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**PHASE - 1**



**TOPIC : - MEASURE ENERGY CONSUMPTION**



## **INTRODUCTION: ARTIFICIAL INTELLIGENCE**

Artificial Intelligence(AI) is the intelligence of machines or software, as opposed to the intelligence of humans or animals. It is also the field of study in computer science that develops and studies intelligent Machines. “AI” may also refer to the machines themselves. AI technology is Widely used throughout industry, government and science. Some high-profile applications are advanced web search engines, recommendation systems, understanding human speech, self-driving cars etc. The various subfields of AI research are centred around particular goals and the use of particular tools. The traditional goals of AI research include reasoning, knowledge representation, planning, learning, natural language processing, perception and support for robotics. There are thousands of successful AI applications used to solve specific problems for specific industries or institutions. In a 2017 survey, one in five companies reported they had incorporated “AI” in some offering or processes. A few examples are energy storage, medical diagnosis, military logistics, applications that predict the result of judicial decisions, foreign policy of supply chain management. In the early 2020s, generative AI gained widespread prominence. ChatGPT, based on GPT-3, and other language models were tried by 14% of American adults.

Artificial Intelligence (AI) is a field of computer science focused on creating systems and machines that can perform tasks that typically require human intelligence. These tasks include problem-solving, learning, reasoning, perception, understanding natural language, and more. AI systems can be categorised into two main types:

**Narrow or Weak AI:** This type of AI is designed for specific tasks and operates within a limited domain. It does not possess general intelligence or consciousness. Examples include virtual assistants like Siri or Alexa, recommendation algorithms, and image recognition software.

**General or Strong AI:** General AI refers to machines that have the ability to understand, learn, and perform a wide range of tasks at a human-like level. This level of AI is still largely theoretical and remains a subject of ongoing research and debate.

AI technologies rely on various techniques and approaches, including machine learning, deep learning, natural language processing, and computer vision. These

systems use large amounts of data to improve their performance and make predictions or decisions.

AI has applications in numerous fields, such as healthcare, finance, autonomous vehicles, robotics, and more. It has the potential to revolutionise industries, automate repetitive tasks, and solve complex problems. However, AI also raises ethical and societal concerns related to bias, privacy, job displacement, and the potential for misuse. AI continues to advance rapidly, and its development and impact on society are areas of ongoing interest and debate.

### **Tools Used:**

**TensorFlow:** TensorFlow applications can be run conveniently on your local machine, cloud, android and iOS devices. As it is built on a deployable scale, it runs on CPU and GPU.

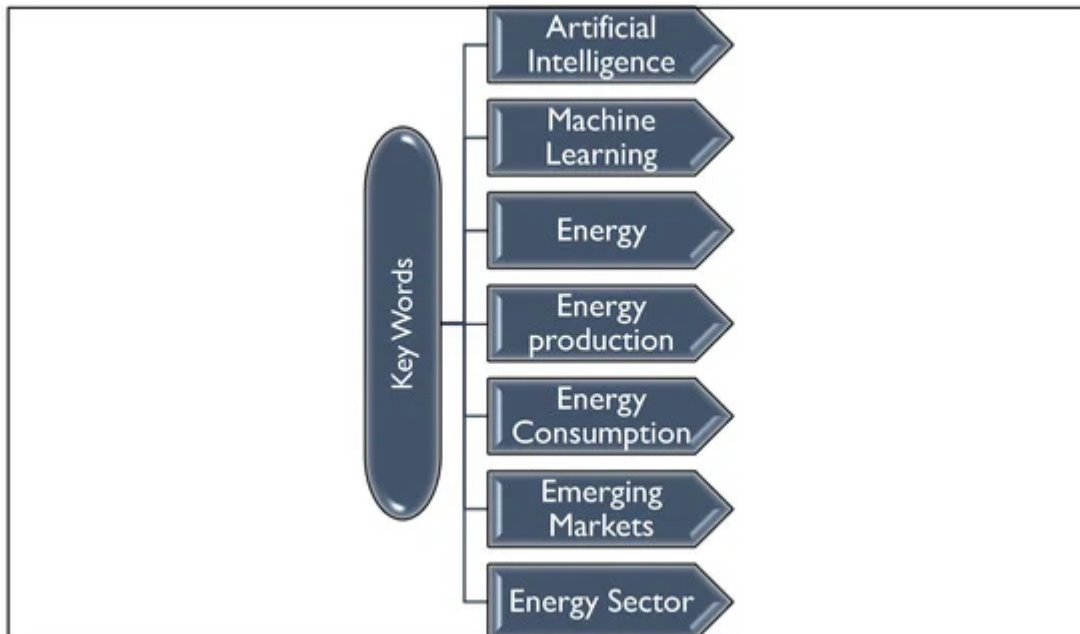
**PyTorch:** PyTorch is similar to TensorFlow in terms of the nature of the projects chosen. However, when the priority is for faster development, PyTorch is the better choice. TensorFlow is gone in case the project involves larger and more complex projects.

