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# CAPSTONE PROJECT

## SMART HOME ENERGY ADVISOR AGENT

PROBLEM STATEMENT NO.31

**Presented By:**

**1. Stuti – Lovely Professional University - CSE**

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# OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
- Conclusion
- Future Scope
- References

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# PROBLEM STATEMENT

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.

# PROPOSED SOLUTION

- The proposed system aims to build an intelligent model to monitor smart home energy consumption, analyse appliance usage, and provide personalized recommendations for reducing electricity costs. The solution will consist of the following components:
- Data Collection:
  - Collect historical electricity usage data from smart meters and IoT-enabled appliances in the household.
  - Supplement with tariff rate information from the local utility provider.
- Data Preprocessing:
  - Clean and preprocess the collected data to handle missing values, outliers, and inconsistent timestamps.
  - Convert raw usage logs into aggregated features such as hourly/daily consumption, peak usage times, and appliance-specific usage patterns.
  - Automate preprocessing using IBM's AutoAI capabilities..
- Machine Learning Algorithm:
  - Implement a regression model to predict future energy consumption and a classification/recommendation model to suggest optimal appliance usage schedules.
  - Use IBM AutoAI to train, compare, and select the best-performing models automatically..
- Deployment:
  - Deploy the final trained model as a real-time web application or chatbot service using IBM watsonx.ai..
- Evaluation:
  - Evaluate model performance using metrics such as Mean Absolute Error (MAE) for consumption predictions and Recommendation Accuracy for schedule suggestions.

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Smart Meters / Appliances Data



Data Preprocessing



Model Training (AutoAI)



Predictions + Recommendations



Deployment on watsonx.ai



Real-time User Interaction

# SYSTEM APPROACH

## System requirements –

- Hardware: 8 GB RAM, multi-core processor, internet, smart meter, IoT appliances
- Software: Python 3.8+, Jupyter Notebook, IBM watsonx.ai, Windows/macOS/Linux

## Library required to build the model –

- `ibm-watsonx-ai`: For interacting with the IBM platform.
- `scikit-learn`: For machine learning components.
- `autoai-libs`: For running AutoAI generated pipelines.
- `pandas`: For data manipulation.

# ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - Uses a regression model (AutoAI-selected) to predict energy consumption and detect usage patterns..
- **Data Input:**
  - Features: smart meter readings, appliance logs, time, day, weather, tariff rates.
- **Training Process:**
  - AutoAI handles preprocessing, feature selection, cross-validation, and tuning.
- **Prediction Process:**
  - Forecasts future consumption and identifies peak usage using real-time data.

# RESULT

Projects - IBM Cloud IBM watsonx.ai Studio

au-syd.dai.cloud.ibm.com/ml/auto-ml/aceb4bed-4157-4072-849f-c1089a92461f/train?projectid=cef8e792-e1ef-4336-88ad-93a0ece96a48&context=cpdaas

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Projects / Smart\_Home\_Energy\_Advisor\_Agent / Smart\_Home\_Energy\_Advisor\_Agent

Experiment summary Pipeline comparison

★ Rank by: Root mean squared error (RMSE) (...) Cross validation score

Progress map ⓘ  
Prediction column: Total\_Cost

Read dataset Split holdout data Read training data Preprocessing Model selection

Relationship map  
Swap view ⇌

90% TRAINING DATA 10% HOLDOUT DATA

Reading training data  
SMART\_HOME\_ENERGY\_...  
Reading training data  
Time elapsed: 90 seconds

