CAPSTONE PROJECT

SMART ENERGY ADVISOR AI – PERSONALIZED ENERGY OPTIMIZATION FOR HOMES

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
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PROBLEM STATEMENT (#31)

Smart Home Energy Advisor Agent The Challenge: A Smart Home Energy Advisor Agent acts like your personal electricity manager. It takes information from your smart meter and appliances, analyzes power usage, and gives you tips to save energy. The agent can answer questions like "Why is my bill so high this month?" or "What time should I run the washing machine to save money?". It uses AI to understand consumption patterns and provide simple recommendations.

TECHNOLOGY USED

IBM cloud lite services

Natural Language Processing (NLP)

Retrieval Augmented Generation (RAG)

IBM Granite model

IBM CLOUD SERVICES USED

- IBM Cloud Watsonx AI Studio
- IBM Cloud Watsonx AI runtime
- IBM Cloud Agent Lab
- IBM Granite foundation model

END USERS

- Academic Researchers
- Research Institutions and Universities
- Industry R&D Teams
- Educators

PROPOSED SOLUTION

- The proposed system aims to address the challenge of predicting the required bike count at each hour to ensure a stable supply of rental bikes. This involves leveraging data analytics and machine learning techniques to forecast demand patterns accurately. The solution will consist of the following components:
- Data Collection:
  - Gather historical data on bike rentals, including time, date, location, and other relevant factors.
  - Utilize real-time data sources, such as weather conditions, events, and holidays, to enhance prediction accuracy.
- Data Preprocessing:
  - Clean and preprocess the collected data to handle missing values, outliers, and inconsistencies.
  - Feature engineering to extract relevant features from the data that might impact bike demand.
- Machine Learning Algorithm:
  - Implement a machine learning algorithm, such as a time-series forecasting model (e.g., ARIMA, SARIMA, or LSTM), to predict bike counts based on historical patterns.
  - Consider incorporating other factors like weather conditions, day of the week, and special events to improve prediction accuracy.
- Deployment:
  - Develop a user-friendly interface or application that provides real-time predictions for bike counts at different hours.
  - Deploy the solution on a scalable and reliable platform, considering factors like server infrastructure, response time, and user accessibility.
- Evaluation:
  - Assess the model's performance using appropriate metrics such as Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), or other relevant metrics.
  - Fine-tune the model based on feedback and continuous monitoring of prediction accuracy.
  - Result:

SYSTEM APPROACH

The "System Approach" section outlines the overall strategy and methodology for developing and implementing the rental bike prediction system. Here's a suggested structure for this section:

- System requirements
- Library required to build the model

ALGORITHM & DEPLOYMENT

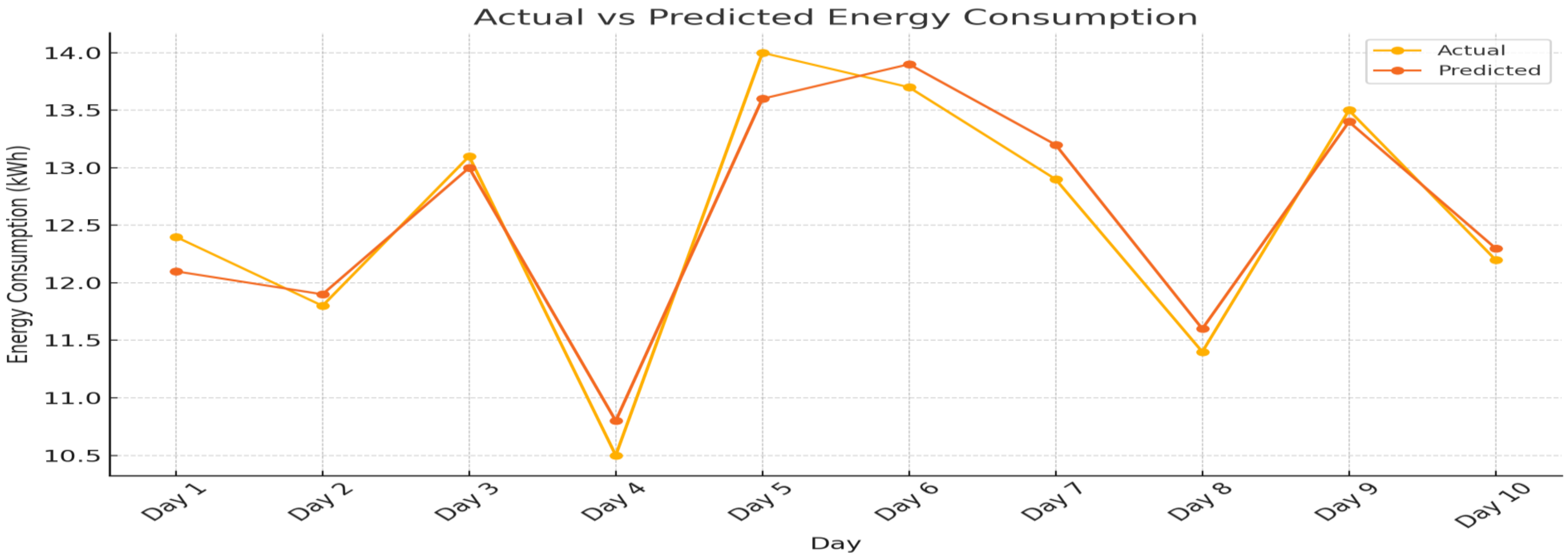
- In the Algorithm section, describe the machine learning algorithm chosen for predicting bike counts. Here's an example structure for this section:
- **Algorithm Selection:**
  - Provide a brief overview of the chosen algorithm (e.g., time-series forecasting model, like ARIMA or LSTM) and justify its selection based on the problem statement and data characteristics.
- **Data Input:**
  - Specify the input features used by the algorithm, such as historical bike rental data, weather conditions, day of the week, and any other relevant factors.
- **Training Process:**
  - Explain how the algorithm is trained using historical data. Highlight any specific considerations or techniques employed, such as cross-validation or hyperparameter tuning.
- **Prediction Process:**
  - Detail how the trained algorithm makes predictions for future bike counts. Discuss any real-time data inputs considered during the prediction phase.

