POWER CONSUMPTION ANALYSIS

1.Project Overview and Objective

Project Overview

The Power Consumption Analysis project focuses on monitoring, analyzing, and visualizing electricity usage patterns to support data-driven decision-making. The objective is to understand how power is consumed across different time periods, locations, or consumer categories, identify inefficiencies, and recommend strategies for optimized energy usage and cost reduction.

This project uses historical power consumption data to uncover trends, seasonal patterns, peak demand periods, and anomalies. By leveraging analytical techniques and interactive dashboards (developed in Power BI), stakeholders can gain real-time insights into energy utilization and performance metrics.

The analysis enables:

- Better demand forecasting and load management
- Identification of high-consumption areas and peak hours
- Evaluation of energy efficiency initiatives
- Support for sustainability and cost-saving decisions

The Power BI dashboard provides dynamic visualizations such as line charts, bar graphs, KPIs, and filters that allow users to drill down by time (hourly, daily, monthly), region, or consumer type. This enhances transparency and helps utilities, organizations, or policymakers make informed decisions to improve energy efficiency and reliability.

Project Objectives

Analyze Power Usage Patterns

To study historical electricity consumption data and identify usage trends across different time periods (hourly, daily, monthly, and yearly).

Identify Peak and Off-Peak Demand

To determine peak load hours and low-demand periods in order to optimize energy distribution and reduce stress on the power system.

Monitor Consumption by Category

To compare power usage across locations, departments, consumer types, or equipment to identify high-consumption areas.

Detect Anomalies and Inefficiencies

To identify unusual spikes, power wastage, or inefficiencies in consumption patterns that may indicate faults or poor energy practices.

Support Cost Optimization

To evaluate electricity usage against tariffs and help reduce operational costs through better load planning and energy-saving strategies.

Enable Data-Driven Decision Making

To provide interactive Power BI dashboards that allow stakeholders to drill down into consumption data and make informed decisions.

Forecast Future Power Demand
To use historical trends to predict future power consumption and assist in capacity planning and infrastructure development.

Promote Energy Efficiency and Sustainability
To support energy conservation initiatives and reduce carbon footprint by optimizing electricity usage.

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2. Data Sources

- **Source Description and Timeline:** GitHub and 2016-2020.
- **Domain**: Power and Utilities Sector

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3. Problem Statement

- Electricity consumption has been increasing rapidly due to population growth, urbanization, and expanding industrial and commercial activities. Many organizations and utility providers lack a centralized and data-driven approach to effectively monitor, analyze, and manage power consumption. As a result, inefficiencies such as power wastage, unexpected peak loads, higher operational costs, and increased strain on energy infrastructure often go unnoticed.
- The absence of real-time visibility and historical analysis makes it difficult to identify consumption patterns, peak demand periods, and abnormal usage. Without actionable insights, stakeholders are unable to optimize energy usage, forecast future demand accurately, or implement effective energy-saving strategies.
- This project aims to address these challenges by analyzing historical power consumption data and developing interactive Power BI dashboards that provide clear insights into energy usage trends, peak and off-peak periods, and consumption behavior across different time frames or consumer segments. The goal is to support informed decision-making, improve energy efficiency, reduce costs, and promote sustainable power usage.

Key Issues Addressed

- Lack of visibility into power consumption trends
- Inefficient energy usage and power wastage
- Difficulty in identifying peak demand and anomalies
- Limited support for forecasting and planning
- Rising energy costs and sustainability concerns

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4. Attribute (Column /Features) Details:

Attribute Name	Data Type	Description
Date	Date	Date of recorded energy consumption
Building	String (Text)	Name or ID of the building
Water Consumption	Numeric (Integer)	Total water usage for the day
Electricity Consumption	Numeric (Integer)	Total electricity usage for the day
Gas Consumption	Numeric (Integer)	Total gas usage for the day
Year	Integer (Year)	Calendar year for which the energy price is recorded
Energy Type	Text (Categorical)	Type of energy or utility being measured

Price Per Unit	Cost per unit of the specified energy type	Currency (USD)
City	Text (Categorical)	City where the building is located
Country	Text (Categorical)	Country where the building is located

5. Tools & Technologies

- **Excel:** Data cleaning, transformation, and Pivot Tables.
- **Power BI:** Data modelling, DAX calculations, visualization, and interactive dashboard creation.

