

Workshop | Tools and Techniques for Intelligent and Secure Energy Trading | May 26, 2022

# Energy Forecasting as an Enabler of Security for Industry 5.0

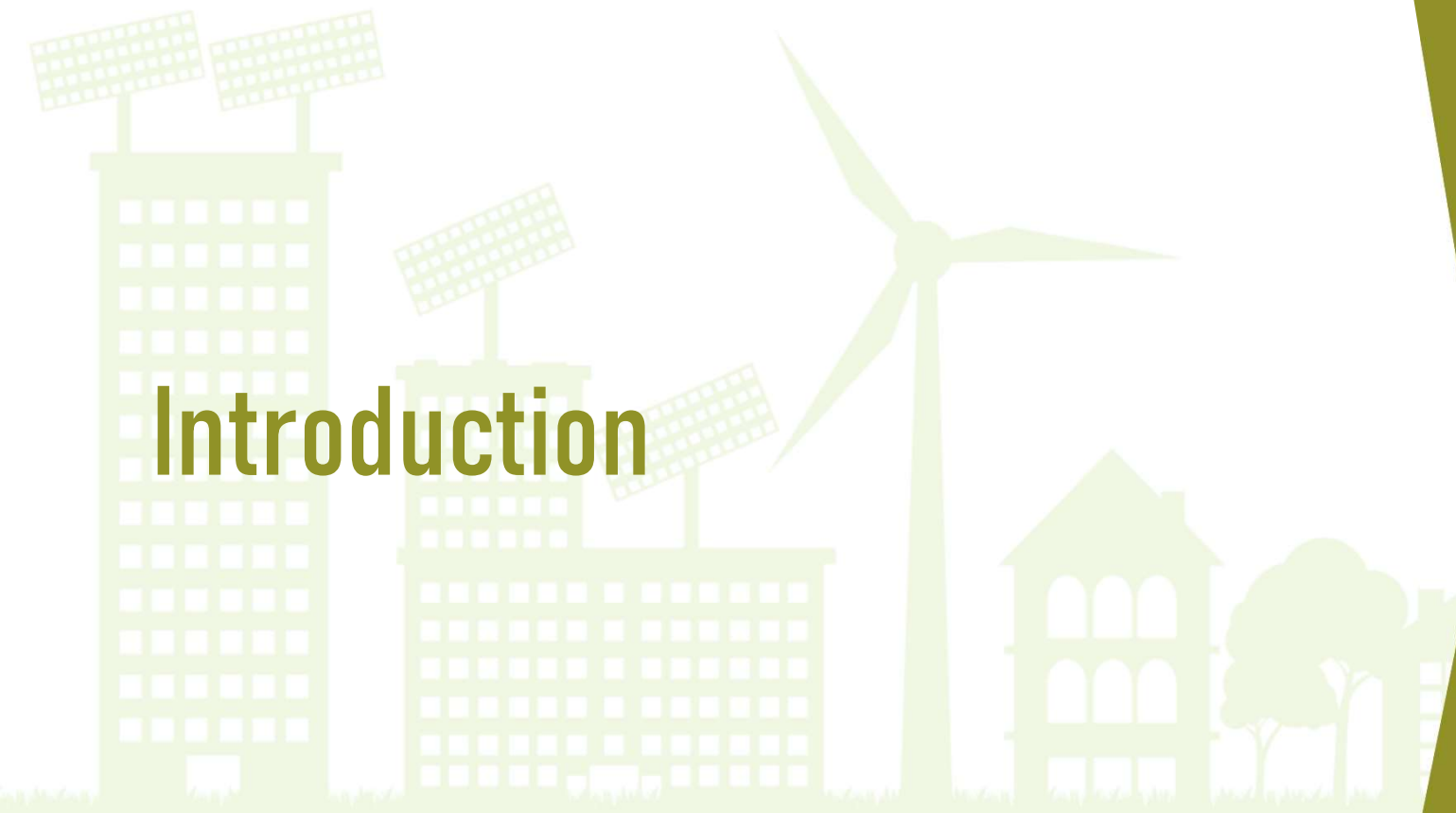
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School of Engineering, Polytechnic of Porto, Portugal (ISEP/IPP)

Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development (GECAD)



