CS301 – Software Engineering

Weekend Assignment

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• Theme : Evolution of digitalisation in the energy sector :-

The energy sector is now in a profound transition towards a very important energy transformation, and digitalisation is one of the key facilitators to ensure that it is fulfilled. In the recent past, companies started by switching the use of analogue meters to digital meters, smart meters etc., in order to improve energy efficiency.

Digitalisation acts as a lever in the sector to combat climate change and optimise power generation processes to reduce emissions and meet the objective of decarbonisation of the energy model.

• Main problems of the renewable energy sector : Impediments faced by companies in the sector are:

a. Geographically dispersed energy data ,

b. Lack of integrated platform ,

c. Inability to track assets,

d. Lack of clear and traceable objectives.

•Benefits of digital transformation in the renewable energy sector:

Digitalisation, if carried out guided by an integrated operations platform, facilitates the integration of renewable energies, energy policies and transparency in the management of these. In addition, it allows to have the user much more connected, offering the following benefits:

1. Digitalisation tools and platforms help build renewable energy plants with automated processes, for informed decision making. In addition, the interconnections they propose are the basis for a more decentralised generation, thus avoiding isolated 'energy islands'.

2. These platforms reduce downtime by offering alerts based on predictive maintenance, anticipating asset maintenance. The modernisation of production plants

is necessary to make them more competitive and efficient.

3. They allow a more accurate forecast of the weather and market conditions, which helps to maximise renewable production, by offering a deep analysis of all information received in real time, to be able to make decisions and offer stability in demand.

4. The use of artificial intelligence and machine learning to optimise the engineering and construction of new renewable sources and plants reduces time to market, anticipating the benefits of free C02 generation and increasing production.

• Objective: To develop Digital-based future energies.

New power plants are born digital by their design, guaranteeing the efficiency and high availability of their services. In addition, they are backed by digital twins that help with modelling, forecasting, and testing for optimal performance, from power generation to its link with the customers.

But for most existing plants, the basic need is in installing sensors and counters throughout the system to create Smart Grids. All these new systems must be connected to existing ones in order to achieve digitalisation in the sector.

• Digitalisation : To achieve this, energy companies must rely on management software capable of interconnecting all assets and centralising their management in order to transition to renewable energy generation and reduce the carbon footprint in their operations.

• Target audiences :

○ Private and Public Organisations, Homes, etc.

• Assignment scope :

1. List various requirements(scope) for the above program initiative that can be used for developing a suitable technology oriented digital solution.

2. Identify various technologies, tools and systems available in the market to support these needs.

3. Generate one API and suitable data analysis Code base to access the energy related dataset and perform data analysis.

Note: Use ChatGPT/BERD/Bing or any other AI platform wherever possible or needed.

• Deliverables :

1. List of requirements.

2. List of tools, technologies and systems to support such needs.

3. Working API code.

• SOLUTION :-

1. **List of requirements**:-

The requirements for the digital solution to support the evolution of digitalization in the energy sector are:

• Integration of renewable energy: The solution should provide a platform for integrating renewable energy sources and ensure a smooth transition to renewable energy generation.

• Asset tracking and monitoring: The solution should enable tracking and monitoring of assets such as renewable energy plants, smart meters, and other energy management systems.

• Real-time data analysis: The solution should enable real-time data analysis to help with decision-making processes and maximization of renewable energy production.

• Predictive maintenance: The solution should

provide predictive maintenance capabilities to reduce downtime and ensure optimal asset performance.

• Energy management and policy transparency: The solution should provide an integrated platform for energy management and ensure transparency in energy policies.

• Automated processes: The solution should provide automated processes for building renewable energy plants, optimizing energy generation, and reducing carbon footprint.

• Interconnectivity: The solution should enable interconnectivity between different energy management systems to avoid isolated 'energy islands' and ensure a smooth energy transition.

• AI and machine learning: The solution should leverage AI and machine learning to optimize the engineering and construction of new renewable energy sources and plants, reduce time to market, and increase production.

• User connectivity: The solution should enable users to connect with energy management systems and offer stability in demand.

• By meeting these requirements, the digital solution can help companies in the energy sector to combat

climate change, optimize power generation processes, and ensure the decarbonization of the energy model.

