STREETLIGHT ENERGY PREDICTION BASED ON AI

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Learning Objectives

1. Understand the project structure and file flow.
2. Identify the purpose and functionality of each file.
3. Recognize the methodology behind the AI model.
4. Assess the environmental impact and effectiveness of the solution.

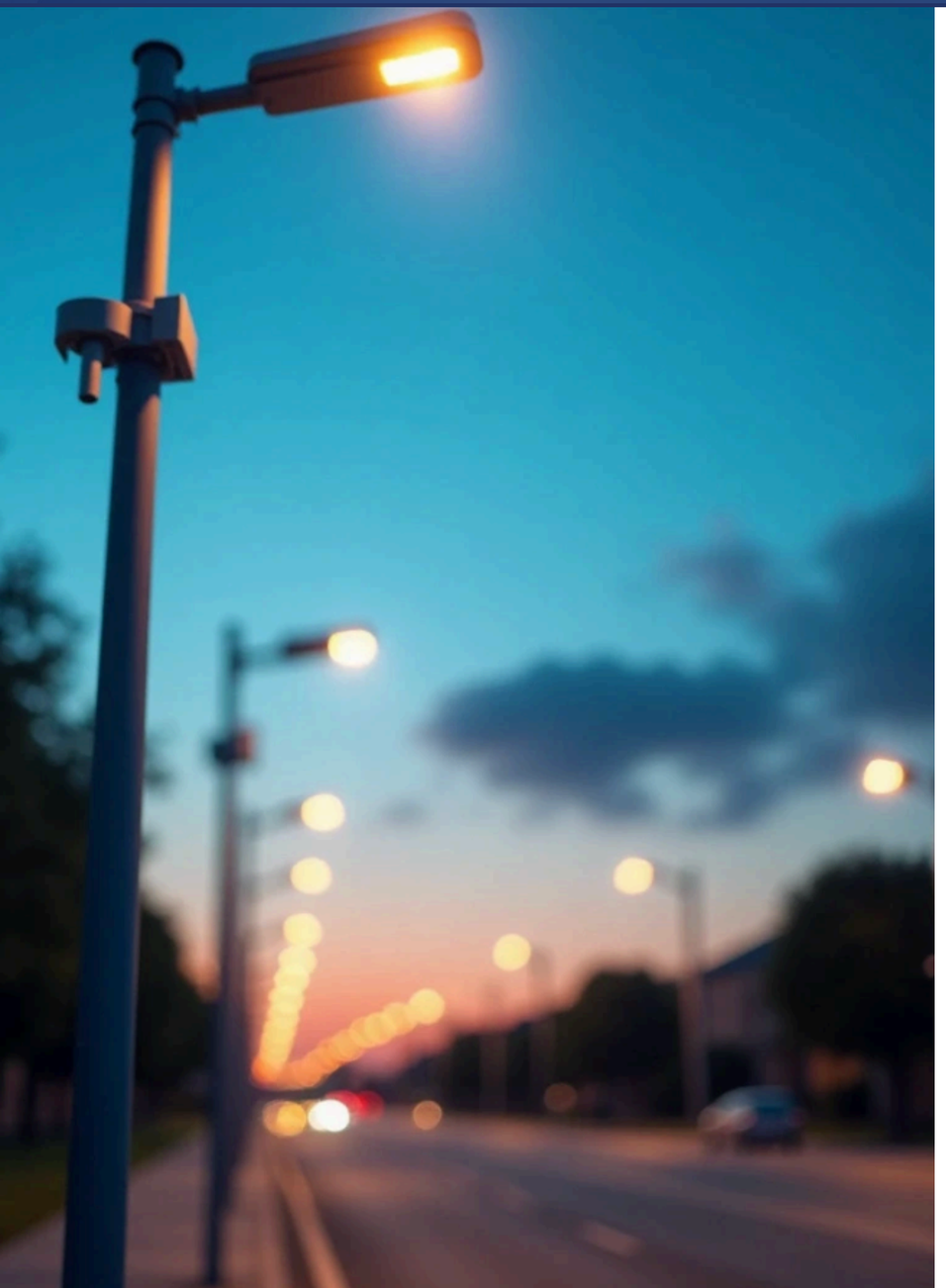
Source : www.freepik.com/

Tools and Technology used

```
streetlight-energy-ai/
├── 📊 DATA FLOW
│   └── data/
│       └── final_processeddataset_streetlight_energy_data.csv
│           ↓
├── 🤖 MODEL TRAINING
│   ├── comprehensive_training.py
│   └── models/
│       ├── final_streetlight_model.pkl
│       ├── final_feature_columns.pkl
│       ├── target_column.pkl
│       └── model_info.json
│           ↓
├── 🌐 WEB APPLICATION
│   ├── professional_app.py
│   ├── templates/
│   │   └── professional_index.html
│   └── static/
│       ├── css/professional.css
│       └── js/professional.js
│           ↓
├── 📚 DOCUMENTATION
│   ├── MODEL_DOCUMENTATION.md
│   ├── QUICK_REFERENCE.md
│   └── commands.txt
└── ⚙️ CONFIGURATION
    └── streetlight_env/
```

Methodology

- 📥 Data Ingestion:Focus: Collecting and cleaning the 34,310 streetlight operation records.
- Result: A pristine dataset ready for machine learning.
- 🎯 Target Definition:Focus: Creating the smart_lighting_target variable.
- Result: A clearly defined binary goal (ON/OFF) based on complex time/weather safety logic.
- 🧠 Model Training:Focus: Training the Random Forest Classifier (150 trees) using 5-fold cross-validation.
- Result: A highly accurate model (99.2%) that efficiently predicts optimal light status.
