Data Visualization Project: Indian Power Sector at a Glance

> ## By Nikhil Thosar (224161020)

Note: Change the paths to the csv files before running the codes

Data Cleaning

> Data consistency is essential for accurate analysis and decision-making. When dealing with data on power generation in India, it is important to ensure that the state names are spelled correctly, and there are no duplications or discrepancies in the names. For example, 'Andhra Pradesh' and 'Andhra Pradesh.' may be the same state but with slightly different names. This inconsistency can lead to errors in analysis and should be corrected.
>
> In addition to spelling correction and removal of duplication in state names, data consistency may also involve handling newly formed or combined states or union territories (UTs). For example, in recent years, Telangana was formed by splitting Andhra Pradesh, and Jammu and Kashmir was split into two UTs. This change in the political boundaries of states and UTs requires updating the data to ensure that it is consistent with the current geographic division of the country.
>
> Another challenge in dealing with power generation data is handling NaN values or missing data. NaN values can occur when data is not available or is incomplete. In the case of power generation data, it could be due to a power plant being shut down for maintenance, or due to a delay in data reporting. In such cases, it may be necessary to interpolate the data to estimate the missing values based on available data points. Interpolation can help fill in gaps in the data and make it more consistent, allowing for more accurate analysis.
>
> In particular, the Power_Generation.csv file may have missing data that requires interpolation to estimate the power generation during those periods accurately. Interpolation techniques such as linear interpolation, cubic interpolation, or spline interpolation can be used to fill in missing values.

In [1]:
```
import pandas as pd
from plotnine import *
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
#reading the power generation capacity file
df = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Installed_Power_Capacity_Stat
df.head()
```

Out[2]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_total
0	1	Jan-2019	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	32.40	32.40
1	2	Jan-2019	Northern	Delhi	135.0	2208.40	0.0	2343.40	0.0	0.00	176.21	2519.61

2	3	Jan-2019	Northern	Haryana	5540.0	431.59	0.0	5971.59	0.0	0.00	411.99	6383.58
3	4	Jan-2019	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	9809.02	864.50	10673.52
4	5	Jan-2019	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3449.00	188.88	3812.88

In [3]:
```
#converting 'month-year' format to 'month' and 'year' two columns for convinience in plo
df['year'] = df['month'].str[-4:].astype(int)
df['state'] = df['state'].replace({'Andhra Pradesh.': 'Andhra Pradesh'})
df[['Month', 'Year']] = df['month'].str.split('-', n=1, expand=True)
df.head()
```

Out[3]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_total
0	1	Jan-2019	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	32.40	32.40
1	2	Jan-2019	Northern	Delhi	135.0	2208.40	0.0	2343.40	0.0	0.00	176.21	2519.61
2	3	Jan-2019	Northern	Haryana	5540.0	431.59	0.0	5971.59	0.0	0.00	411.99	6383.58
3	4	Jan-2019	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	9809.02	864.50	10673.52
4	5	Jan-2019	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3449.00	188.88	3812.88

> Given statewise generation capacity data have some discrepancy due to administrative changes for geographical regions. Eg. Daman & Diu and "Dadra & Nagar Haveli" merged to one UT. So I summed up the capacity throughout the period to show a consistent data trend, otherwise it would have created confusion while interpreting the plot.

In [4]:
```
df_diu = df[df["state"] == "Daman & Diu"]
df_dnh = df[df["state"] == "Dadra & Nagar Haveli"]

df_diu_sum = df_diu.groupby(["month", "Year", "region"]).sum()
df_dnh_sum = df_dnh.groupby(["month", "Year", "region"]).sum()

df_combined = df_diu_sum.add(df_dnh_sum, fill_value=0)

df_combined["state"] = "Dadra and Nagar Haveli and Dam"

df_combined.reset_index(inplace=True)
df_combined.drop('year', axis=1, inplace=True)
df_combined = df_combined[['id', 'month', 'region', 'state', 'coal', 'gas', 'diesel', 't
df_combined.head()
```

Out[4]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_total
0	251	Apr-2019	Western	Dadra and Nagar Haveli and Dam	0.0	0.0	0.0	0.0	0.0	0.0	19.93	19.93
1	1123	Apr-2020	Western	Dadra and Nagar Haveli and Dam	0.0	0.0	0.0	0.0	0.0	0.0	25.32	25.32
2	2011	Apr-	Western	Dadra and	0.0	0.0	0.0	0.0	0.0	0.0	46.01	46.01

		2021		Nagar Haveli and Dam								
3	539	Aug-2019	Western	Dadra and Nagar Haveli and Dam	0.0	0.0	0.0	0.0	0.0	0.0	20.91	20.91
4	1419	Aug-2020	Western	Dadra and Nagar Haveli and Dam	0.0	0.0	0.0	0.0	0.0	0.0	32.24	32.24

In [22]:
```
#reading data file
df = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Installed_Power_Capacity_Stat
```

In [5]:
```
df = df.drop(df[(df['state'] == 'Dadra & Nagar Haveli') | (df['state'] == 'Daman & Diu')
df = pd.concat([df, df_combined])
df.reset_index(drop=True, inplace=True)
df.head()
```

Out[5]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_total
0	1	Jan-2019	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	32.40	32.40
1	2	Jan-2019	Northern	Delhi	135.0	2208.40	0.0	2343.40	0.0	0.00	176.21	2519.61
2	3	Jan-2019	Northern	Haryana	5540.0	431.59	0.0	5971.59	0.0	0.00	411.99	6383.58
3	4	Jan-2019	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	9809.02	864.50	10673.52
4	5	Jan-2019	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3449.00	188.88	3812.88

In [6]:
```
df['year'] = df['month'].str[-4:].astype(int)
df['state'] = df['state'].replace({'Andhra Pradesh.': 'Andhra Pradesh'})
df[['Month', 'Year']] = df['month'].str.split('-', n=1, expand=True)
df["state"].replace("Dadra and Nagar Haveli and Dam", "Dadra Nagar Haveli and Daman and
df.head()
```

Out[6]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_total
0	1	Jan-2019	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	32.40	32.40
1	2	Jan-2019	Northern	Delhi	135.0	2208.40	0.0	2343.40	0.0	0.00	176.21	2519.61
2	3	Jan-2019	Northern	Haryana	5540.0	431.59	0.0	5971.59	0.0	0.00	411.99	6383.58
3	4	Jan-2019	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	9809.02	864.50	10673.52
4	5	Jan-2019	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3449.00	188.88	3812.88

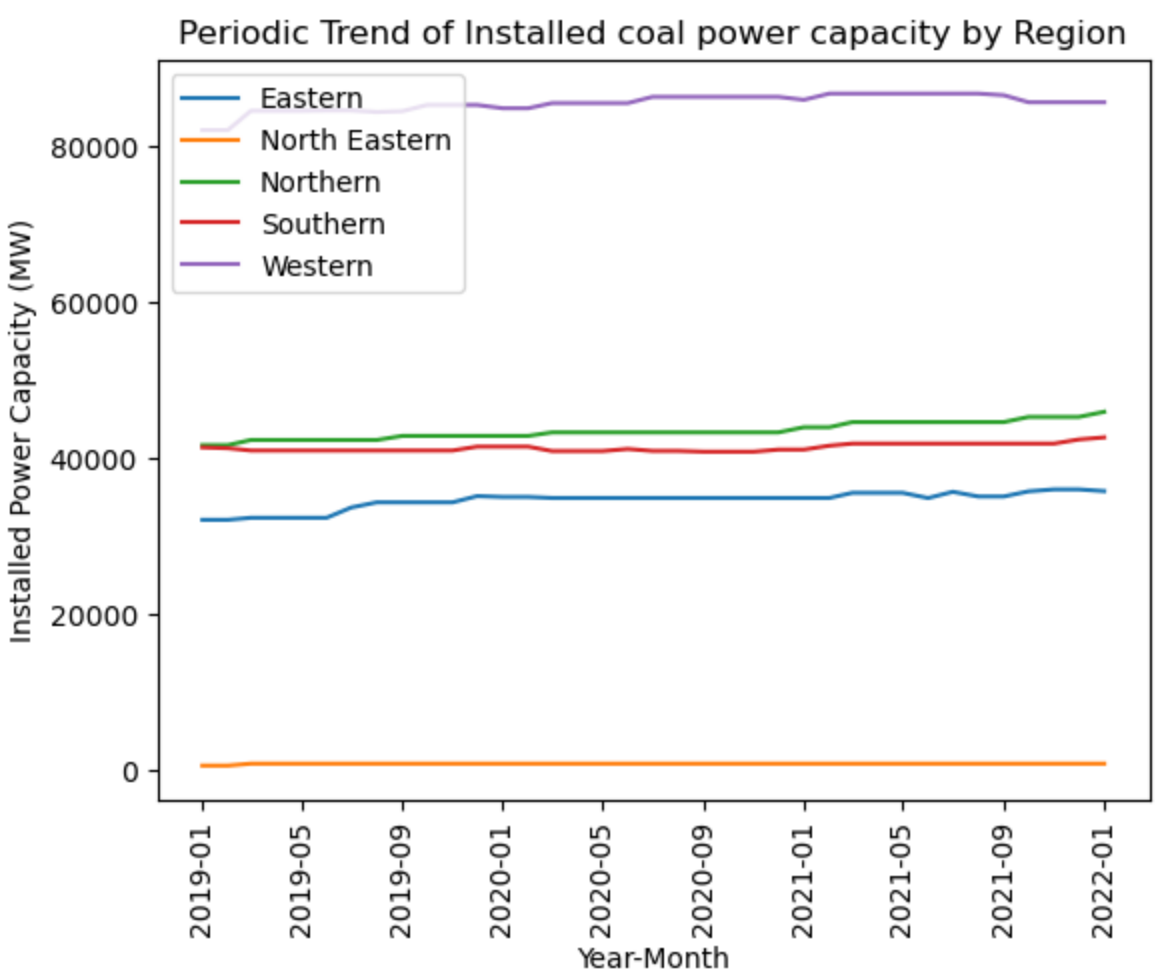
In [7]:
```
#color palette for bar plots
custom_palette = ['#008080', '#ff9900']
```

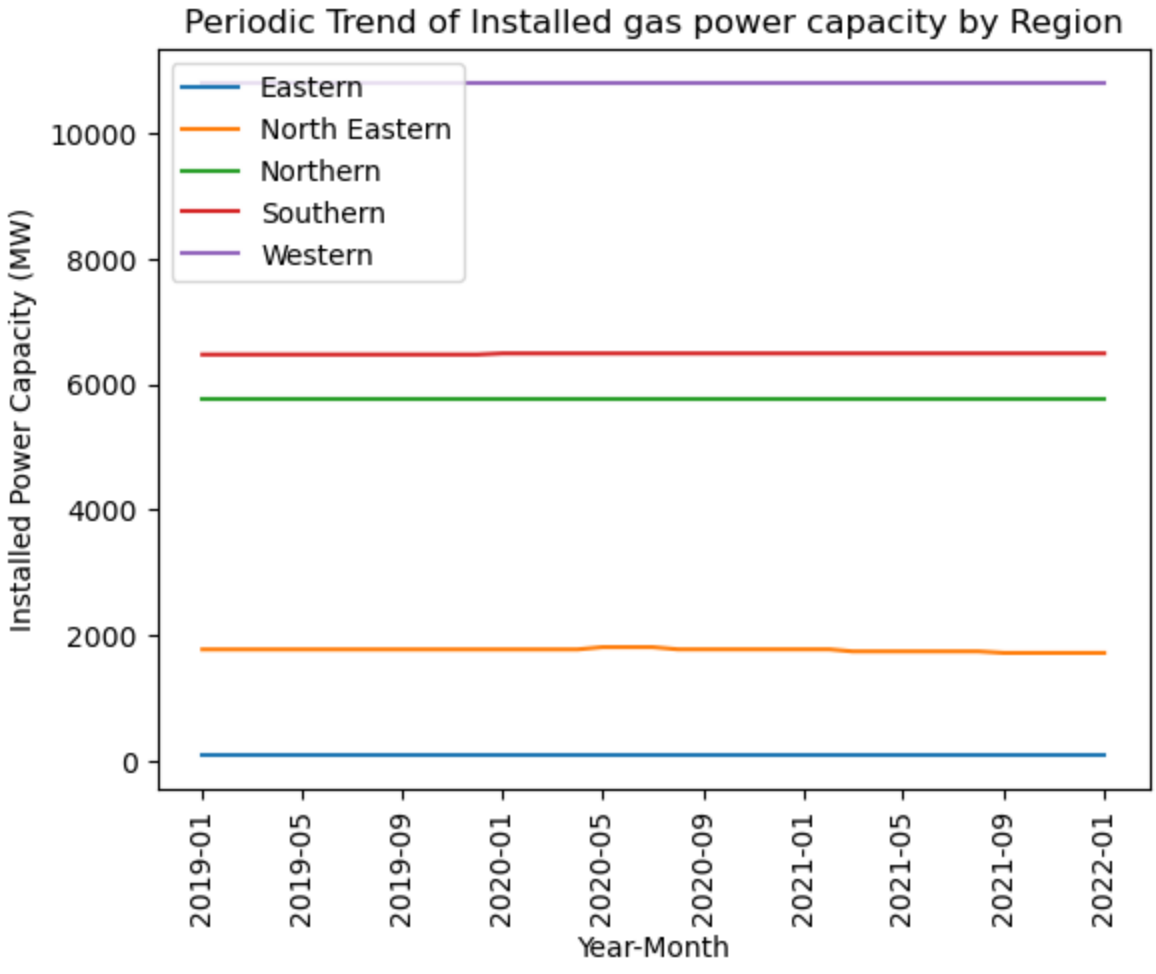
Plot I: Line Plots - Installed Power Capacity Over the Years