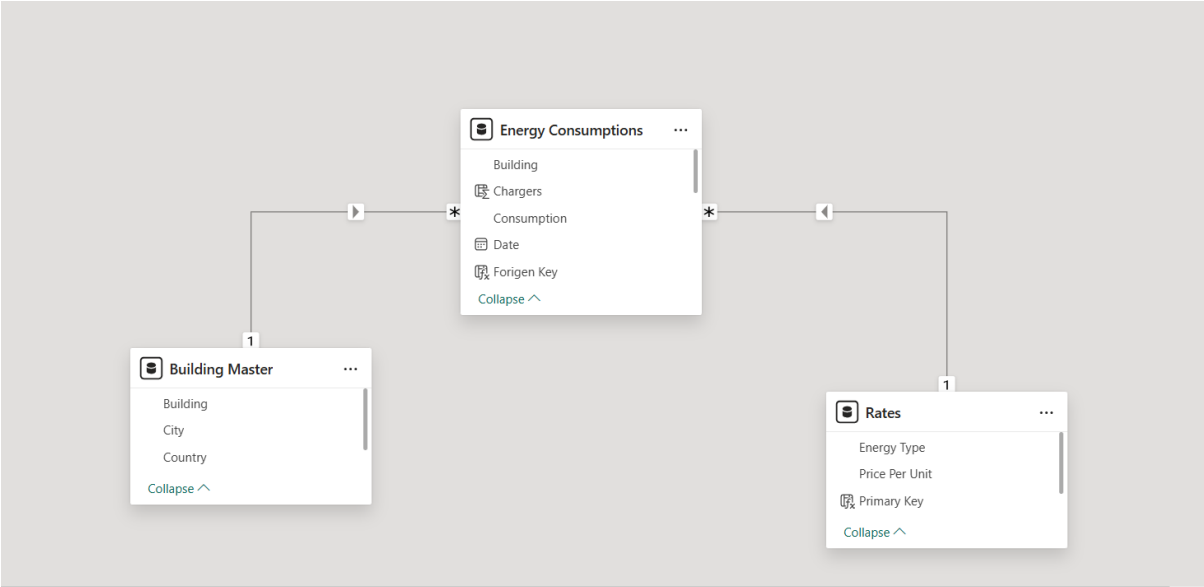
6. Data Pre-Processing (Excel / Power Query)

Tasks Performed:

- **Data Cleaning & Transformation:** Removed duplicates, handled missing values, standardized formats, and created calculated fields.
- **Filtering & Sorting:** Organized data to focus on relevant records.
- Water Consumption, Gas Consumption, and Electricity Consumption were unpivoted into a single Consumption column, and the year was extracted from the Date field as Year. The Year–Consumption combination was used as a foreign key in the fact table. Finally, the Year and Energy Type fields in the Rates table were combined to create a primary key for establishing relationships between the tables

7. Data Modelling and DAX (Power BI)

- **Data Model:** Established relationships between tables, defined cardinality, its come under star schema.



SCREENSHOT OF DATA MODELLING

Calculated Columns:

- Forigen_Key = CONCATENATE('Energy Consumptions'[Year],'Energy Consumptions'[Consumption])
- Year = Year('Energy Consumptions'[Date])
- Primary Key = CONCATENATE(Rates[Year],Rates[Energy Type])

DAX Measures:

- Unit_Cosumed = sum('Energy Consumptions'[Unit])
- Unit_Consumed = sum('Energy Consumptions'[Unit])/COUNT('Energy Consumptions'[Unit])

