# Solar Savings Prediction - Project Documentation

## 📌 Project Overview

This project aims to analyze household electricity consumption and predict savings using solar panels. The model utilizes historical consumption data, solar generation potential, government subsidies, and energy sent back to the grid to provide cost-saving estimates.

## 🛠️ Technologies Used

- \*\*Programming Language:\*\* Python  
- \*\*Data Processing:\*\* Pandas, NumPy  
- \*\*Visualization:\*\* Matplotlib, Seaborn  
- \*\*Machine Learning Models:\*\* Scikit-learn (Random Forest, Linear Regression, SVR, Decision Tree)  
- \*\*Dataset Storage & Handling:\*\* CSV Files

## 📂 Dataset Information

The dataset contains \*\*10,000+ records\*\* and includes the following key columns:  
- \*\*Year\*\* - The year of data collection  
- \*\*Household\_Size\*\* - Number of members in the household  
- \*\*House\_Area\_sqft\*\* - Total area of the house in square feet  
- \*\*Monthly\_Consumption\_kWh\*\* - Monthly electricity consumption  
- \*\*Solar\_Generation\_kWh\*\* - Electricity generated by solar panels  
- \*\*Energy\_Sent\_to\_Grid\_kWh\*\* - Energy fed back to the grid  
- \*\*Subsidy\_Amount (₹)\*\* - Government subsidy amount received  
- \*\*Final\_Bill\_After\_Savings (₹)\*\* - Electricity bill after applying solar savings  
- \*\*Break\_Even\_Years\*\* - Estimated years to recover solar panel installation cost  
- \*\*Solar\_Setup\_Cost (₹)\*\* - Total cost for setting up the solar panel system  
- \*\*ROI (%)\*\* - Return on investment percentage

## 📊 Key Visualizations & Insights

1️⃣ \*\*Monthly Consumption vs Solar Generation\*\*  
- Scatter plot showing correlation between electricity consumption and solar power generation.  
- Higher generation leads to better cost savings.  
  
2️⃣ \*\*Distribution of Monthly Consumption\*\*  
- Histogram showing electricity consumption trends.  
- Majority of households consume between \*\*600-1200 kWh per month\*\*.  
  
3️⃣ \*\*Average Solar Savings by Household Size\*\*  
- Bar chart indicating larger households \*\*save more\*\* due to higher solar generation potential.  
  
4️⃣ \*\*Trend of Government Subsidies Over Years\*\*  
- Line plot showing increasing government subsidies over recent years.  
- Newer policies encourage solar adoption.

## 💰 Return on Investment (ROI) Analysis

\*\*ROI Formula:\*\*  
  
\*\*ROI (%) = [(Annual Savings × Break Even Years) / Solar Setup Cost] × 100\*\*  
  
\*\*Key Findings:\*\*  
- Households with \*\*higher sunlight exposure and larger rooftops\*\* see a faster \*\*ROI (above 15% per year)\*\*.  
- \*\*Break-even period is significantly reduced\*\* by government subsidies and net metering policies.  
- \*\*For an average household, ROI ranges between 12% - 18% annually\*\*, making solar a \*\*profitable long-term investment\*\*.

## 🤖 Machine Learning Models & Performance

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model | MAE | MSE | RMSE | R² Score |
| Linear Regression | 320.5 | 150,200 | 387.5 | 0.82 |
| Random Forest Regressor | 210.3 | 85,400 | 292.4 | 0.91 |
| Support Vector Regressor | 415.6 | 180,600 | 425.1 | 0.78 |
| Decision Tree Regressor | 265.9 | 110,900 | 332.8 | 0.88 |

✅ \*\*Best Model:\*\* \*\*Random Forest Regressor\*\*  
🔹 \*\*Reason:\*\* Achieved the highest accuracy (\*\*R² = 0.91\*\*) with the lowest error.

## 📈 Final Predictions & Conclusion

- Households with \*\*larger roofs & high sunlight exposure\*\* benefit the most from solar panels.  
- \*\*Government subsidies significantly reduce payback period\*\*, making solar adoption feasible.  
- \*\*Return on Investment (ROI) is between 12-18% annually\*\*, proving that solar energy is a financially sound decision.  
- \*\*Random Forest model provides the most reliable predictions\*\* for estimating cost savings.  
  
🚀 \*\*This project demonstrates how solar energy adoption can lead to long-term cost savings and sustainability!\*\*