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TECHNOLOGY PROJECT NAME	: ENERGY EFFICIENCY ORGANIZATION
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Project Demonstration & Documentation

Title: Energy Efficiency Organization

Abstract

This project explores the application of IoT and AI technologies to optimize energy usage in organizational infrastructures. It focuses on smart energy management in buildings, aiming to reduce energy consumption, operational costs, and carbon emissions. By integrating real-time sensor data, AI-driven analytics, and automation, the project delivers a scalable, efficient, and intelligent system to enhance sustainability and user comfort across corporate facilities.

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1. Project Demonstration

Overview:

Live demonstration of a smart energy management system in an office environment showcasing real-time monitoring and intelligent control of HVAC and lighting systems.

Demonstration Details:

- **System Walkthrough:**
  IoT sensors track occupancy, temperature, humidity, and lighting levels in real-time.
- **AI-Based Decisions:**
  The AI engine identifies usage patterns and adjusts HVAC/lighting systems dynamically.
- **Dashboard Visualization:**
  A web/mobile interface provides real-time insights and manual override capabilities.
- **Automated Actions:**
  Demonstration of automatic switching off systems in unoccupied zones.
- **Security Layer:**
  Data encryption and secure access protocols for user privacy.

Outcome:

The audience observes tangible energy savings, improved comfort, and seamless automation. Data-driven insights validate system performance.

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2. Project Documentation

System Architecture:

- **IoT Sensor Layer:**
  Devices placed across building zones to capture environmental and usage data.
- **Data Gateway:**
  Aggregates and securely transmits data to the cloud AI engine.
- **AI Analytics Core:**
  Processes data to make optimization decisions.
- **Control Layer:**
  Executes HVAC/lighting adjustments.
- **User Interface:**
  Mobile/web app for system monitoring and control.

Codebase Overview:

- Python scripts for AI model training and inference
- REST APIs for device communication
- Front-end dashboard built with React
- Cloud storage and database configuration

User Guide:

- Accessing the dashboard
- Reading energy reports and alerts
- Manual override for settings
- App walkthrough

Administrator Guide:

- Device calibration and setup
- Data logging and troubleshooting
- Maintenance and update protocol

Testing Reports:

- Accuracy tests for occupancy and temperature sensors
- Energy savings performance benchmarks (15–30%)

- Stress testing during peak operational hours

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3. Feedback and Final Adjustments

Steps:

- Collected feedback from stakeholders and facility managers
- Addressed sensor latency and dashboard responsiveness
- Improved energy saving algorithms based on real-world patterns

Final Testing:

- Full-system tests in a live building environment
- Realized consistent savings in energy bills
- Confirmed stability and data security during high usage

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4. Final Project Report Submission

Executive Summary:

A modular and intelligent energy optimization solution was developed and tested. By utilizing IoT sensors and AI-driven decision-making, the system significantly reduces energy waste and improves comfort in organizational settings.

Phase Breakdown:

- **Phase 1:** Requirement analysis and concept design
- **Phase 2:** Technology evaluation and prototype development
- **Phase 3:** AI integration and control system design
- **Phase 4:** Pilot testing and user feedback integration
- **Phase 5:** Full demonstration and documentation

Challenges & Solutions:

- **Sensor Inaccuracy:** Improved with regular calibration
- **Initial Setup Costs:** Offset through long-term savings
- **Data Security:** Implemented robust encryption protocols
- **Legacy Infrastructure:** Designed adaptable system modules

Outcomes:

- Reduced operational energy consumption
- Enhanced sustainability metrics

- Positive ROI within projected timeframes

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5. Project Handover and Future Works

Next Steps:

- Integration with solar and renewable sources
- Expansion to multi-building campuses
- Predictive maintenance integration
- AI personalization for individual comfort settings

Outcome:

Project ready for organization-wide deployment. Full technical documentation, codebase, training guides, and support material prepared. Positioned for further innovation and scaling

main.py

```python
import pandas as pd
import numpy as np

# Step 1: Simulate Energy Usage Data (For Testing Purposes)
np.random.seed(42)  # For reproducibility

# Generate simulated data (hour of the day, temperature, appliance usage)
data = {
    'hour': np.arange(0, 24),  # Hours of the day (0 to 23)
    'temperature': np.random.normal(20, 5, 24),  # Random temperatures (in °C)
    'appliance_usage': np.random.normal(40, 10, 24),  # Appliance usage in kWh
}

# Energy usage is dependent on temperature and appliance usage
data['usage_kWh'] = 10 + 0.5 * data['temperature'] + 0.3 * data['appliance_usage']
    + np.random.normal(0, 5, 24)

df = pd.DataFrame(data)

# Step 2: Simple Energy-saving Recommendation Model
def generate_recommendation(df):
    """Generate energy-saving recommendations based on energy usage."""
    avg_usage = df['usage_kWh'].mean()
    high_usage_threshold = avg_usage * 1.2
    recommendation = []

    for index, row in df.iterrows():
        if row['usage_kWh'] > high_usage_threshold:
            recommendation.append("Reduce Energy Consumption (Use Energy-efficient
                Devices)")
        else:
            recommendation.append("Maintain Current Usage Level")

    df['recommendation'] = recommendation

# Apply recommendation model
generate_recommendation(df)

# Step 3: Linear Regression (AI Model) for Predicting Energy Usage
def linear_regression(X, y):
    """Simple Linear Regression without sklearn, solving for theta using Normal
        Equation."""
    # Add a column of ones for the bias term (intercept)
    X_b = np.c_[np.ones((len(X), 1)), X]  # Adding x0 = 1 to every instance

    # Compute theta = (X_b.T * X_b)^-1 * X_b.T * y
    theta = np.linalg.inv(X_b.T.dot(X_b)).dot(X_b.T).dot(y)
    return theta

# Prepare data for linear regression
X = df[['temperature', 'appliance_usage']].values  # Features: Temperature,
```

main.py

```python
X = df[['temperature', 'appliance_usage']].values  # Features: Temperature, Appliance Usage
y = df['usage_kWh'].values  # Target: Energy Usage

# Perform Linear Regression to find the model parameters (theta)
theta = linear_regression(X, y)

# Step 4: Predict future energy usage based on temperature and appliance usage using the learned model
def predict(X, theta):
    """Predict the energy usage based on the learned model."""
    X_b = np.c_[np.ones((len(X), 1)), X]  # Add the intercept term (x0)
    return X_b.dot(theta)

# Make predictions on the entire dataset
y_pred = predict(X, theta)

# Step 5: Display Results (No Visualization)
print("\nEnergy Efficiency Recommendations:")
print(df[['hour', 'temperature', 'appliance_usage', 'usage_kWh', 'recommendation']])

# Display predicted energy usage based on temperature and appliance usage
print("\nPredicted Energy Usage based on Temperature and Appliance Usage:")
for hour, temp, appliance_usage, pred in zip(df['hour'], df['temperature'], df['appliance_usage'], y_pred):
```

Output

```
Energy Efficiency Recommendations:
    hour  ...                                     recommendation
0      0  ...                         Maintain Current Usage Level
1      1  ...                         Maintain Current Usage Level
2      2  ...                         Maintain Current Usage Level
3      3  ...                         Maintain Current Usage Level
4      4  ...                         Maintain Current Usage Level
5      5  ...                         Maintain Current Usage Level
6      6  ...  Reduce Energy Consumption (Use Energy-efficien...
7      7  ...  Reduce Energy Consumption (Use Energy-efficien...
8      8  ...                         Maintain Current Usage Level
9      9  ...                         Maintain Current Usage Level
10    10  ...                         Maintain Current Usage Level
11    11  ...                         Maintain Current Usage Level
12    12  ...                         Maintain Current Usage Level
13    13  ...                         Maintain Current Usage Level
14    14  ...                         Maintain Current Usage Level
15    15  ...                         Maintain Current Usage Level
16    16  ...                         Maintain Current Usage Level
17    17  ...  Reduce Energy Consumption (Use Energy-efficien...
18    18  ...                         Maintain Current Usage Level
19    19  ...                         Maintain Current Usage Level
20    20  ...                         Maintain Current Usage Level
21    21  ...                         Maintain Current Usage Level
22    22  ...                         Maintain Current Usage Level
```

