

# **Clean Energy for Sustainable Power Production in U.S. Analysis**

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DAB 16**

# Scenario

Sustainable energy is one of the key SDGs that Bahrain aims to achieve by 2050. To move toward this objective, the country is reducing its reliance on natural gas by integrating renewable power sources into its energy mix. The United States, one of the global leaders in renewable energy deployment, offers valuable insights and best practices. Studying the U.S. experience can help Bahrain identify effective strategies and adapt suitable technologies.

7 AFFORDABLE AND CLEAN ENERGY



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



13 CLIMATE ACTION



# Approaches



**Which type of energy source demonstrates the highest operational performance?**

**Which type of energy source generates the greatest amount of electricity?**

**Which type of energy source is the most economically and technically feasible to develop?**

**In which U.S. states is each energy source type most highly concentrated?**

**Which type of renewable energy is most suitable for deployment in Bahrain?**



# Technical Terminologies

# Fuel Type Classification

## Renewable

Solar

Geothermal

Hydroelectric

Other Renewables

Wind

## Non-Renewable

Coal

Natural Gas

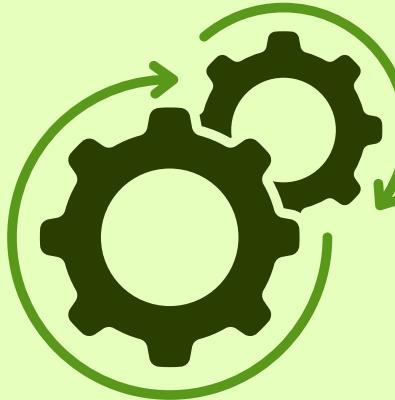
Oil

## Carbon Free

Nuclear

# Comparative Performance

Operational Performance

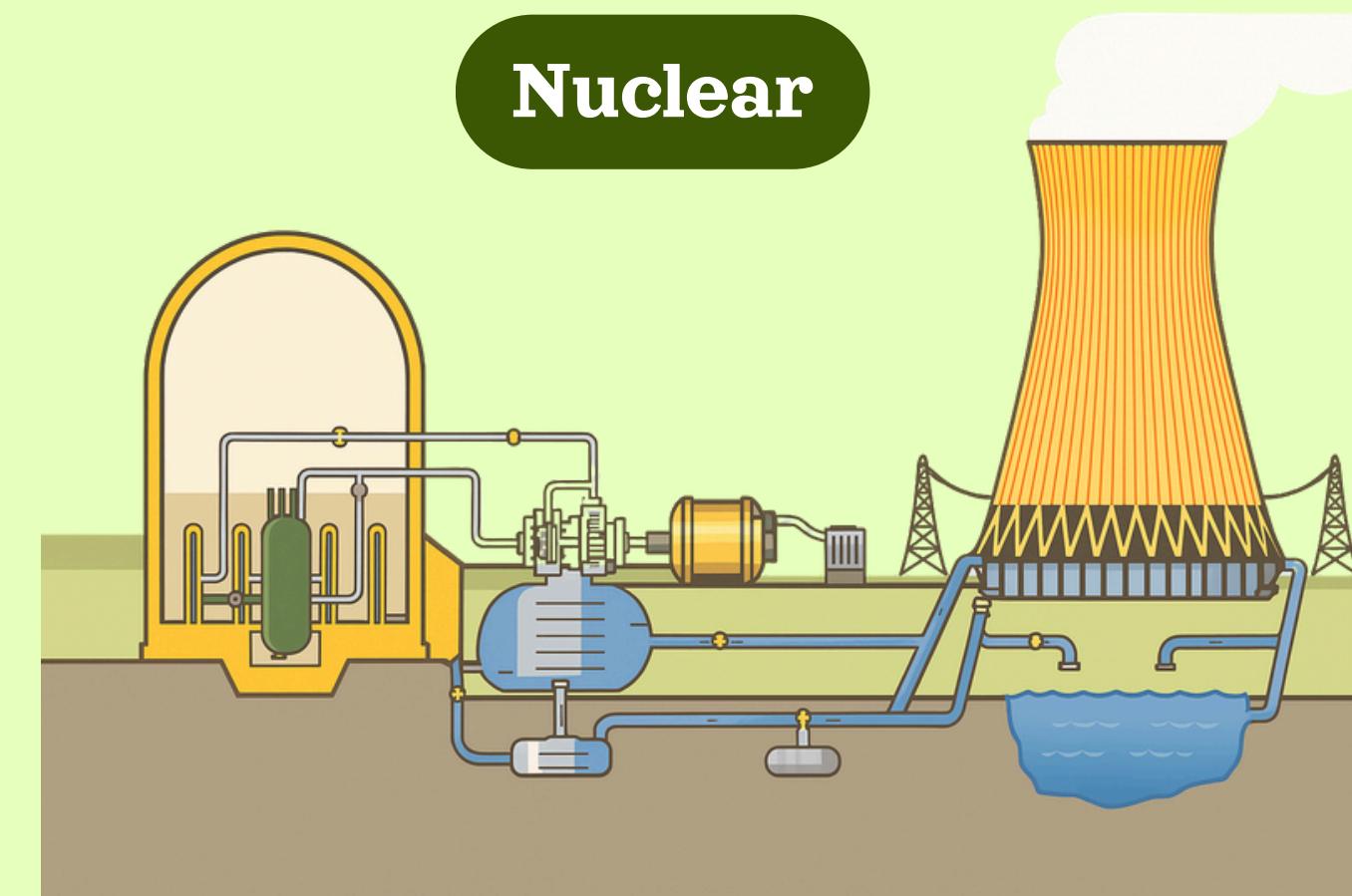
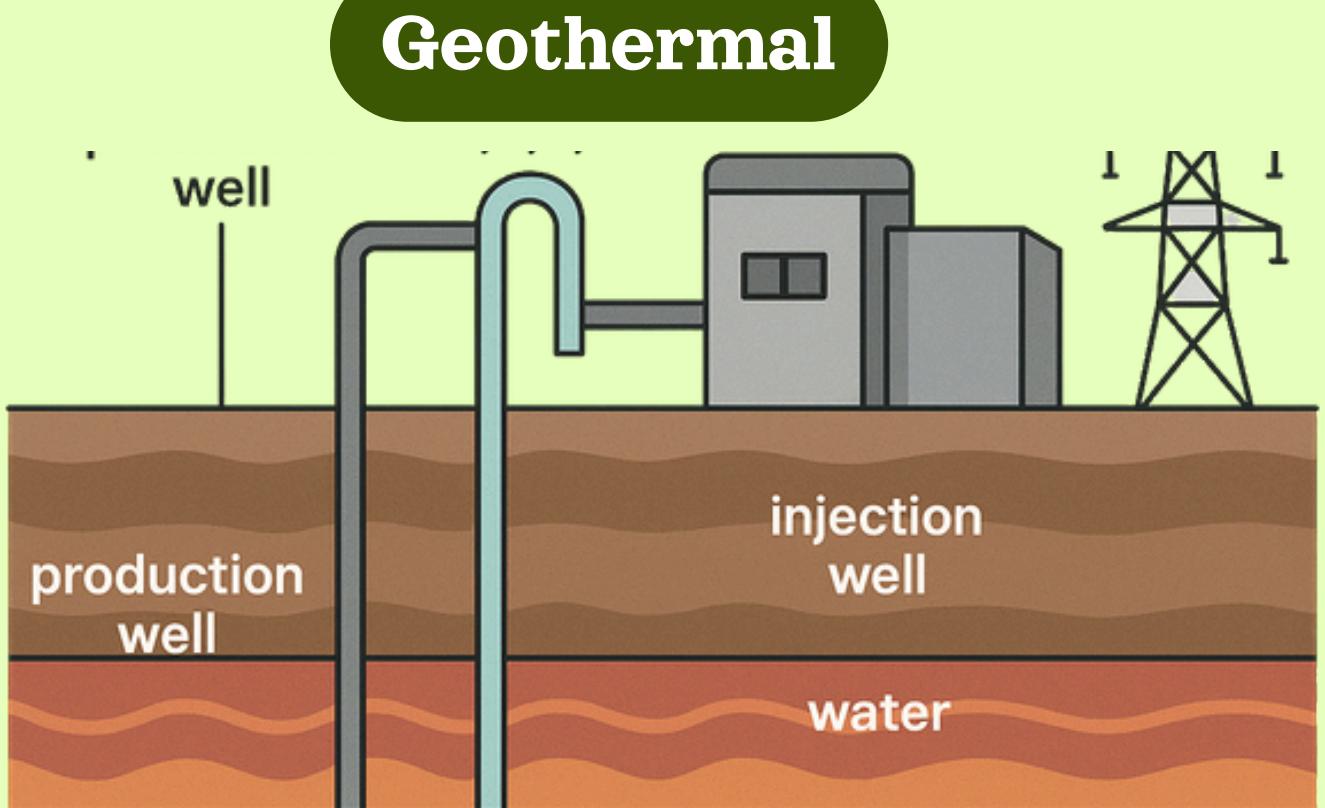
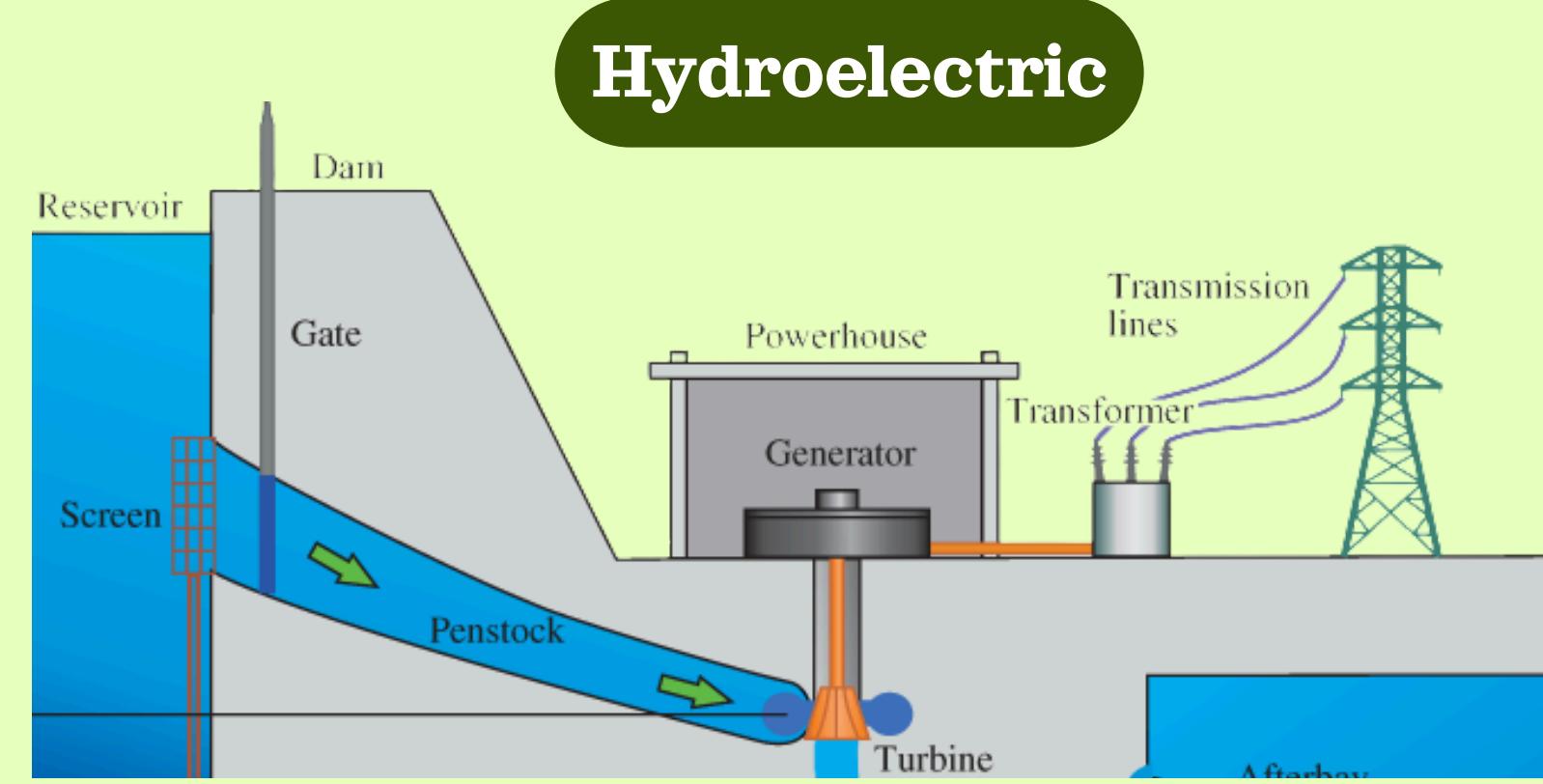
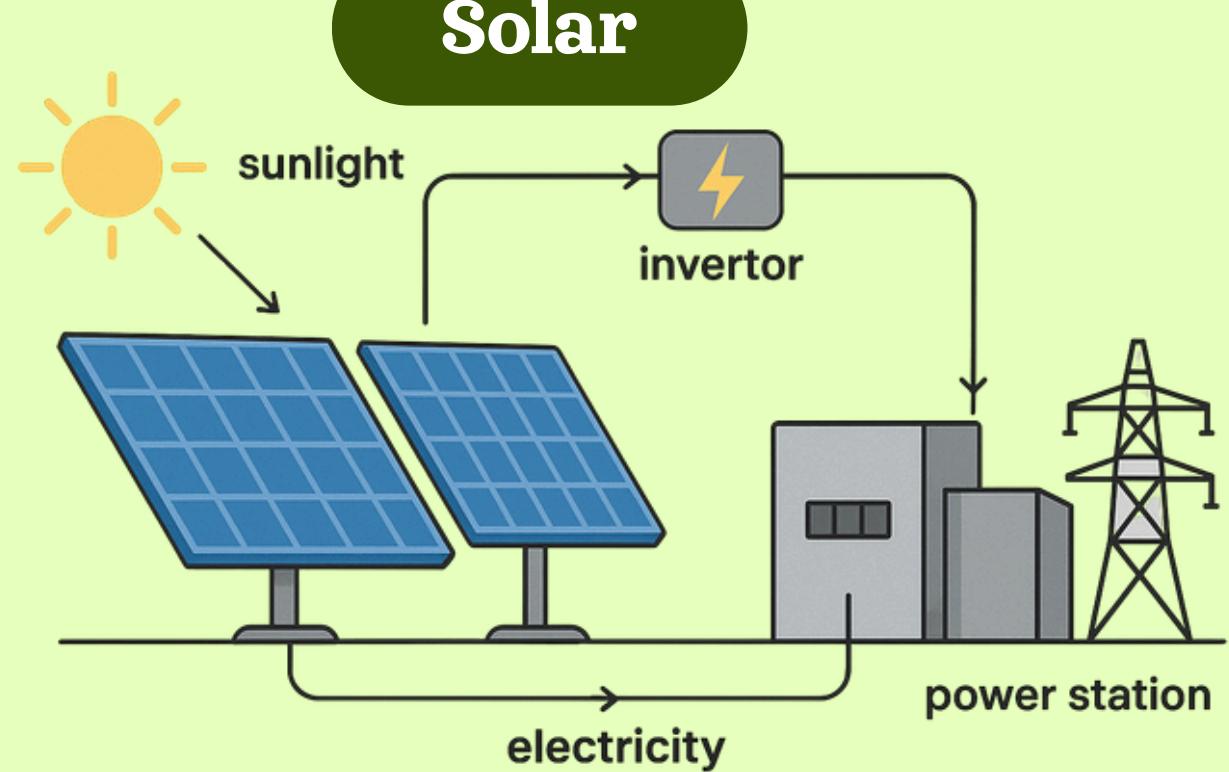