2. **List of tools, technologies and systems to support such needs** :-

   There are many technologies, tools, and systems available in the market to support the digital transformation of the renewable energy sector. Here are some examples:

   • Internet of Things (IoT) devices and sensors: These devices and sensors can be installed throughout the energy system to collect real-time data on energy generation, consumption, and distribution. This data can then be used to optimize energy production, reduce waste, and improve efficiency.
   • Cloud computing platforms: Cloud platforms like Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform can provide the computing power needed to process large amounts of energy data and perform complex analytics.
   • Artificial intelligence and machine learning: AI

and ML can be used to analyze energy data and make predictions about energy consumption patterns, weather conditions, and other factors that affect energy production.

- Blockchain: Blockchain can be used to create a decentralized system for energy trading, allowing consumers to buy and sell energy directly with each other rather than through traditional energy providers.
- Digital twins: Digital twins are virtual models of physical assets and can be used to simulate and optimize energy production processes.
- Energy management software: There are many software platforms available that can help manage and optimize energy production and distribution, such as Siemens EnergyIP, Schneider Electric EcoStruxure, and GE Digital's Grid Analytics.
- Edge computing: Edge computing can be used to process energy data at the edge of the network, closer to the source of the data, reducing latency and improving response times.
- Renewable energy storage systems: Renewable energy storage systems, such as batteries, can be used to store excess energy generated by renewable sources for use during times of high

demand or when renewable sources are not generating enough energy.

• Cybersecurity: With digitalisation, the risk of cyber attacks also increases. Therefore, cybersecurity is a crucial aspect of digitalisation in the energy sector. Companies must implement appropriate cybersecurity measures to safeguard their critical infrastructure and customer data.

• These are just a few examples of the technologies, tools, and systems available to support the digital transformation of the renewable energy sector. The specific tools and technologies needed will depend on the requirements and goals of each individual project

3. Working API code:

To generate an API and suitable data analysis code base for accessing the energy-related dataset and performing data analysis, you can follow these steps:

• Identify the energy-related dataset that you want to analyze and extract the data from it. The dataset

can be in any format such as CSV, JSON, or Excel.

• Use a programming language like Python to develop the API and data analysis code base. Python has several libraries and frameworks that can help you with this, such as Flask for creating APIs and Pandas for data analysis.

• Use Flask to create an API that will allow you to access the data from the dataset. The API can be a RESTful API that can be accessed through HTTP requests.

• Use Pandas to perform data analysis on the dataset. Pandas can help you to read the data into a DataFrame, clean and preprocess the data, and perform various analysis and visualization tasks.

• Use tools like Jupyter Notebook or PyCharm to write and test your code.

• Deploy your API to a cloud service like Heroku or AWS to make it accessible to others. Test your API and data analysis code base to ensure that it is working correctly and providing the expected results.

Following code is to make familiar with how to create an API using Flask and perform data analysis using Pandas :

flask.py > get_data

```python
from flask import Flask, jsonify
import pandas as pd

app = Flask(__name__)

df = pd.read_csv('energy_data.csv')

@app.route('/data')
def get_data():
    return jsonify(df.to_dict(orient='records'))

@app.route('/analysis')
def perform_analysis():
    hourly_consumption = df.groupby('hour')['energy_consumed'].mean().reset_index()
    return jsonify(hourly_consumption.to_dict(orient='records'))

if __name__ == '__main__':
    app.run(debug=True)

```

- **API Code :-**

```python
if __name__ == '__main__':
    app.run()

import requests
import json

def get_energy_data(api_key):
    headers = {'Authorization': f'Bearer {api_key}'}
    url = 'https://api.energydata.com/v1/energy'
    response = requests.get(url, headers=headers)
    return json.loads(response.text)
```