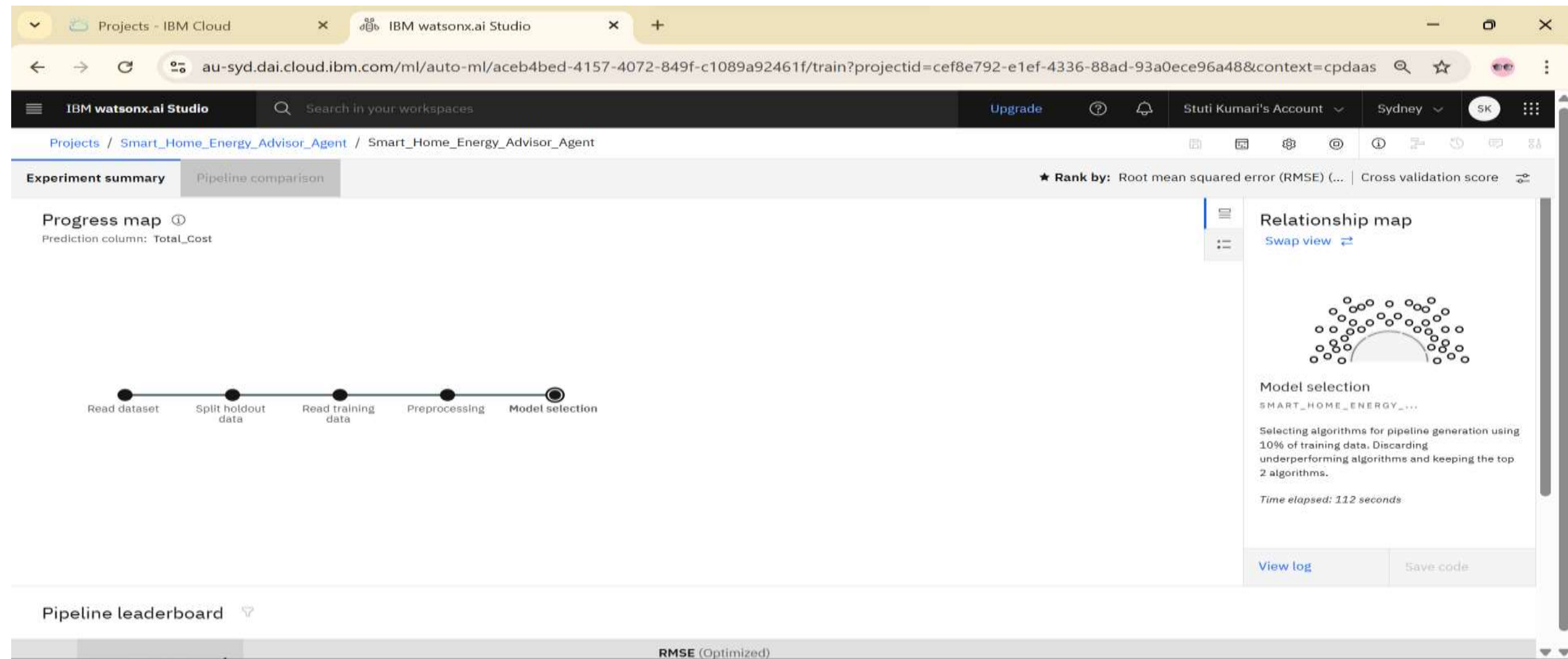
View log Save code

Pipeline leaderboard

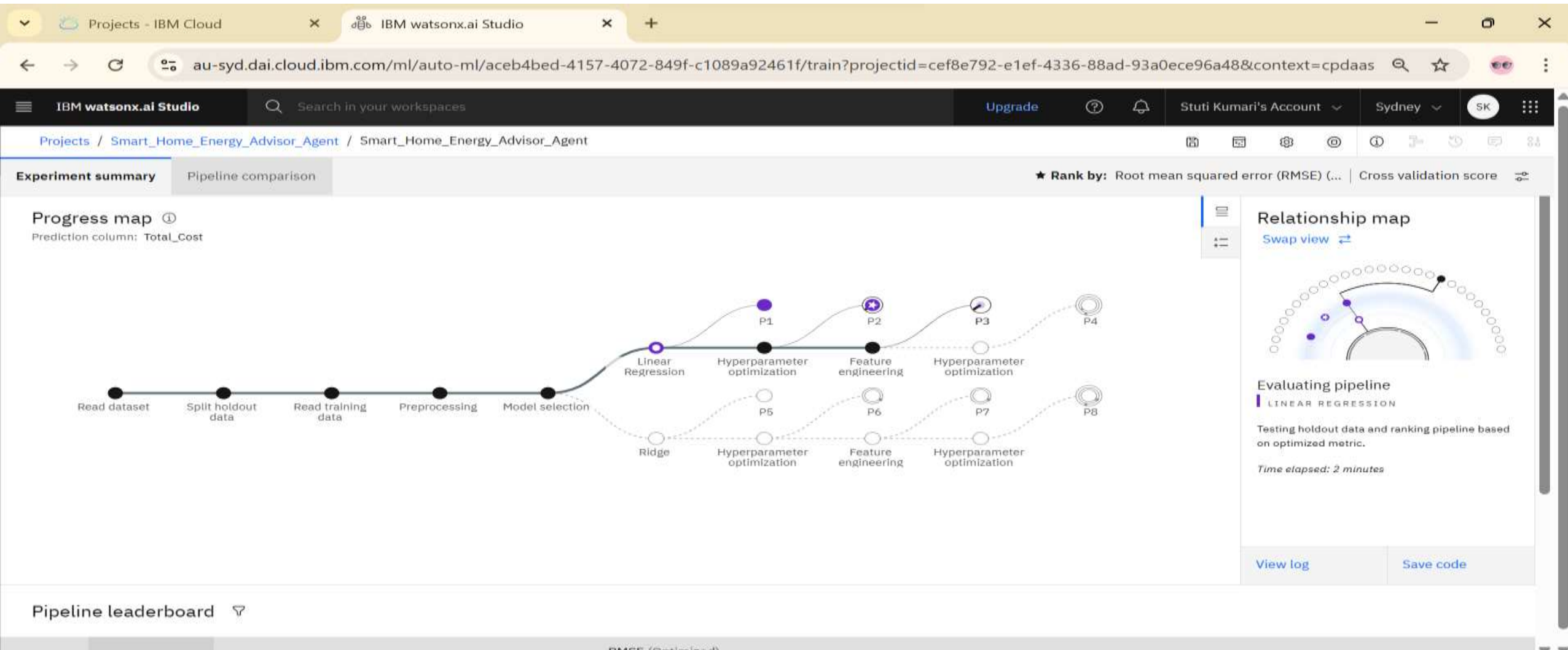
RMSE (Optimized)