Infrastructure Comparison



Fuel Efficiency

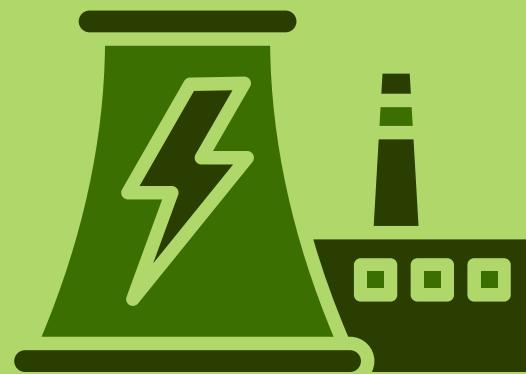
# Energy Generation Process



# Overall Comparison



## Total Plants



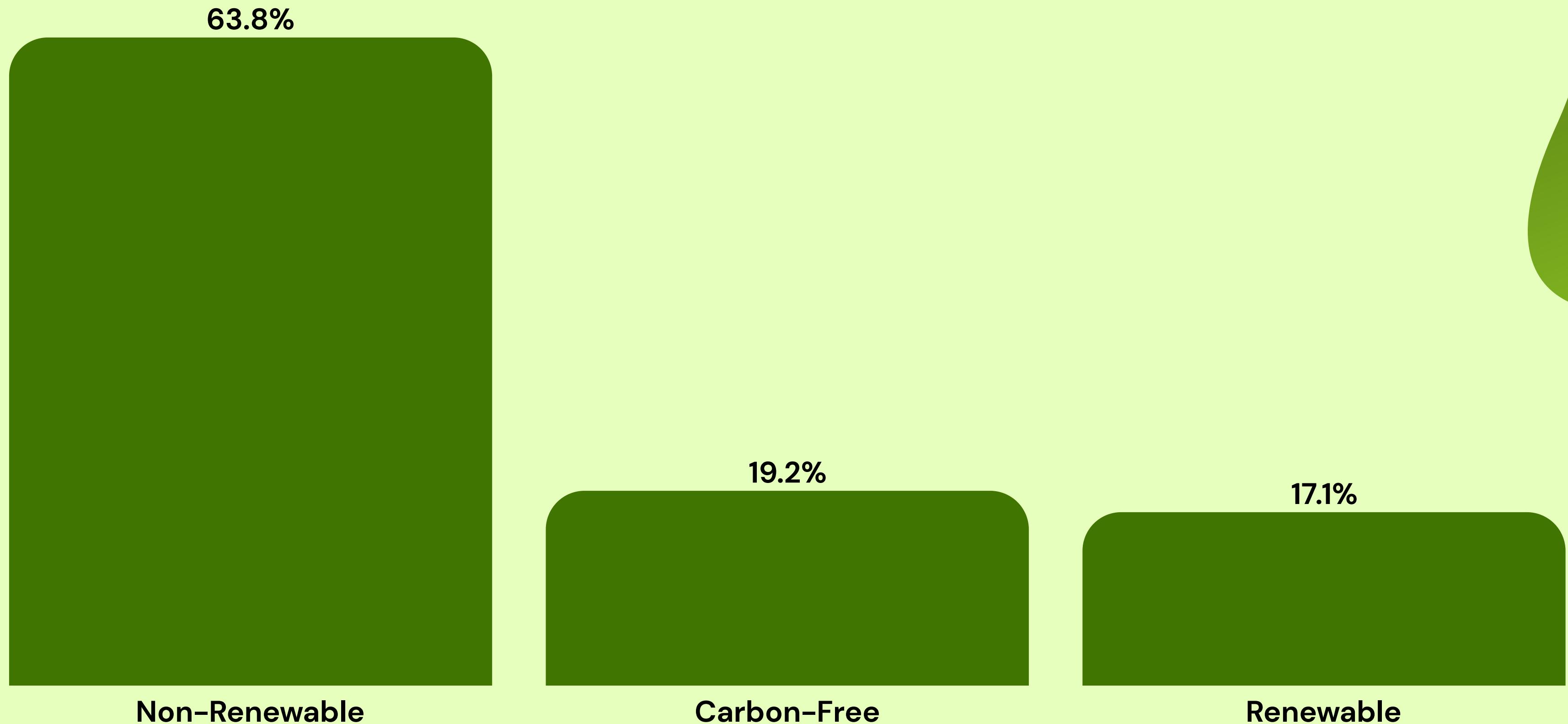
**14,247**

## Total Generation



**4,308 TWh**

# Contribution To US Power Production



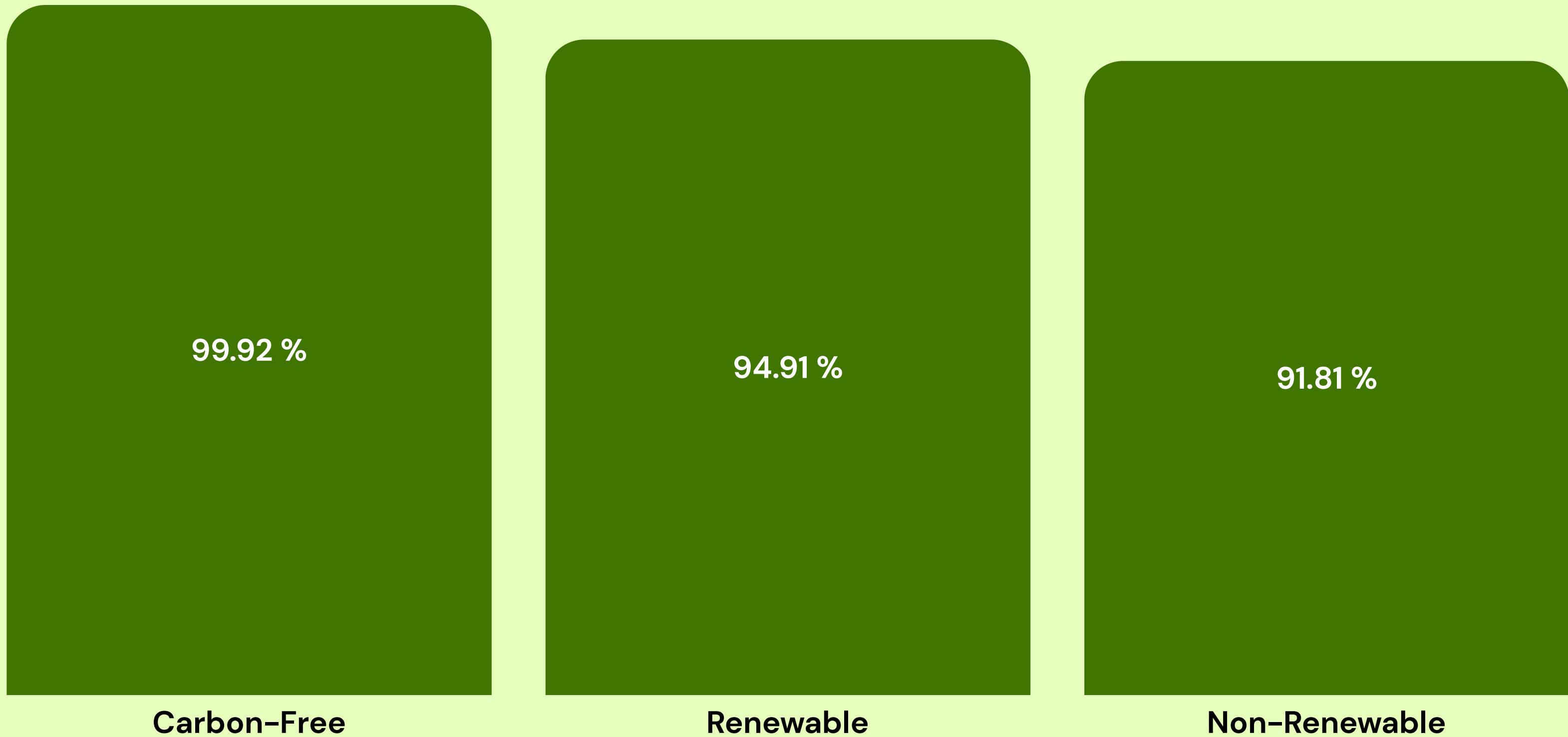
## Operational Performance

**Efficiency** =  $\frac{\text{Fuel Utilized as Electricity}}{\text{Total Fuel Consumed}}$

**Lost Fuel** =  $\text{Total Fuel Consumed} - \text{Fuel Utilized as Electricity}$

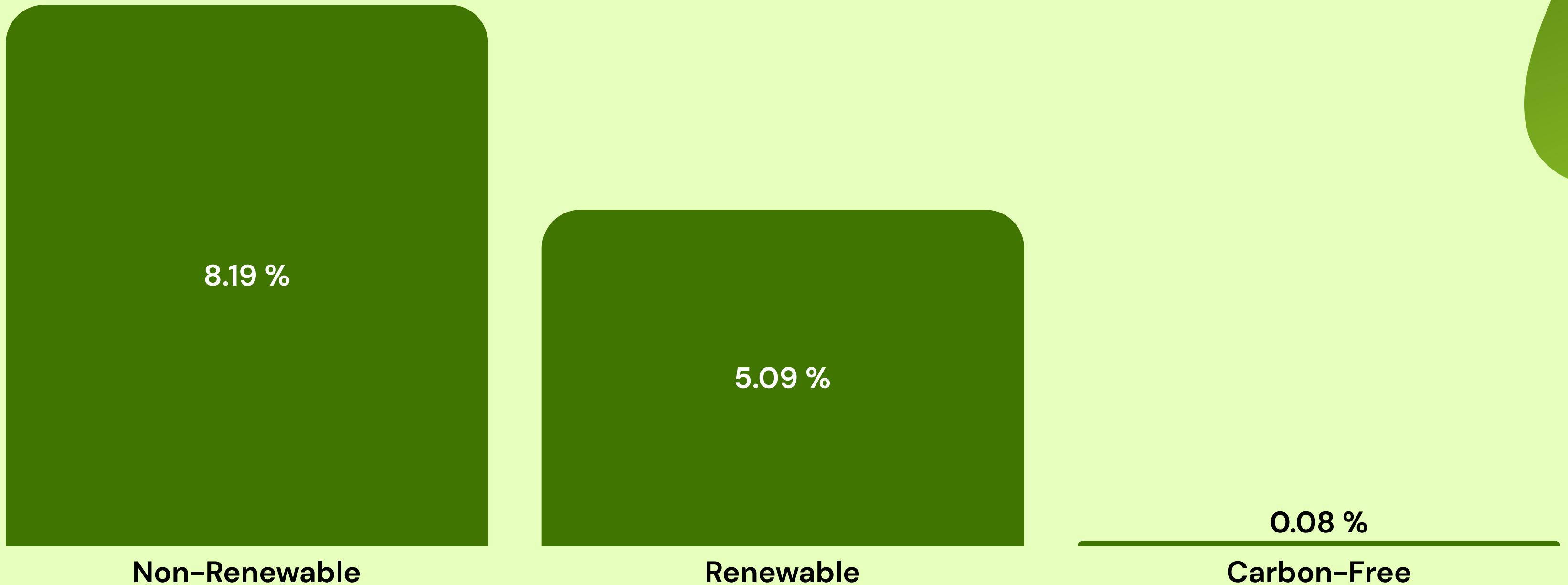