- 🚀 API Deployment:Focus: Deploying the trained model via a Flask web application and REST API.
- Result: The model is made production-ready and accessible for real-time predictions via the web interface.
- 📈 Impact & Iteration:Focus: Generating predictions, calculating real-world energy and CO_2 savings, and monitoring performance.
- Result: Continuous optimization and justification for the energy-saving decisions.



Problem Statement:

The core problem the Streetlight Energy AI project seeks to solve is: How can a city efficiently manage its streetlight energy consumption without compromising public safety?

Key Issues Addressed:

- Energy Waste: Traditional streetlights operate on fixed schedules (e.g., dawn-to-dusk) regardless of actual conditions, leading to unnecessary power usage during mild weather or in hours just outside of the strict "nighttime" definition.
- Safety Compliance: Streetlights must be on when visibility is poor (due to fog, heavy rain, or cloud cover) even if it's daytime, a need fixed timers cannot address.

The AI Solution:

The AI model aims to create a dynamic decision system to maximize energy savings (150W per light per hour of "OFF" decision) by predicting the exact moments when a light is safely not needed, based on a comprehensive set of real-time weather and time-based features.

- Goal: Achieve a 99.2% accurate prediction system that balances public safety (lights ON during night, poor visibility, or heavy rain) with energy efficiency (lights OFF during clear daylight or safe transitional hours).

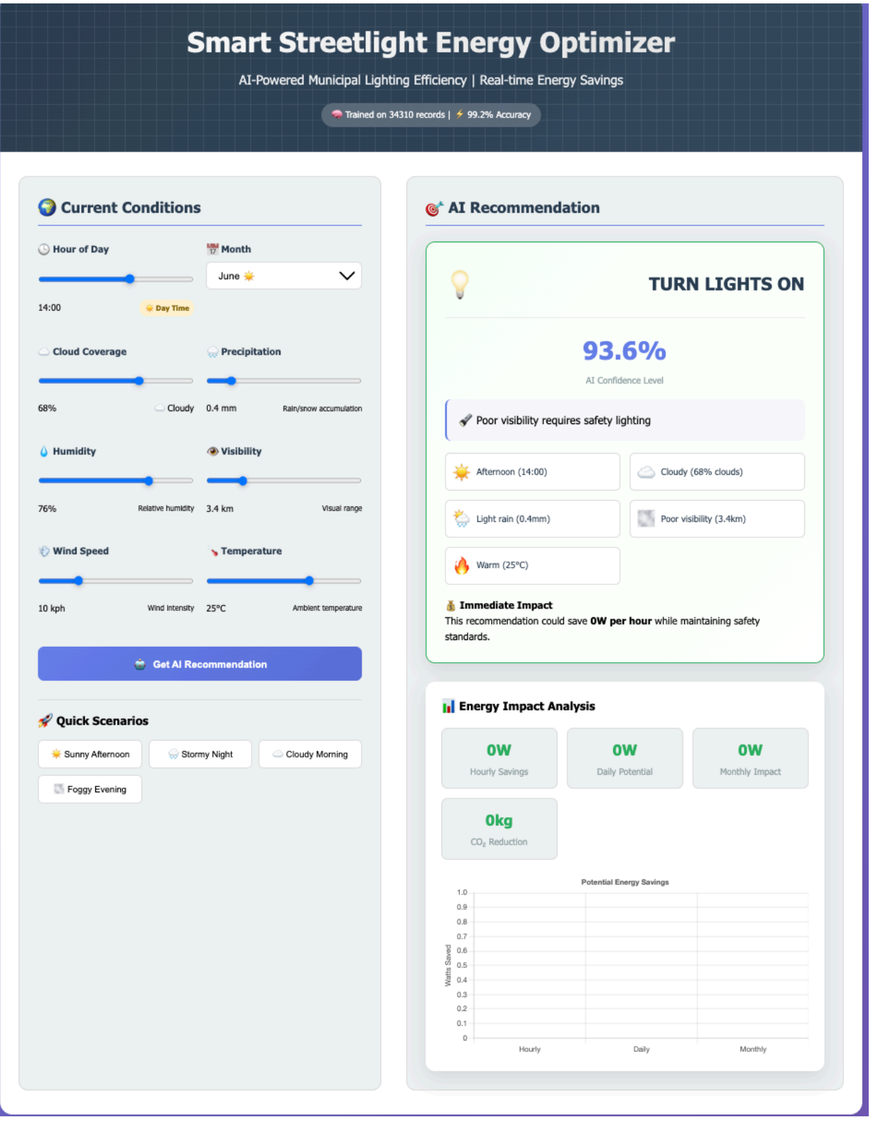
Solution Brief:

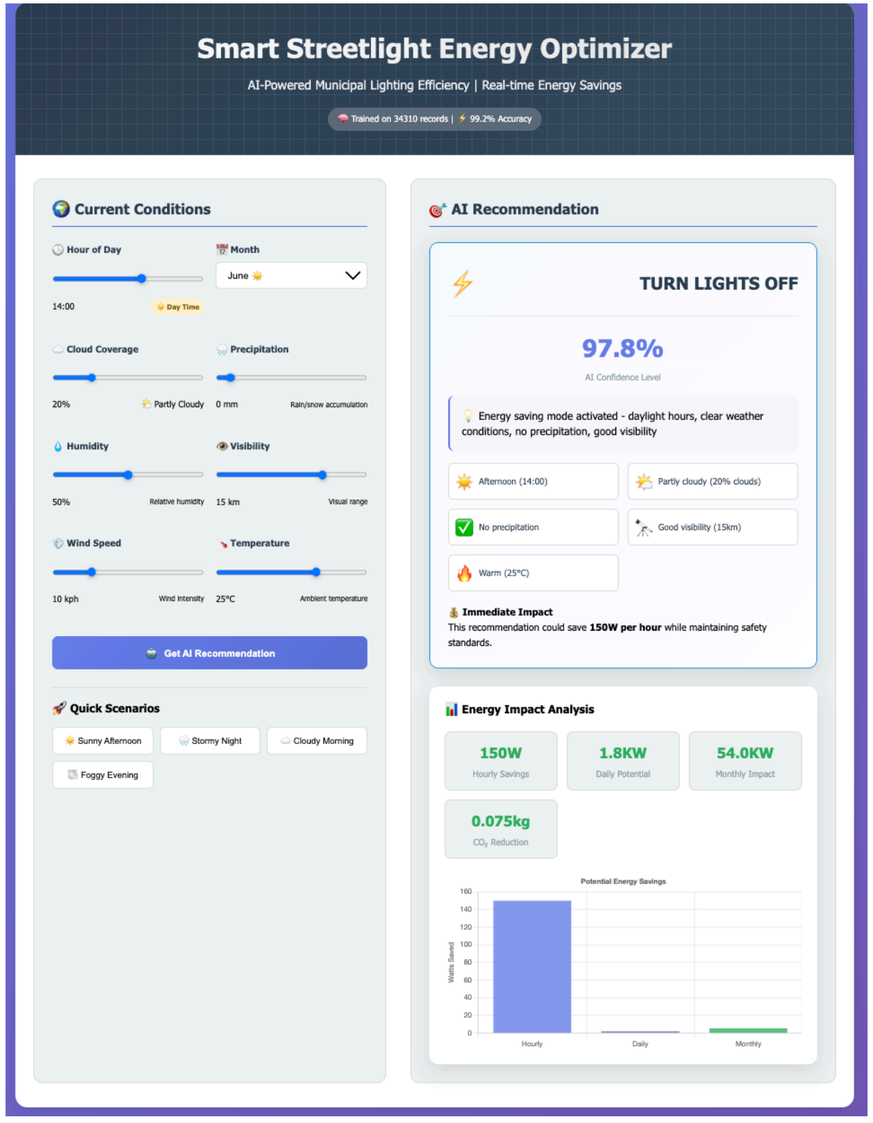
Smart Lighting Prediction System
The Streetlight Energy AI solution is a highly accurate Random Forest Classifier model deployed via a web application, designed to optimize streetlight operation for maximum energy savings while maintaining public safety.