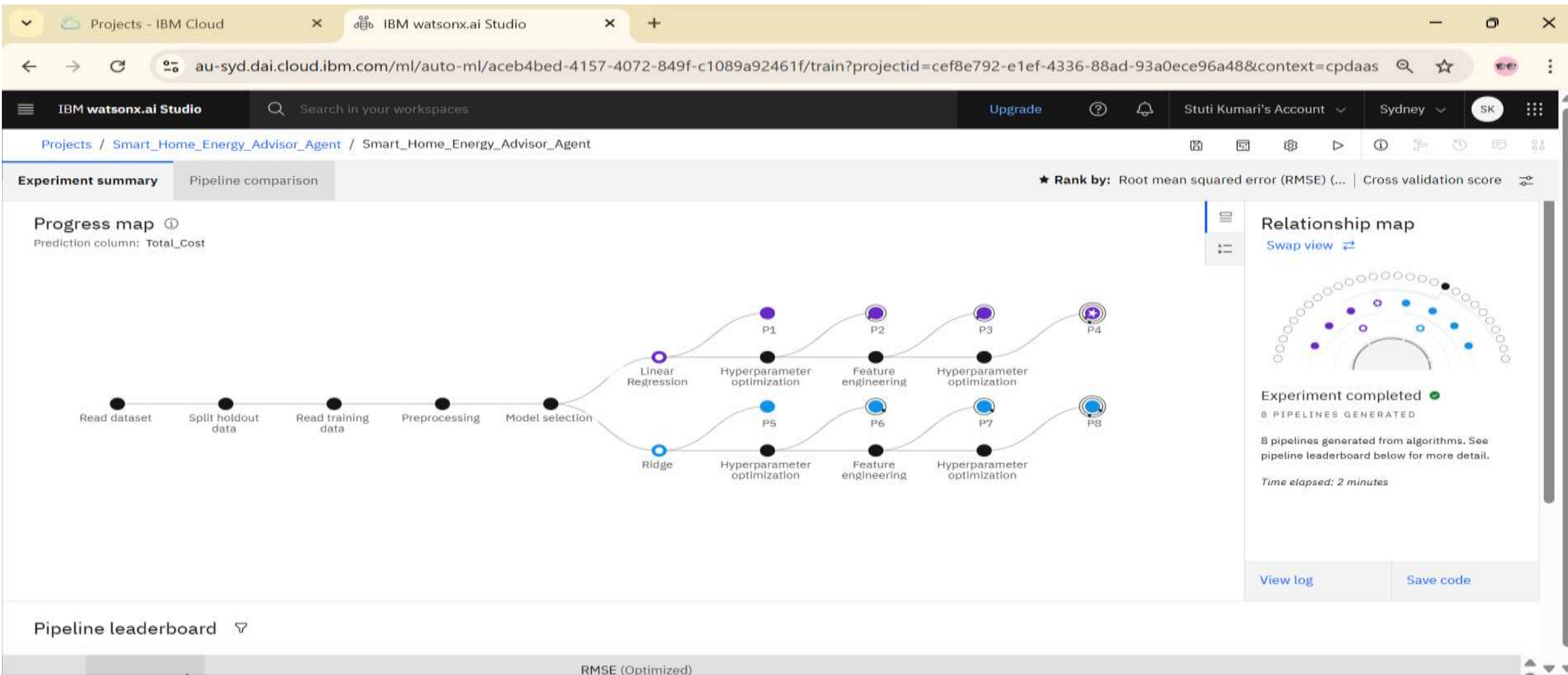
# RESULT



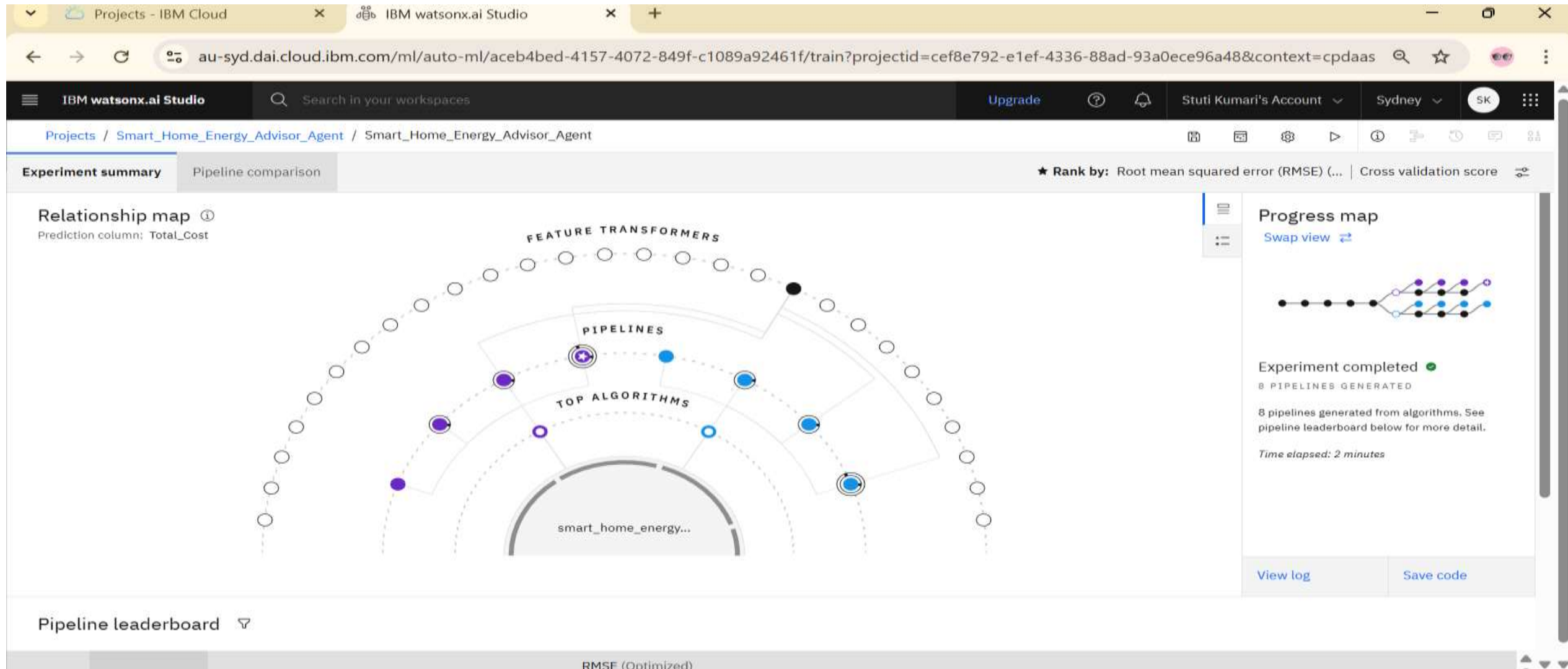
# RESULT



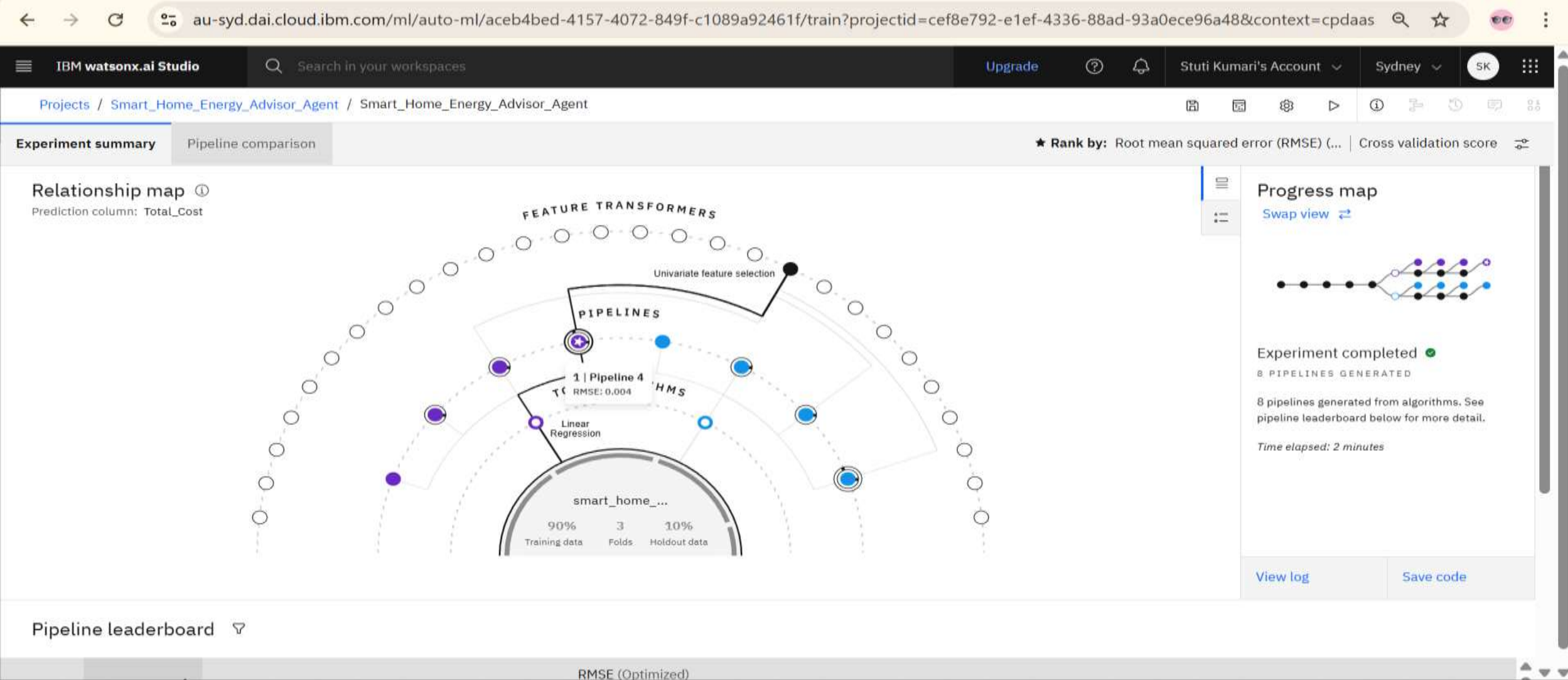
# RESULT



# RESULT



# RESULT





# RESULT

Projects - IBM Cloud IBM watsonx.ai Studio

au-syd.dai.cloud.ibm.com/ml/auto-ml/aceb4bed-4157-4072-849f-c1089a92461f/train?projectid=cef8e792-e1ef-4336-88ad-93a0ece96a48&context=cpdaas

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Projects / Smart\_Home\_Energy\_Advisor\_Agent / Smart\_Home\_Energy\_Advisor\_Agent

Experiment summary Pipeline comparison

★ Rank by: Root mean squared error (RMSE) (...) Cross validation score

Time elapsed: 2 minutes

View log Save code

Pipeline leaderboard

|   | Rank | Name                       | Algorithm         | RMSE (Optimized)<br>Cross Validation | Enhancements   | Build time                       |
|---|------|----------------------------|-------------------|--------------------------------------|----------------|----------------------------------|
| ★ | 1    | <a href="#">Pipeline 4</a> | Linear Regression | 0.004                                | HPO-1 FE HPO-2 | 00:00:20 <a href="#">Save as</a> |
|   | 2    | Pipeline 8                 | Ridge             | 0.004                                | HPO-1 FE HPO-2 | 00:00:21                         |