# Operational Performance

## Efficiency



# Operational Performance

Lost Fuel



# Infrastructure Comparison

**Total Plants Over Time**

**Plants Distribution**

**Electricity Generated / Area**

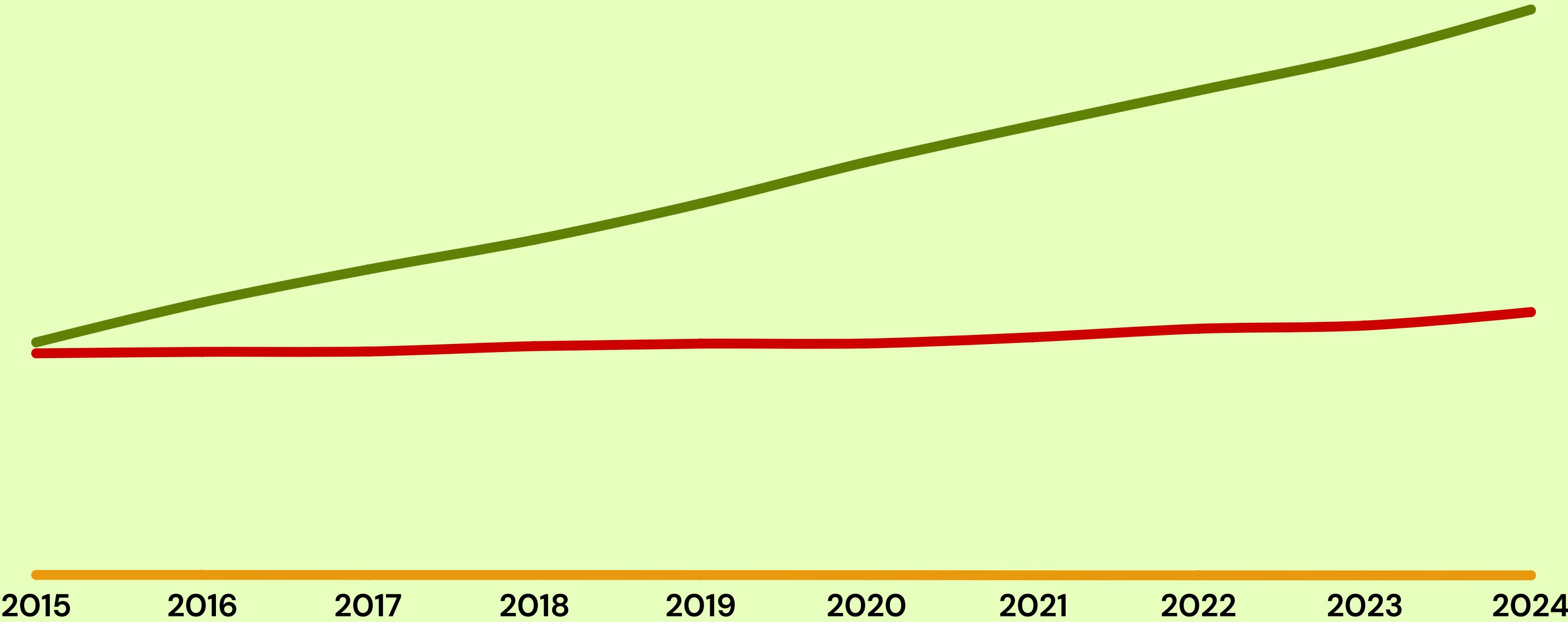
# Infrastructure Comparison

Total Plants

● Renewable

● Non-Renewable

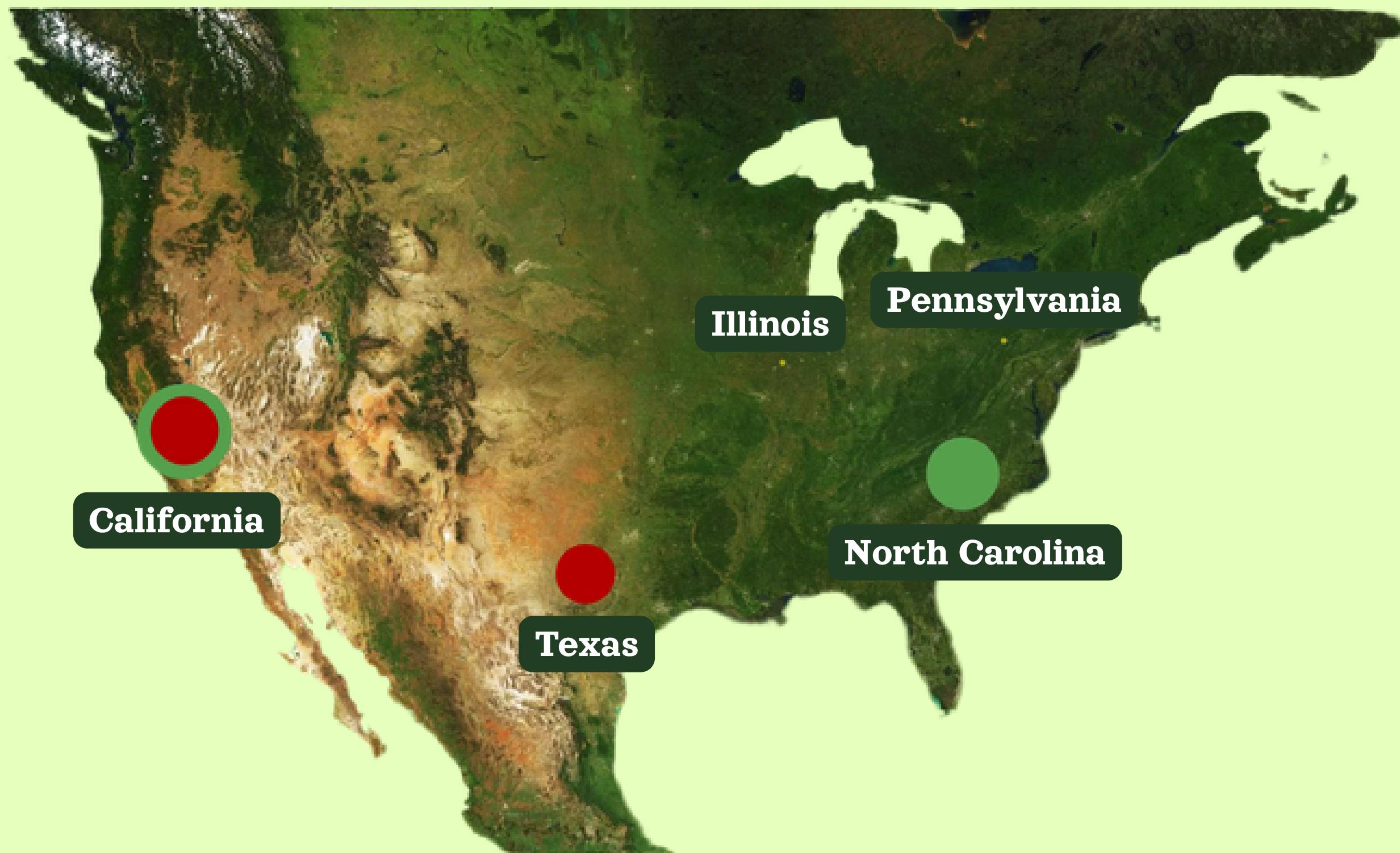
● Carbon-Free



# Infrastructure Comparison

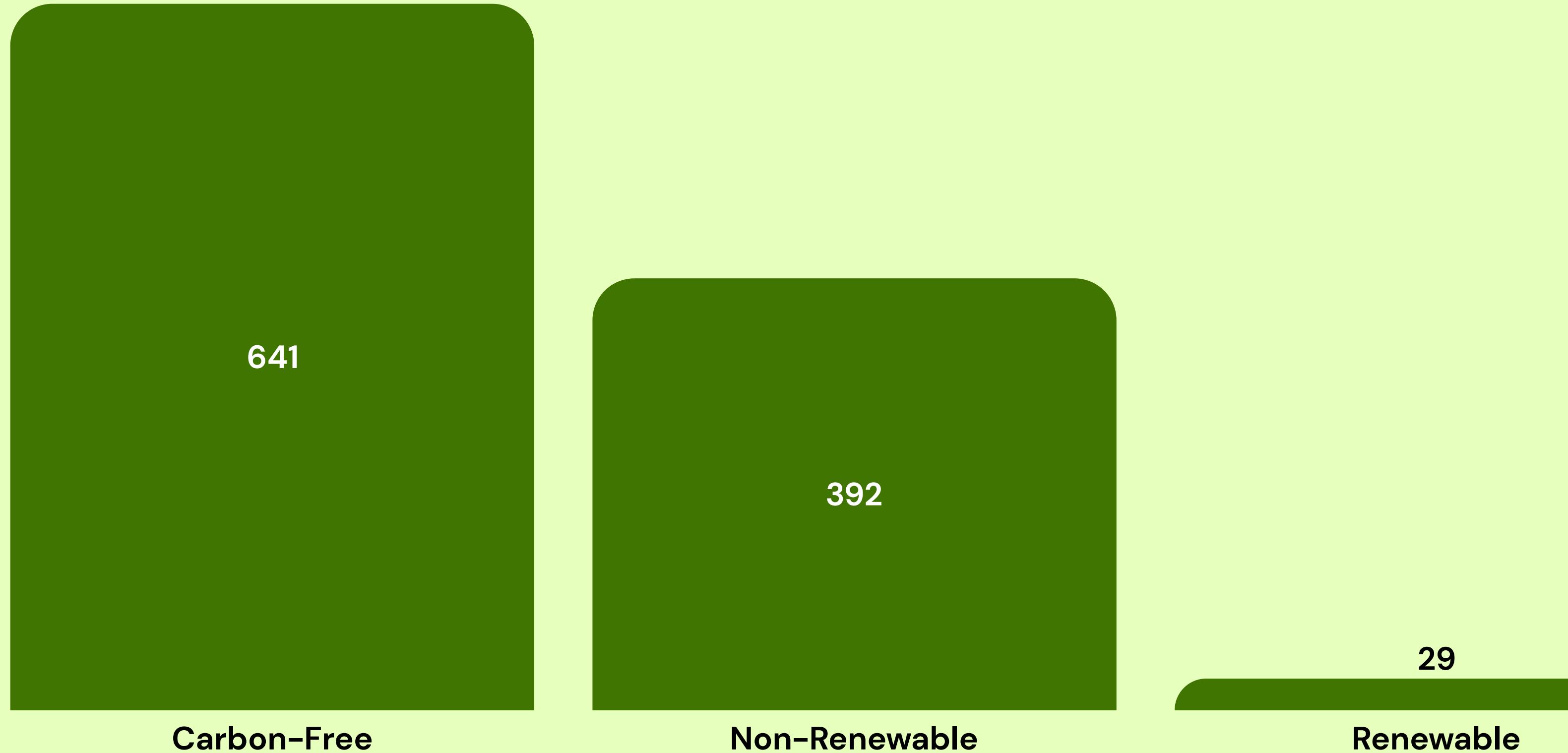
## Plant Distribution

● Renewable   ● Non-Renewable   ● Carbon-Free



# Infrastructure Comparison

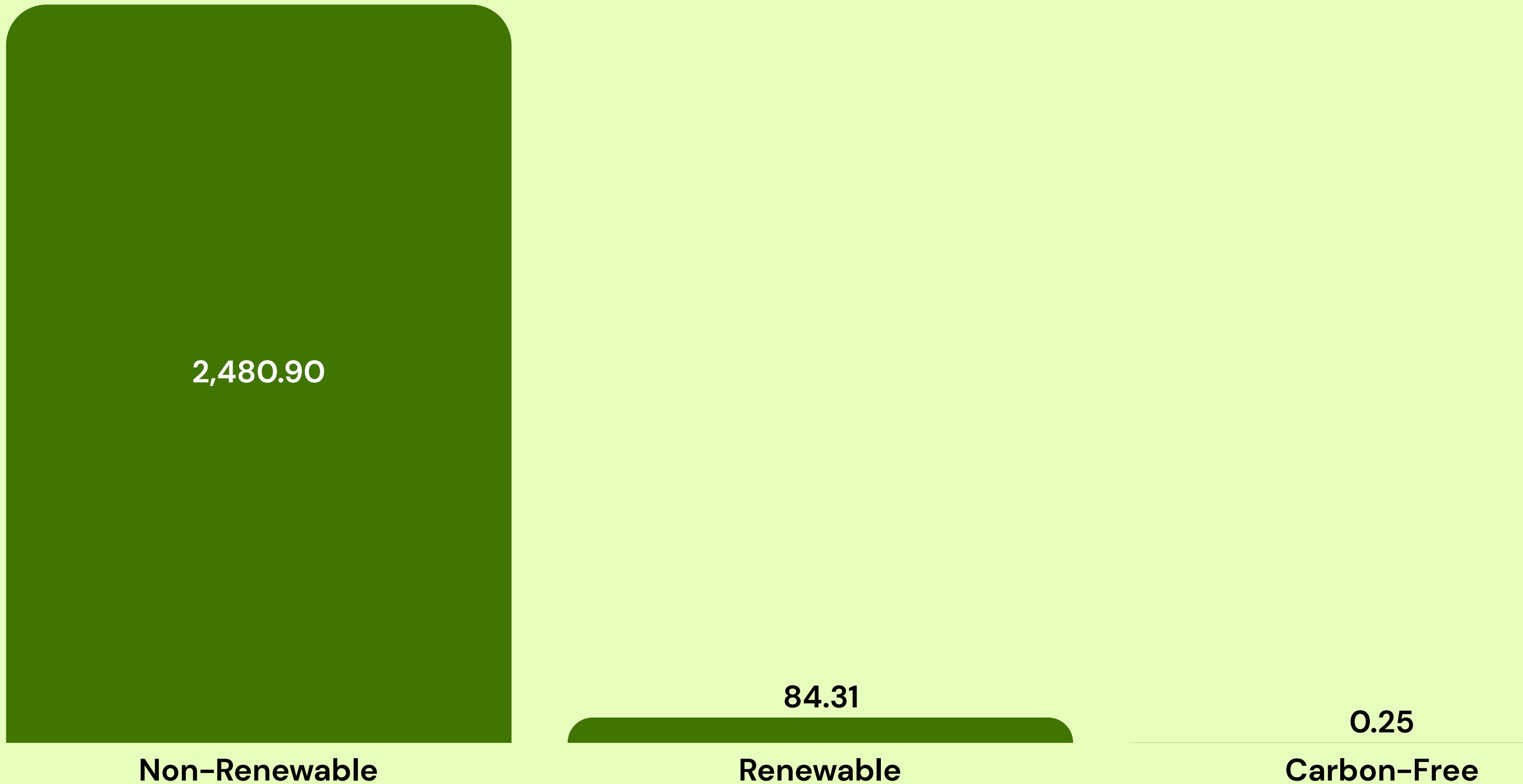
Generation / Area (MWh/Km<sup>2</sup>)