**Scikit Learn:** Scikit-learn is a widely praised Artificial Intelligence tool that simplifies the complexities of machine learning tasks. It boasts an intuitive and user-friendly interface that caters to learners across different proficiency levels. Scikit-learn equips users with the means to construct and deploy machine learning models effortlessly.

**Natural Language Processing:** It focuses on developing natural interactions between humans and computers. Specialised software helps machines process human language, create understandable words, and interact with humans through language.

**Figstack:** Figstack provides a comprehensive set of artificial intelligence tools designed to support developers in comprehending and documenting code more effectively. Its diverse array of features is geared towards simplifying the coding process, featuring a natural language interpreter capable of understanding code in nearly any programming language.

## **MEASURE ENERGY CONSUMPTION**



### **ENERGY**

Energy is a fundamental concept in physics and refers to the capacity or ability of a system to do work. It comes in various forms and is neither created nor destroyed, according to the law of conservation of energy, but can be transformed from one form to another.

### **MEASURING ENERGY CONSUMPTION**

Measuring energy consumption in detail requires a systematic approach and the use of appropriate tools and devices. Here are the key steps and methods for measuring energy consumption:

**Identify the Energy Sources:** Determine the energy sources you want to measure. This could include electricity, natural gas, heating oil, or other forms of energy.

**Select Measurement Units:** Choose the appropriate units for measuring energy consumption. Common units include kilowatt-hours (kWh) for electricity, therms for

natural gas, and gallons for heating oil.

**Install Energy Meters:** Install energy meters or monitoring devices for each energy source you want to measure. For electricity, this may involve using smart meters provided by utility companies. For other sources, you may need separate energy meters.

**Record Readings:** Regularly record readings from the energy meters. The frequency of readings may vary depending on your needs, but daily, weekly, or monthly readings are common.

**Analyze Consumption Patterns:** Use software or tools to analyze the consumption data. Look for patterns and trends in energy usage. Some utility companies provide online platforms for tracking and analyzing energy consumption.

**Monitor Real-time Data:** For a more detailed understanding, consider real-time monitoring systems that provide continuous data on energy usage. These systems can offer insights into peak usage times and help identify energy-saving opportunities.

**Weather Normalisation:** Consider normalising energy consumption data for weather variations. Heating and cooling energy consumption can be significantly affected by temperature fluctuations. Normalisation helps to compare energy use across different time periods accurately.

**Energy Audits:** Conduct energy audits, either self-assessment or with the help of professionals, to identify areas of energy waste and opportunities for improvement. This can involve inspecting insulation, HVAC systems, lighting, and appliances.

**Appliance-level Monitoring:** For a detailed breakdown of energy usage, you can install specialised energy monitoring devices on individual appliances and equipment. These devices provide real-time data on how much energy each appliance consumes.

**Energy Management Systems:** In commercial and industrial settings, energy management systems (EMS) are used to monitor and control energy usage. These systems integrate various sensors and controls to optimise energy consumption.

**Data Logging:** Maintain a detailed record of all your energy consumption data. This historical data is valuable for tracking long-term trends and making informed decisions

about energy efficiency improvements.

**Set Energy Goals:** Based on your analysis, set energy reduction goals and implement energy-efficient measures to achieve them. Regularly monitor progress toward these goals.