# Introduction



# Introduction

## Energy Forecasting

A technique that uses **historical data** as inputs to make **predictions** of the future **generation/consumption**



## Energy Markets

- **Challenge:** means to store generated energy
- **Goal of Energy Forecasting:** balance between consumption and generation

## Industry 4.0 & Industry 5.0



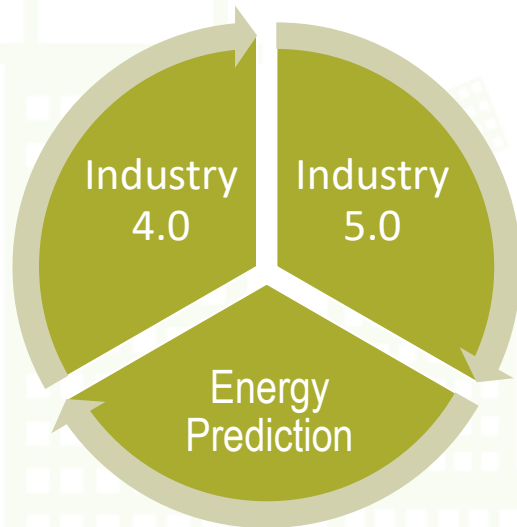
- **Industry 4.0:** digital revolution of IT-driven aspects in industries
- **Technology-driven:** smart factories, cyber-physical systems, decentralized self-organization



- **Industry 5.0:** complement Industry 4.0
- **Value-driven:** sustainable, human-centric, resilient European industry