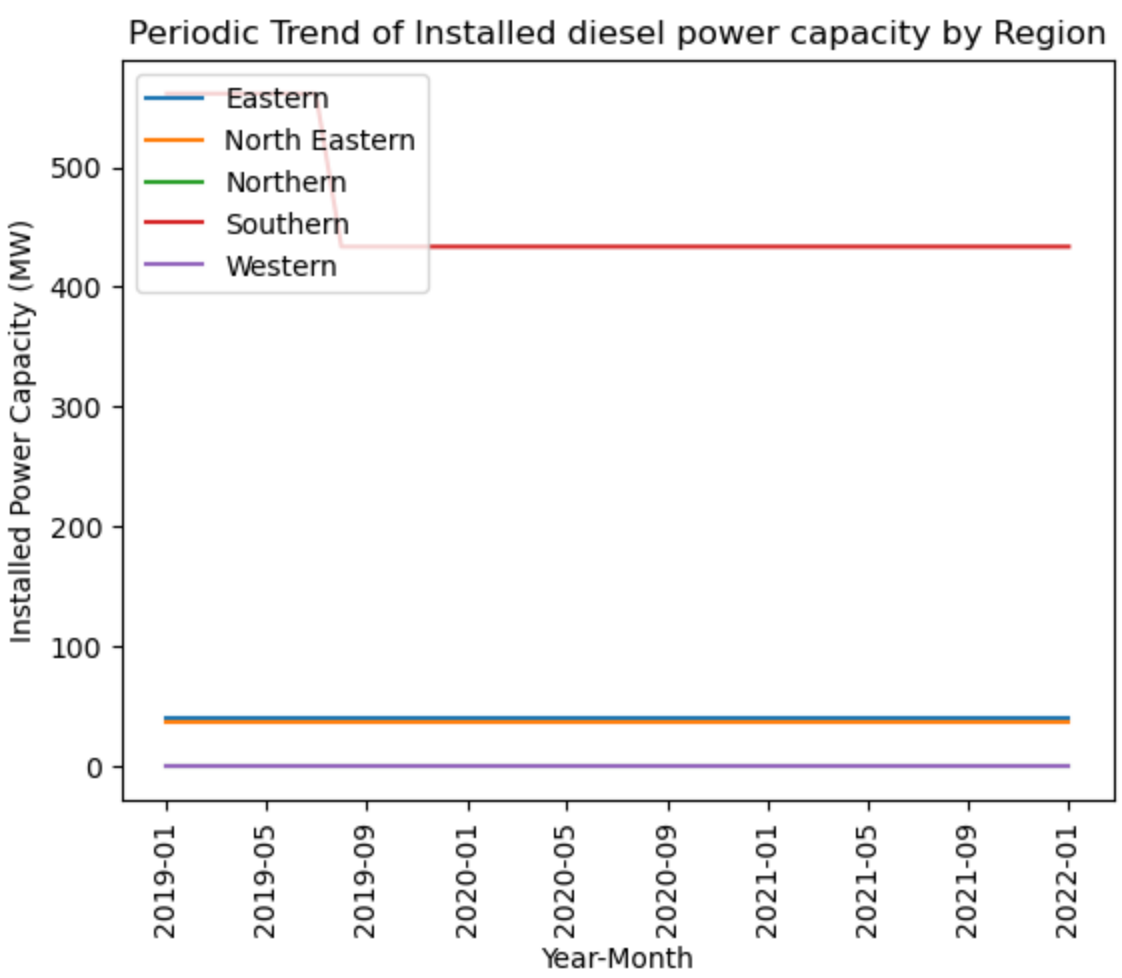
(2019-2022)

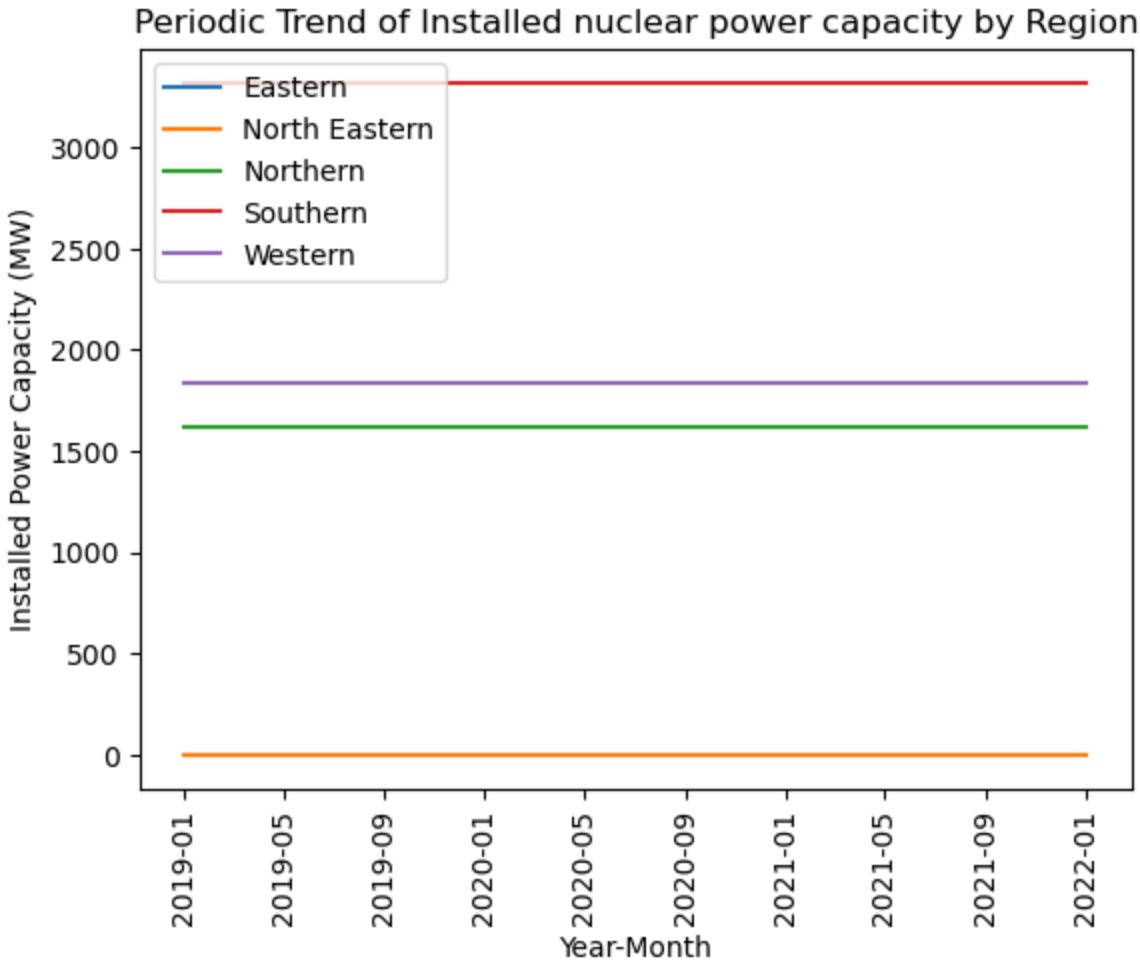
> In India, power generation from various energy sources has been growing steadily over the years. To showcase the periodic trend of installed power capacity, five line plots have been generated, each representing one energy source and displaying different colored lines for the five regions of India. Overall, these line plots demonstrate a positive trend in installed power capacity for various energy sources across different regions in India from 2019 to 2022.

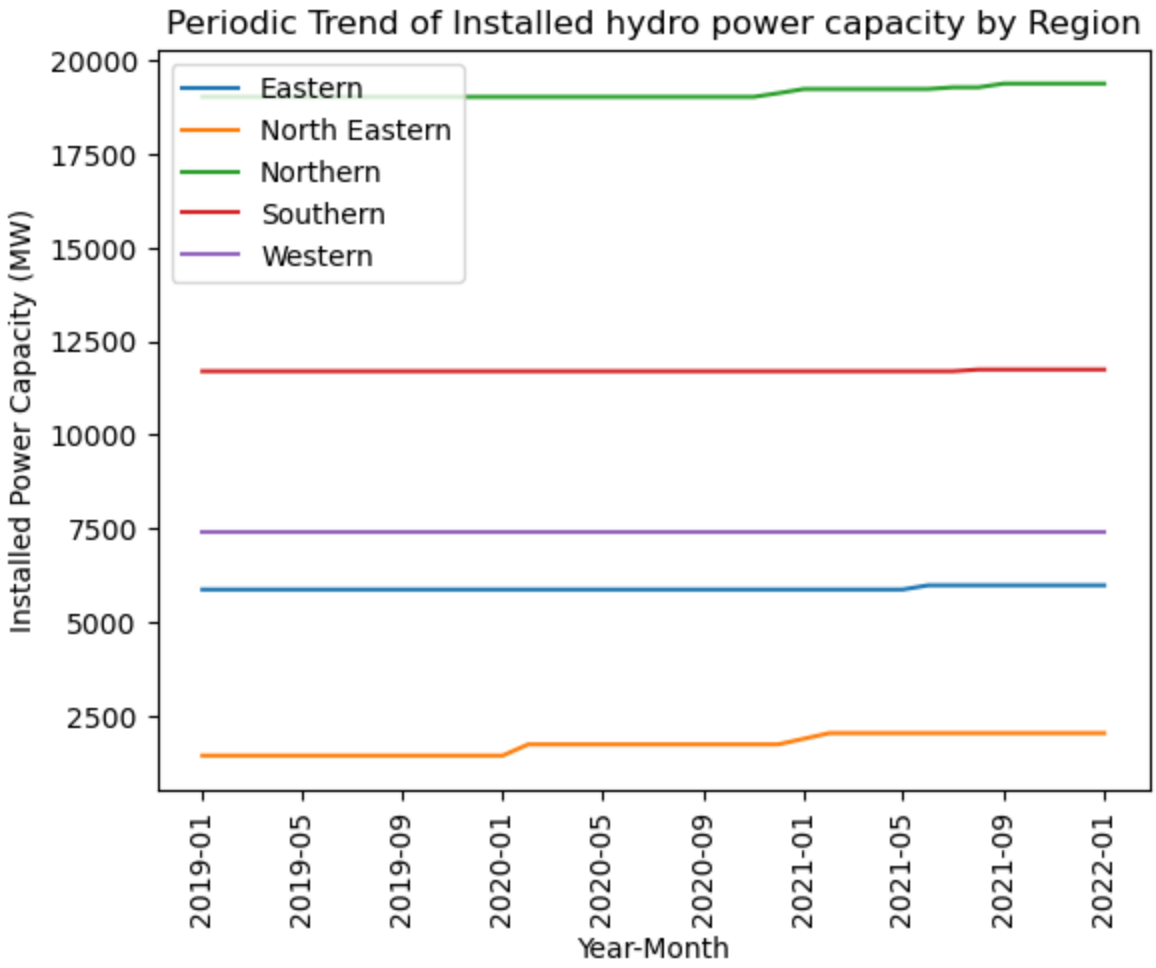
In [8]:
```
# Convert the 'month' column to a datetime format
df['month'] = pd.to_datetime(df['month'], format='%b-%Y')

# Create a pivot table of the installed power capacity columns with month as the index a
sources = ['coal', 'gas', 'diesel', 'nuclear', 'hydro', 'res']
for source in sources:
    # Create a pivot table of the grand_total column with month as the index and region
    df_pivot = df.pivot_table(values=source, index='month', columns='region', aggfunc='s

    # Plot each region separately using a loop
    for col in df_pivot.columns:
        plt.plot(df_pivot.index, df_pivot[col], label=col)

    # Add labels, legend, and title to the plot
    plt.xlabel('Year-Month')
    plt.ylabel('Installed Power Capacity (MW)')
    plt.xticks(rotation=90)  # Rotate x tick labels by 90 degrees
    plt.legend(loc='upper left')
    plt.title(f'Periodic Trend of Installed {source} power capacity by Region')

    # Display the plot
    plt.show()
```