**Educate and Involve Stakeholders:** Educate building occupants or employees about energy conservation practices and encourage their involvement in reducing energy consumption.

**Review and Adjust:** Continuously review and adjust your energy management strategies based on the data and insights gathered. This iterative process can lead to ongoing energy savings.

Accurate and detailed energy consumption measurement is essential for optimising energy use, reducing costs, and minimising environmental impact. Depending on the scale and complexity of your energy needs, you may need to consult with energy professionals or use advanced energy management systems to achieve the highest level of detail and efficiency.

## **ROLE OF ARTIFICIAL INTELLIGENCE IN MEASURE ENERGY CONSUMPTION**

Artificial Intelligence (AI) plays a significant and evolving role in measuring energy consumption. AI technologies have the potential to transform how we collect, analyse, and utilise energy consumption data.

**Data Analysis and Prediction:** AI algorithms can analyze historical energy consumption data and predict future usage patterns. This helps energy managers and utility companies anticipate demand fluctuations and plan for efficient energy distribution.

**Anomaly Detection:** AI can identify abnormal energy consumption patterns that may indicate equipment malfunction, energy theft, or inefficiencies. Early detection of anomalies allows for timely intervention to reduce waste and prevent costly issues.

**Smart Grid Management:** AI is used to manage smart grids efficiently. It can balance energy supply and demand in real-time, reduce power losses during transmission, and

integrate renewable energy sources effectively.

**Building Energy Management:** In commercial and residential buildings, AI-powered systems can control heating, ventilation, and air conditioning (HVAC) systems, lighting, and appliances based on occupancy and weather conditions. This ensures that energy is used only when needed.

**Energy Optimization:** AI can optimize energy consumption in industrial processes and manufacturing. Machine learning models can adjust production schedules, equipment settings, and energy sources to minimize energy costs while maintaining productivity.

**Energy-Efficient Routing:** AI algorithms can optimize the routes of delivery vehicles and public transportation to reduce fuel consumption. This is particularly useful for fleets and logistics companies.

**Energy Monitoring:** AI-based energy monitoring systems can provide real-time insights into energy consumption at a granular level. This allows users to identify energy-intensive areas and take corrective actions promptly.

**Demand Response:** AI can enable demand response programs by automatically adjusting energy consumption during peak demand periods. This helps utilities avoid overloads and the need for additional infrastructure.

**Energy Forecasting:** AI can improve the accuracy of energy demand and supply forecasting. This is crucial for planning energy generation and distribution effectively, especially when integrating renewable energy sources.

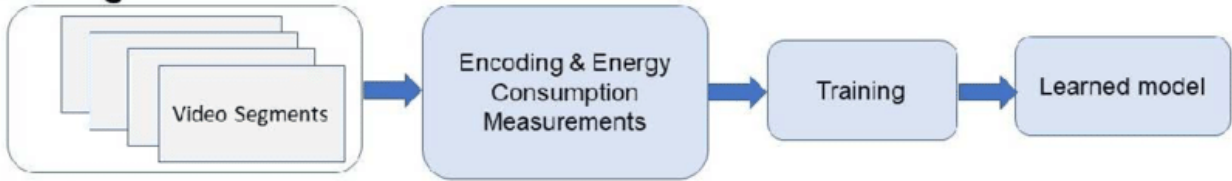
**Grid Maintenance:** AI-powered drones and robots can inspect power lines and other grid infrastructure for maintenance needs, reducing downtime and improving reliability.

**Energy Efficiency Recommendations:** AI systems can analyze a building's energy usage data and provide recommendations for energy-efficient upgrades or behavioral changes to reduce consumption.