- Unit_Consumed_in_water = CALCULATE(sum('Energy Consumptions'[Unit]),'Energy Consumptions'[Consumption]="Water")
- Unit_Consumed_in_water = CALCULATE(sum('Energy Consumptions'[Unit]),'Energy Consumptions'[Consumption]="Gass")
- Unit_Consumed_in_water = CALCULATE(sum('Energy Consumptions'[Unit]),'Energy Consumptions'[Consumption]="Electricity")
- Total Charges = sum('Energy Consumptions'[Chargers])

SCREENSHOT OF DASHBOARD /REPORT

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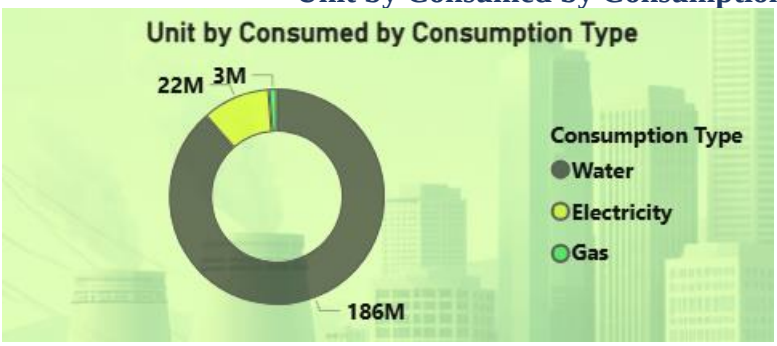
8. Analysis and Visualizations Insights

- **Key Findings:** Summarize trends, patterns, or anomalies identified in the data

Visualizations based on problem statement:

Unit by Consumed by Consumption Type



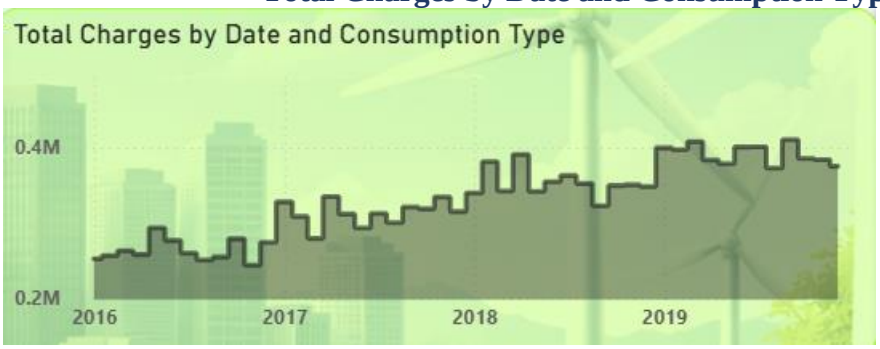
Key Observations

- **Water dominates consumption** at **186M units**, making up the vast majority of total usage.
- **Electricity consumption** is **22M units**, significantly lower than water but still substantial.
- **Gas consumption** is the lowest at **3M units**, indicating minimal usage compared to other utilities.

Percentage Insight (Approx.)

- **Water:** ~88–90% of total consumption
- **Electricity:** ~10–11%
- **Gas:** ~1–2%