# Introduction

## Research Target

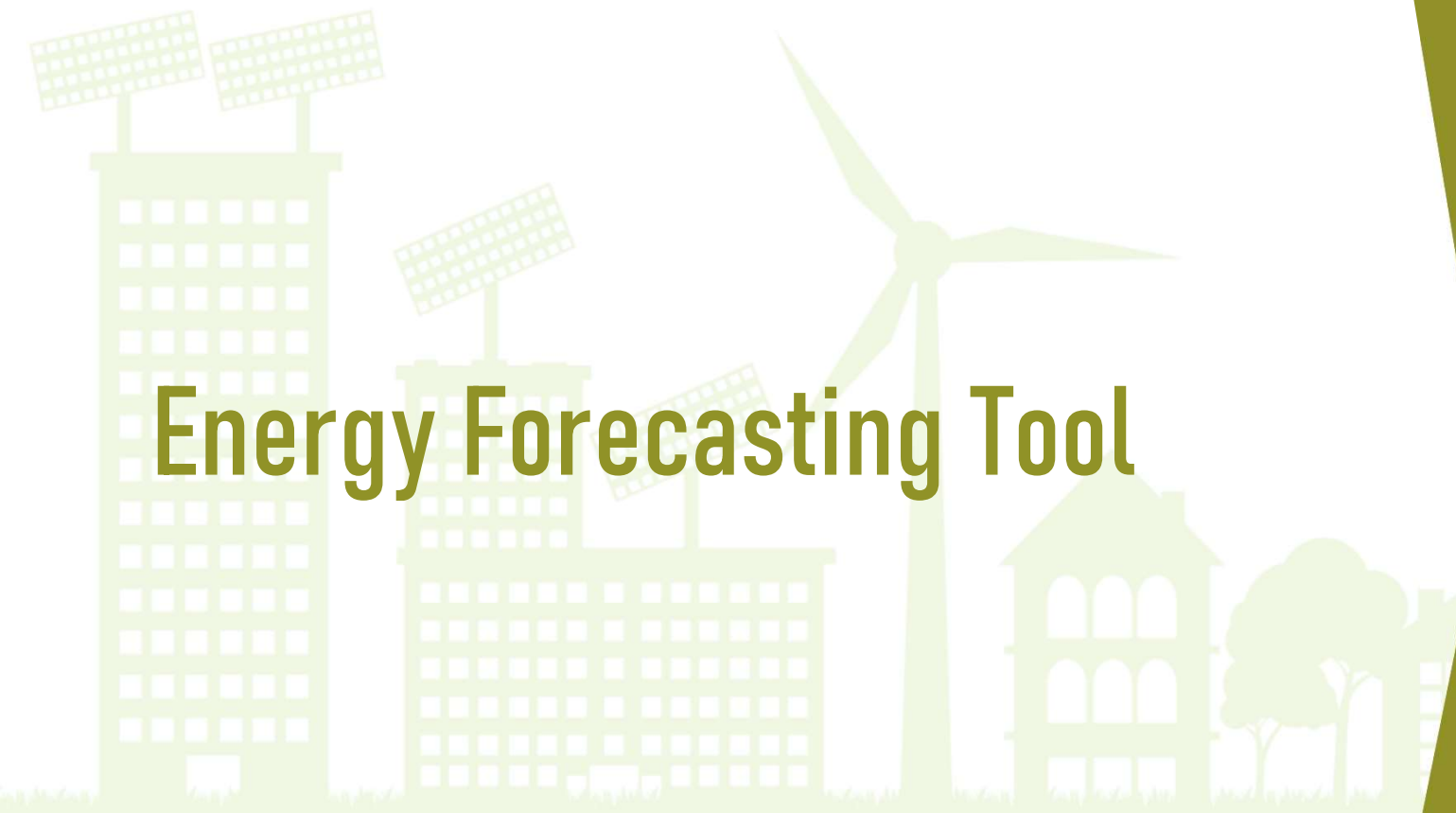


- Matching energy prediction and Industry 4.0 & 5.0 aspects
- Incorporate energy forecasting:
  - Raise awareness regarding security incidents
  - Protect workers and physical/informational assets
- Two **Energy Forecasting Based** systems:
  - Sets of machine learning models
  - Dynamic monitoring services (SaaS)