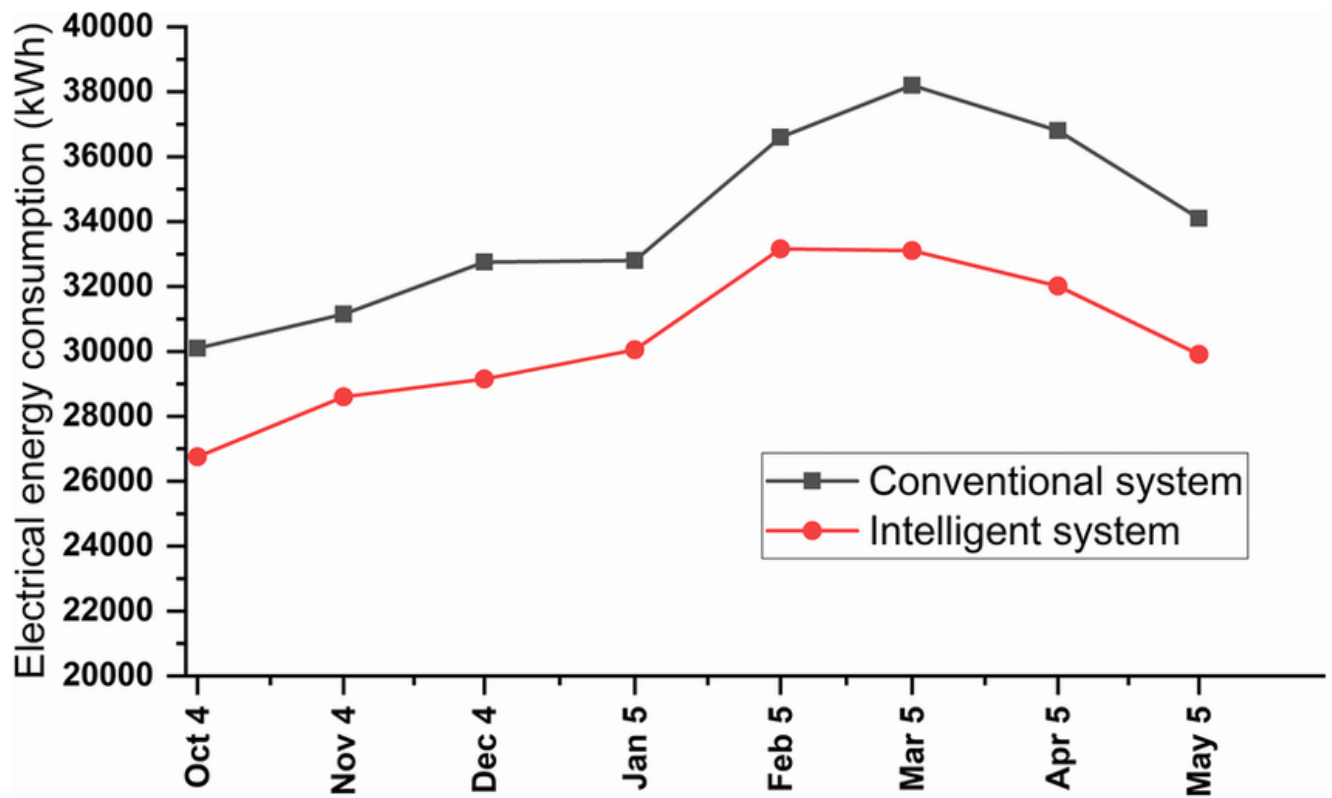
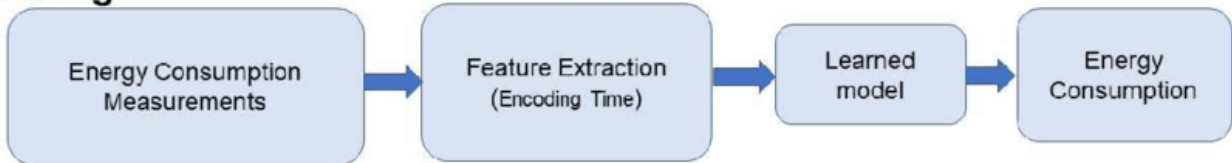
**Energy Billing and Management:** AI can automate the billing process for utility companies, ensuring accurate and timely billing for consumers. It can also help consumers monitor their energy bills and make informed decisions.