Total Charges by Date and Consumption Type



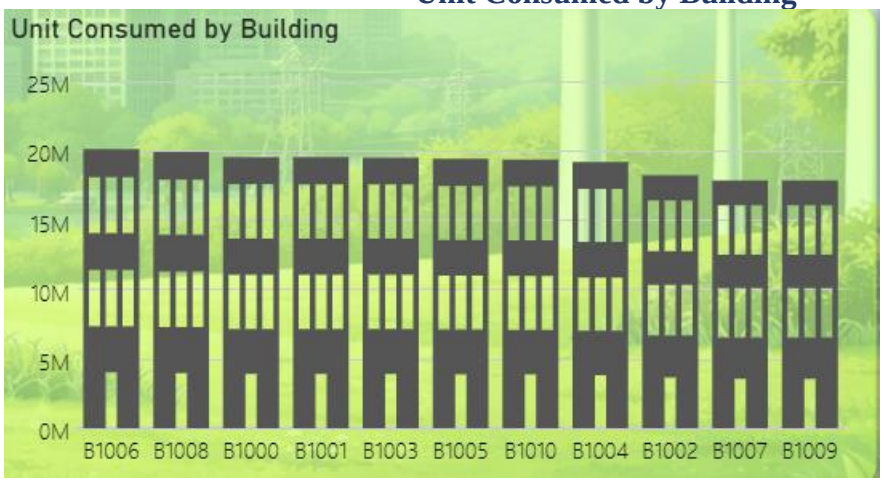
Trend Analysis

- Overall upward trend (2016–2019):
  Total charges steadily increase over time, indicating rising consumption costs or higher tariffs.
- Growth acceleration after 2017:
  Charges rise more sharply from 2017 onward, suggesting increased demand, price hikes, or expansion in operations.

Variability & Patterns

- Short-term fluctuations:
  Periodic ups and downs indicate seasonal consumption patterns or varying operational activity.
- Peaks around **2019 (~0.4M):**
  The highest charges occur toward the end of the timeline, signaling peak consumption or maximum pricing impact.

Unit Consumed by Building



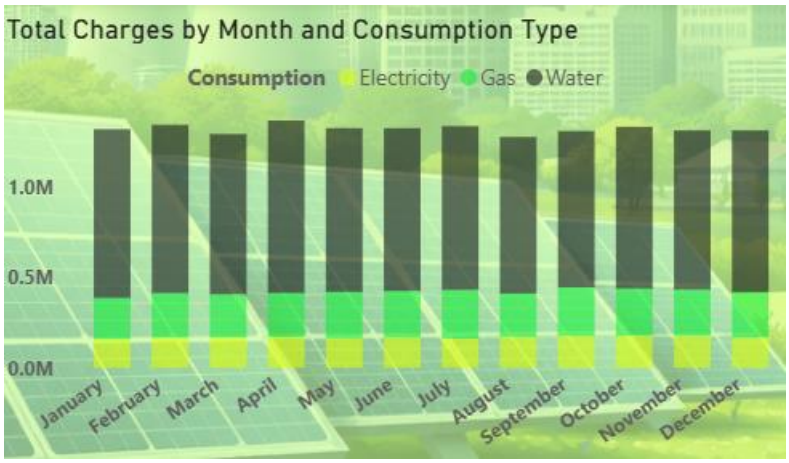
Consumption Comparison

- Consumption is fairly uniform across buildings, mostly ranging between **17M–20M** units.
- No single building is an extreme outlier, indicating balanced utility usage across locations.

High & Low Consumers

- Higher consumption buildings:
  Buildings like **B1006, B1008, B1001, B1003, and B1010** appear slightly higher than others, nearing the upper range.
- Lower consumption buildings:
  B1002, B1007, and B1009 show comparatively lower usage, suggesting better efficiency or lower occupancy/activity.

Total Charges by Month and Consumption Type



Overall Monthly Pattern

- Total charges remain relatively stable across all months, with only minor fluctuations.
- This indicates consistent utility usage and cost behavior throughout the year, with no extreme seasonal spikes.