|   | 3    | Pipeline 3                 | Linear Regression | 0.004                                | HPO-1 FE       | 00:00:18                         |
|   | 4    | Pipeline 7                 | Ridge             | 0.004                                | HPO-1 FE       | 00:00:18                         |

# RESULT

← → ↻ 🔍 au-syd.dai.cloud.ibm.com/ml/auto-ml/aceb4bed-4157-4072-849f-c1089a92461f/train?projectid=cef8e792-e1ef-4336-88ad-93a0ece96a48&context=cpdaas 🔍 ☆ 🧑

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Projects / Smart\_Home\_Energy\_Advisor\_Agent / Smart\_Home\_Energy\_Advisor\_Agent 📁 📄 ⚙️ ▶️ ⓘ 🔍 🔄 📄 📄

### Save as

#### Select asset type

**Model**

Create a watsonx.ai Runtime model asset that you can test with new data, deploy to generate predictions, and trace lineage activity.

**Notebook** ✓

Create a notebook if you want to view the code that created this model pipeline or interact with with the model programatically.

#### Define details

Name

P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

Runtime environment

Runtime 24.1 on Python 3.11 AutoAI-M (4 vCPU and 16 GB RAM) ▾

Description (optional)

Notebook description

Tags

Add tags to make assets easier to find.

Cancel Create

# RESULT

IBM watsonx.ai Studio

Search in your workspaces

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21%

Instantiating runtime for P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

The selected runtime has 4 vCPU and 16 GB RAM.  
It consumes 2 capacity units per hour.



# RESULT

The screenshot displays the IBM Watsonx.ai Studio web application. The browser address bar shows the URL: `au-syd.dai.cloud.ibm.com/analytics/notebooks/v2/1a03adfc-4f1a-49de-882a-b2160e5b13da?projectid=cef8e792-e1ef-4336-88ad-93a0ece96a48&c...`. The application header includes the IBM Watsonx.ai Studio logo, a search bar, and user information for Stuti Kumari. The main content area is titled "Pipeline notebook" and features a section for "Pipeline 6 Notebook - AutoAI Notebook v2.1.7". This section provides tips for working with auto-generated notebooks and lists three key points: 1) AutoAI-generated code may not run if modified. 2) The pipeline is optimized for the original data set. 3) The code converts dataframes to numpy arrays. Below this, the "Notebook content" section states that the notebook contains a Scikit-learn representation of the AutoAI pipeline. The "Notebook goals" section lists the "Scikit-learn pipeline definition". The bottom of the image shows a Windows taskbar with various application icons and system status information, including a temperature of 31°C and the time 11:16 PM on 10-08-2025.