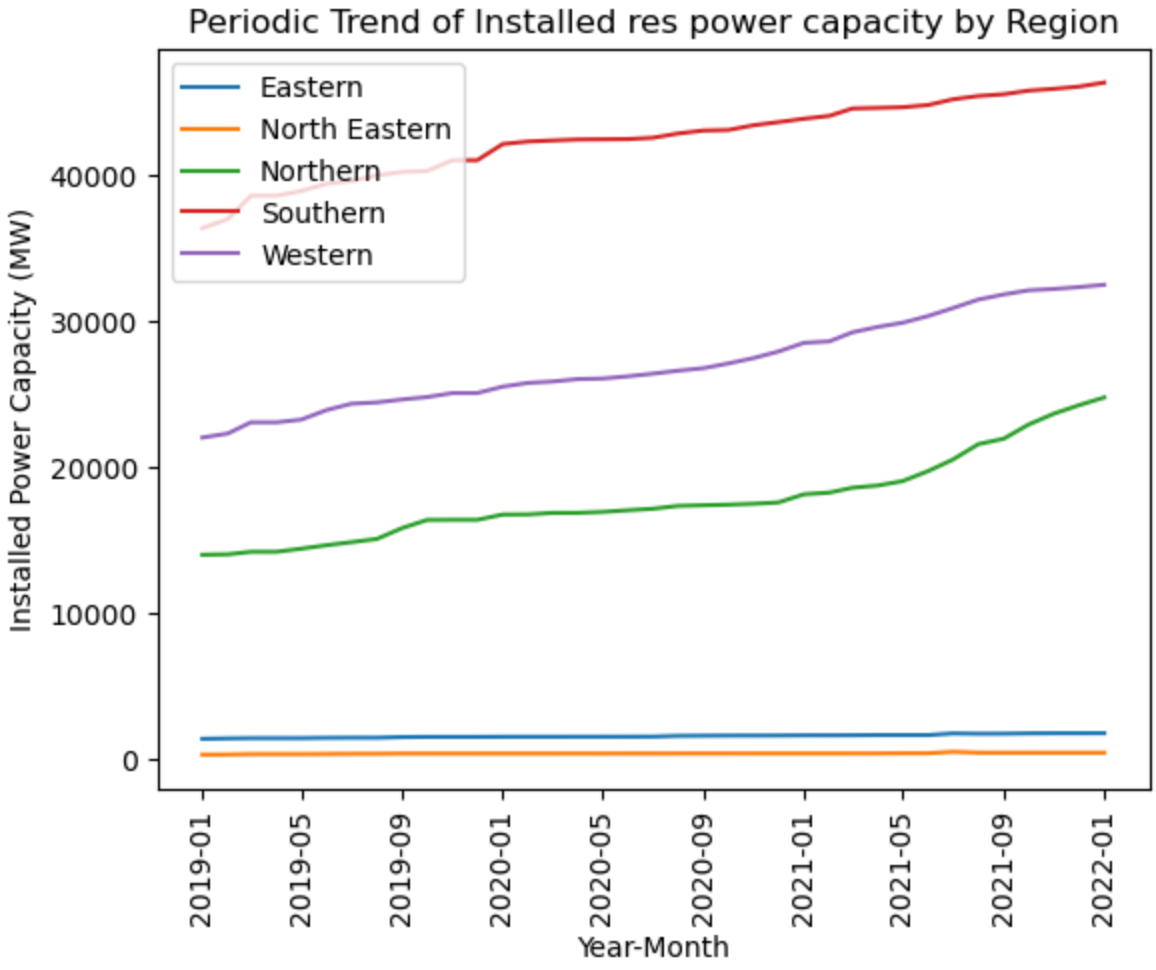

Periodic Trend of Installed coal power capacity by Region
Eastern
North Eastern
Northern
Southern
Western
Installed Power Capacity (MW)
0
20000
40000
60000
80000
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
Year-Month


Periodic Trend of Installed gas power capacity by Region
Eastern
North Eastern
Northern
Southern
Western
Installed Power Capacity (MW)
0
2000
4000
6000
8000
10000
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
Year-Month


Periodic Trend of Installed diesel power capacity by Region
Eastern
North Eastern
Northern
Southern
Western
Installed Power Capacity (MW)
0
100
200
300
400
500
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
Year-Month


Periodic Trend of Installed nuclear power capacity by Region
Eastern
North Eastern
Northern
Southern
Western
Installed Power Capacity (MW)
0
500
1000
1500
2000
2500
3000
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
Year-Month



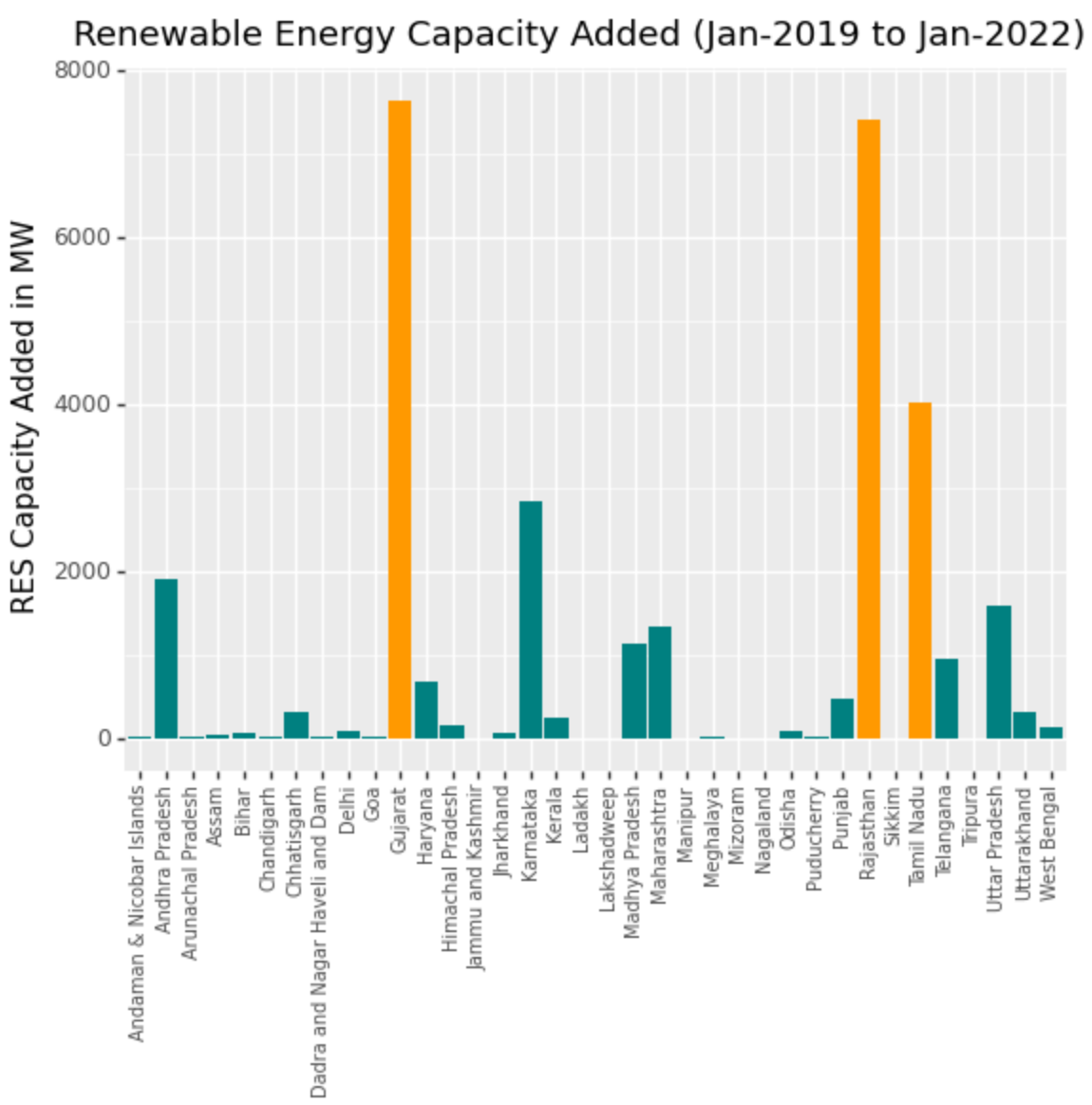


Plot II: Bar Plot

> This bar plot shows the Renewable Energy Capacity added by diffrent states from 2019-2022. Highlighted the bars for top 2 states, that added the maximum capacity.

In [9]:
```
df = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Installed_Power_Capacity_Stat


df['year'] = df['month'].str[-4:].astype(int)
df['state'] = df['state'].replace({'Andhra Pradesh.': 'Andhra Pradesh'})
df[['Month', 'Year']] = df['month'].str.split('-', n=1, expand=True)
df_diu = df[df["state"] == "Daman & Diu"]
df_dnh = df[df["state"] == "Dadra & Nagar Haveli"]

df_diu_sum = df_diu.groupby(["month", "Year", "region"]).sum()
df_dnh_sum = df_dnh.groupby(["month", "Year", "region"]).sum()

df_combined = df_diu_sum.add(df_dnh_sum, fill_value=0)

df_combined["state"] = "Dadra and Nagar Haveli and Dam"

df_combined.reset_index(inplace=True)
df_combined.drop('year', axis=1, inplace=True)
df_combined = df_combined[['id', 'month', 'region', 'state', 'coal', 'gas', 'diesel', 't

df = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Installed_Power_Capacity_Stat
df = df.drop(df[(df['state'] == 'Dadra & Nagar Haveli') | (df['state'] == 'Daman & Diu')
df = pd.concat([df, df_combined])
df.reset_index(drop=True, inplace=True)
df.head()

df_filtered = df[df['month'].isin(['Jan-2019', 'Jan-2022'])]

df_pivot = df_filtered.pivot(index='state', columns='month', values='res')

df_pivot['RES Capacity Added in MW'] = (df_pivot['Jan-2022'] - df_pivot['Jan-2019'])

df_pivot = df_pivot.reset_index()

top_states = df_pivot.sort_values(by='RES Capacity Added in MW', ascending=False)['state

increment_plot = (ggplot(df_pivot, aes(x='state', y='RES Capacity Added in MW', fill=df_
                  + geom_col(position=position_dodge(1), width=0.9)
                  + scale_fill_manual(values=[custom_palette[0], custom_palette[1]], gui
                  + labs(x='State / Union territory (UT)', y='RES Capacity Added in MW',
                         title='Renewable Energy Capacity Added (Jan-2019 to Jan-2022)')
                  + theme(axis_text_x=element_text(angle=90, size=7),
                          axis_title_x=element_blank())
                  )

print(increment_plot)
```

```
C:\Users\PC\anaconda3\lib\site-packages\plotnine\layer.py:411: PlotnineWarning: geom_col
: Removed 1 rows containing missing values.
```



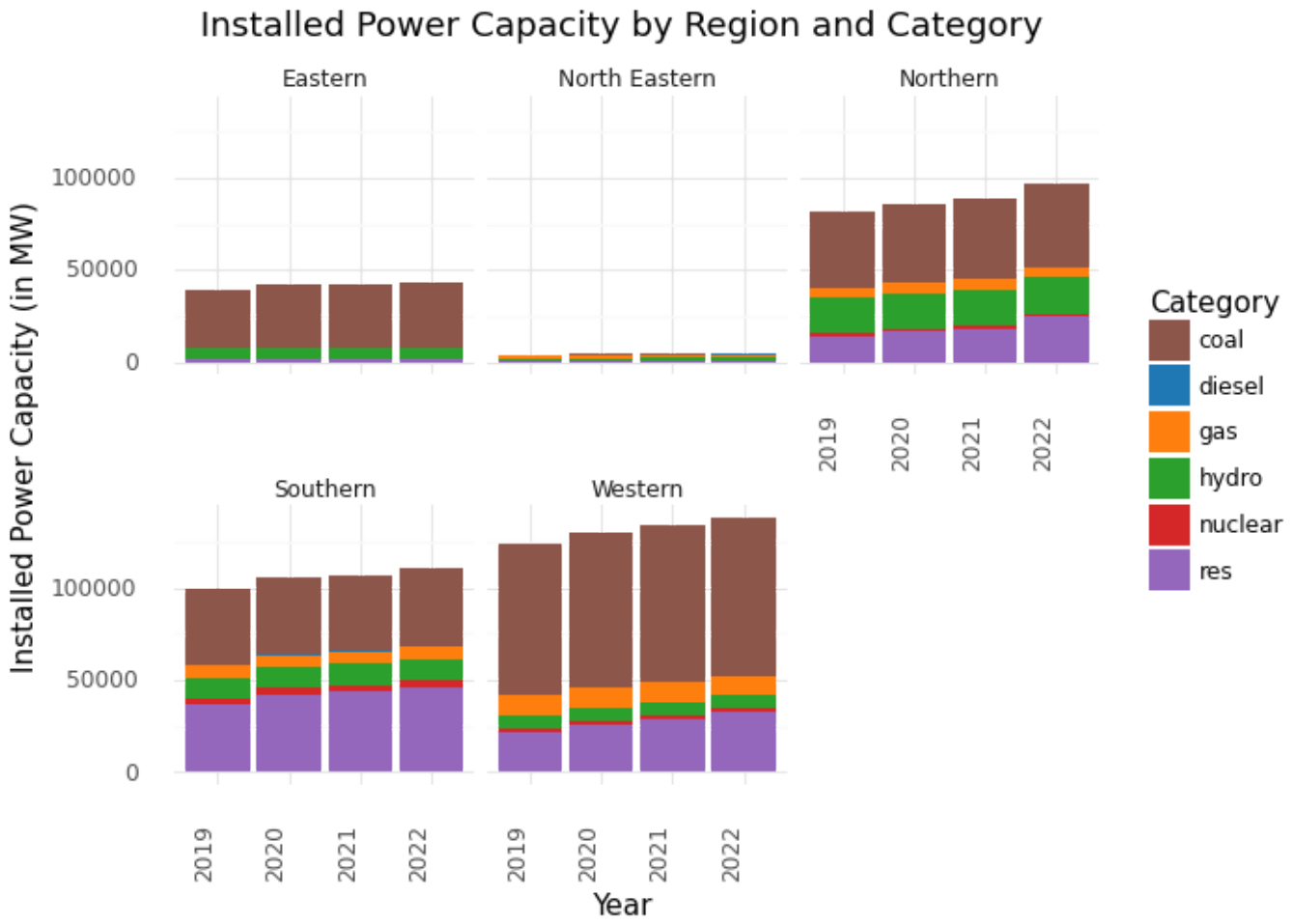
Plot III: Stacked Bar Plot

> This region-wise facetted plots shows the gradual growth of each energy resource installed power capacity.