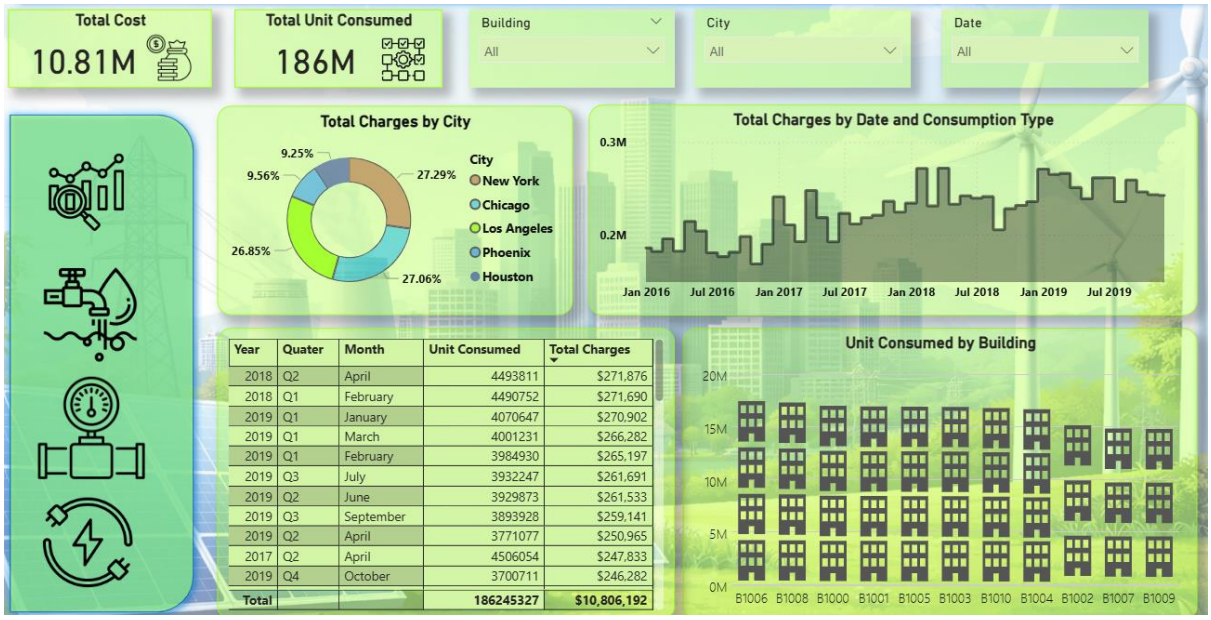
Consumption Type Contribution

- Water is the largest contributor to total charges every month.
- Gas is the second-highest contributor, showing steady monthly costs.
- Electricity contributes the least, remaining low and consistent across all months.

Seasonal Insights

- Slight increases mid-year (around **June–August**) may be linked to higher cooling demand, operational load, or water usage.
- No sharp seasonal volatility, suggesting good control over consumption or fixed-rate billing structures.

WATER



Year	Quater	Month	Unit Consumed	Total Charges
2018	Q2	April	4493811	$271,876
2018	Q1	February	4490752	$271,690
2019	Q1	January	4070647	$270,902
2019	Q1	March	4001231	$266,282
2019	Q1	February	3984930	$265,197
2019	Q3	July	3932247	$261,691
2019	Q2	June	3929873	$261,533
2019	Q3	September	3893928	$259,141
2019	Q2	April	3771077	$250,965
2017	Q2	April	4506054	$247,833
2019	Q4	October	3700711	$246,282
Total			186245327	$10,806,192

- **Total Cost: 10.81M**
- **Total Units Consumed: 186M units**

  Indicates high energy usage with significant cost impact, making efficiency optimization critical.

City-wise Charges Distribution

New York (27.29%), Chicago (27.06%), Los Angeles (26.85%)

- These three cities together contribute ~81% of total charges.
- Represent primary consumption and revenue centers.

Phoenix (9.56%) and Houston (9.25%)

- Lower contribution, suggesting smaller demand or better efficiency.
- Potential regions for growth or benchmarking best practices.

Charges Trend Over Time (2016–2019)

Consistent upward trend in total charges across years.

2018–2019 show the highest and most stable charge levels.

Repeated peaks indicate:

- Seasonal consumption patterns
- Increased operational activity

Despite short-term fluctuations, long-term growth is strong and steady.

Unit Consumption by Building

Significant variation across buildings **(B1000–B1010).**

Some buildings consistently consume **above 15–20M units, indicating:**

- Higher operational load
- Potential inefficiencies

Lower-consuming buildings can serve as efficiency benchmarks.