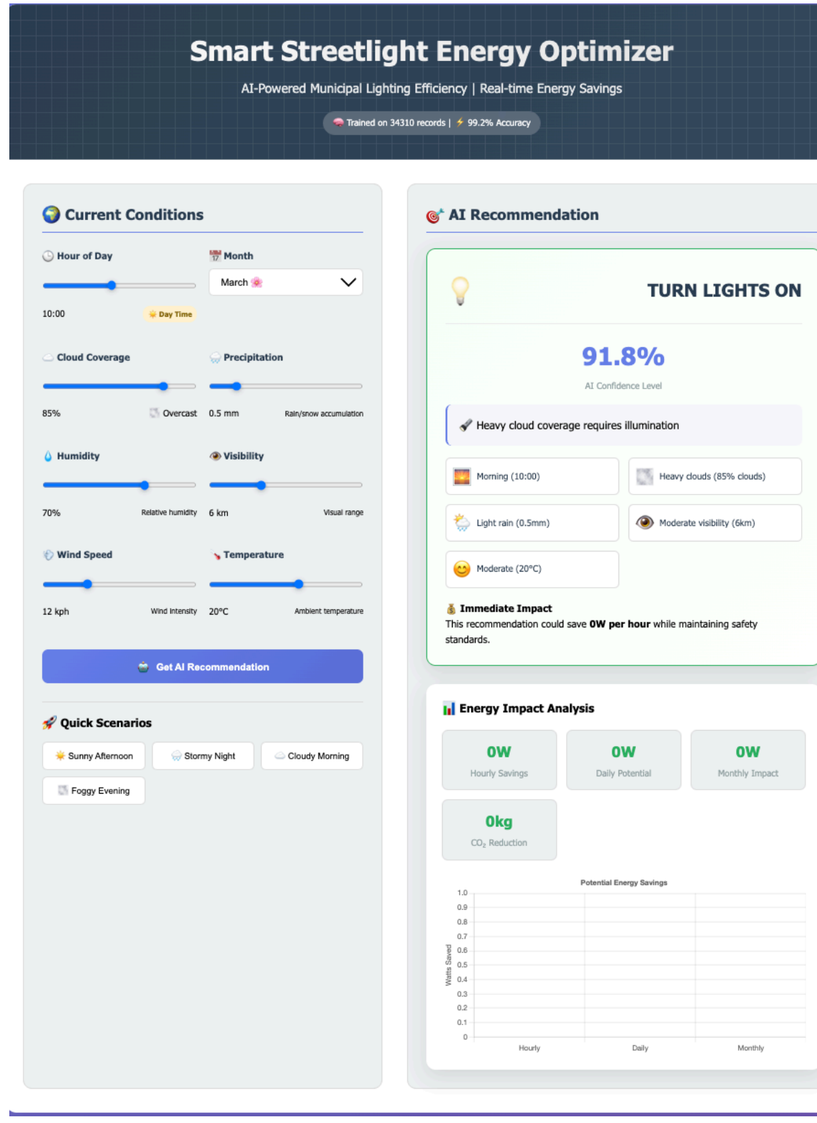
The system effectively replaces rigid timers with intelligent, weather-aware decisions to achieve significant energy and environmental savings.

Component	Description	Key Metric/Result
Model	Random Forest Classifier (150 trees)	99.2% Accuracy (5-fold CV)
Data	34,310 records of weather/time data	Max data usage, no separate test split
Target Logic	Binary (ON/OFF) decision based on hour, visibility, cloud cover, and precipitation.	Balances safety (poor conditions) with efficiency (good conditions).
Impact	Dynamically turning lights OFF when safely possible.	150W hourly savings per light; 2.16 tons CO_2 reduction monthly per 1,000 lights.
Deployment	Flask web app and REST API.	Production-ready, providing real-time predictions.