## Heat Rate

**Heat Rate** =  $\frac{\text{Fuel Consumed (MMBTU)}}{\text{Electricity Produced (MWh)}}$

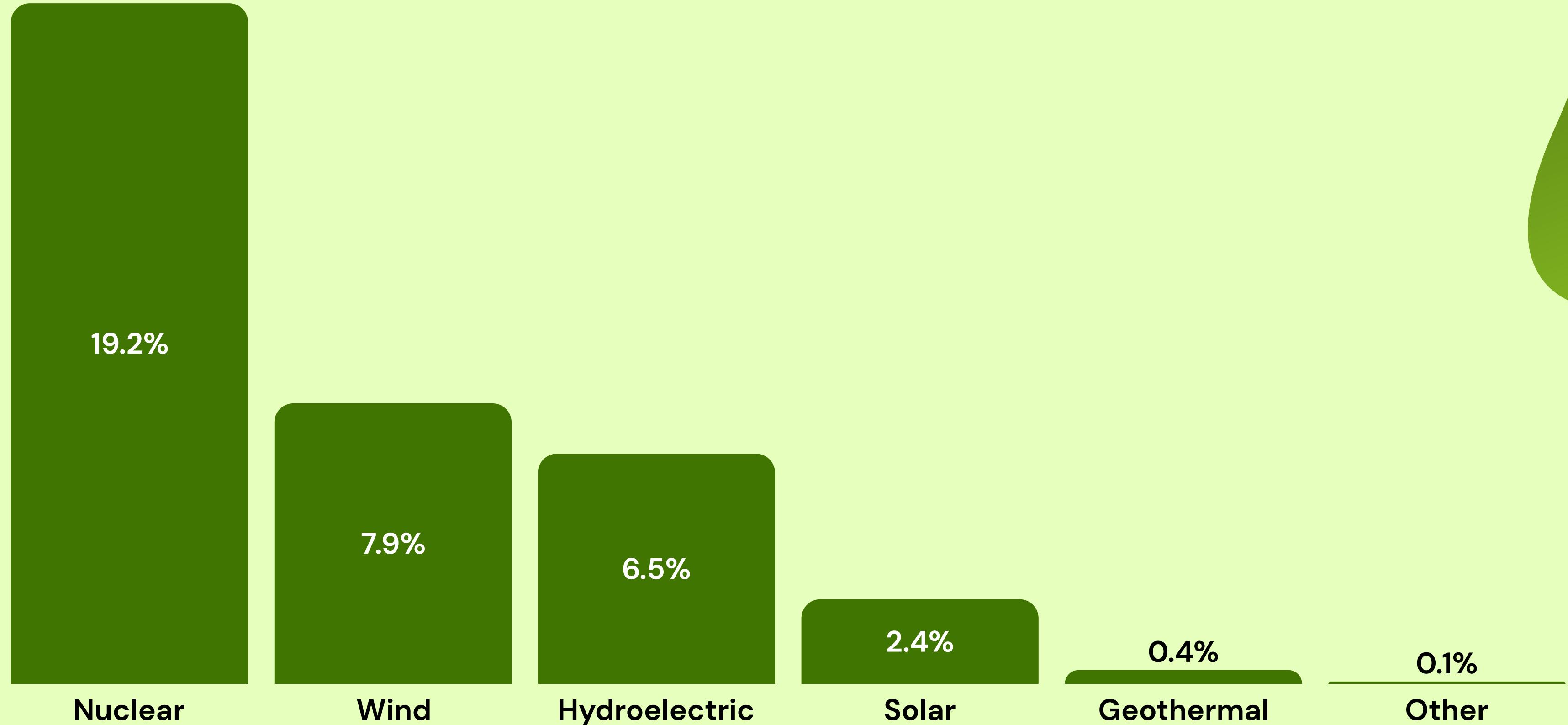
# Heat Rate (MMBTU/MWh)



