Green IT Data Visualization Project

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In class, the environmental footprint of IT was discussed. There were two key takeaways:

- Data centers are responsible for about 1.5% of the global electricity consumption.
- Energy efficiency is measured as Power Usage Effectiveness.
  (PUE $= \frac{total\ power\ consumption\ dc}{power\ consumption\ IT}$)

Learning Objectives

By the end of this project, you will be able to: - Calculate and interpret Power Usage Effectiveness (PUE) metrics - Create professional data visualizations with matplotlib - Analyze trends in global e-waste generation and recycling - Connect data analysis to real-world sustainability challenges

In this notebook, you will calculate PUEs of given companies and visualize (and interpret) E-waste data.

Exercise1: Power Usage Effectiveness (PUE)

```
# --- Setup (do not modify) ---
import pandas as pd
import matplotlib.pyplot as plt

# --- Data: PUE values of major cloud providers ---
# Sources: see reference table below
data_centers = {
    "Name": [
        "Google (global, 2024)",
        "AWS (global, 2024)",
        "Microsoft (global, 2022)",
        "Meta (Luleå, 2024)",
        "Industry Average (2024)"
```

```
    ],
    "PUE": [
        1.09,    # Google Environmental Report 2025
        1.15,    # AWS Sustainability Report 2024
        1.18,    # Microsoft Azure Blog (2022)
        1.07,    # Meta/DCPulse (Luleå, Sweden)
        1.56     # Uptime Institute Survey 2024
    ]
}
df_dc = pd.DataFrame(data_centers)
```

Good Visualization Practices

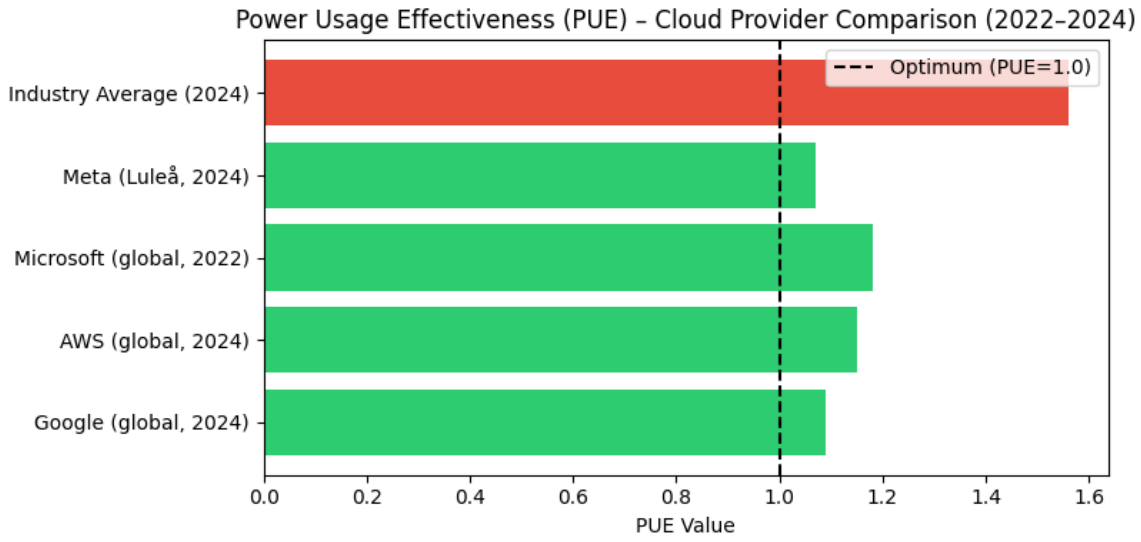
Before you start coding, consider: 1. **Clear labels**: Always label axes and add a title. 2. **Color meaning**: Use color to convey information (green = good, red = bad). 3. **Reference lines**: Add lines for benchmarks (e.g., PUE = 1.0). 4. **Legend**: Explain what colors or symbols mean.

```

# TODO 1: Create a horizontal bar chart (barh) of the PUE values.
#
# HINTS:
# - Use df_dc["Name"] for the y-axis labels
# - Use df_dc["PUE"] for the x-axis values
# - To color bars conditionally, create a list:
#   colors = ['green' if pue < 1.2 else 'orange' if pue < 1.4
#             else 'red' for pue in df_dc["PUE"]]
# - Add a vertical line: plt.axvline(x=1.0, color='black',
#   linestyle='--', label='Theoretical Optimum')
# - Don't forget plt.xlabel(), plt.ylabel(), plt.title(),
#   plt.legend()
fig, ax = plt.subplots(figsize=(8, 4))
colors = [
    "#2ecc71" if pue < 1.2
    else "#f39c12" if pue < 1.4
    else "#e74c3c"
    for pue in df_dc["PUE"]
]
ax.barh(df_dc["Name"], df_dc["PUE"], color=colors)
ax.axvline(x=1.0, color="black", linestyle="--",
           label="Optimum (PUE=1.0)")
ax.set_xlabel("PUE Value")
ax.set_title("Power Usage Effectiveness (PUE) "
```

```
            "- Cloud Provider Comparison (2022-2024)")
ax.legend()
plt.tight_layout()
plt.show()

```



Exercise 2: E-Waste Analysis

```
# --- Data: Global e-waste ---
# Source: Global E-Waste Monitor 2024
# (UNITAR/ITU), including projections
data_ewaste = {
    "Year": [
        2010, 2014, 2019, 2022, 2030
    ],
    "E_Waste_Million_Tonnes": [
        34.0, 41.8, 53.6, 62.0, 82.0
    ],
    "Recycled_Percent": [
        23.5, 22.5, 17.4, 22.3, 20.0
    ]
}
df_ew = pd.DataFrame(data_ewaste)

# TODO 2: Create a line chart with two y-axes: e-waste
# (million tonnes) on the left axis and recycling rate (%)
```

```
# on the right axis, over time.
#
# HINTS:
# - Use plt.plot() for both lines
# - For the second y-axis: ax2 = ax1.twinx()
# - Mark 2030 as a projection using a dashed line or different
#   marker (e.g., linestyle='--' for years >= 2030, or use
#   plt.axvline(x=2030, linestyle=':', label='Projection'))
# - Label both y-axes: ax1.set_ylabel("..."),
#   ax2.set_ylabel("...")
# - Add a legend: ax1.legend(loc='upper left'),
#   ax2.legend(loc='upper right')


# TODO 3:
# (a) Calculate unrecycled e-waste in 2022:
#     unrecycled_tonnes = total_2022 * (1 - recycled_percent
 ↪  / 100)
#
# (b) Calculate value of unrecycled materials:
#     If total value = USD 62 bn and recycling rate = 22.3%,
#     then unrecycled value = 62 * (1 - 0.223) billion USD
#
# Print both results.
```

References

Organization	Report/Source	Year
Google	Environmental Report 2025	2025
AWS	Sustainability Report 2024	2024
Microsoft	Azure Blog (PUE Metrics)	2022
Meta	DCPulse (Luleå Data Center)	2024
Uptime Institute	Global Data Center Survey	2024
UNITAR/ITU	Global E-Waste Monitor 2024	2024

Links: - Google: https://sustainability.google/reports/ - AWS: https://sustainability.aboutamazon.com/ - Microsoft: https://azure.microsoft.com/en-us/blog/ - Meta: https://sustainability.fb.com/ - Uptime Institute: https://uptimeinstitute.com/ - UNITAR: https://ewastemonitor.info/