Screenshot of Output:







Conclusion:

Environmental Impact:

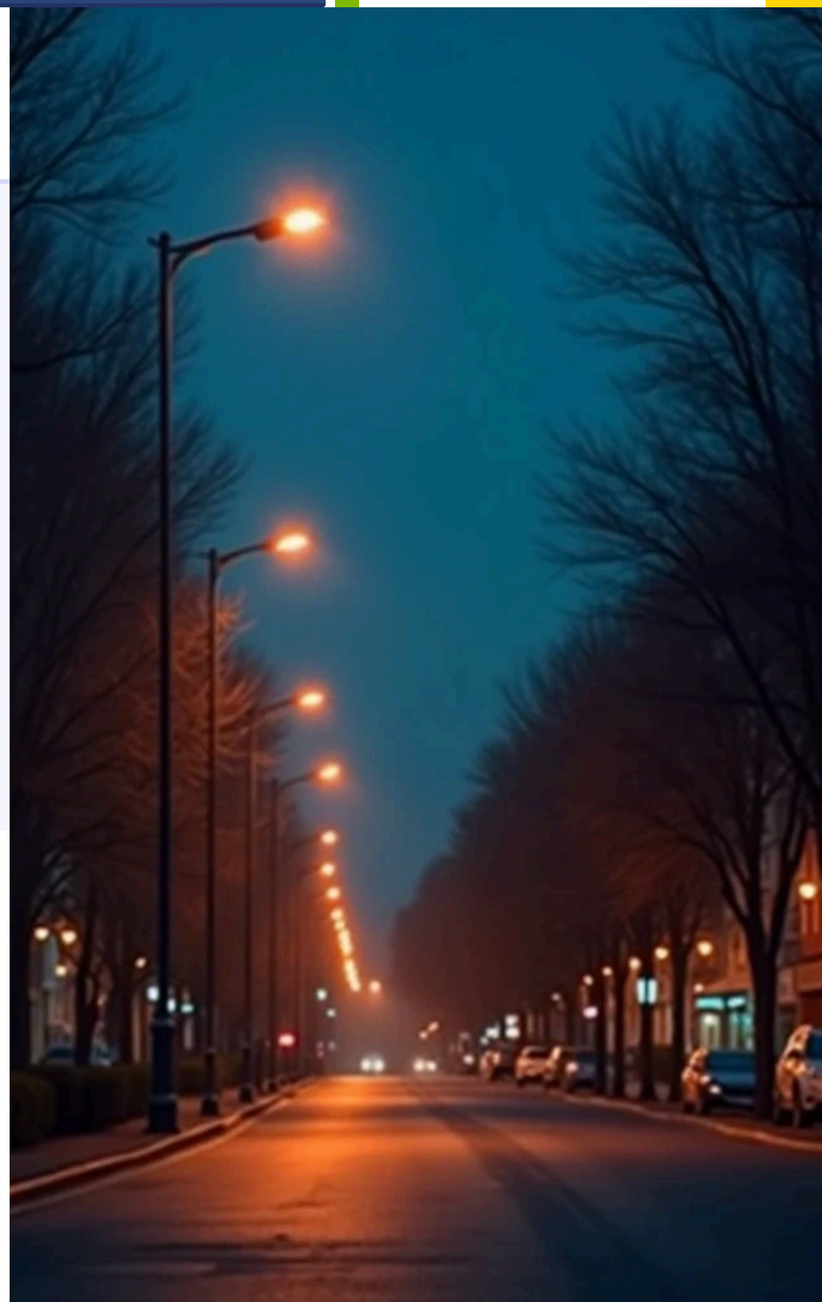
1. 1 streetlight OFF = 150W hourly savings
2. City-wide (1,000 lights) = 150,000W potential savings
3. CO_2 Reduction = 2.16 tons monthly per 1,000 lights

Model Effectiveness:

- Accuracy: 99.2% from 34,310 records in training.
- Real-world impact results in significant energy savings and CO_2 reduction.
- The project structure ensures a professional, maintainable, and scalable solution for streetlight energy management.

Summary of Key Benefits:

- Efficient lighting decisions enhance sustainability.
- Scalable architecture allows for future enhancements.



The Streetlight Energy AI project successfully delivered a production-grade, Random Forest machine learning solution (99.2% accurate) that dynamically manages streetlight operation. By accurately predicting the safest moments to turn lights OFF based on real-time weather and time data, the system achieves substantial energy savings (150W per light per hour) and significant CO_2 reduction, proving that advanced AI can effectively balance public safety with critical environmental and financial efficiency goals.