In [10]:

```
df[['Month', 'Year']] = df['month'].str.split('-', n=1, expand=True)
# Define the colors for each source
colors = {
    'diesel': 'tab:blue',
    'coal': 'tab:brown',
    'gas': 'tab:orange',
    'hydro': 'tab:green',
    'nuclear': 'tab:red',
    'res': 'tab:purple'
}

# Filter the data to include only January for each year
df_jan = df[df['Month'] == 'Jan']

# Sum the state capacities for each region and year
df_grouped = df_jan.groupby(['region', 'Year']).sum()[['coal', 'gas', 'diesel',  'nuclea
df_grouped = df_grouped.reset_index()

# Melt the DataFrame to a long format
```

```
df_melted = pd.melt(df_grouped, id_vars=['region', 'Year'], var_name='Category', value_n

# Create the stacked bar chart
stacked_bar_chart = (ggplot(df_melted, aes(x='Year', y='Capacity', fill='Category'))
                     + geom_bar(stat='identity')
                     + scale_fill_manual(values=colors)  # Use the color mappings
                     + labs(x='Year', y='Installed Power Capacity (in MW)', title='Insta
                     + theme_minimal()
                     + theme(axis_text_x=element_text(angle=90, hjust=1),panel_spacing_y
                     + facet_wrap('~region', ncol=3)
                    )

print(stacked_bar_chart)
```



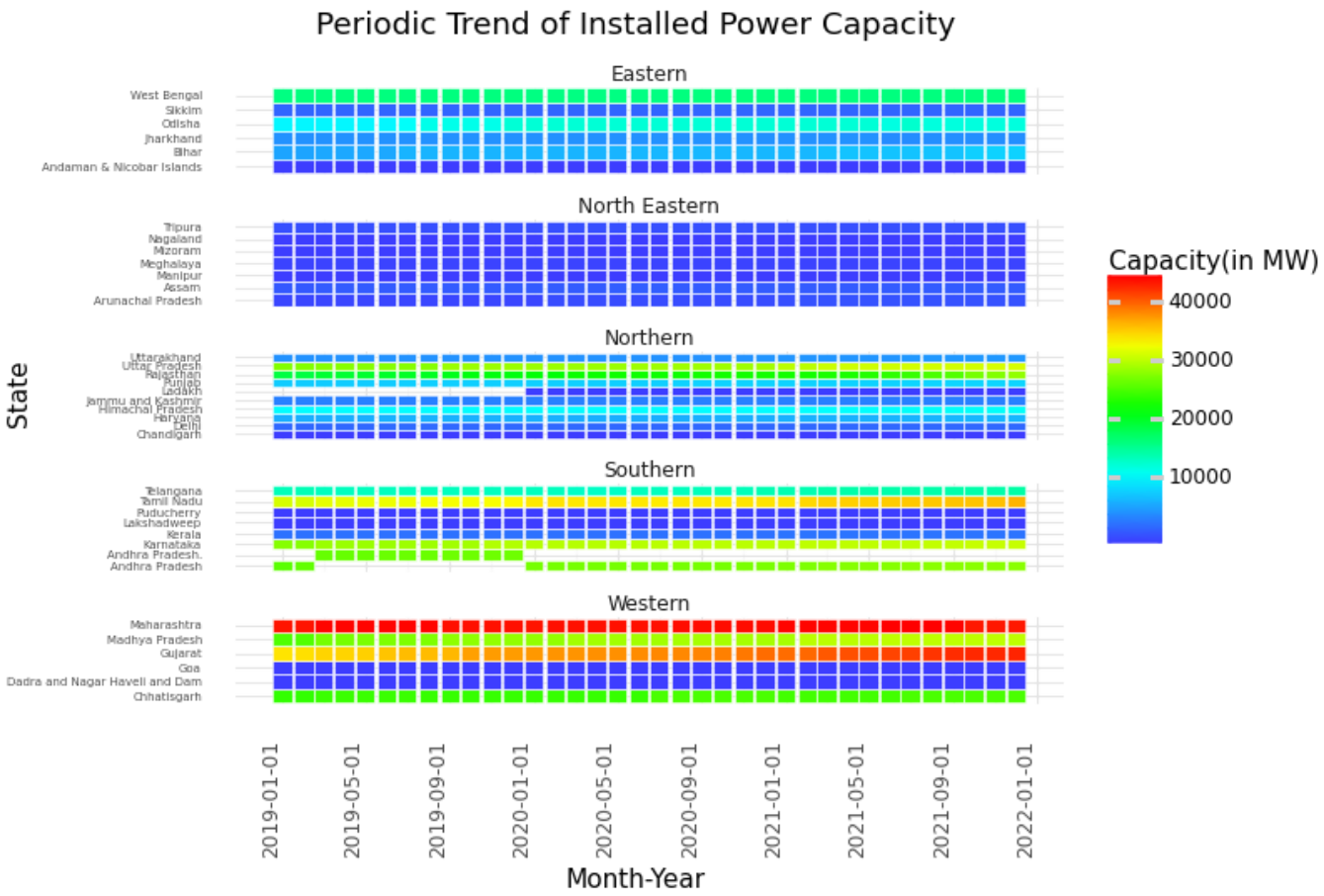
Plot IV:

> This facetted Heatmap gives the overall idea of trend of increase it capacity throughout years for each state and moreover from colors of heatmap and scale given, comparative study between the regions can be done. We can see the Maharashtra is consistenly have the highest Power Generation Capacity installed. Western region have most developed infrastructure and Northeastern the least.

In [18]:

```
df['year'] = df['month'].str[-4:].astype(int)
df = df[df['year'] <= 2021]
# Convert 'month' column to datetime and sort it in ascending order
df['month_new'] = pd.to_datetime(df['month'], format='%b-%Y')
df = df.sort_values('month_new')

# Group by 'state' and 'month' and calculate the sum of 'grand_total'
```

```
df_heatmap = df.groupby(['region', 'state', 'month_new']).sum()['grand_total'].reset_ind

# Melt the DataFrame to a long format
df_heatmap = pd.melt(df_heatmap, id_vars=['region', 'state', 'month_new'], var_name='Cat

# Create the heatmap plot with a multi-color gradient and region-wise facets
heatmap_plot = (ggplot(df_heatmap, aes(x='month_new', y='state', fill='Capacity(in MW)')
                + geom_tile(color='white', size=0.25)
                + scale_fill_gradientn(colors=['#3D3DFF', '#00FFFF', '#00FF00', '#FFFF00
                + labs(x='Month-Year', y='State', title='Periodic Trend of Installed Pow
                + theme_minimal()
                + theme(axis_text_x=element_text(angle=90, hjust=1),
                        axis_text_y=element_text(size=5))
                + facet_wrap('~region',scales='free_y', ncol=1)
               )


print(heatmap_plot)
```



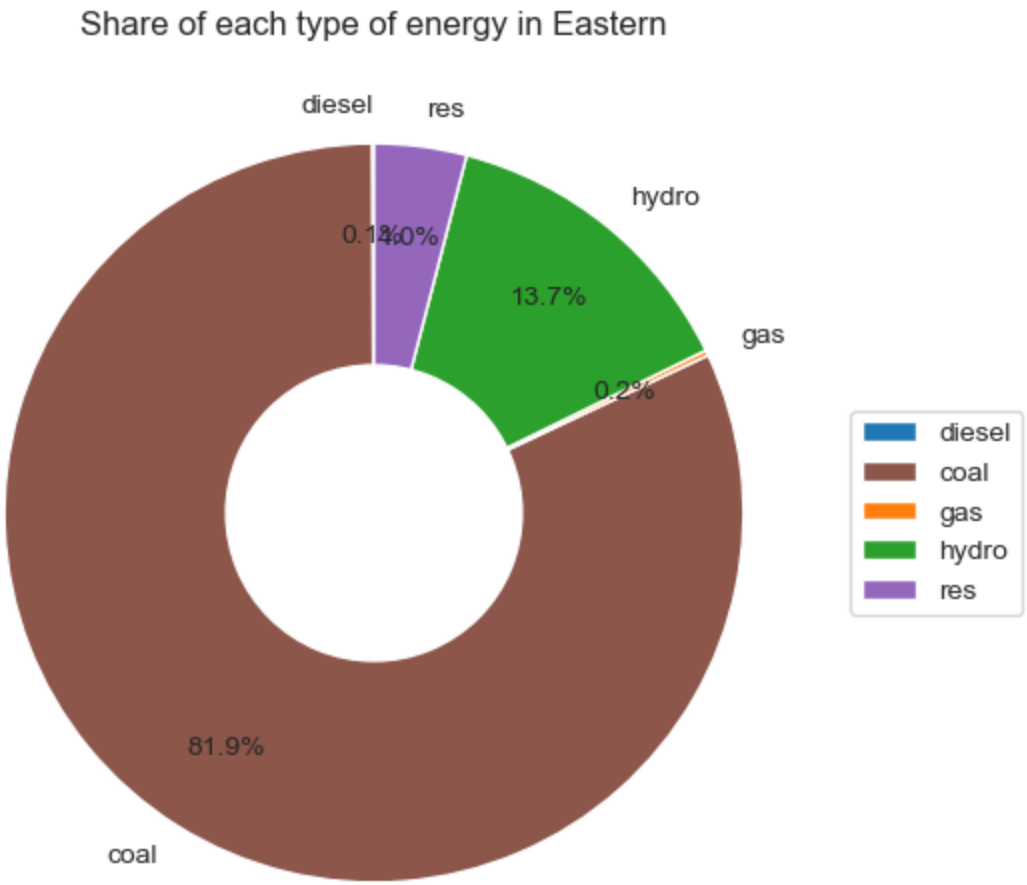
Plot V: Donut Charts

> These are region-wise charts showing the status of latest distribution of energy coming from diffrent sources. Observing carefully, we can get interesting insights like, Northeastern India unlike other regions have dominance of Hydro and Gas generation, whereas other regions show dominance of Conventional Coal Plants. Moreover Southern region have significant percentage of its energy coming from Renewable Resources.

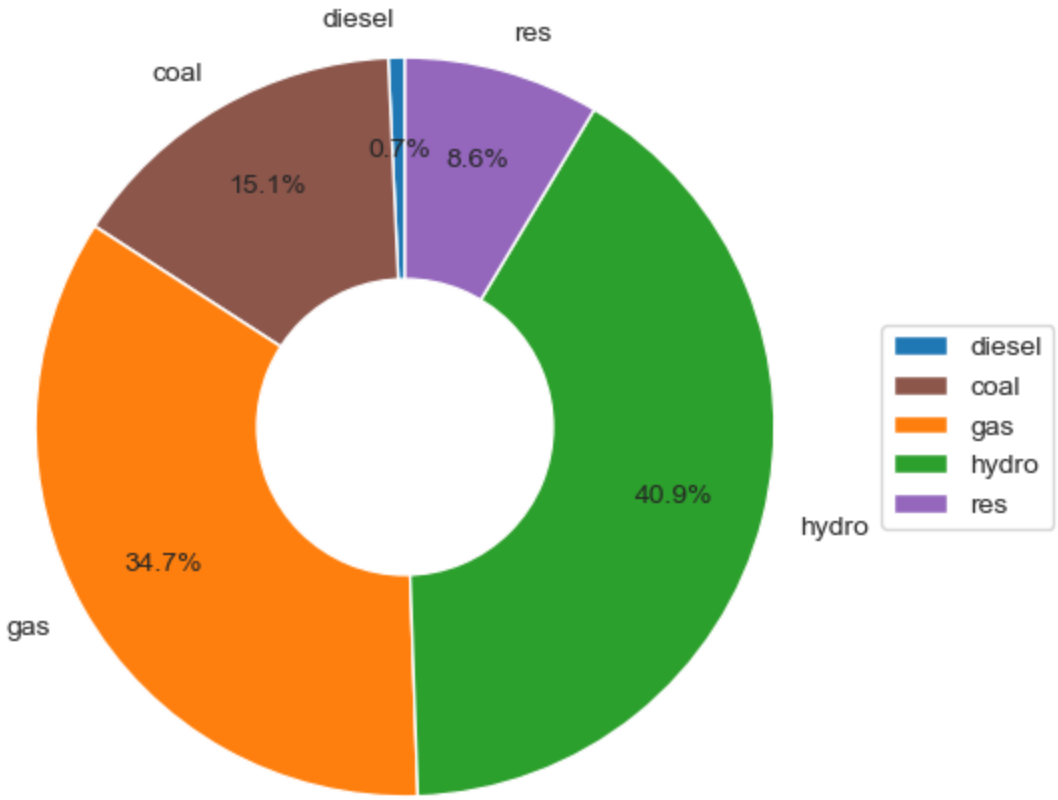
In [100…

```
df_jan2022 = df[df['month'].isin(['Jan-2022'])]
df_pie = df_jan2022.groupby('region').sum()[['diesel','coal', 'gas', 'hydro', 'nuclear',

df_pie_pct = df_pie.apply(lambda x: x / x['grand_total'] * 100, axis=1)
```