# Clean Energy Comparison

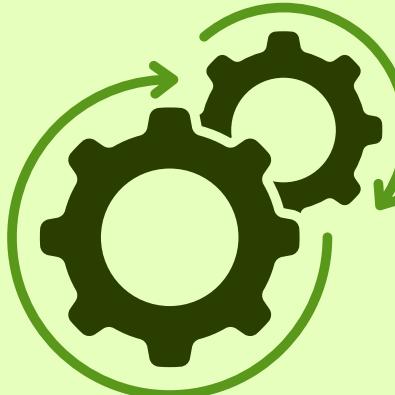


# Contribution To US Power Production



# Comparative Performance

Operational Performance



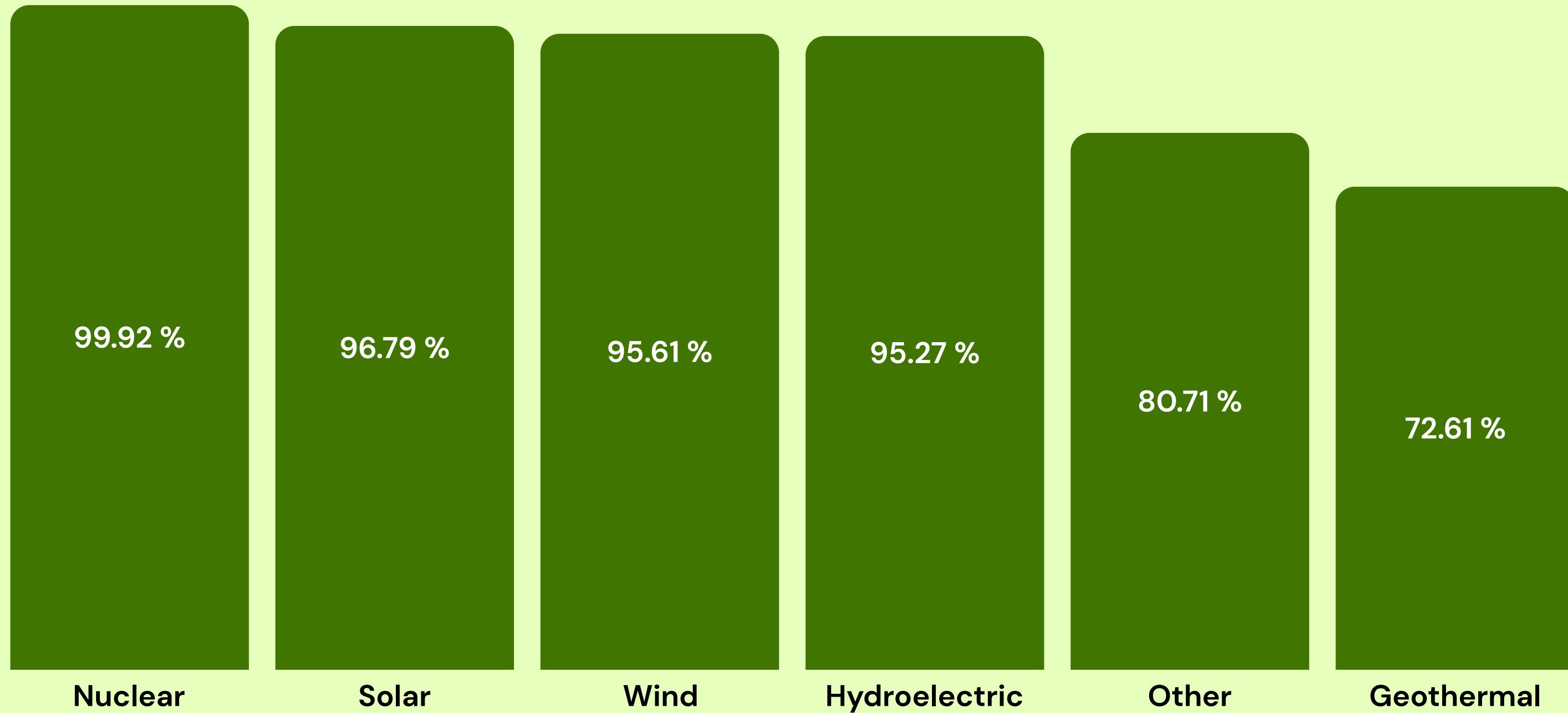
Infrastructure Comparison



Cost Analysis

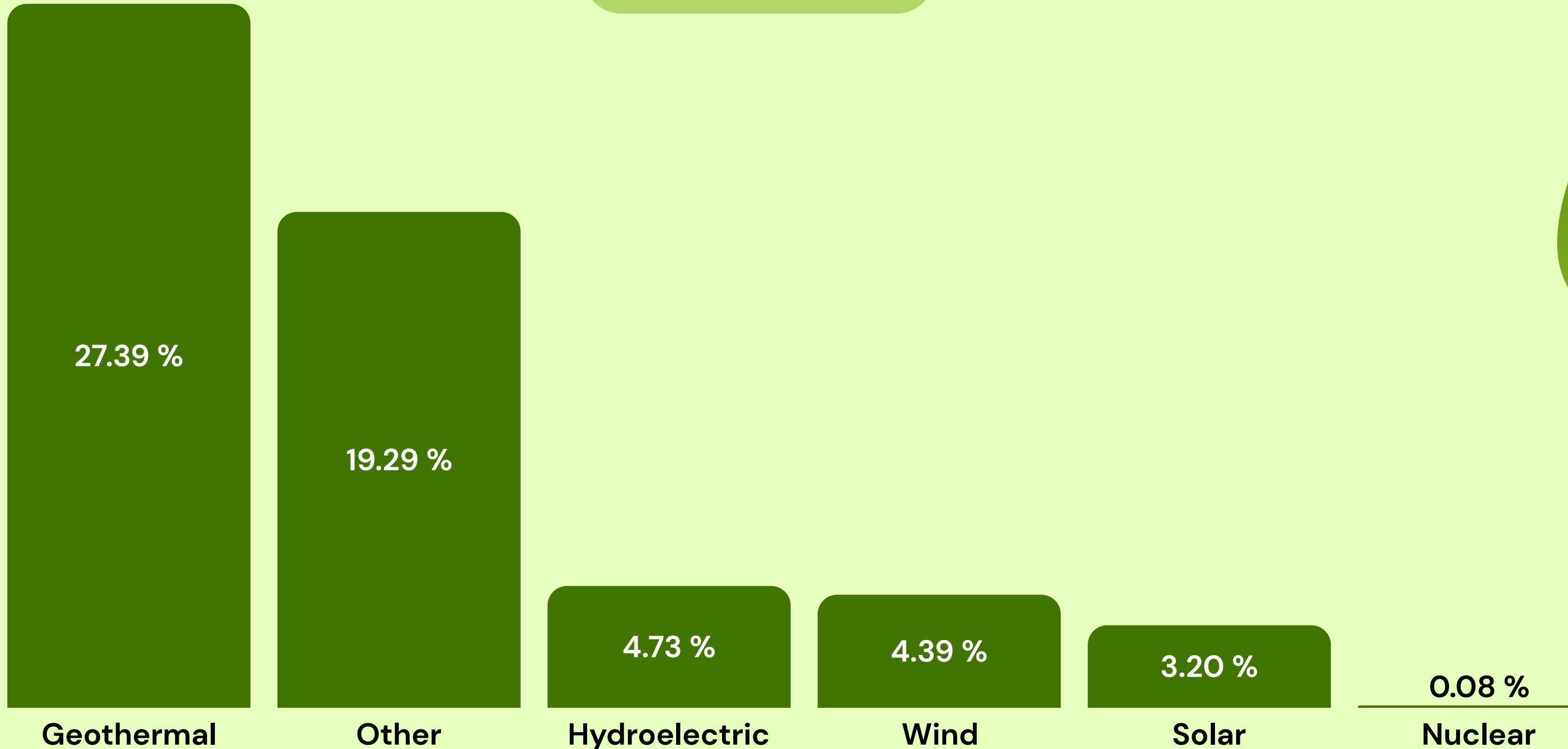
# Operational Performance

## Efficiency

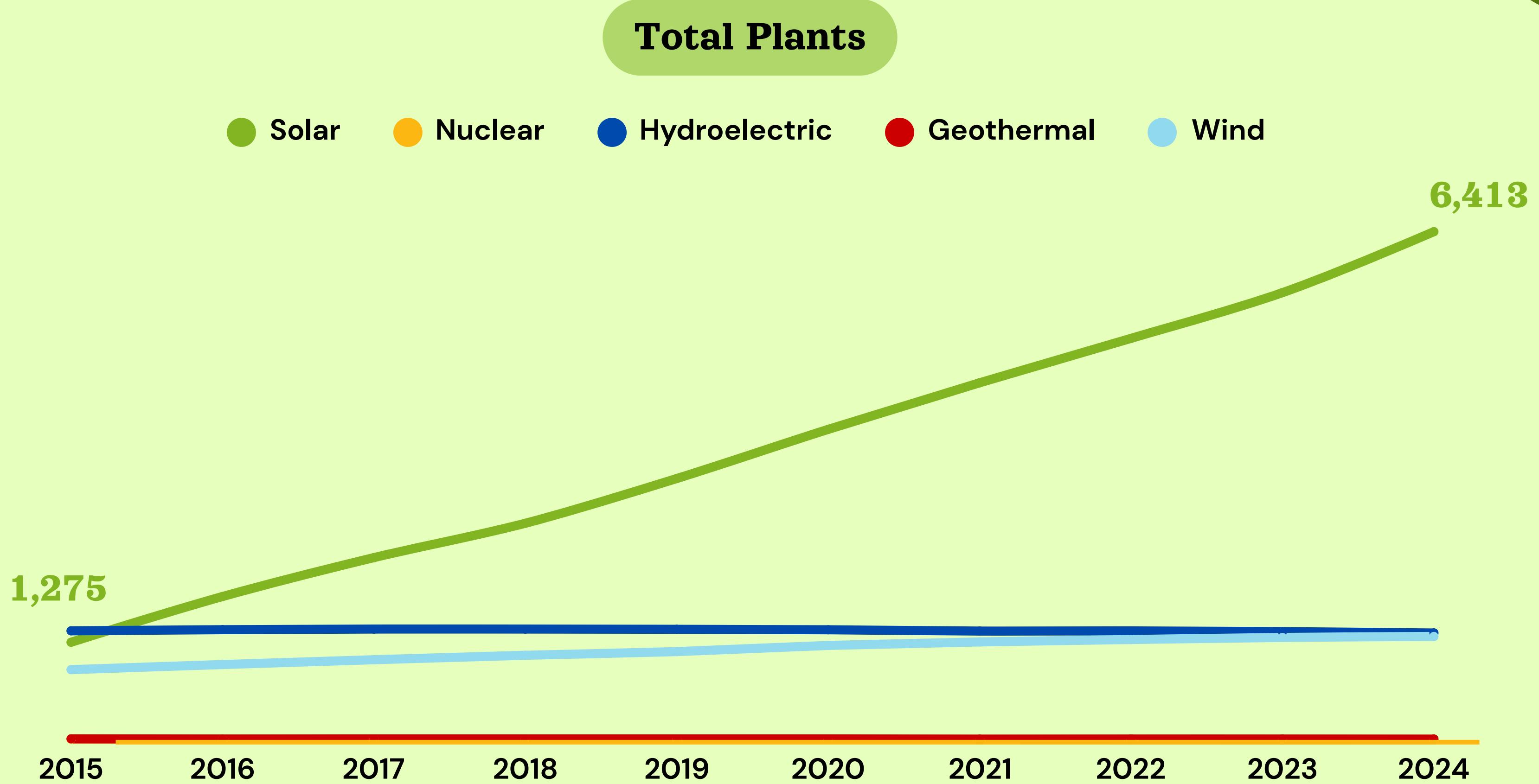


# Operational Performance

Lost Fuel



# Infrastructure comparison



# Infrastructure comparison

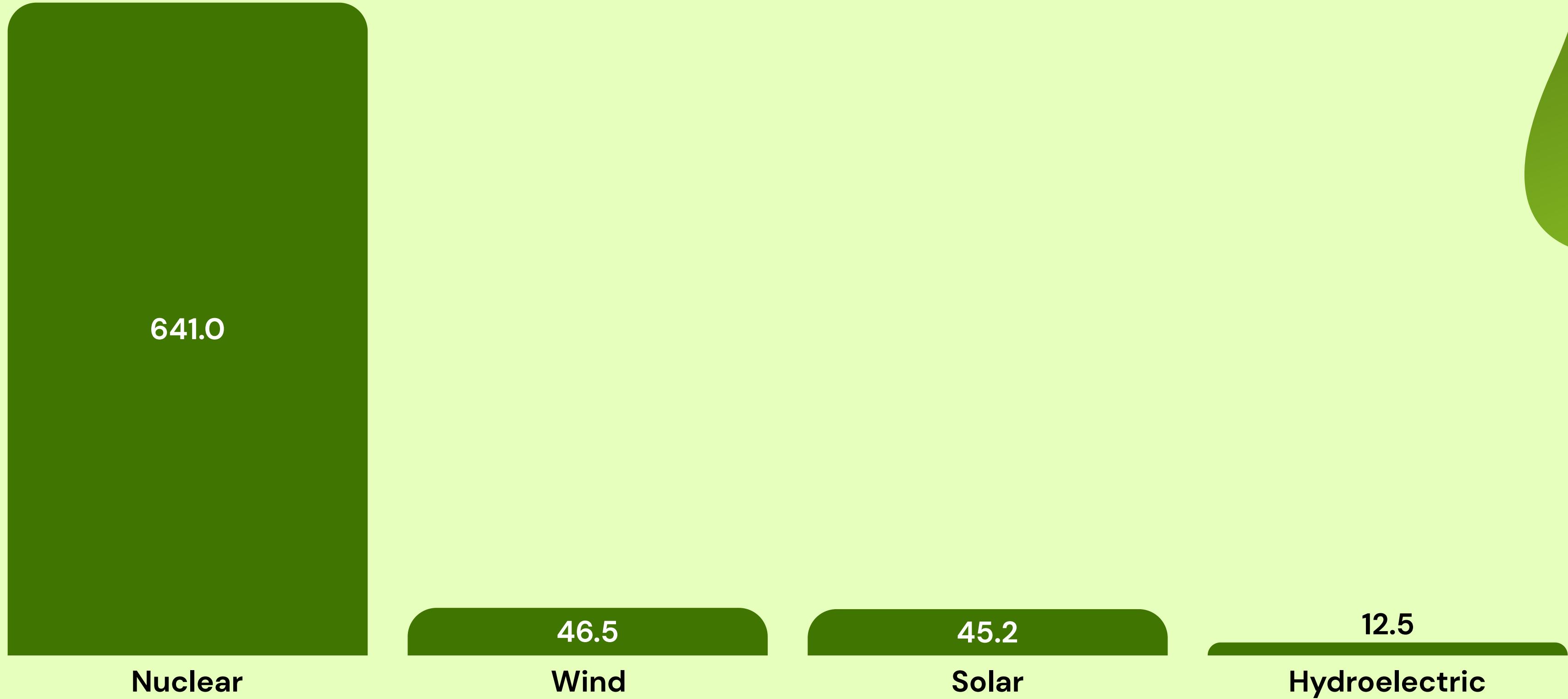