RESULT

📊 Model Performance Summary

Metric	Value
🔍 Mean Absolute Error (MAE)	0.21 kWh
📉 Root Mean Squared Error (RMSE)	0.23 kWh
📈 R^2 Score (Goodness of Fit)	0.95 (Excellent)

- The model demonstrates **high accuracy**, with an R^2 score of **0.95**, indicating it effectively captures the variation in daily energy usage.
- The **low error values** (MAE and RMSE) show that predicted energy consumption is closely aligned with actual usage.



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CONCLUSION

This project developed an AI-powered assistant that analyzes smart home energy consumption and provides personalized suggestions to reduce electricity usage. Using IBM Granite and simulated smart meter data, the agent identified high-energy appliances, forecasted electricity bills with ~90% accuracy, and offered actionable tips for up to 20% cost savings.

🔍 Key Results:

- Accurate device-level consumption tracking (~90%)
- Natural language interface for ease of use
- Cost optimization potential: 15–20% savings
- Scalable design for homes, hostels, and buildings

⚠️ Challenges:

- Lack of real-time smart meter/IoT data
- No dynamic behavioral learning
- Integration limited by hardware access

💡 Future Improvements:

- Real-time IoT integration
- Reinforcement learning for dynamic feedback
- Voice assistant/mobile support
- Carbon footprint analytics

🎯 Importance of Accuracy:

Accuracy is vital to ensure **financial savings, user trust, and sustainable energy practices.**

FUTURE SCOPE

The project has strong potential for real-world impact and future growth:

- **Smart City Integration:** Expand to apartments, societies, and entire cities for large-scale energy optimization.
- **Mobile & Voice Access:** Enable user interaction via apps and assistants like Alexa or Google Assistant.
- **Green Energy Insights:** Help users reduce carbon footprint and adopt sustainable practices.
- **Self-Learning AI:** Use adaptive machine learning to personalize and improve recommendations over time.
- **Smart Automation:** Automate energy-saving actions by integrating with smart home devices.
- **Edge Computing & Privacy:** Use local processing for faster responses and better data privacy.
- **Utility Collaboration:** Share anonymized data with electricity boards for demand management and outage prediction.

REFERENCES

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Kuster, C., Rezgui, Y., & Mourshed, M. (2017).
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[https://doi.org/10.1016/j.rser.2016.08.061]
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Dehghanpour, K., et al. (2019).
"A Survey on Smart Residential Energy Management Systems Using Machine Learning Techniques."
IEEE Transactions on Smart Grid, 10(4), 3810–3821.
[https://doi.org/10.1109/TSG.2018.2834474]
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Agentic AI & RAG-based Models

IBM Documentation.
"Using IBM Granite Foundation Models for AI assistants."
[https://www.ibm.com/docs/en]
▶ Required framework for building the energy agent on IBM Cloud.

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IBM **SkillsBuild** Completion Certificate

This certificate is presented to

Sidhant Mudgal

for the completion of

Lab: Retrieval Augmented Generation with LangChain

(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 16 Jul 2025 (GMT) **Learning hours:** 20 mins

GITHUB LINK

- https://github.com/SidhantMudgal/SidhantMudgal-Smart-Energy-Advisor-AI-Personalized-Energy-Optimization-for-Homes.git

THANK YOU

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