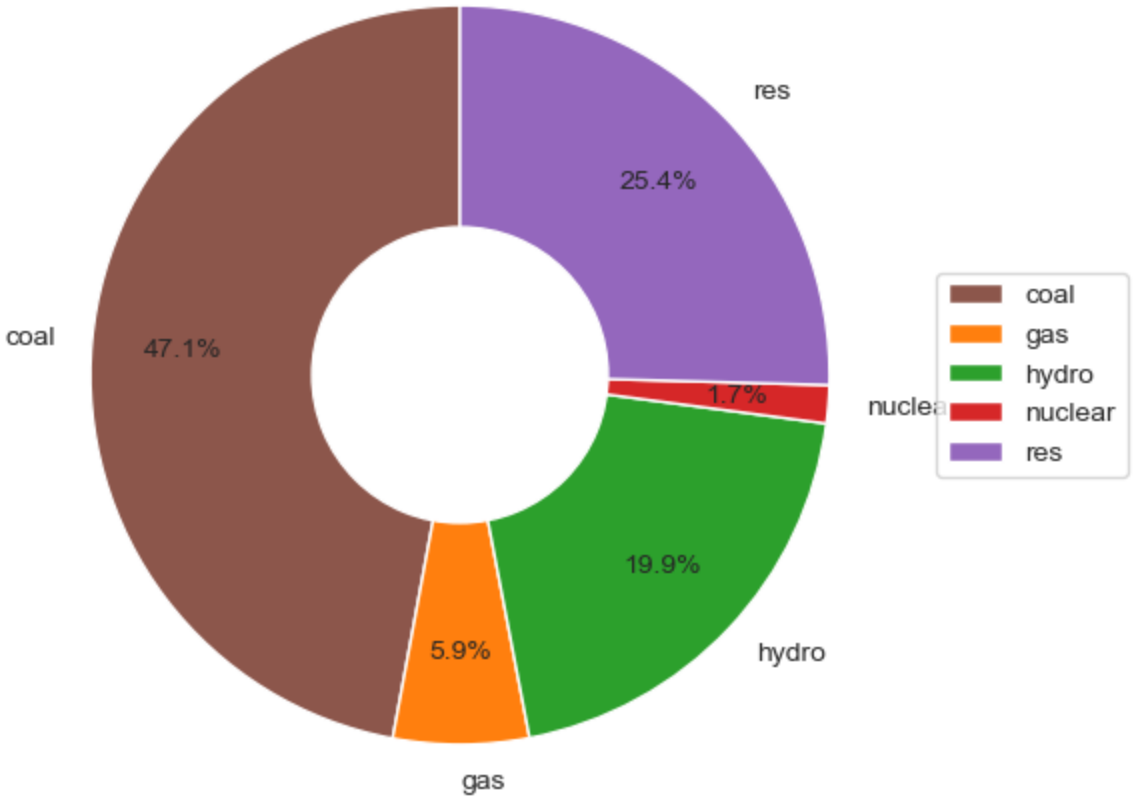
```
df_pie_pct.drop('grand_total', axis=1, inplace=True)

inner_radius = 0.4
outer_radius = 1.0

colors = {
    'diesel': 'tab:blue',
    'coal': 'tab:brown',
    'gas': 'tab:orange',
    'hydro': 'tab:green',
    'nuclear': 'tab:red',
    'res': 'tab:purple'
}

for state in df_pie_pct.index:
    non_zero_pct = df_pie_pct.loc[state][df_pie_pct.loc[state] != 0.0]
    labels = non_zero_pct.index

    if len(labels) == 0:
        continue

    fig, ax = plt.subplots(figsize=(6, 6))
    ax.pie(non_zero_pct, labels=labels, radius=outer_radius, autopct='%1.1f%%', startang
    ax.set_title(f'Share of each type of energy in {state}')
    ax.pie([100], radius=inner_radius, colors='w')

    ax.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.show()
```



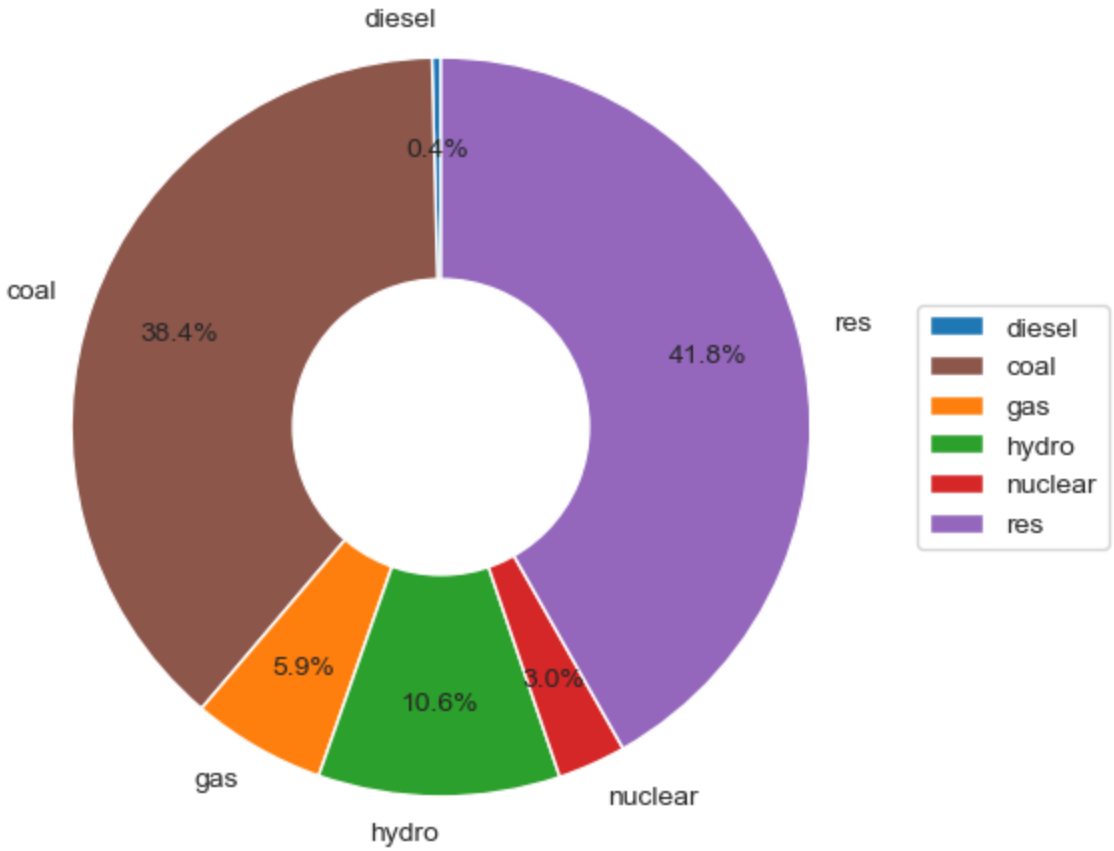
Share of each type of energy in North Eastern



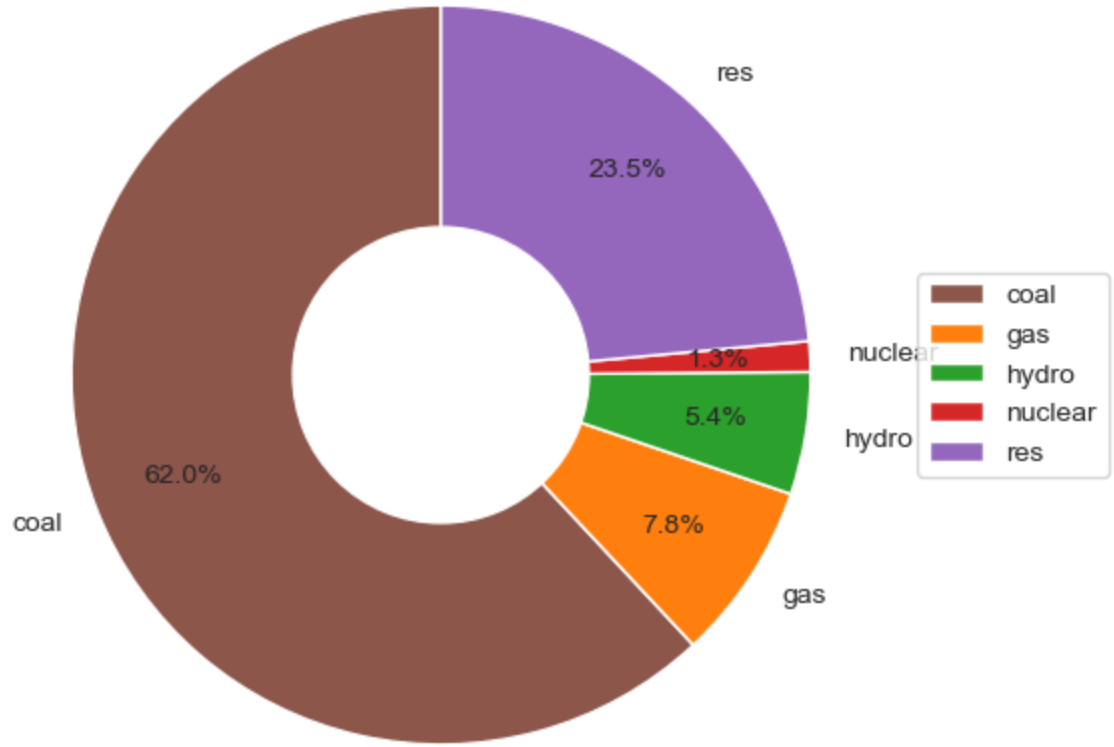
Share of each type of energy in Northern