## Plants Distribution

● Solar   ● Nuclear   ● Hydroelectric   ● Geothermal   ● Wind



# Infrastructure comparison

Generation / Area (MWh/Km )

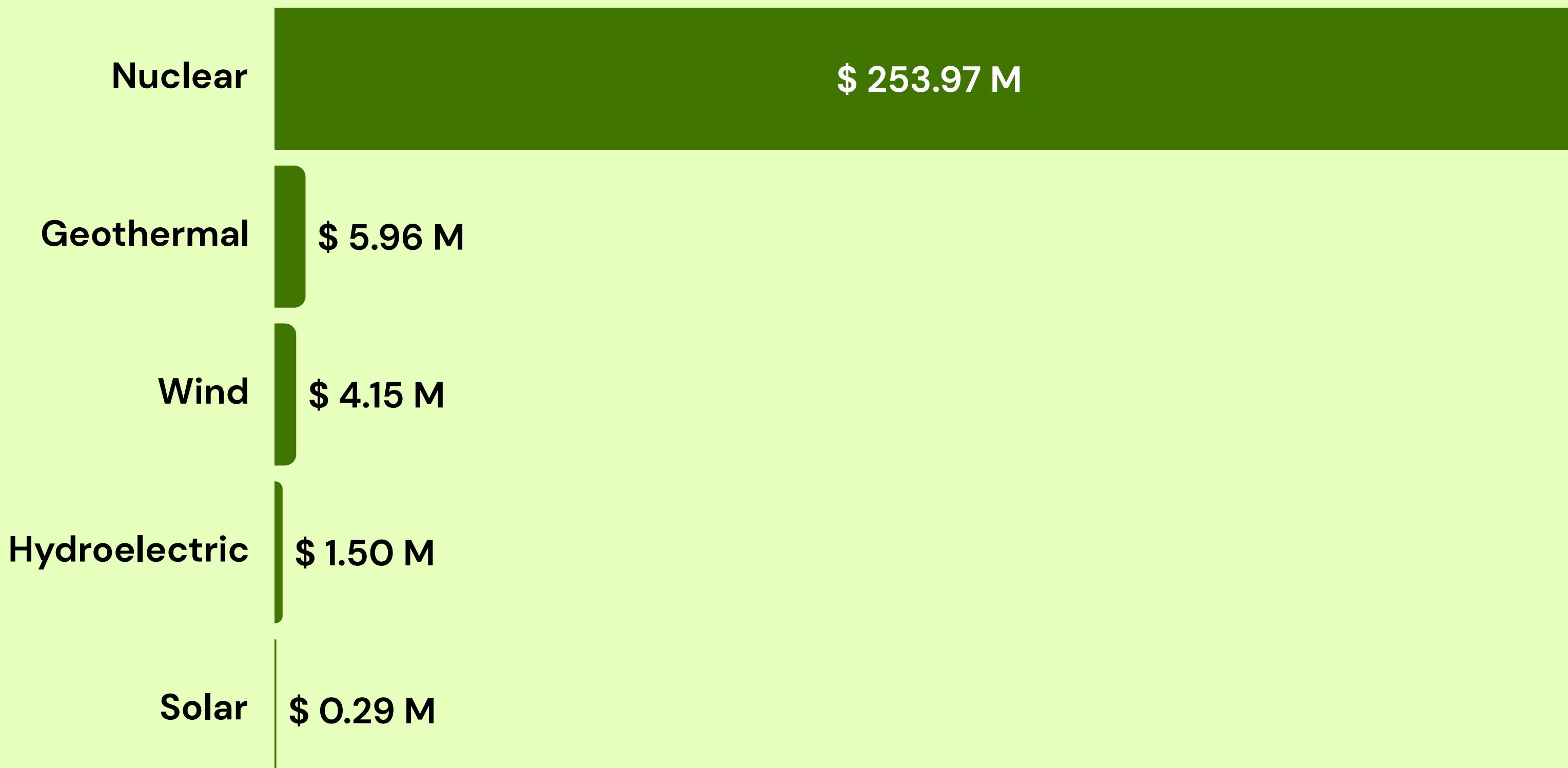


# Cost Analysis

**Operational Cost =  $\frac{\text{Fuel Consumed (MMBTU)}}{\text{Electricity Produced (MWh)}}$**

Energy Type	Variable Cost
Geothermal	\$ 27 / MWh
Nuclear	\$ 31 / MWh
Hydroelectric	\$ 8 / MWh
Wind	\$ 15 / MWh
Solar	\$ 11 / MWh