📊 Detailed Monthly & Quarterly Insights

Highest monthly unit consumption:

- April 2018 & February 2018 (~4.49M units)

Peak monthly charges:

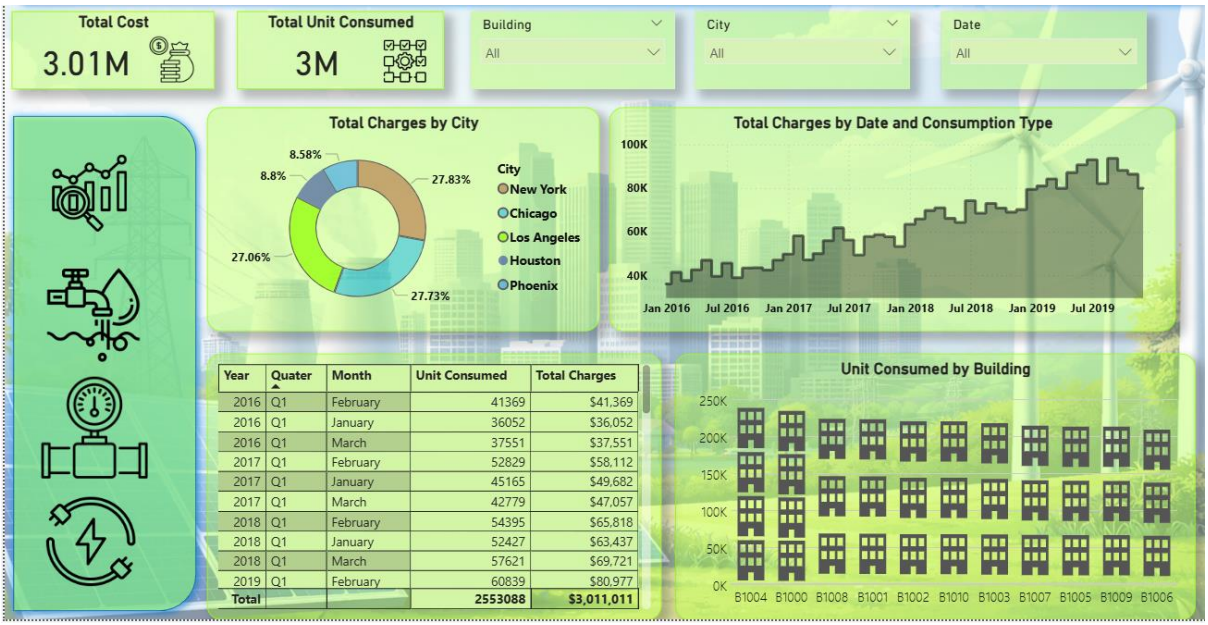
- Around $271K–$272K

Q1 and Q2 quarters show higher consumption, indicating seasonal impact.

Total verified:

- 186,245,327 units
- $10,806,192 total charges

GAS



Year	Quater	Month	Unit Consumed	Total Charges
2016	Q1	February	41369	$41,369
2016	Q1	January	36052	$36,052
2016	Q1	March	37551	$37,551
2017	Q1	February	52829	$58,112
2017	Q1	January	45165	$49,682
2017	Q1	March	42779	$47,057
2018	Q1	February	54395	$65,818
2018	Q1	January	52427	$63,437
2018	Q1	March	57621	$69,721
2019	Q1	February	60839	$80,977
Total			2553088	$3,011,011

- **Total Cost: $3.01M**
- **Total Units Consumed: 3.0M units**

  ➡️ Reflects a **focused subset of data** (likely limited buildings, cities, or dates).

🏙️ Total Charges by City

New York (27.83%), Chicago (27.73%), Los Angeles (27.06%)

- Nearly **equal contribution** across the top three cities.
- Indicates **balanced energy usage and cost distribution**.

Houston (8.80%) & Phoenix (8.58%)

- Significantly lower shares.
- Potential for either **lower demand** or **higher efficiency**.

🔍 *Insight:* No single city dominates—energy consumption is **geographically well distributed**.