Share of each type of energy in Southern



Share of each type of energy in Western

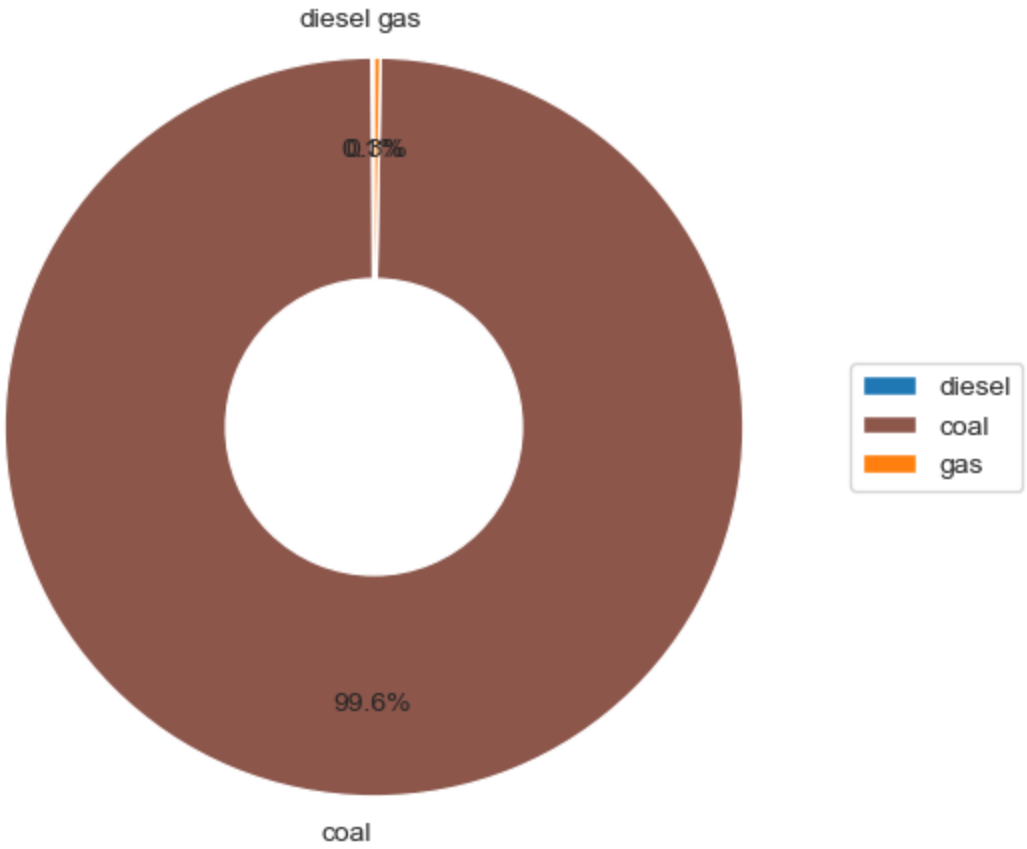


Plot VI: Donut Charts

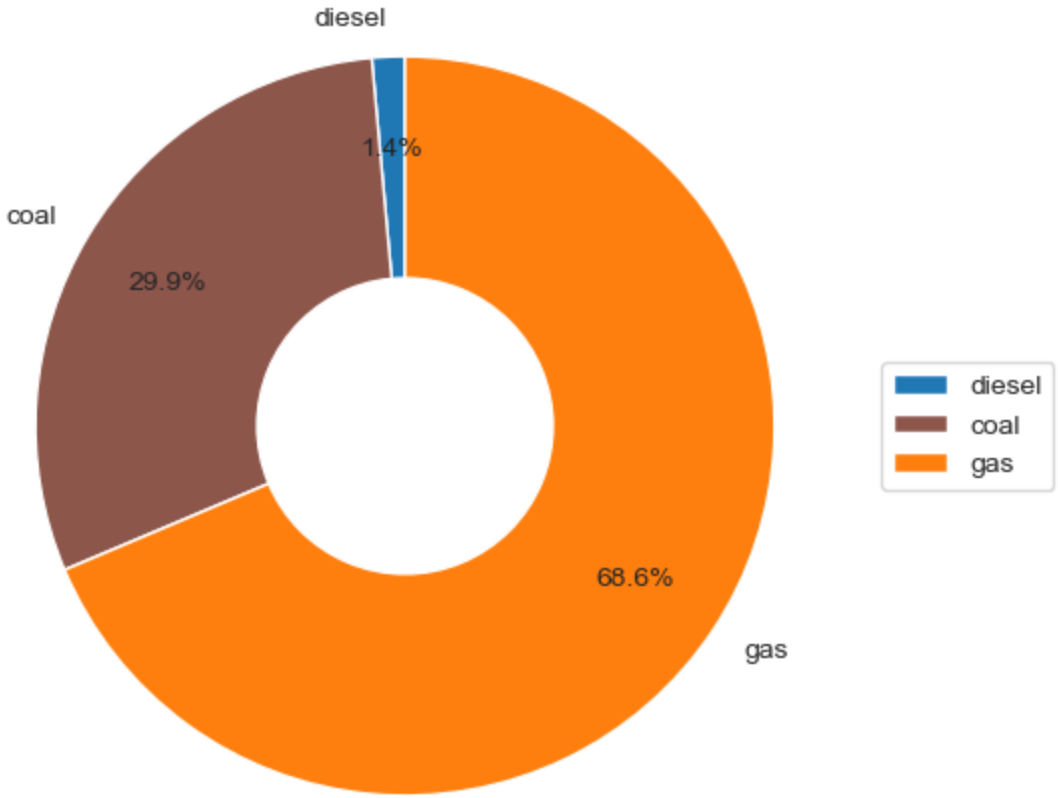
> These are region-wise charts showing the status of latest distribution of energy coming from diffrent thermal sources only.

In [83]:
```
df_pie = df_jan2022.groupby('region').sum()[['diesel','coal', 'gas' , 'thermal_total']]

df_pie_pct = df_pie.apply(lambda x: x / x['thermal_total'] * 100, axis=1)
df_pie_pct.drop('thermal_total', axis=1, inplace=True)

inner_radius = 0.4
outer_radius = 1.0

colors = {
    'diesel': 'tab:blue',
    'coal': 'tab:brown',
    'gas': 'tab:orange',
}

for state in df_pie_pct.index:
    non_zero_pct = df_pie_pct.loc[state][df_pie_pct.loc[state] != 0.0]
    labels = non_zero_pct.index

    if len(labels) == 0:
        continue

    fig, ax = plt.subplots(figsize=(6, 6))
    ax.pie(non_zero_pct, labels=labels, radius=outer_radius, autopct='%1.1f%%', startang
    ax.set_title(f'Share of each type of energy in {state}')

    ax.pie([100], radius=inner_radius, colors='w')

    ax.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))

    plt.show()
```

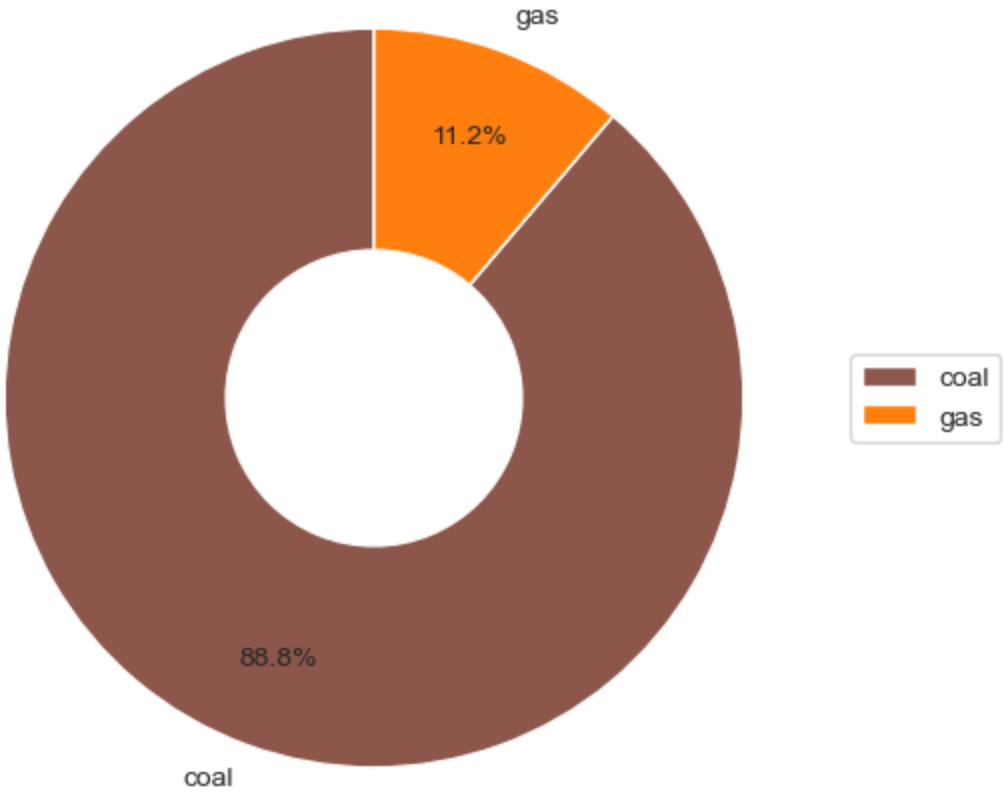
Share of each type of energy in Eastern



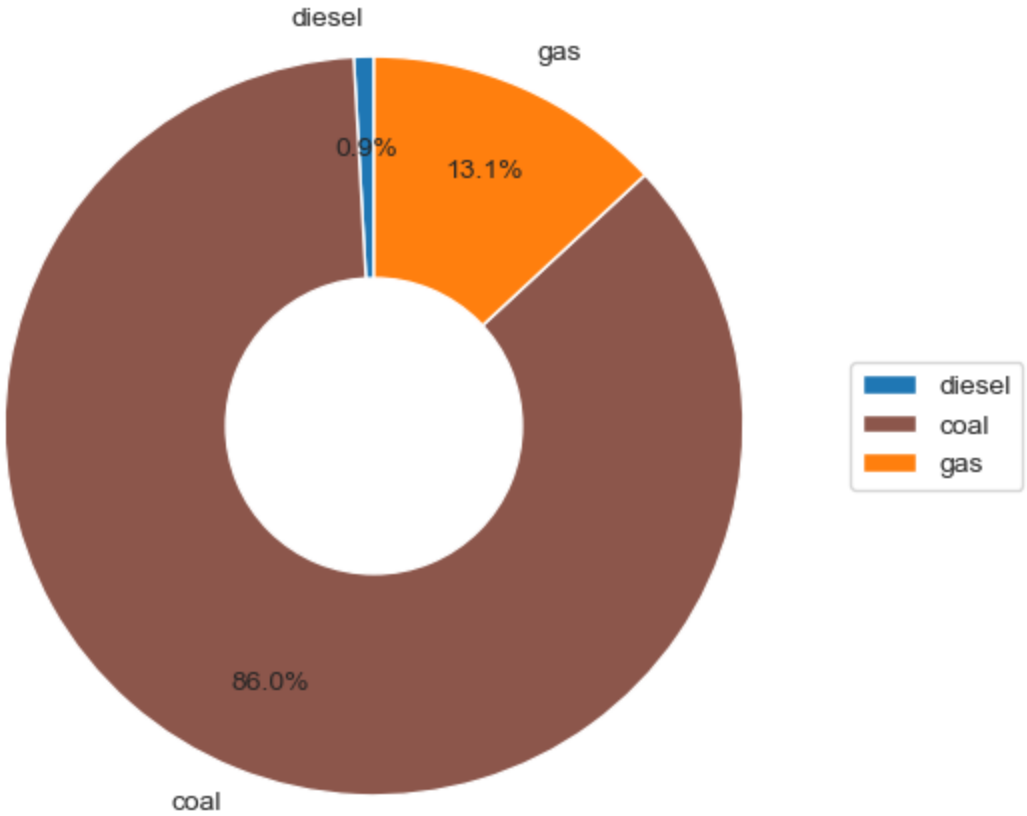
Share of each type of energy in North Eastern

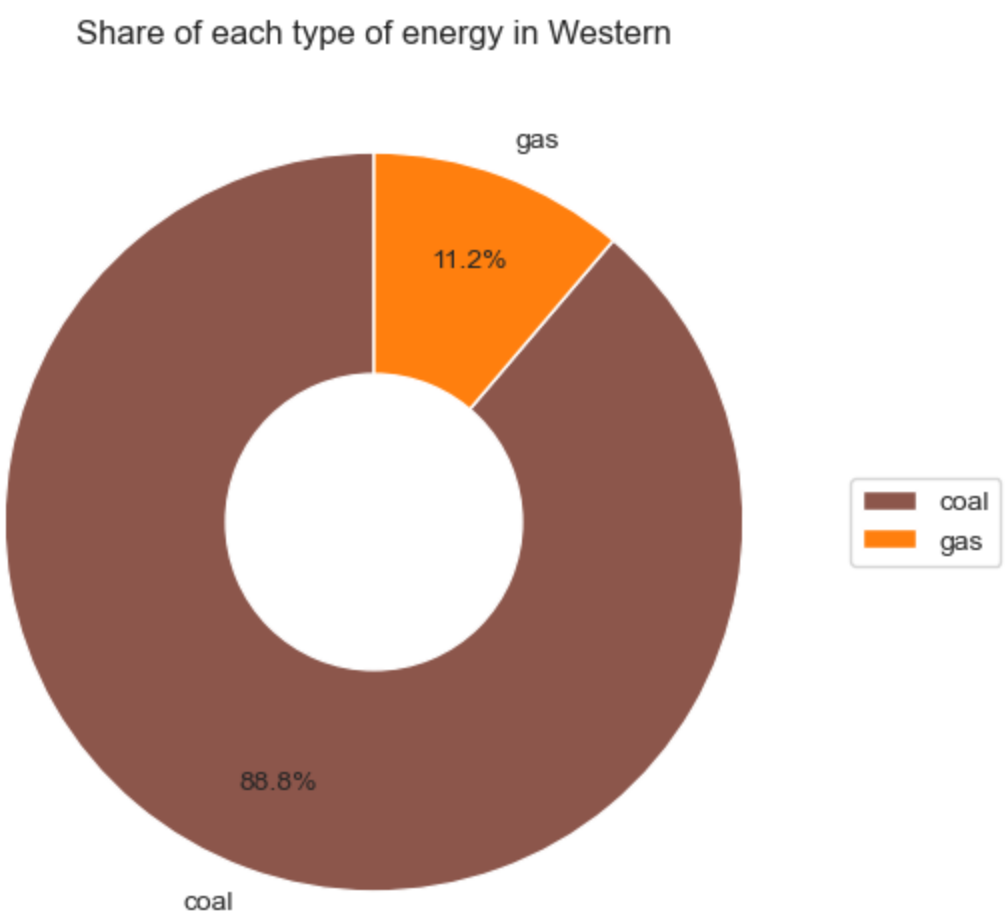


Share of each type of energy in Northern



Share of each type of energy in Southern





In [102…

```
#reading genartion data
data = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Power_Generation.csv")
```

In [24]:

```
# Create a dictionary to hold the separate data frames
dfs = {}

# Loop through each region and create a separate data frame for it
for region in data['Region'].unique():
    region_df = data[data['Region'] == region].copy()
    region_df.reset_index(drop=True, inplace=True)
    dfs[region] = region_df

northern_df = dfs['Northern']
western_df = dfs['Western']
southern_df = dfs['Southern']
eastern_df = dfs['Eastern']
northeastern_df = dfs['NorthEastern']

northern_df.fillna(northern_df.mean(), inplace=True)
western_df.fillna(western_df.mean(), inplace=True)
southern_df.fillna(southern_df.mean(), inplace=True)
eastern_df.fillna(eastern_df.mean(), inplace=True)
northeastern_df.fillna(northeastern_df.mean(), inplace=True)
northeastern_df = northeastern_df[['index','Date','Region','Thermal Generation Actual (i
eastern_df =  eastern_df[['index','Date','Region','Thermal Generation Actual (in MU)','T

df = pd.concat([northern_df, western_df, southern_df, eastern_df, northeastern_df])
df.reset_index(drop=True, inplace=True)
```

```
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\3611620112.py:16: FutureWarning: Dropping
of nuisance columns in DataFrame reductions (with 'numeric_only=None') is deprecated; in
a future version this will raise TypeError.  Select only valid columns before calling th
```

```
e reduction.
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\3611620112.py:17: FutureWarning: Dropping
of nuisance columns in DataFrame reductions (with 'numeric_only=None') is deprecated; in
a future version this will raise TypeError.  Select only valid columns before calling th
e reduction.
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\3611620112.py:18: FutureWarning: Dropping
of nuisance columns in DataFrame reductions (with 'numeric_only=None') is deprecated; in
a future version this will raise TypeError.  Select only valid columns before calling th
e reduction.
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\3611620112.py:19: FutureWarning: Dropping
of nuisance columns in DataFrame reductions (with 'numeric_only=None') is deprecated; in
a future version this will raise TypeError.  Select only valid columns before calling th
e reduction.
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\3611620112.py:20: FutureWarning: Dropping
of nuisance columns in DataFrame reductions (with 'numeric_only=None') is deprecated; in
a future version this will raise TypeError.  Select only valid columns before calling th
e reduction.
```