Energy  
Forecasting  
Tool

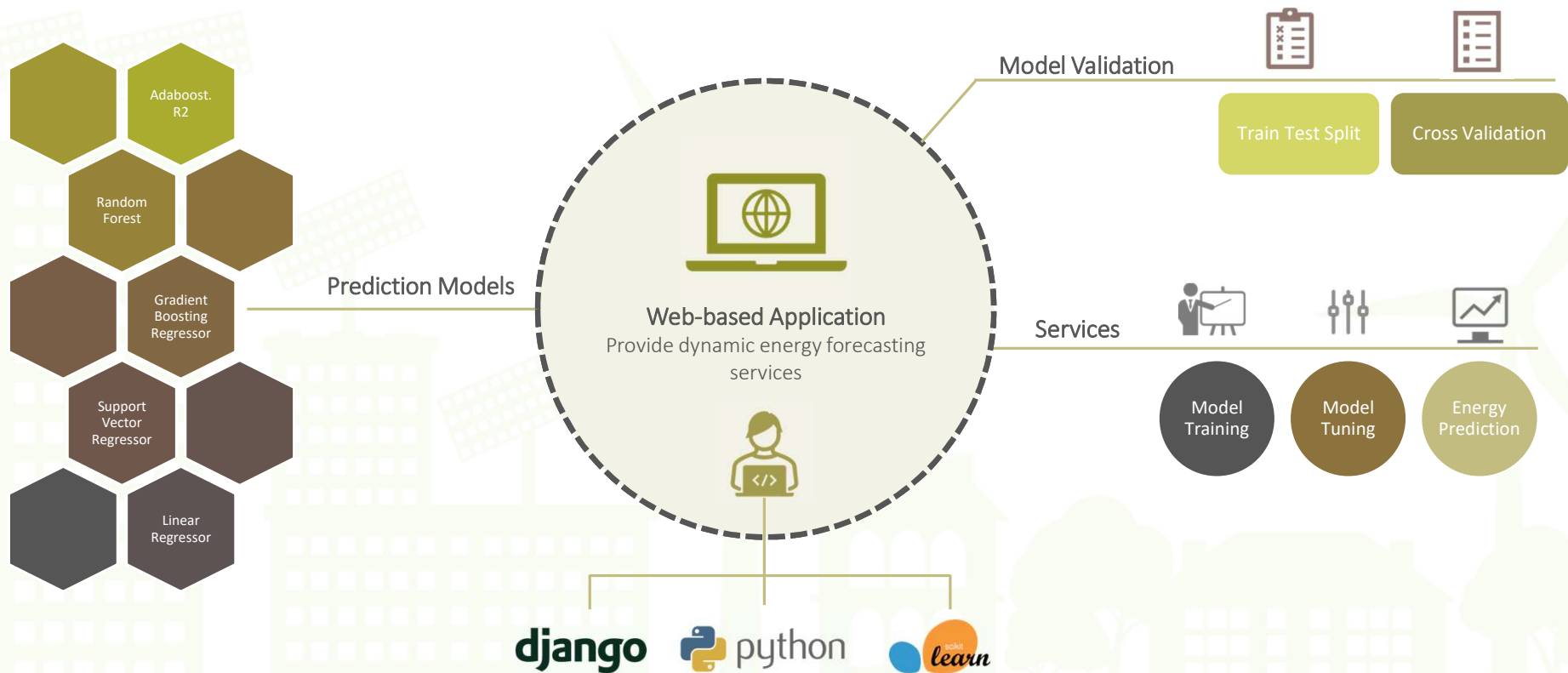
Energy  
Forecasting  
Analyzer

# Energy Forecasting Tool



# Energy Forecasting Tool

## Overview



# Energy Forecasting Tool

## UI Samples

### Historical Data File

Choose the historical data file to be used for model training (please make sure that it has [this structure](#)).

historicalData-Consumption\_data\_jose.xlsx

Browse

### Learning Algorithms

Select the algorithms you want to be used, then choose the appropriate parameters.

<p><input checked="" type="checkbox"/> Adaboost</p> <p>#Estimators: 50</p> <p>Learning Rate: 1</p> <p>Random State*: Leave empty for (None)</p> <p>Loss Function: linear</p> <p><input type="checkbox"/> Scale Data</p> <p>Note: Base estimator details: DecisionTreeRegressor(max_depth: 10, max_features: auto, min_samples_leaf: 4, min_samples_split: 10)</p>	<p><input checked="" type="checkbox"/> Random Forest</p> <p>#Estimators: 100</p> <p>Max Features: auto</p> <p>Max Depth*: Leave empty for (None)</p> <p>Min Samples Split: int 2</p> <p>Min Samples Leaf: int 1</p> <p>Random State*: Leave empty for (None)</p> <p>Bootstrap: True</p> <p><input type="checkbox"/> Scale Data</p>	<p><input checked="" type="checkbox"/> Gradient Boosting Regressor</p> <p>#Estimators: 100</p> <p>Learning Rate: 0.1</p> <p>Max Features: None</p> <p>Max Depth: 3</p> <p>Min Samples Split: int 2</p> <p>Min Samples Leaf: int 1</p> <p>Subsample: 1.0</p> <p>Random State*: Leave empty for (None)</p> <p><input type="checkbox"/> Scale Data</p>
<p><input checked="" type="checkbox"/> Support Vector Regressor</p> <p>Kernel: rbf</p> <p>Degree (for 'poly'): 3</p> <p>C: 1.0</p> <p>Epsilon: 0.1</p> <p>Gamma (for 'rbf', 'poly', 'sigmoid'): scale</p> <p>Cache Size: 200</p> <p><input type="checkbox"/> Scale Data (highly recommended)</p>	<p><input checked="" type="checkbox"/> Linear Regression</p> <p>Fit Intercept: True</p> <p>Normalize (for Fit Intercept = True): False</p> <p><input type="checkbox"/> Scale Data</p>	

### Training

**Historical Data File**  
Choose the historical data file to be used for model training please make sure that it has [this structure](#).  
historicalData-Consumption\_data\_jose.xlsx Browse

**Learning Algorithms**  
Select the algorithms you want to be used, then choose the appropriate parameters.

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Note: Base estimator details:  
DecisionTreeRegressor(max\_depth: 10, max\_features: auto, min\_samples\_leaf: 4, min\_samples\_split: 10)

<p><input checked="" type="checkbox"/> Support Vector Regressor</p> <p>Kernel: rbf</p> <p>Degree (for 'poly'): 3</p> <p>C: 1.0</p> <p>Epsilon: 0.1</p> <p>Gamma (for 'rbf', 'poly', 'sigmoid'): scale</p> <p>Cache Size: 200</p> <p><input type="checkbox"/> Scale Data (highly recommended)</p>	<p><input checked="" type="checkbox"/> Linear Regression</p> <p>Fit Intercept: True</p> <p>Normalize (for Fit Intercept = True): False</p> <p><input type="checkbox"/> Scale Data</p>
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**Model Validation**  
Select the validation method you want to be used; then choose the appropriate parameters.