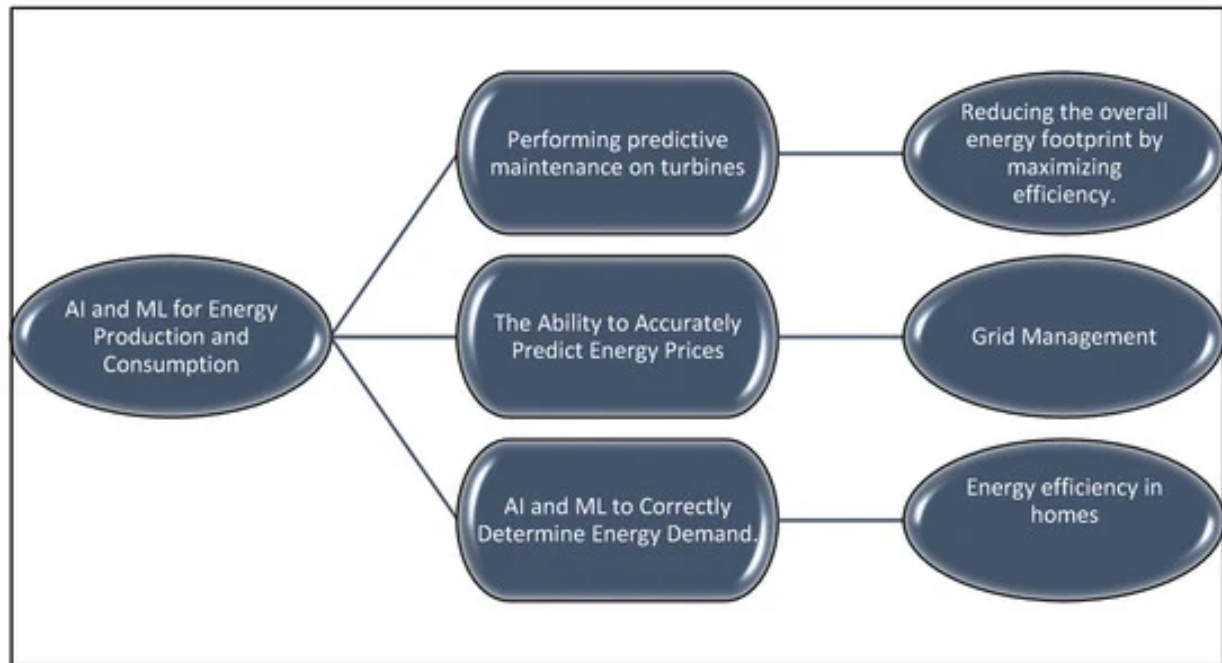
## Training



## Testing



## FORECASTING ENERGY CONSUMPTION WITH AI



Energy consumption has a lasting effect in terms of environmental impact and costs in buildings. Utility meters in buildings generate a growing number of energy data and this data is very crucial for energy budgeting and sustainability. Most of the companies try to reduce energy consumption and costs by implementing various energy conservation measures. This is important for two main goals: (1) **decreasing costs** and (2) **reducing carbon emission** for the planet.

In order to save energy, energy data should be analyzed comprehensively, and actions should be taken in light of the insights from the analyzed data. However, basic statistical techniques have become insufficient to analyze energy consumption and to give meaningful insights. Hopefully, there are state-of-art applications or more complex techniques such as **Machine Learning** and **Artificial Intelligence** methods. Machine Learning is a branch of Artificial Intelligence (AI) focused on building an application that learns from data and improves its accuracy over time without being programmed to do so.[1] That means AI learns from data by analyzing it and therefore does not need a human to give insights.

Recent studies have shown that AI and ML can be used in different domains with

different kinds of datasets. One of the applications of machine learning is **forecasting** which is basically predicting future values. In light of these studies, predicting the energy consumption of the future is possible and could be very useful for energy savings and budgeting. So the question here would be “**How can we use AI for forecasting energy consumption?**”

The energy consumption data is gathered in different time intervals and these data are called time-series data. Since the AI learns from data, it is very crucial to collect data in a healthy way. Therefore, the data should be cleaned and transformed to desired datasets properly for training the AI model to forecast energy consumption precisely. Then, energy data is preprocessed, models are evaluated again and again, selected models are trained and the forecasting results are visualized.