📈 Charges Trend Over Time (2016–2019)

- Clear **upward trend** in total charges.
- Charges rise steadily from ~40K in 2016 to **90K+ by 2019**.
- Periodic dips suggest **seasonal or operational variability**, but growth remains consistent.

🏢 Unit Consumption by Building

Consumption ranges broadly between **~150K to 250K units**.

Certain buildings consistently show **higher energy demand**, indicating:

- Larger facility size
- Higher operational load
- Possible inefficiencies

Lower-consuming buildings may represent **best practices**.

📋 Monthly Consumption & Charges (Table Insights)

Highest monthly unit consumption:

- **Feb 2019 – 60,839 units**

Highest monthly charges:

- **Feb 2019 – $80,977**

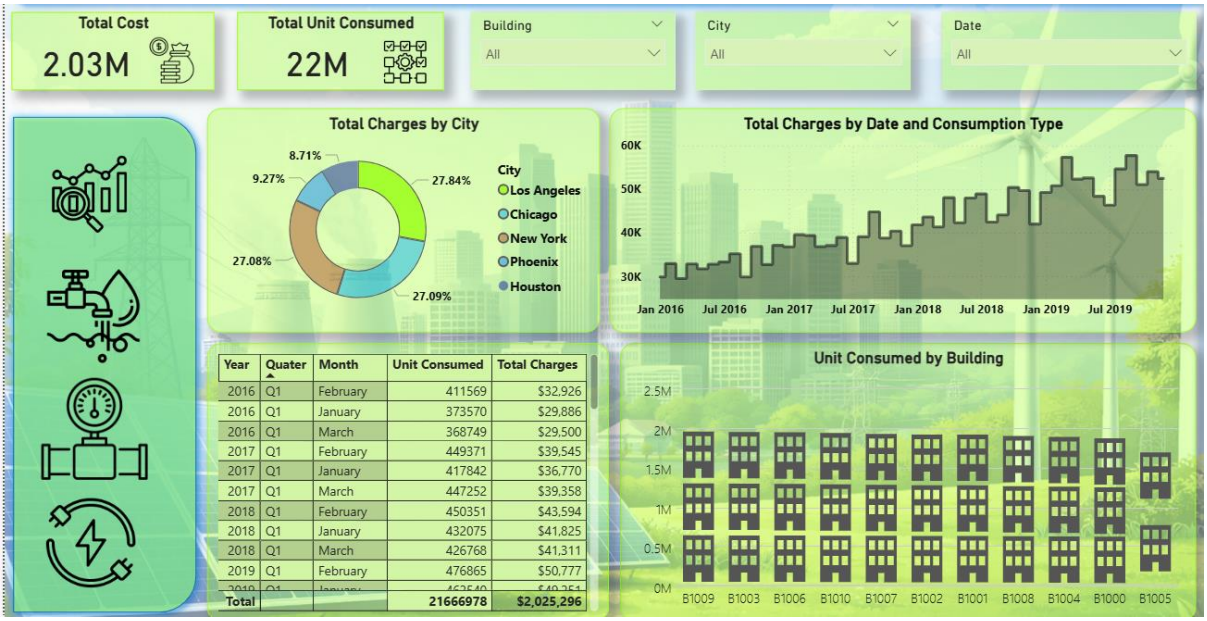
Q1 months (Jan–Mar) show:

- Consistent rise year-over-year
- Strong seasonal demand pattern

📌 Totals (Table):

- **2,553,088 units**
- **$3,011,011 total charges**

ELECTRICITY



- **Total Cost: $2.03M**
- **Total Units Consumed: 22M units**

  ➡ Indicates **moderate energy usage** compared to previous views, likely due to a different filter selection.

🏙 Total Charges by City

Los Angeles (27.84%), **Chicago (27.09%)**, **New York (27.08%)**

- Almost **equal contribution** from the top three cities.
- Shows **uniform cost distribution** across major metros.