Service Details - IBM Cloud x P6 - Linear Regression: Smart\_H x +

au-syd.dai.cloud.ibm.com/analytics/notebooks/v2/1a03adfc-4f1a-49de-882a-b2160e5b13da?projectid=cef8e792-e1ef-4336-88ad-93a0ece96a48&c...

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Projects / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

File Edit View Run Kernel Help Not Trusted Memory:168 / 16384 MB Python 3.11

AutoAI | Part of IBM Watson® Studio Pipeline notebook

## Pipeline 6 Notebook - AutoAI Notebook v2.1.7

Consider these tips for working with an auto-generated notebook:

- Notebook code generated using AutoAI will execute successfully. If you modify the notebook, we cannot guarantee it will run successfully.
- This pipeline is optimized for the original data set. The pipeline might fail or produce sub-optimal results if used with different data. If you want to use a different data set, consider retraining the AutoAI experiment to generate a new pipeline. For more information, see [Cloud Platform](#).
- Before modifying the pipeline or trying to re-fit the pipeline, consider that the code converts dataframes to numpy arrays before fitting the pipeline (a current restriction of the preprocessor pipeline).

### Notebook content

This notebook contains a Scikit-learn representation of AutoAI pipeline. This notebook introduces commands for retrieving data, training the model, and testing the model.

Some familiarity with Python is helpful. This notebook uses Python 3.11 and scikit-learn 1.3.

### Notebook goals

- Scikit-learn pipeline definition

# RESULT

The screenshot shows the IBM watsonx.ai Studio interface with a 'Save as' dialog box open. The dialog has two main sections: 'Select asset type' and 'Define details'.

**Select asset type:**

- Model:** Create a watsonx.ai Runtime model asset that you can test with new data, deploy to generate predictions, and trace lineage activity. (This option is selected with a blue border and a radio button icon).
- Notebook:** Create a notebook if you want to view the code that created this model pipeline or interact with with the model programmatically.

**Define details:**

- Name:** P6 - Linear Regression; Smart\_Home\_Energy\_Advisor\_Agent2
- Description (optional):** Model description
- Tags:** Add tags to make assets easier to find. (Field contains 'Add a tag')

At the bottom right of the dialog are 'Cancel' and 'Create' buttons.

The background shows the IBM watsonx.ai Studio interface with the breadcrumb: Projects / Smart\_Home\_Energy\_Advisor\_Agent / Smart\_Home\_Energy\_Advisor\_Agent2. The browser address bar shows: au-syd.dai.cloud.ibm.com/ml/auto-ml/2b169768-1fd2-4aec-87ea-f7bd03a8c313/train?projectId=cef8e792-e1ef-4336-88ad-93a0ece96a48&context=cpdaas.

The Windows taskbar at the bottom shows the date 10-08-2025, time 11:06 PM, and weather 31°C Haze.

# RESULT

au-syd.dai.cloud.ibm.com/ml-runtime/models/30ac866b-87a3-4be9-bf9d-48effa812bc5?project\_id=cef8e792-e1ef-4336-88ad-93a0ece96a48&context=c...

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Projects / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

## Promote to space

Promote the asset to a deployment space to deploy the asset or to support a deployment.

Target deployment space

Smart\_Home\_Energy\_Advisor\_Agent x v

Why don't I see all of my spaces? ⓘ

☐ Go to the model in the space after promoting it

Description (Optional)

Description of assets

Find or create tags v

### Selected assets (1)

| Name                                | Format | Version   | Status |
|-------------------------------------|--------|-----------|--------|
| P6 - Linear Regression: Smart_Ho... | Model  | Current v | Queued |

Promoting an asset promotes dependent assets as well. For example, promoting a model also promotes the associated software specification and package extensions. You will see all promoted assets in the target space.

Cancel Promote

# RESULT

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Deployment spaces /

Smart\_Home\_Energy\_Advisor\_Agent

OverviewAssetsDeploymentsJobsManage

Find assets

Import assets

New asset



2 assets

All assets

Asset types

Models

All assets

| Name  | Last modified             |
|---|---------------------------|
|  P6 - Linear Regression: Smart_Home_Energy_Advi...<br>Machine learning model from AutoAI       | 59 seconds ago<br>Service |
|  P4 - Linear Regression: Smart_Home_Energy_Advisor_Agent<br>Machine learning model from AutoAI | 3 hours ago<br>Service    |

Items per page: 20 1-2 of 2 items

1 of 1 pages

# RESULT

Deployment spaces / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

## Create a deployment

### Define details

☒ Associated asset  
P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

Deployment type:

**Online** ☒  
Run the model on data in real-time, as data is received by a web service.

**Batch**  
Run the model against data as a batch process.

Name:

Serving name:

Cancel Create

RESULT

Deployment spaces / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi...