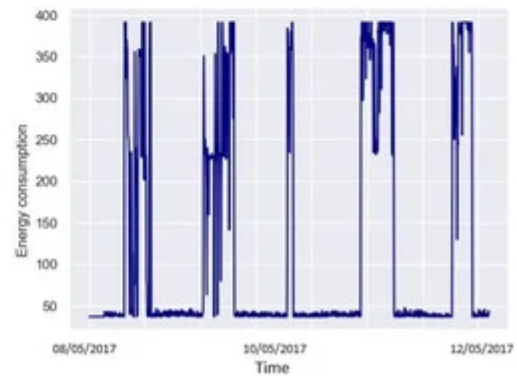
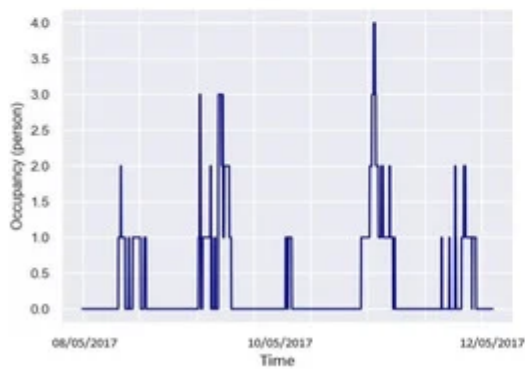
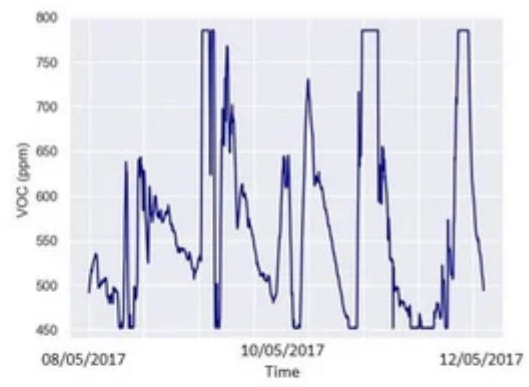
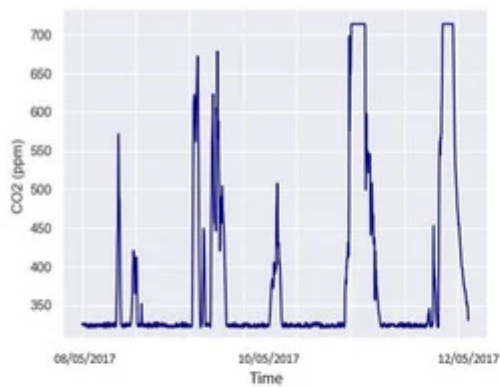
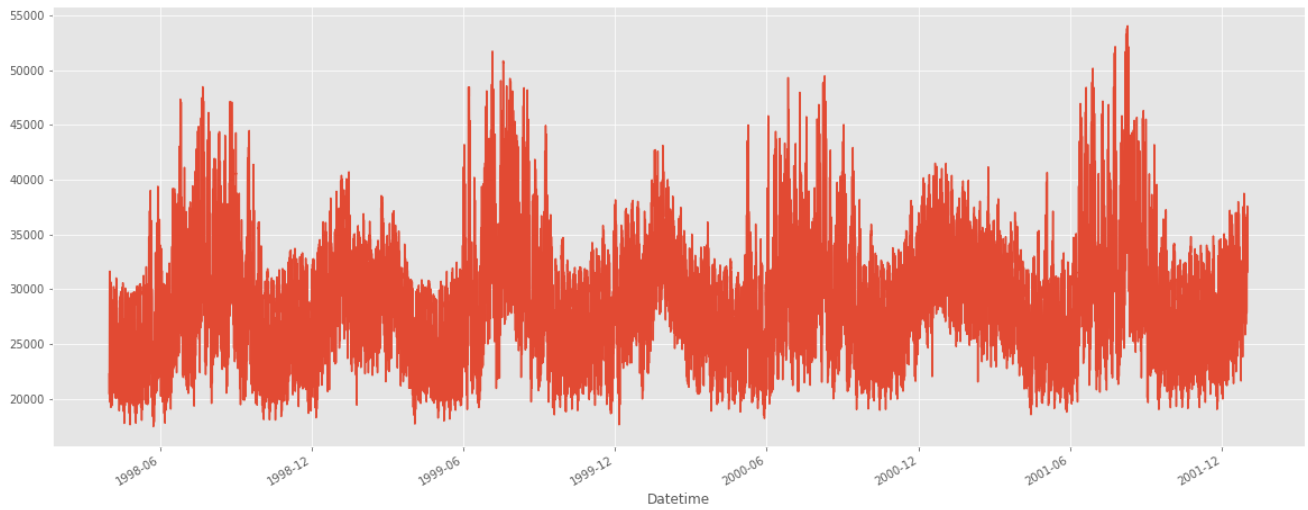
The energy consumption of buildings and facilities commonly consists of periodic consumption behaviors, trends and patterns. Analyzing these consumption data with these pieces allows forecasting future energy consumption information. At that point, ML algorithms help to analyze historical data and develop forecasting applications.