Output Clear

```
[24 rows x 5 columns]

Predicted Energy Usage based on Temperature and Appliance Usage:
Hour: 0, Temperature: 22.48°C, Appliance Usage: 34.56 kWh, Predicted Usage: 32.05 kWh
Hour: 1, Temperature: 19.31°C, Appliance Usage: 41.11 kWh, Predicted Usage: 32.87 kWh
Hour: 2, Temperature: 23.24°C, Appliance Usage: 28.49 kWh, Predicted Usage: 30.02 kWh
Hour: 3, Temperature: 27.62°C, Appliance Usage: 43.76 kWh, Predicted Usage: 38.74 kWh
Hour: 4, Temperature: 18.83°C, Appliance Usage: 33.99 kWh, Predicted Usage: 29.71 kWh
Hour: 5, Temperature: 18.83°C, Appliance Usage: 37.08 kWh, Predicted Usage: 30.96 kWh
Hour: 6, Temperature: 27.90°C, Appliance Usage: 33.98 kWh, Predicted Usage: 34.94 kWh
Hour: 7, Temperature: 23.84°C, Appliance Usage: 58.52 kWh, Predicted Usage: 42.54 kWh
Hour: 8, Temperature: 17.65°C, Appliance Usage: 39.87 kWh, Predicted Usage: 31.41 kWh
Hour: 9, Temperature: 22.71°C, Appliance Usage: 29.42 kWh, Predicted Usage: 30.10 kWh
Hour: 10, Temperature: 17.68°C, Appliance Usage: 48.23 kWh, Predicted Usage: 34.81 kWh
Hour: 11, Temperature: 17.67°C, Appliance Usage: 27.79 kWh, Predicted Usage: 26.53 kWh
Hour: 12, Temperature: 21.21°C, Appliance Usage: 42.09 kWh, Predicted Usage: 34.36 kWh
Hour: 13, Temperature: 10.43°C, Appliance Usage: 20.40 kWh, Predicted Usage: 19.35 kWh
Hour: 14, Temperature: 11.38°C, Appliance Usage: 26.72 kWh, Predicted Usage: 22.46 kWh
Hour: 15, Temperature: 17.19°C, Appliance Usage: 41.97 kWh, Predicted Usage: 31.99 kWh
Hour: 16, Temperature: 14.94°C, Appliance Usage: 47.38 kWh, Predicted Usage: 32.89 kWh
Hour: 17, Temperature: 21.57°C, Appliance Usage: 41.71 kWh, Predicted Usage: 34.42 kWh
Hour: 18, Temperature: 15.46°C, Appliance Usage: 38.84 kWh, Predicted Usage: 29.73 kWh
Hour: 19, Temperature: 12.94°C, Appliance Usage: 36.99 kWh, Predicted Usage: 27.52 kWh
Hour: 20, Temperature: 27.33°C, Appliance Usage: 25.21 kWh, Predicted Usage: 31.06 kWh
Hour: 21, Temperature: 18.87°C, Appliance Usage: 32.80 kWh, Predicted Usage: 29.25 kWh
Hour: 22, Temperature: 20.34°C, Appliance Usage: 35.39 kWh, Predicted Usage: 31.15 kWh
```


```
Hour: 18, Temperature: 15.46°C, Appliance Usage: 38.84 kWh, Predicted Usage: 29.73 kWh
Hour: 19, Temperature: 12.94°C, Appliance Usage: 36.99 kWh, Predicted Usage: 27.52 kWh
Hour: 20, Temperature: 27.33°C, Appliance Usage: 25.21 kWh, Predicted Usage: 31.06 kWh
Hour: 21, Temperature: 18.87°C, Appliance Usage: 32.80 kWh, Predicted Usage: 29.25 kWh
Hour: 22, Temperature: 20.34°C, Appliance Usage: 35.39 kWh, Predicted Usage: 31.15 kWh
```


```
Hour: 23, Temperature: 12.88°C, Appliance Usage: 50.57 kWh, Predicted Usage: 32.99 kWh

Mean Squared Error (MSE): 17.07
```