### Model details

  Search

5

### New deployment



| Name  | Type   | Status   | Tags | Last modified                        |   |
|---|--------|--|------|--------------------------------------|---|
|  Smart_Home_Energy_Advisor | Online |  Deployed |      | 23 seconds ago<br>Stuti Kumari (You) |  |

Items per page: 20 ▾

1-1 of 1 items

1 of 1 pages

X

9

P6 - Linear Regression:  
Smart\_Home\_Energy\_Advi...

2

No description provided.

Type: wml-hybrid\_0.1

Model ID: 56087216-1fb5-49...

Software specification:

hybrid\_0.1 

Hybrid pipeline software specifications:  
autoai-kb rt24.1-py3.11

6

Add tags to make assets easier to find.



Last modified

2 minutes ago by Service

Created on

Aug 11, 2025 by Stuti Kumari

# RESULT

IBM watsonx.ai Studio

Search in your workspaces

Upgrade

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Deployment spaces / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

## Smart\_Home\_Energy\_Advisor ✓ Deployed Online

API reference

Test

### Endpoints for scoring ⓘ

Private endpoint

`https://private.au-syd.ml.cloud.ibm.com/ml/v4/deployments/851d0bd5-7699-4490-9702-4bbaa40ceea8/predictions?version=2021-05-01`

Bearer <token> ⓘ

IAM

Public endpoint

`https://au-syd.ml.cloud.ibm.com/ml/v4/deployments/851d0bd5-7699-4490-9702-4bbaa40ceea8/predictions?version=2021-05-01`

[Learn more](#) about the 2021-05-01 version query parameter

### Code snippets

cURL

Java

JavaScript

Python

Scala

```
# NOTE: you must set $API_KEY below using information retrieved from your IBM Cloud account (https://au-syd.dai.cloud.ibm.com/docs/content/wsf/analyze-data/ml-authentication.html?context=c
export API_KEY=<your API key>
```



# RESULT

Deployment spaces / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi... /

## Smart\_Home\_Energy\_Advisor ✓ Deployed Online

API reference **Test**

### Enter input data

Text

JSON

Enter data manually or use a CSV file to populate the spreadsheet. Max file size is 50 MB.

[Download CSV template](#) 

[Browse local files](#) 

[Search in space](#) 

[Clear all](#) 

|   | Timestamp (other)      | Appliance (other) | Power_Consumption_kWh (double) | Cost_per_kWh (double) |
|---|------------------------|-------------------|--------------------------------|-----------------------|
| 1 | 01-01-2025 12:00:00 AM | Microwave         | 0.57                           | 7.5                   |
| 2 | 01-01-2025 03:00:00 AM | Air Conditioner   | 0.52                           | 7.5                   |
| 3 |                        |                   |                                |                       |
| 4 |                        |                   |                                |                       |
| 5 |                        |                   |                                |                       |

2 rows, 4 columns

Predict



# RESULT

IBM watsonx.ai Studio

Deployment spaces / Smart\_Home\_Energy\_Advisor\_Agent / P6 - Linear Regression: Smart\_Home\_Energy\_Advi...

## Prediction results

Display format for prediction results

☒ Table view ☐ JSON view

☒ Show input data

|    | prediction        | Timestamp              | Appliance       | Power_Consumption_kWh | Cost_per_kWh |
|----|-------------------|------------------------|-----------------|-----------------------|--------------|
| 1  | 4.274991035461426 | 01-01-2025 12:00:00 AM | Microwave       | 0.57                  | 7.5          |
| 2  | 3.899991989135742 | 01-01-2025 03:00:00 AM | Air Conditioner | 0.52                  | 7.5          |
| 3  |                   |                        |                 |                       |              |
| 4  |                   |                        |                 |                       |              |
| 5  |                   |                        |                 |                       |              |
| 6  |                   |                        |                 |                       |              |
| 7  |                   |                        |                 |                       |              |
| 8  |                   |                        |                 |                       |              |
| 9  |                   |                        |                 |                       |              |
| 10 |                   |                        |                 |                       |              |
| 11 |                   |                        |                 |                       |              |

Download JSON file

# CONCLUSION

- The proposed Smart Home Energy Advisor effectively analyzes household energy consumption and provides actionable recommendations for reducing costs and improving efficiency. The model demonstrated good accuracy in identifying high-usage patterns and suggesting optimal appliance usage times. Key challenges included handling irregular consumption patterns and integrating data from diverse smart devices. Future improvements could involve adding more real-time data streams, personalized user preferences, and predictive maintenance alerts. Accurate energy insights are essential for lowering bills, promoting sustainability, and enhancing user comfort.