<p><input checked="" type="checkbox"/> Cross Validation (recommended)</p> <p>KFolds Random State*: Leave empty for (None)</p> <p>KFolds Number: 5</p> <p><input checked="" type="checkbox"/> Shuffle Data (highly recommended)</p>	<p><input type="checkbox"/> Train Test Split</p> <p>Random State*: Leave empty for (None)</p> <p>Test Size (%): 25</p>
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**Historical Columns**  
Select the historical attributes you want to be used for model learning. Choose the columns to be considered and enter the column names as presented in the data file.

Historical Attributes	Other Values
<input checked="" type="checkbox"/> Day of the month: day_m	<input type="checkbox"/> Temperature: temp
<input checked="" type="checkbox"/> Month of the year: month	<input type="checkbox"/> 31st Previous Value: prev_con_1
<input checked="" type="checkbox"/> Hour of the day: hour	<input type="checkbox"/> 30th Previous Value: prev_con_2
<input checked="" type="checkbox"/> Year: year	<input type="checkbox"/> 29th Previous Value: prev_con_3
<input checked="" type="checkbox"/> Day of the week: day_w	<input type="checkbox"/> Target Attribute Column: consumption

\* For (None) leave the field empty.

[Start Training](#)

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# Energy Forecasting Tool

## Case Study

### Goal:

- Monitoring assets and raise awareness of security incidents

### Material and Methods

#### Data Set

#### Industry shop floor

- Energy consumption livestream
- 10 sensors/analyzers

### ➤ Two analyzers:

- historical time window (3 months)
- predefined model: instantly trained and used to predict future samples
- future data samples (next 24 hours)



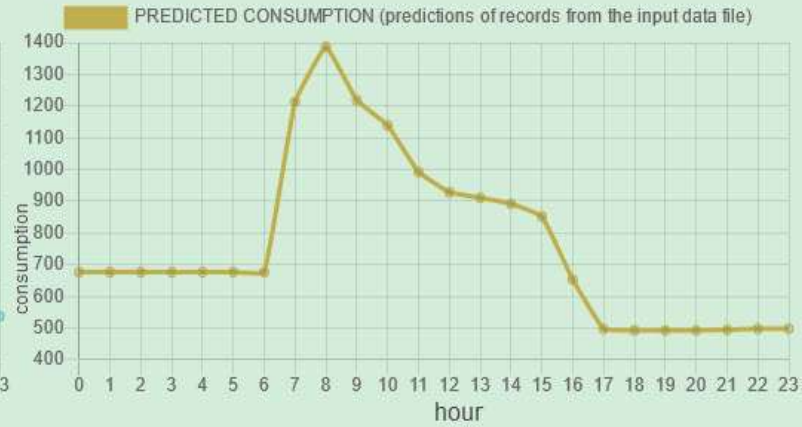
## Results and Discussion

Dep #1 analyzer

Profile Chart:



Prediction Chart:



Prediction accuracy  $R^2 \approx 0.67$

- **Predictions:** close to the analyzers' profiles
- **Dep #1 analyzer:** variation between profile and prediction (low prediction accuracy)

### Monitor analyzer's behavior:

- Compare actual behavior with daily profile and predicted chart
- No match or unexpected sudden spike/drop
- Generate alert to check the deficiency

Dep #2 analyzer

Profile Chart:

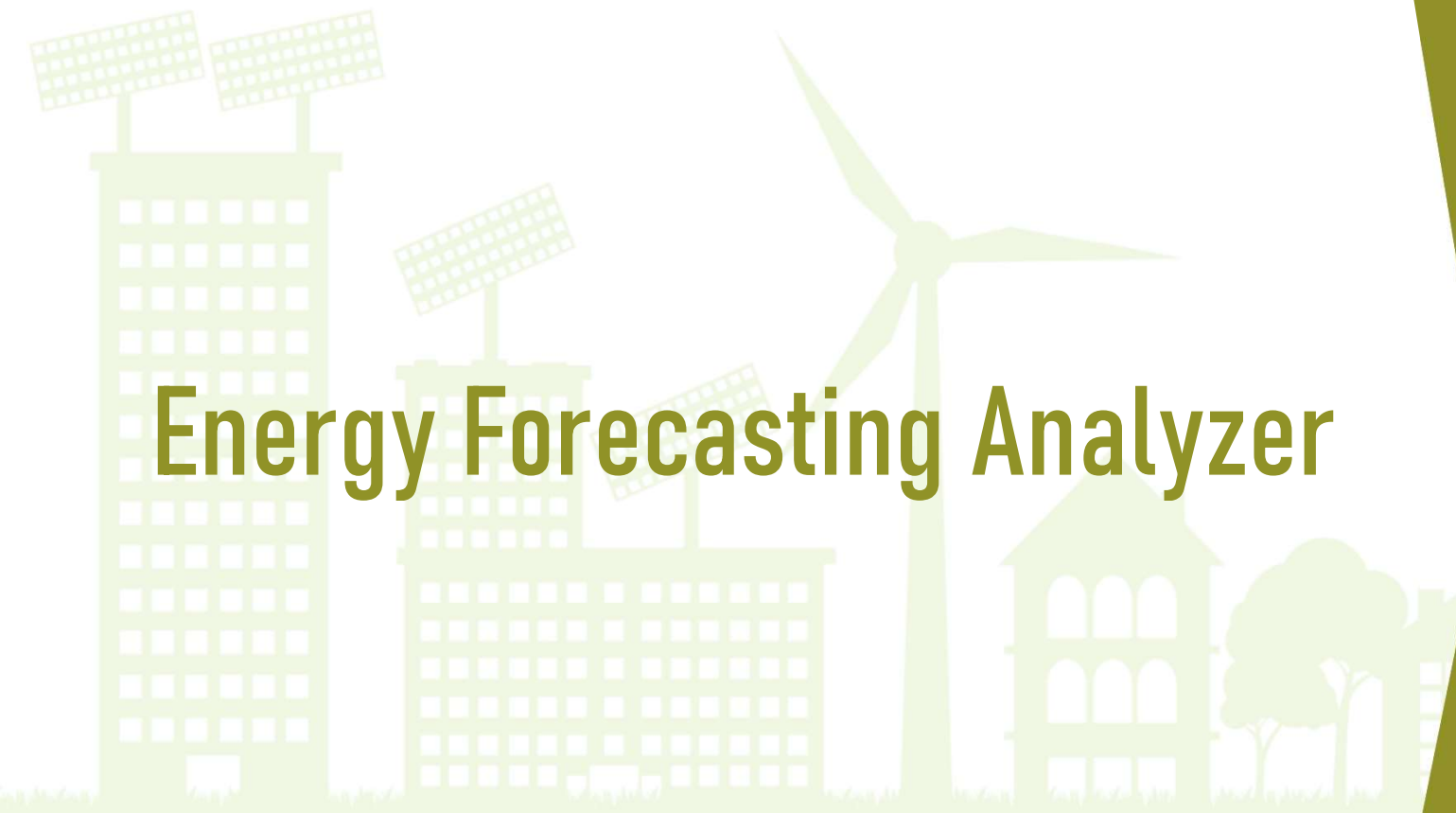


Prediction Chart:



Prediction accuracy  $R^2 \approx 0.88$


# Energy Forecasting Analyzer



# Energy Forecasting Analyzer

## Overview


- Part of integrated multi-domain system architecture
- Security and safety mechanisms for FoF
- Microservices architecture:
  - Scalability, availability, and resilience of the decentralized systems


**Energy Forecasting Analyzer** 


Analyzing energy consumption to monitor buildings and detect deficiencies over time