In [25]:
```
northern_df_new = northern_df[["Date","Region" ,"Thermal Generation Actual (in MU)"]]
northern_df_new = northern_df_new[northern_df_new['Date'].str.startswith('2019')]
northern_df_new["Thermal Generation Actual (in MU)"] = pd.to_numeric(northern_df_new["Th
northern_df_new.head()
```

Out[25]:

	Date	Region	Thermal Generation Actual (in MU)
485	2019-01-01	Northern	691.66
486	2019-01-02	Northern	691.66
487	2019-01-03	Northern	692.52
488	2019-01-04	Northern	692.52
489	2019-01-05	Northern	686.77

In [26]:
```
import pandas as pd

# Extract month from "Date" column and create a new column for it
northern_df_new['Month'] = pd.to_datetime(northern_df_new['Date']).dt.to_period('M')
northern_df_new
```

Out[26]:

	Date	Region	Thermal Generation Actual (in MU)	Month
485	2019-01-01	Northern	691.66	2019-01
486	2019-01-02	Northern	691.66	2019-01
487	2019-01-03	Northern	692.52	2019-01
488	2019-01-04	Northern	692.52	2019-01
489	2019-01-05	Northern	686.77	2019-01
...	...	...	...	...
845	2019-12-27	Northern	685.97	2019-12
846	2019-12-28	Northern	685.97	2019-12
847	2019-12-29	Northern	685.97	2019-12
848	2019-12-30	Northern	685.97	2019-12
849	2019-12-31	Northern	703.04	2019-12

365 rows × 4 columns

In [27]:
```
# Group data by month and find average thermal generation for each month
northern_df_monthly = northern_df_new.groupby('Month')['Thermal Generation Actual (in MU

# Display the resulting dataframe
print(northern_df_monthly)
```

```
      Month  Thermal Generation Actual (in MU)
0   2019-01                         676.047097
1   2019-02                         663.731786
2   2019-03                         666.431613
3   2019-04                         692.206000
4   2019-05                         725.139355
5   2019-06                         717.745667
6   2019-07                         645.733871
7   2019-08                         669.701290
8   2019-09                         703.970667
9   2019-10                         710.351935
10  2019-11                         655.826333
11  2019-12                         656.445484
```

Plot VII: Line Charts

In [ ]:
```
northeastern_df.head()
northeastern_df['Date'] = pd.to_datetime(northeastern_df['Date']) # Convert Date column
northeastern_monthly = northeastern_df.groupby(pd.Grouper(key='Date', freq='M')).sum().r
northeastern_monthly.replace(0, np.nan, inplace=True)
northeastern_monthly.replace(0.00, np.nan, inplace=True)
northeastern_monthly = northeastern_monthly.interpolate(method='backfill')
northeastern_monthly.head()
(ggplot(northeastern_monthly, aes(x='Date', y='Hydro Generation Actual (in MU)')) +
  geom_line(color='blue') +
  geom_line(aes(x='Date', y='Hydro Generation Estimated (in MU)'), color='red') +
  labs(title='Monthly Hydro Generation in the Northeastern Region', x='Date', y='Hydro G
 + theme(axis_text_x=element_text(angle=90, size=7) ))
```

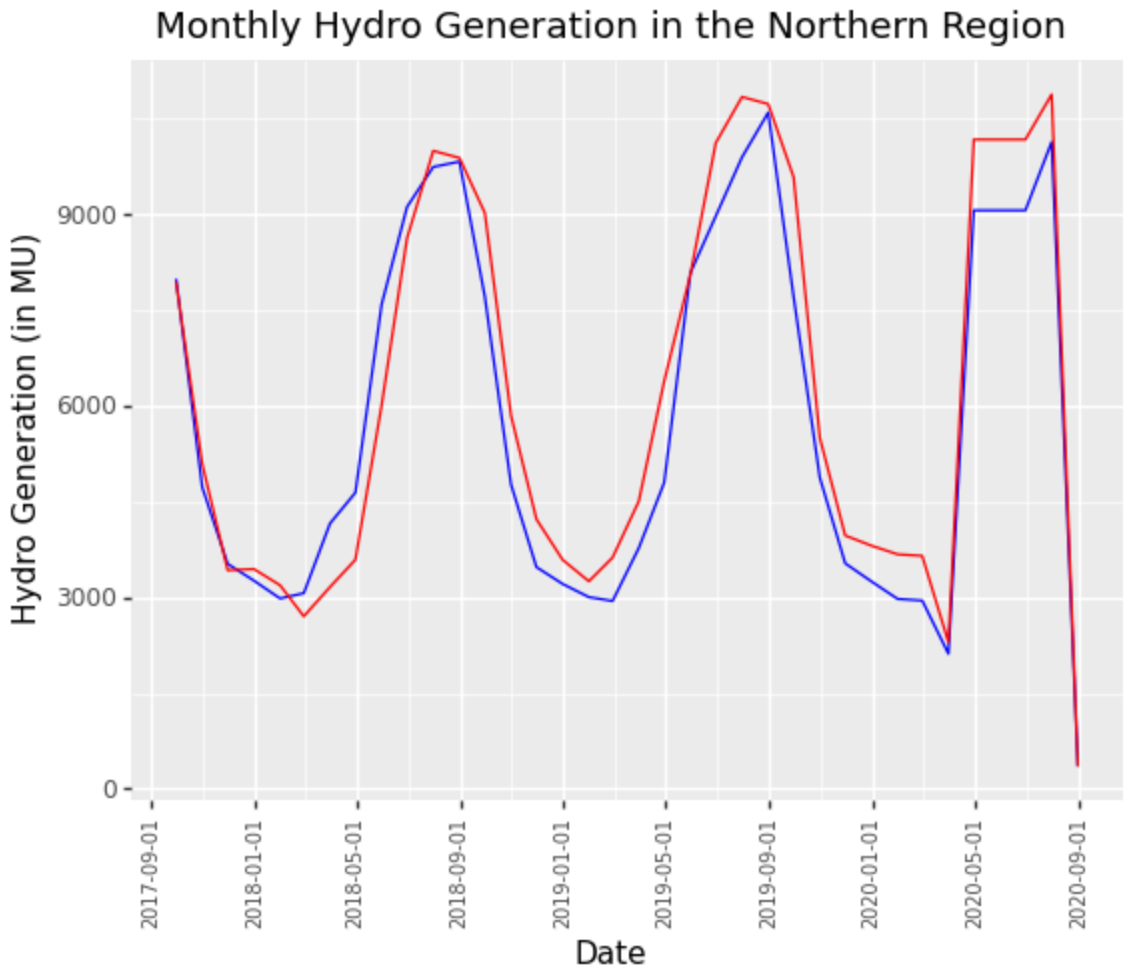
In [22]:
```
northern_df.head()
```

Out[22]:

	index	Date	Region	Thermal Generation Actual (in MU)	Thermal Generation Estimated (in MU)	Nuclear Generation Actual (in MU)	Nuclear Generation Estimated (in MU)	Hydro Generation Actual (in MU)	Hydro Generation Estimated (in MU)
0	0	2017-09-01	Northern	624.23	484.21	30.36	35.57	273.27	320.81
1	5	2017-09-02	Northern	624.23	507.42	30.36	35.69	273.27	317.19
2	10	2017-09-03	Northern	624.23	492.69	30.36	35.65	273.27	316.69
3	15	2017-09-04	Northern	624.23	568.34	30.36	35.62	273.27	297.47
4	20	2017-09-05	Northern	628.58	597.08	30.36	35.72	273.27	290.23

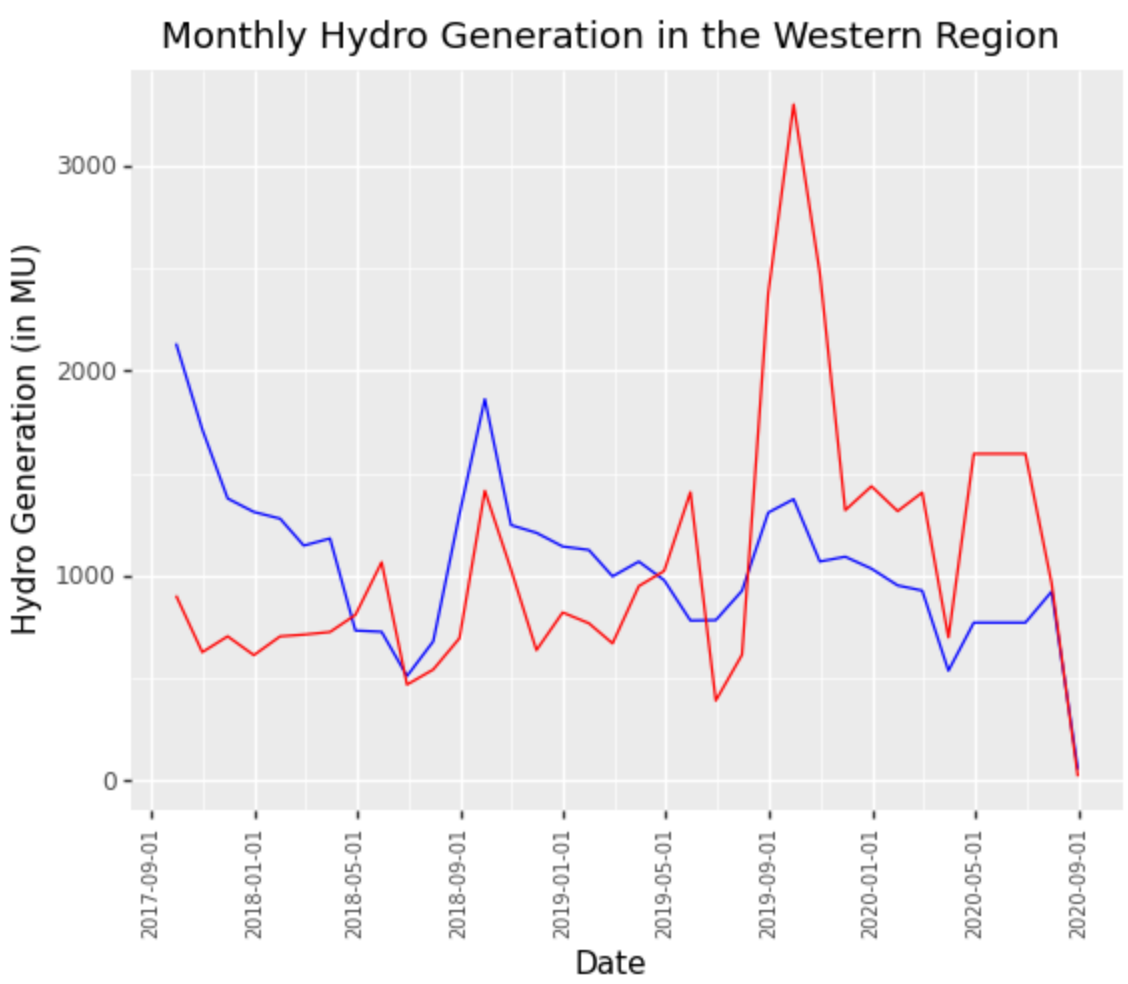
In [31]:
```
northern_df.head()
northern_df['Date'] = pd.to_datetime(northern_df['Date']) # Convert Date column to datet
northern_monthly = northern_df.groupby(pd.Grouper(key='Date', freq='M')).sum().reset_ind
northern_monthly.replace(0, np.nan, inplace=True)
northern_monthly.replace(0.00, np.nan, inplace=True)
northern_monthly = northern_monthly.interpolate(method='backfill')
northern_monthly.head()
```

```
(ggplot(northern_monthly, aes(x='Date', y='Hydro Generation Actual (in MU)')) +
  geom_line(color='blue') +
  geom_line(aes(x='Date', y='Hydro Generation Estimated (in MU)'), color='red') +
  labs(title='Monthly Hydro Generation in the Northern Region', x='Date', y='Hydro Gener
 + theme(axis_text_x=element_text(angle=90, size=7) ))
```