Phoenix (9.27%) and **Houston (8.71%)**

- Lower contribution but still consistent.
- Suggests either **smaller facilities or better efficiency**.

🔍 *Insight:* No city is a dominant cost driver; energy demand is **geographically balanced**.

📈 Charges Trend Over Time (2016–2019)

- Strong **upward trend** in total charges.
- Charges increase from ~30K in 2016 to **55–60K by 2019**.
- Short-term dips indicate **seasonal or operational variations**, but overall growth remains steady.

🏢 Unit Consumption by Building

Unit consumption ranges up to **~2.5M units** per building.

Some buildings clearly consume **significantly more energy**, highlighting:

- High operational intensity
- Potential inefficiencies

Lower-consuming buildings can be used as **efficiency benchmarks**.

📋 **Monthly & Quarterly Insights (Table)**

Highest monthly unit consumption:

- **Feb 2019 – 476,865 units**

Highest monthly charges:

- **Feb 2019 – $50,777**

Q1 months (Jan–Mar) consistently show higher consumption across years.

Table total confirms:

- **21,666,978 units**
- **$2,025,296 total charges**

Analysis Insights

1. Descriptive Analysis

Key Metrics Overview

- Total Cost: **~ $2.03M**
- Total Units Consumed: ~ **22M units**
- Data spans **2016–2019**, covering Electricity, Water, and Gas consumption**.**

City-wise Charges

- Los Angeles, Chicago, and New York each contribute **~27–28%** of total charges.
- Phoenix and Houston contribute **less (~9% each).**
- Overall, energy cost distribution is balanced across major cities.

Time-based Trends

- Total charges show a steady upward trend year over year.
- Consumption and charges are lowest in **2016 and highest in 2018–2019.**
- Short-term fluctuations indicate seasonal usage patterns.

Building-wise Consumption

- Significant variation across buildings.
- Some buildings consume **2–3x more energy** than others, indicating uneven operational loads.

2. Diagnostic Analysis

Rising Costs Over Time

Increase driven by:

- Growth in unit consumption
- Expansion of operations
- Possible tariff or rate increases

City-level Balance

Similar cost shares across top cities suggest:

- Comparable infrastructure size
- Similar operational intensity
- Standardized pricing mechanisms

Seasonal Peaks

Higher usage observed in Q1 (Jan–Mar):

- Heating demand
- Increased operational hours

Explains recurring spikes in both units consumed and total charges.

High-Consumption Buildings

Likely causes:

- Larger facility size
- Older or inefficient equipment
- Continuous or energy-intensive processes

3. Predictive Analysis

Cost Trend Projection

If current patterns continue:

- Total energy cost will continue to rise annually
- Expected growth of **8–12%** per year

Seasonal Forecast

- **Q1 and Q2** will remain peak consumption periods.
- Buildings with historically **high usage will continue** to drive majority of costs.

Risk Indicators

Without intervention:

- High-consuming buildings may cause disproportionate cost escalation
- Budget overruns likely during peak seasons

4. Prescriptive Analysis

Building-level Actions

Conduct energy audits for top-consuming buildings.

Upgrade to:

- Energy-efficient HVAC systems
- Smart meters and automation

Implement predictive maintenance.

Seasonal Cost Control

Introduce:

- Peak-hour load shifting
- Demand-response strategies

Plan budgets proactively for Q1 & Q2 peaks.

City-wide Strategy

Since cities are balanced:

- Roll out standardized energy efficiency policies across all locations.

Benchmark low-performing buildings against efficient ones.

Monitoring & Governance

Set alerts for:

- Abnormal consumption spikes
- Cost per unit thresholds

Use dashboards for continuous monitoring and forecasting.

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9. Conclusions

The dashboard reveals a clear upward trend in energy consumption and cost, driven primarily by seasonal demand and high-consuming buildings rather than geographic imbalance. By focusing on building-level efficiency, seasonal planning, and predictive monitoring, organizations can significantly reduce costs, improve sustainability, and enhance operational efficiency...