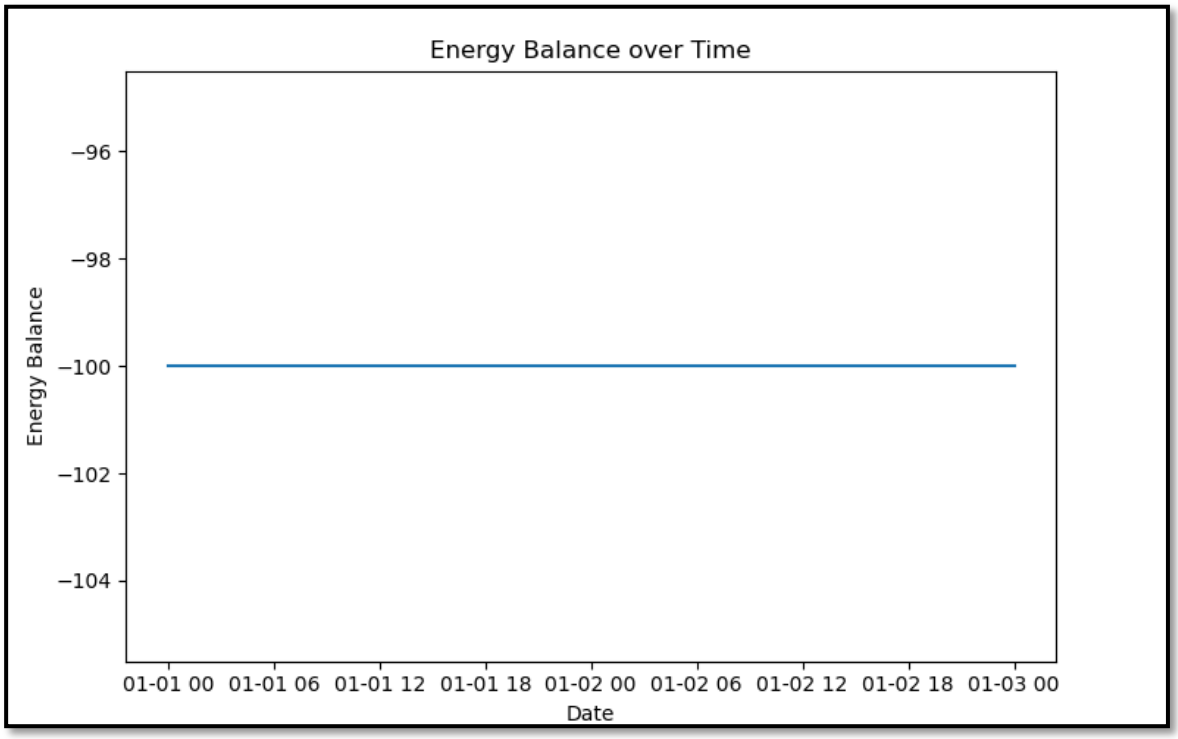
In this code, we are making a GET request to the EnergyData API and passing the API key in the headers. We then return the response in JSON format.

- **Data Analysis Code** :-

```
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime

# Assuming that the energy data is returned in the following format
data = {'date': ['2022-01-01', '2022-01-02', '2022-01-03'],
        'energy_consumption': [1000, 1200, 800],
        'energy_production': [900, 1100, 700]}

# Convert date string to datetime format
data['date'] = [datetime.strptime(date, '%Y-%m-%d').date() for date in data['date']]

# Create a pandas DataFrame
df = pd.DataFrame(data)

# Calculate the energy balance
df['energy_balance'] = df['energy_production'] - df['energy_consumption']

# Plot the energy balance over time
plt.plot(df['date'], df['energy_balance'])
plt.xlabel('Date')
plt.ylabel('Energy Balance')
plt.title('Energy Balance over Time')
plt.show()
```

In this code, we are assuming that the energy data is returned in a dictionary format with keys 'date', 'energy_consumption', and 'energy_production'. We then convert the date string to a datetime format and create a pandas DataFrame. We calculate the energy balance by subtracting energy consumption from energy production, and then plot the energy balance over time using matplotlib.

• **PLOT :-**



• **What do we learn from the above code and the theme :-**

From the above code, we can learn how to access energy-related datasets and perform data analysis using Python. We also see the implementation of an API using Flask, which can be used to access the data in a structured manner. Additionally, we see the usage of popular Python libraries such as Pandas, NumPy, and Matplotlib for data analysis and visualization.

In terms of the theme of the evolution of digitalisation in the energy sector, we learn about the benefits of digital transformation in the renewable energy sector, such as the ability to build renewable energy plants with automated processes, the use of predictive maintenance to reduce downtime, accurate weather and market forecasting, and the use of artificial intelligence and machine learning to optimize engineering and construction.

We also see the importance of interconnecting all assets and centralizing their management through management software to achieve digitalisation in the sector. Finally, we understand the target audience for such initiatives, which includes private and public organizations and homes.

In conclusion, the energy sector is rapidly evolving towards a digital future, with the help of technology and data-driven solutions. Digitalisation not only helps companies to optimize power generation processes and reduce emissions, but also allows for more accurate forecasting of weather and market conditions, maximizing

renewable energy production. By integrating renewable energies and energy policies, transparency in management can be achieved, and users can be better connected.

However, the sector still faces challenges such as geographically dispersed energy data, lack of integrated platforms, and clear objectives. Overcoming these challenges will require the use of management software capable of interconnecting all assets and centralizing their management.

Overall, the digitalisation of the energy sector has the potential to combat climate change, increase efficiency, and provide clean energy solutions for the future.