Machine Learning algorithms and frameworks become significantly important to extract knowledge and insights into the energy industry. Plenty of tasks and techniques developed and studied due to that purpose and one of those is time series forecasting. Time series forecasting is an approximation task which is aiming to estimate future values of observations based on current and past values of the sequence and developing a model describing the underlying relationship.

There is a lot of research and different methods and techniques about time series forecasting. The methods are based on analyzing the time series data to develop a model describing the relationship between past and current data. There are Machine Learning techniques such as Autoregressive Integrated Moving Average (ARIMA) and Artificial Neural Networks (ANN) which are two of the several techniques in forecasting tasks.

Artificial Neural Networks (ANN) that are suitable for building data-driven models, can handle nonlinear relationships in the energy consumption dataset. ANN algorithms are very popular over the last decades. There is a lot of research about the usage of ANN as a time series forecasting technique and there are also ANN algorithms such as Recurrent Neural Networks (RNN) and Long-Short Term Memory networks (LSTM)

as time series forecasting techniques.



## **CODE FOR MEASURE ENERGY CONSUMPTION**

```
# Simple Python code to calculate simulated energy consumption

# Function to calculate energy consumption

def calculate_energy_consumption(power, time):

    # Energy (in kilowatt-hours, kWh) = Power (in kilowatts, kW) x Time (in hours, h)

    energy = power * time

    return energy