# Operational Cost





أهداف التنمية المستدامة البحريني  
BAHRAIN SDGs

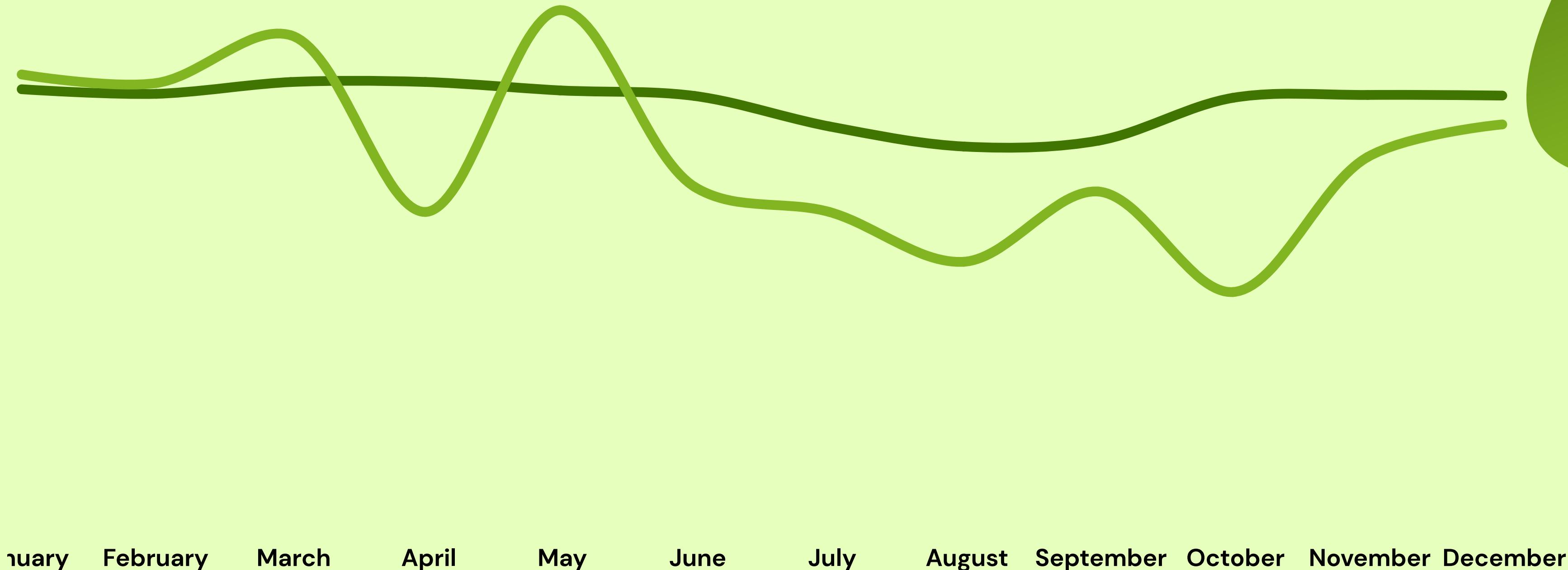


# Bahrain Vision

# Renewable Energies

## 1- Wind Energy

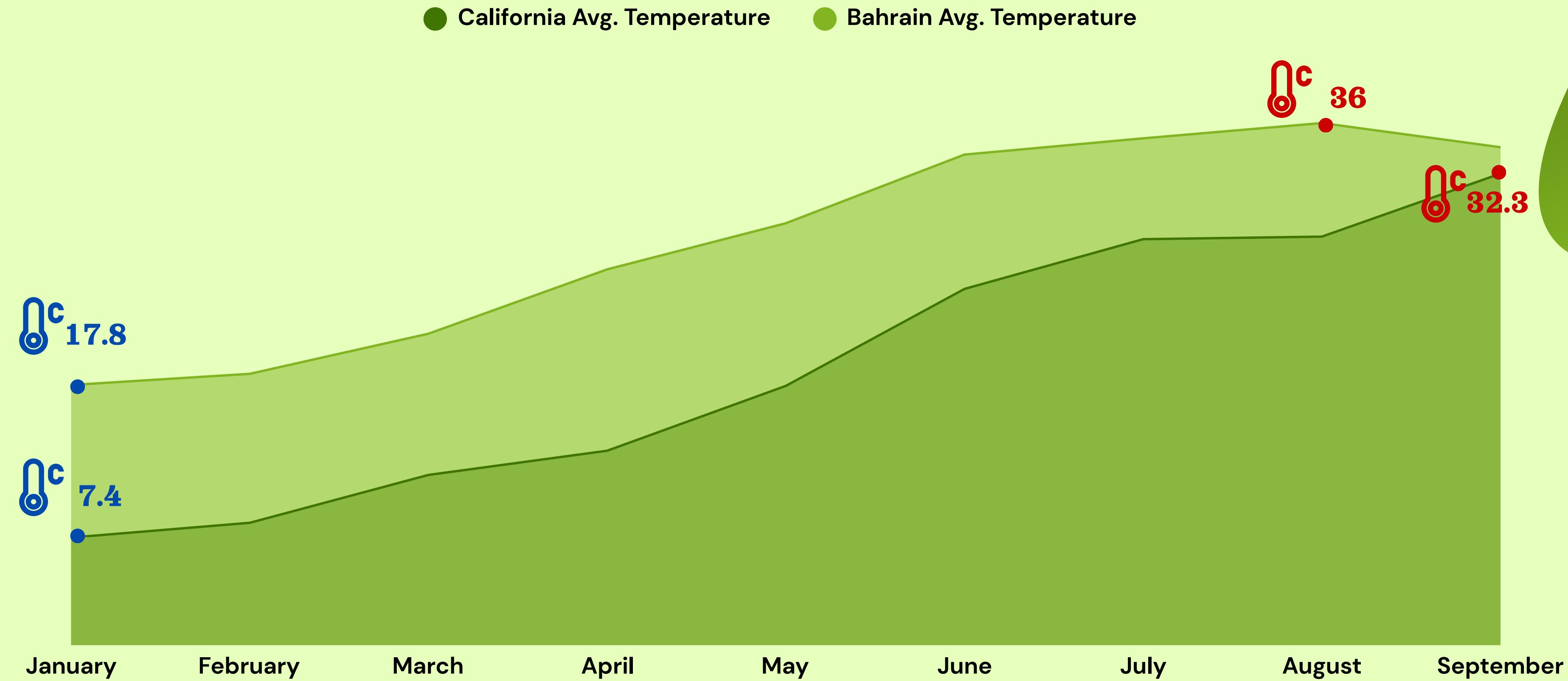
● Texas Avg. Wind Speed (m/s)      ● Bahrain Avg. Wind Speed (m/s)



[Link: Source](#)

