. While the world is plagued with increasing environmental worries, increasing global geopolitical instability, and the fact that fossil fuels are finite, there is an urgent need for a paradigm shift to the use of renewable energy

sources. Historically, the energy policies of EU member states have been focused on the utilization of non-renewable energy sources such as coal and shale gas, and oil, commodities that are not only crippling to the environment but also economically frisky. Given the crying need for a more sustainable and self-sustaining energy footprint, solar energy has emerged as a strategic priority and key focus of the hefty European ambition for climate neutrality by 2050 [1].

The switch to a renewable-based energy sector is not only essential in environmental affairs but also economically and politically strategic. Solar energy, in particular, has become more prominent due to its scalability, decreasing costs, and ability to produce local energy. Unlike fossil fuels, solar energy is not localized; instead, it is plentiful and easily accessible in Europe. In such a case, it provides a platform where energy security can be improved, greenhouse gas (GHG) emissions can be minimized, and green economic growth can be implemented. In 2022, the EU installed a record 41.4 GW of solar photovoltaic (PV) capacity, representing an increase of almost 50% year-on-year, underscoring the rapid growth of the sector [2].

The EU's ambitious goals, including a 55% reduction in GHG emissions by 2030 and a net-zero state by 2050,

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