 **kafka**

Apache Kafka  
Distributed event streaming platform

Human Behavior Analyzer 

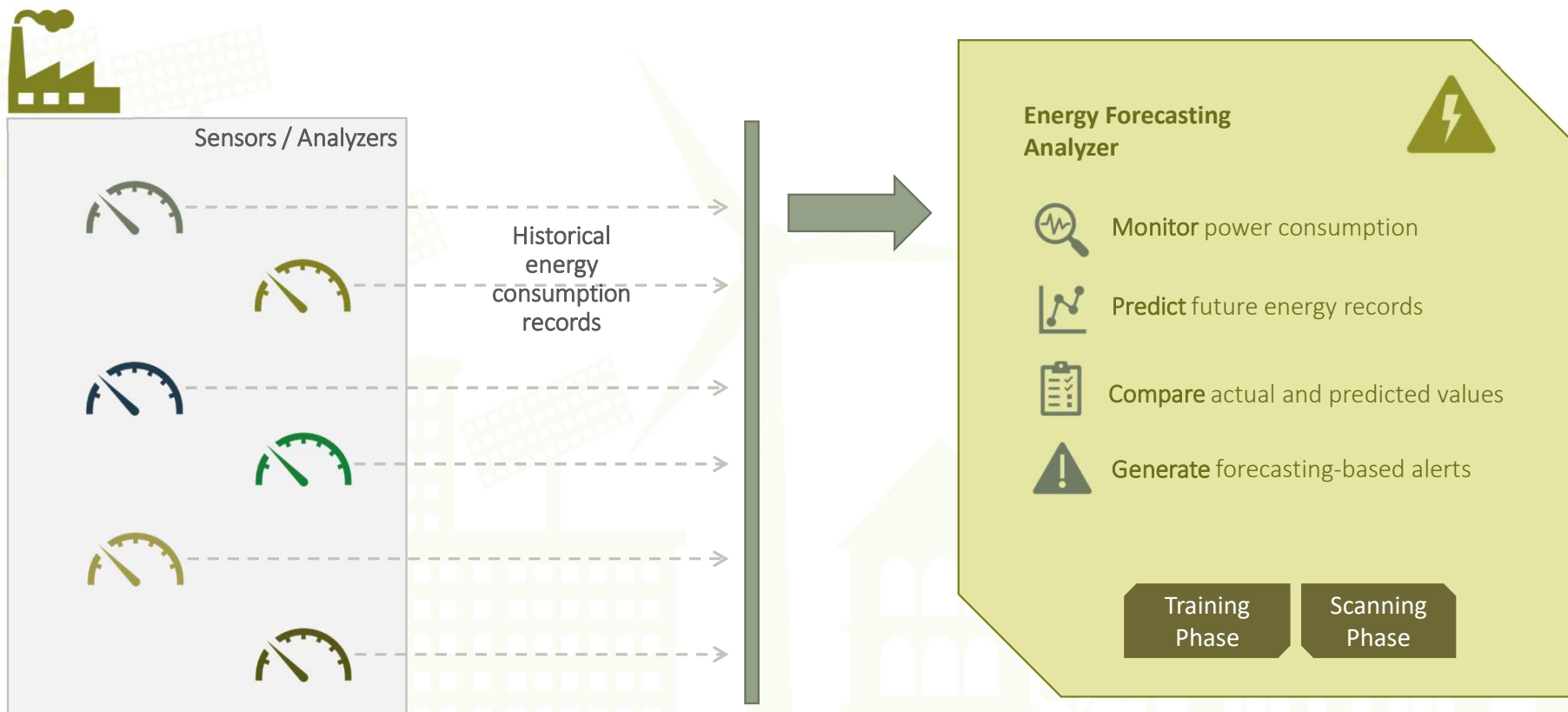
Network Analyzer 

Intelligent Correlator 

Correlator Interface 

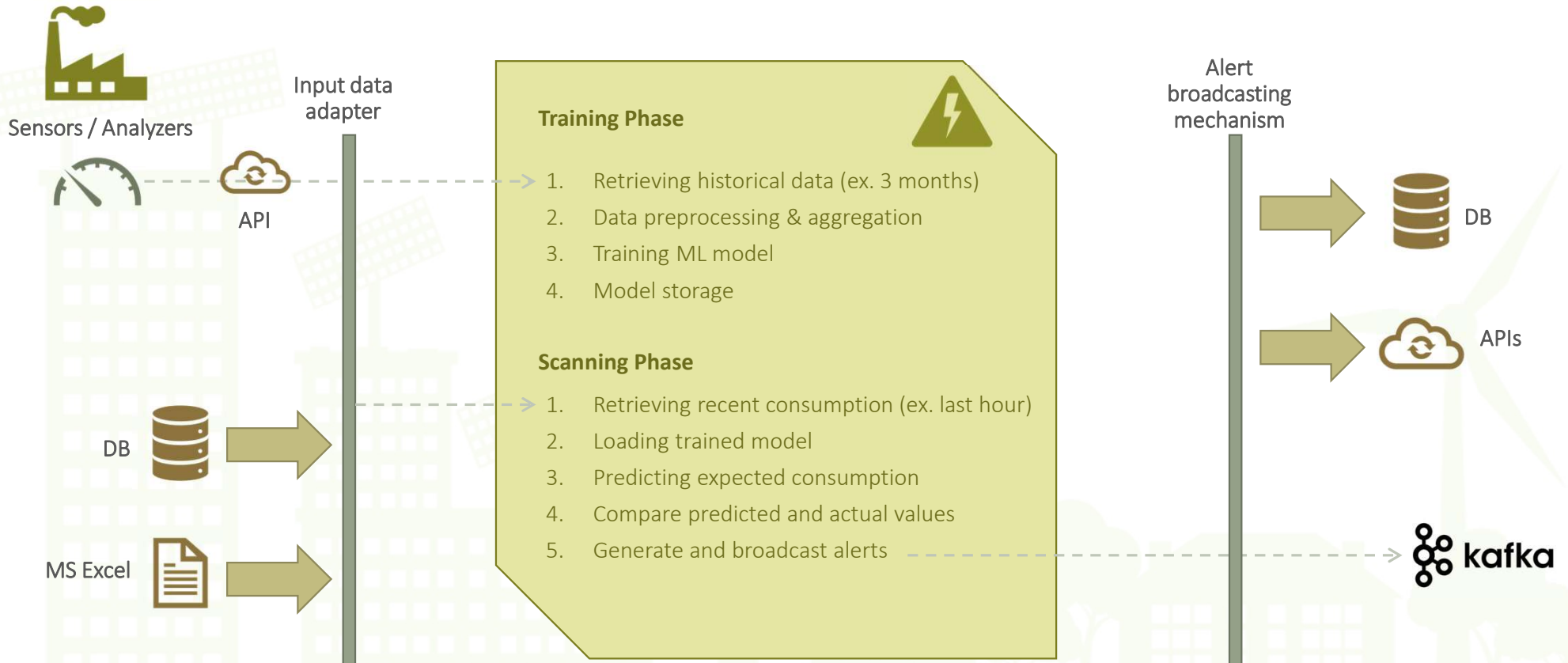
# Energy Forecasting Analyzer

How It Works



# Energy Forecasting Analyzer

Training / Scanning



# Energy Forecasting Analyzer

Alert Sample

```
{
  "trigger_time": "2022-01-17T16:24:54.787484+00:00",
  "processing_time": "2022-01-17T16:24:54.997518+00:00",
  "description": "Energy value exceeded the designated threshold during the last HOUR. Energy Value is: 13833 Predicted Value is: 11665.076923076924",
  "analyzer": " ",
  "provider": " ",
  "training_details": {
    "start_time": "2022-01-17T16:24:20.562542+00:00",
    "end_time": "2022-01-17T16:24:22.381506+00:00",
    "accuracy_r2": 0.8392024963776039,
    "columns": "[\"year\", \"month\", \"day\", \"hour\", \"target\"]",
    "data_rows_num": 73,
    "data_columns_num": 5,
    "estimator_details": "AdaBoostRegressor()",
    "validation_details": "KFold(n_splits=5, random_state=None, shuffle=True)",
    "aggregation_window": "HOUR"
  },
  "scanning_details": {
    "start_time": "2022-01-17T16:24:53.981535+00:00",
    "end_time": "2022-01-17T16:24:55.184482+00:00",
    "prediction_sample": "[2022, 1, 17, 15]",
    "actual_energy_value": 13833.0,
    "predicted_energy_value": 11665.076923076924,
    "diff_energy_value": 2167.923076923076,
    "threshold_energy_value": 1000.0
  }
}
```

# Questions ...

# Thank You ...

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