# Input power in kW

power = float(input("Enter the power rating of the device (in kW): "))

# Input time in hours

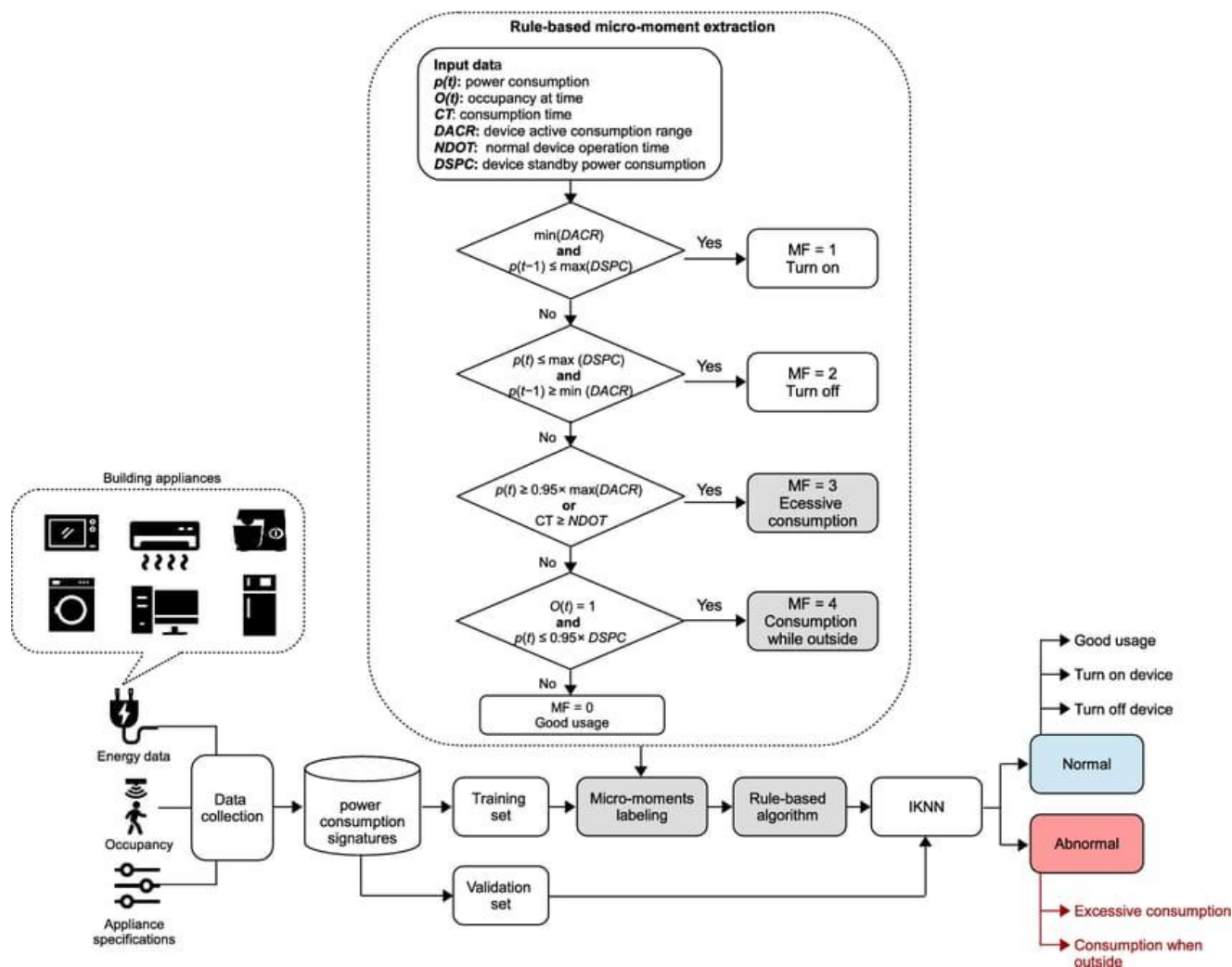
time = float(input("Enter the time the device was used (in hours): "))

# Calculate energy consumption

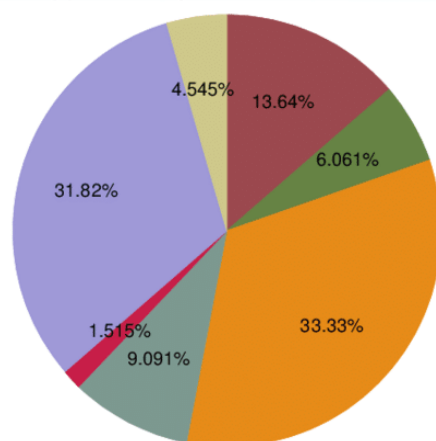
energy_consumed = calculate_energy_consumption(power, time)

# Display the result

print(f"Energy Consumption: {energy_consumed} kWh")
```



## Energy-saving measures



Energy-saving measure: Cogeneration	Energy-saving measure: Solar panels
Energy-saving measure: Solar boiler	Energy-saving measure: Extra insulation
Energy-saving measure: Draught strips	Energy-saving measure: Heating pump
Energy-saving measure: Double glazing	Energy-saving measure: Other

## **CONCLUSION**

Artificial intelligence (AI) is revolutionizing the measurement of energy consumption with several key trends. Firstly, AI-powered smart meters and IoT sensors are becoming ubiquitous, providing real-time data for granular analysis. Secondly, machine learning algorithms are being used for load forecasting, helping utilities predict and manage energy demand more accurately. Thirdly, AI-driven building and industrial energy management systems are optimizing energy usage in real-time, reducing waste. Moreover, AI is facilitating predictive maintenance of energy-related equipment, ensuring operational efficiency. Lastly, AI is supporting the development of data-driven energy policies and grid expansion plans, driving the transition to cleaner and more sustainable energy sources. These trends collectively enhance energy efficiency, reduce costs, and promote environmental sustainability in the energy sector.