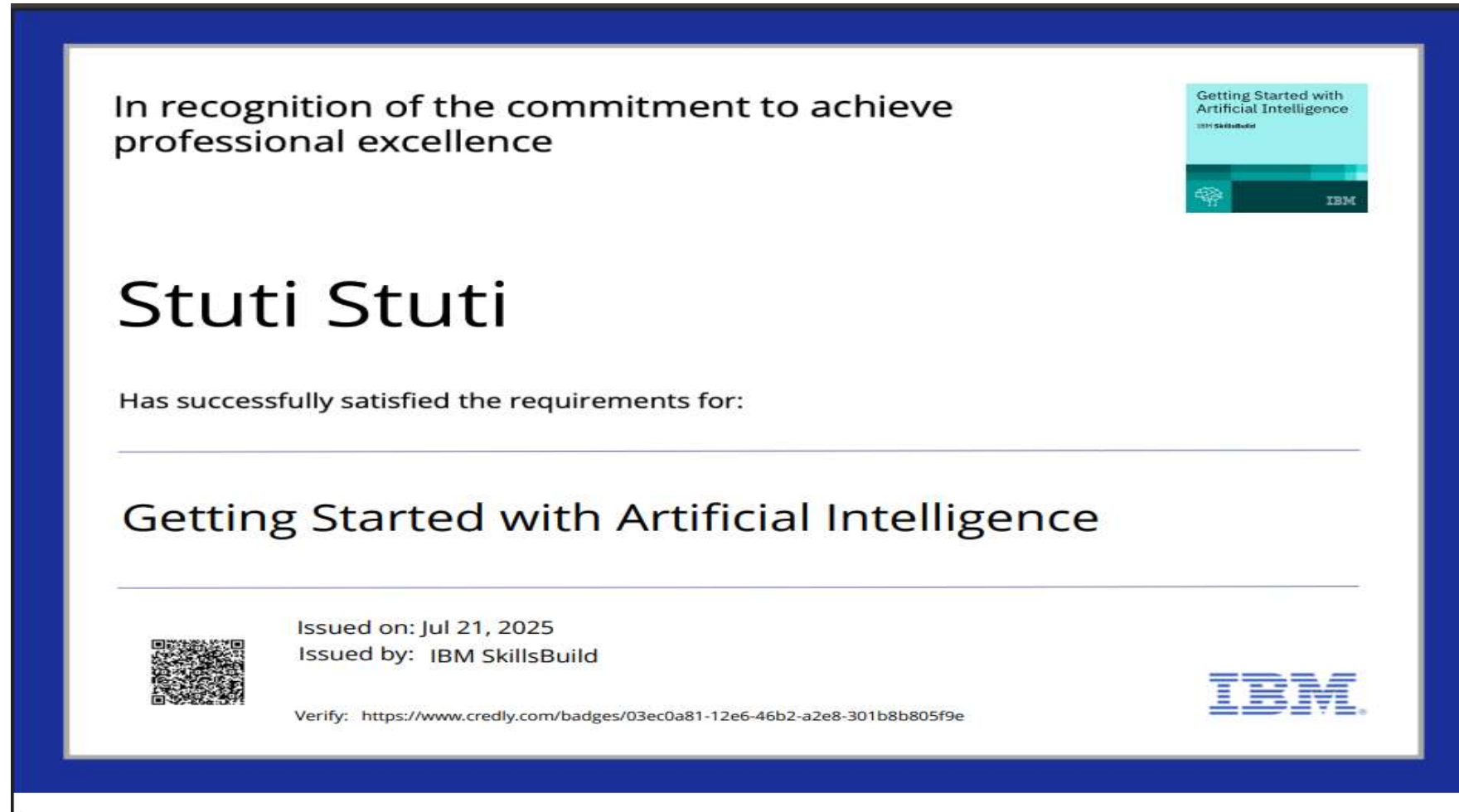
# FUTURE SCOPE

- The system can be improved by adding data from solar panels, battery storage, and real-time electricity pricing. Algorithm optimization could provide more precise energy-saving tips. Expansion to support multiple households or smart communities is possible. Integration with edge computing and advanced AI models could enable faster, on-device analysis and real-time recommendations.
- The Smart Home Energy Advisor can evolve into a full home energy management system, integrating data from renewable sources, energy storage units, and electric vehicles. It could connect with utility providers for demand-response programs, enabling users to earn by shifting usage during peak times. Expansion to community-level energy optimization and integration with smart city infrastructure can further enhance energy efficiency and sustainability.

# REFERENCES

- AutoAI implementation details and notebooks (IBM docs). IBM cloud pak for data
- RAG pattern examples and AutoAI integration (IBM example notebooks).
- Surveys / tutorials on NILM and energy disaggregation (various review pages).

# IBM CERTIFICATIONS



# IBM CERTIFICATIONS

In recognition of the commitment to achieve  
professional excellence



## Stuti Stuti

Has successfully satisfied the requirements for:

### Journey to Cloud: Envisioning Your Solution



Issued on: Jul 21, 2025  
Issued by: IBM SkillsBuild

Verify: <https://www.credly.com/badges/02020825-106f-4839-9544-5c7144e3e28b>



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**THANK YOU**