# Renewable Energies

## 2- Solar Energy



# Renewable Energies

## 2- Solar Energy

### Bahrain's Total Consumption (2023)



**40,000 GWh**

### Eleven Miles Solar Hybrid



**8.1 Km**

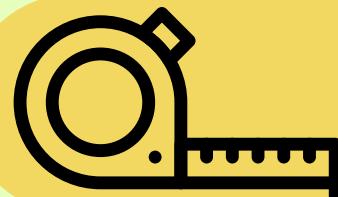


**\$ 1 billion**



**441 GWh**

### Requirements to Cover Bahrain's Consumption



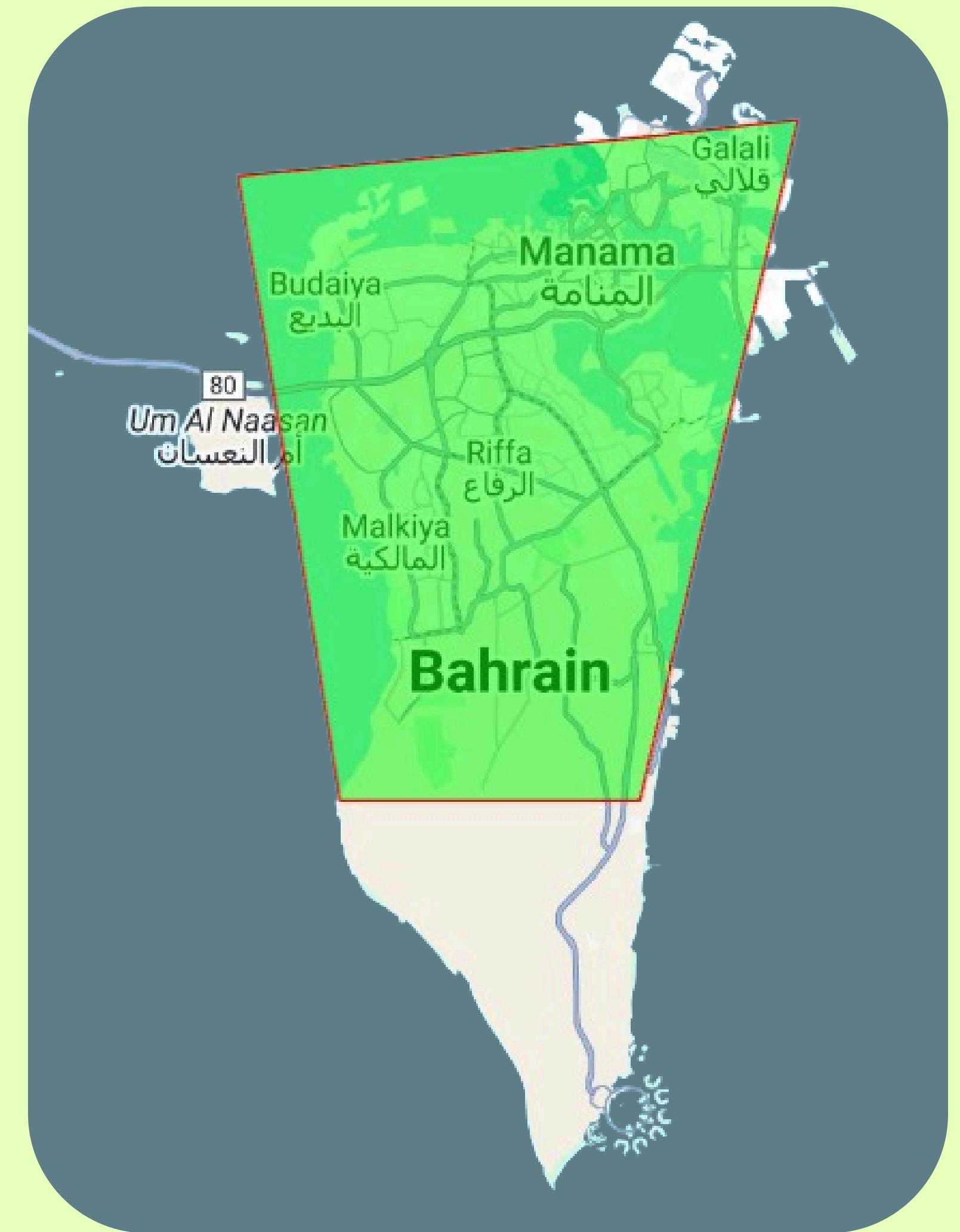
**734 Km**



**\$ 90.6 billion**



**40,000 GWh**



# Renewable Energies

## 3- Nuclear Energy

### Bahrain's Total Consumption (2023)



**40,000 GWh**

### Callaway Nuclear Generation Station



**11.2 Km**

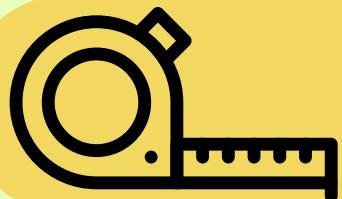


**\$ 5.9 billion**



**88,000 GWh**

### Requirements to Cover Bahrain's Consumption



**5.1 Km**



**\$ 2.7 billion**



**40,000 GWh**

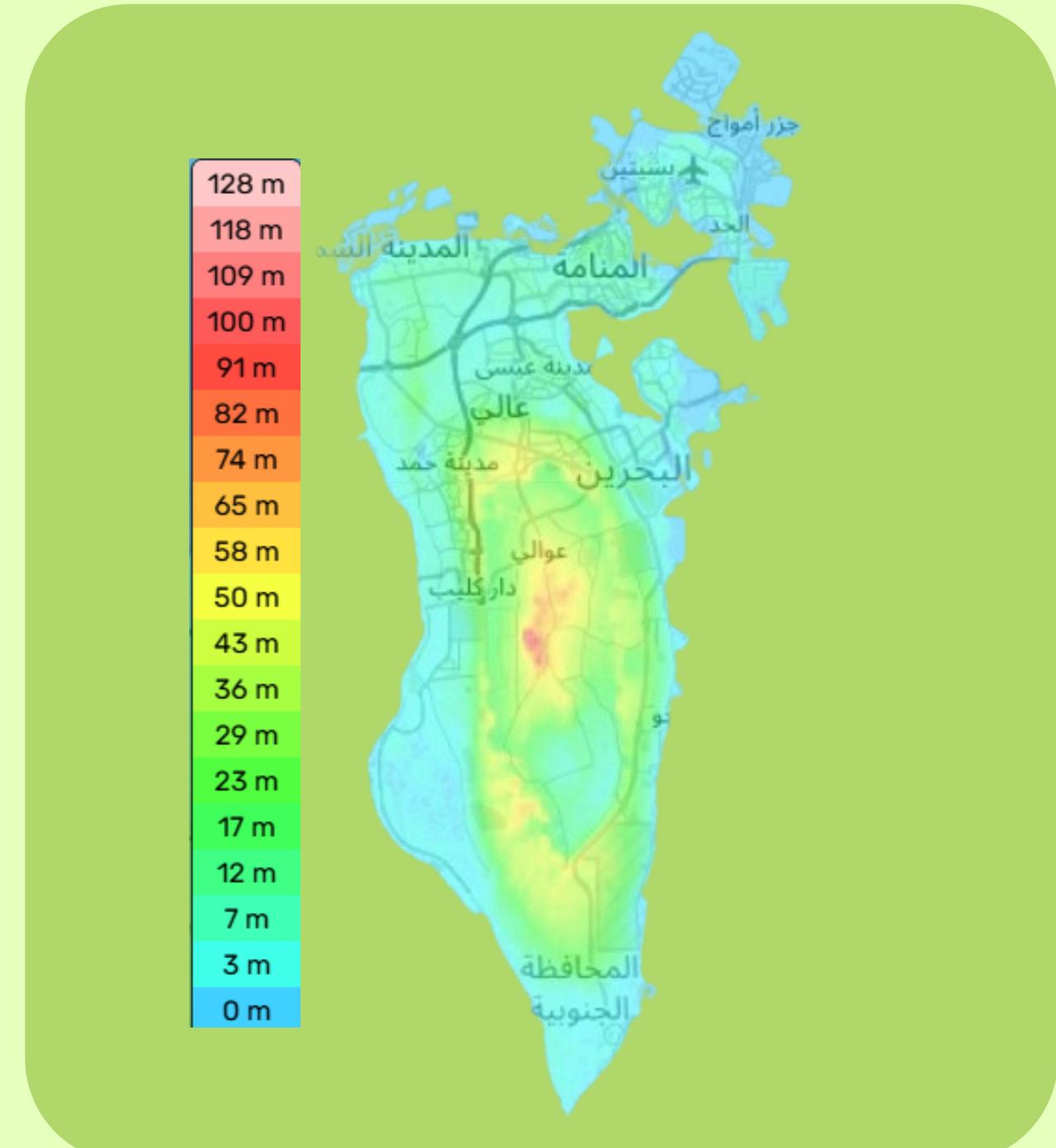


# Renewable Energies

## 4- Hydroelectric Energy

No Rivers or Large Fresh Water Source

Flat Topography



# Renewable Energies

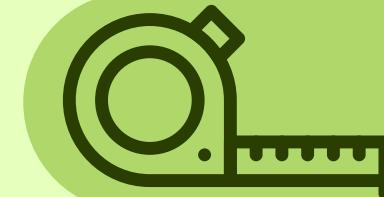
## 5- Geothermal Energy

### Bahrain's Total Consumption (2023)



**40,000 GWh**

### McGinness Hills Geothermal Complex



**1 Km**

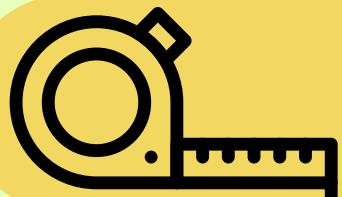


**\$ 316.3 million**



**4,600 GWh**

### Requirements to Cover Bahrain's Consumption



**8.7 Km**



**\$ 2.8 billion**



**40,000 GWh**

# Renewable Energies

## Summary

Renewable Energy	Area	Fixed Cost	O & M Cost	Generation / Area
Wind	High	Mid	Mid	Mid
Solar	High	Mid	Mid	Mid
Nuclear	Mid	High	High	High
Geothermal	Low	Low	High	High
Hydroelectric	High	High	Low	Low

# Conclusion

## Renewables Share



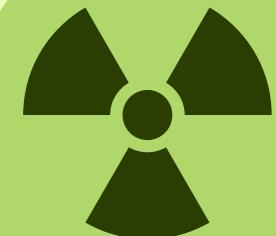
**36.3%**

## Nuclear

**Highest Contribution**

**Highest Efficiency**

## Candidates



**Nuclear**



**Geothermal**

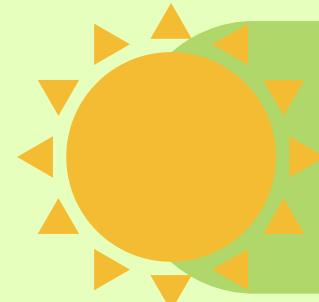
# Recommendation



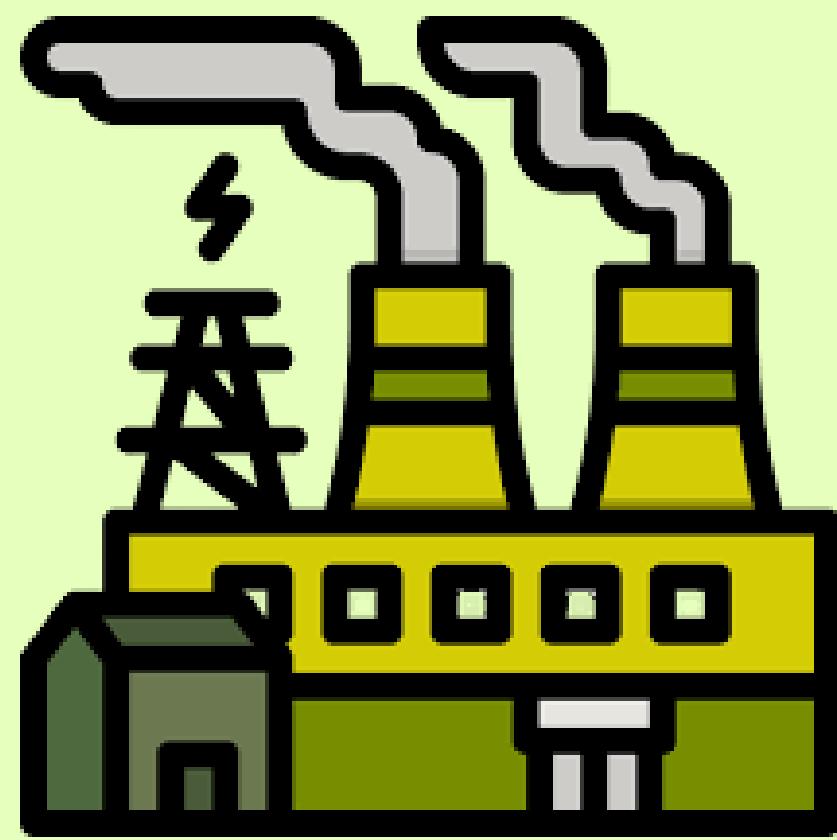
**Comprehensive Comparison**



**Nuclear Energy Education**



**Solar System Footprint**



# Thank You