Out[31]: <ggplot: (124160907201)>

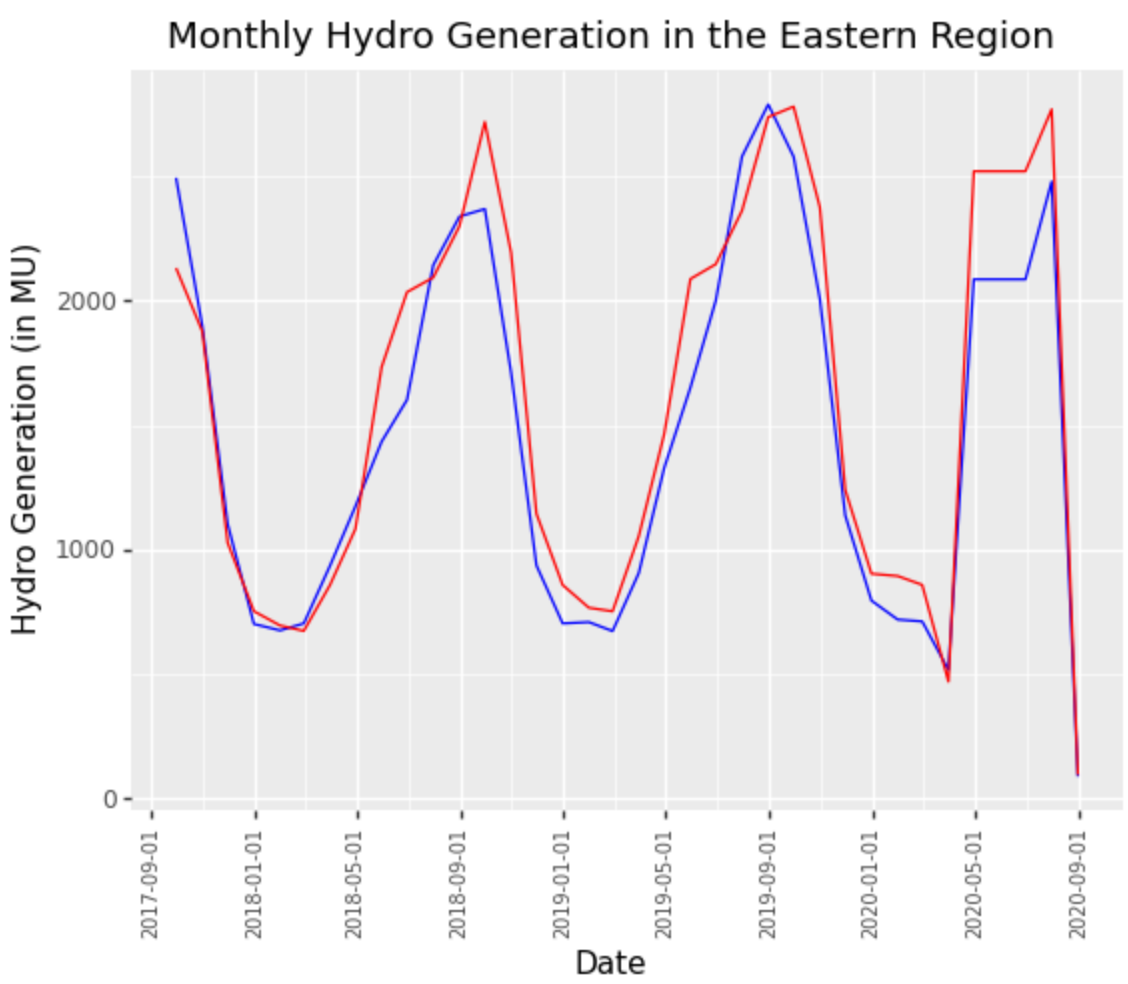
In [32]:
```
western_df.head()
western_df['Date'] = pd.to_datetime(western_df['Date']) # Convert Date column to datetim
western_monthly = western_df.groupby(pd.Grouper(key='Date', freq='M')).sum().reset_index
western_monthly.replace(0, np.nan, inplace=True)
western_monthly.replace(0.00, np.nan, inplace=True)
western_monthly = western_monthly.interpolate(method='backfill')
western_monthly.head()
(ggplot(western_monthly, aes(x='Date', y='Hydro Generation Actual (in MU)')) +
  geom_line(color='blue') +
  geom_line(aes(x='Date', y='Hydro Generation Estimated (in MU)'), color='red') +
  labs(title='Monthly Hydro Generation in the Western Region', x='Date', y='Hydro Genera
 + theme(axis_text_x=element_text(angle=90, size=7) ))
```



Out[32]: <ggplot: (124160754469)>

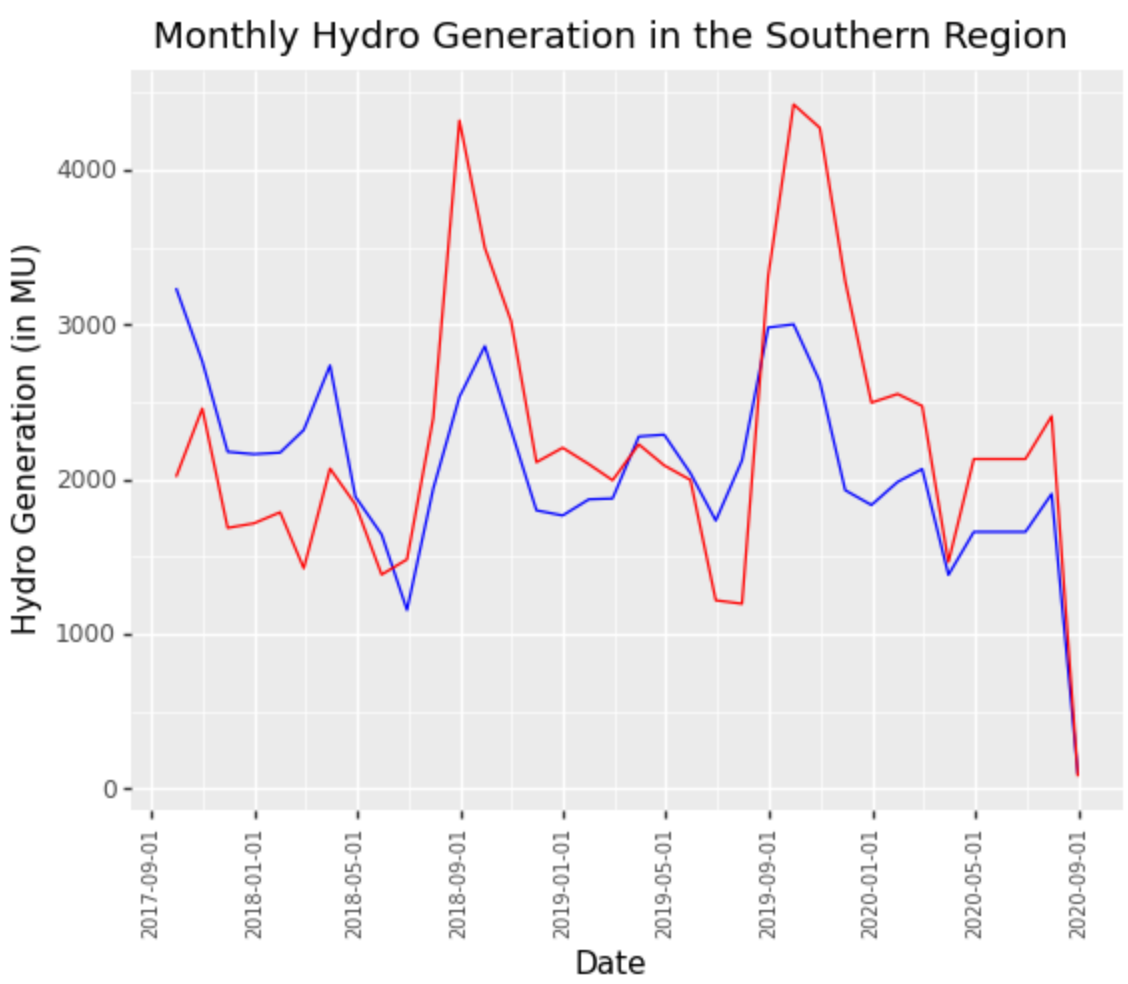
In [33]:
```
eastern_df.head()
eastern_df['Date'] = pd.to_datetime(western_df['Date']) # Convert Date column to datetim
eastern_monthly = eastern_df.groupby(pd.Grouper(key='Date', freq='M')).sum().reset_index
eastern_monthly.replace(0, np.nan, inplace=True)
eastern_monthly.replace(0.00, np.nan, inplace=True)
eastern_monthly = eastern_monthly.interpolate(method='backfill')
eastern_monthly.head()
(ggplot(eastern_monthly, aes(x='Date', y='Hydro Generation Actual (in MU)')) +
  geom_line(color='blue') +
  geom_line(aes(x='Date', y='Hydro Generation Estimated (in MU)'), color='red') +
  labs(title='Monthly Hydro Generation in the Eastern Region', x='Date', y='Hydro Genera
 + theme(axis_text_x=element_text(angle=90, size=7) ))
```

```
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\1641135932.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
```



Out[33]: <ggplot: (124161407139)>

In [34]:
```
southern_df.head()
southern_df['Date'] = pd.to_datetime(western_df['Date']) # Convert Date column to dateti
southern_monthly = southern_df.groupby(pd.Grouper(key='Date', freq='M')).sum().reset_ind
southern_monthly.replace(0, np.nan, inplace=True)
southern_monthly.replace(0.00, np.nan, inplace=True)
southern_monthly = southern_monthly.interpolate(method='backfill')
southern_monthly.head()
(ggplot(southern_monthly, aes(x='Date', y='Hydro Generation Actual (in MU)')) +
  geom_line(color='blue') +
  geom_line(aes(x='Date', y='Hydro Generation Estimated (in MU)'), color='red') +
  labs(title='Monthly Hydro Generation in the Southern Region', x='Date', y='Hydro Gener
 + theme(axis_text_x=element_text(angle=90, size=7) ))
```



Out[34]: <ggplot: (124161408907)>

In [35]:
```
northern_monthly['Year'] = northern_monthly['Date'].dt.year
```

In [36]:
```
northern_monthly.head()
```

Out[36]:

	Date	index	Nuclear Generation Actual (in MU)	Nuclear Generation Estimated (in MU)	Hydro Generation Actual (in MU)	Hydro Generation Estimated (in MU)	Year
0	2017-09-30	2175.0	880.44	955.82	7993.64	7946.24	2017
1	2017-10-31	6675.0	774.00	1087.77	4723.80	5087.98	2017
2	2017-11-30	11175.0	594.00	1109.62	3525.00	3424.77	2017
3	2017-12-31	16275.0	889.60	1088.86	3262.13	3443.43	2017
4	2018-01-31	21080.0	939.61	996.00	2981.58	3189.30	2018

>> GEOGRAPHICAL PLOTS

In [ ]:
```
pip install pyshp
```

In [37]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

```
import seaborn as sns
import geopandas as gpd
import shapefile as shp
```

In [38]:
```
from shapely.geometry import Point
sns.set_style('whitegrid')
```

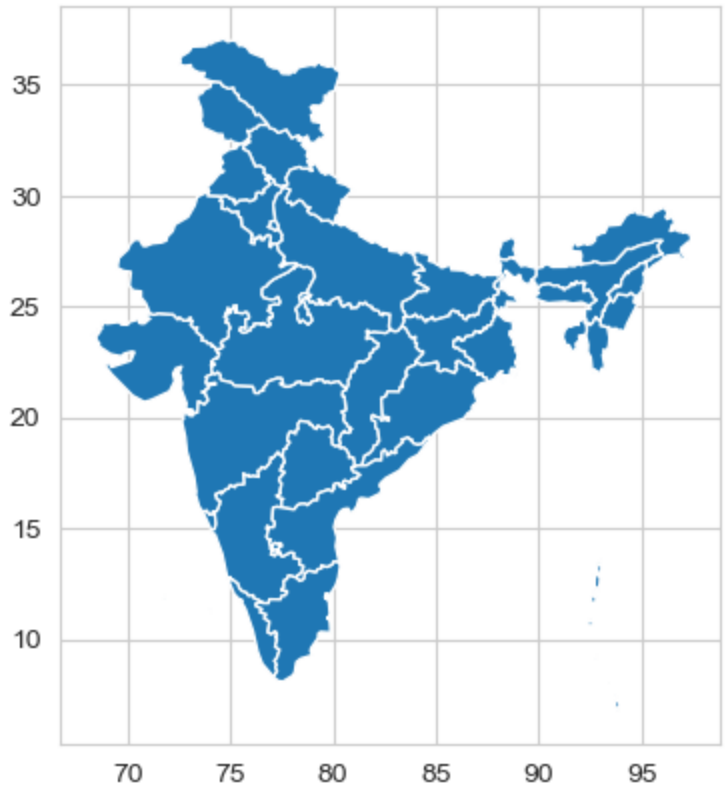
In [39]:
```
fp = r'C:/Users/PC/Desktop/Work/DVProject/Maps_with_python-master/india-polygon.shp'
map_df = gpd.read_file(fp)
map_df_copy = gpd.read_file(fp)
map_df.head()
```

Out[39]:

	id	st_nm	geometry
0	NaN	Andaman and Nicobar Islands	MULTIPOLYGON (((93.84831 7.24028, 93.92705 7.0...
1	NaN	Arunachal Pradesh	POLYGON ((95.23643 26.68105, 95.19594 27.03612...
2	NaN	Assam	POLYGON ((95.19594 27.03612, 95.08795 26.94578...
3	NaN	Bihar	POLYGON ((88.11357 26.54028, 88.28006 26.37640...
4	NaN	Chandigarh	POLYGON ((76.84208 30.76124, 76.83758 30.72552...

In [40]:
```
map_df.plot()
```

Out[40]:
```
<AxesSubplot:>
```



In [41]:
```
df = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Installed_Power_Capacity_Stat
df['year'] = df['month'].str[-4:].astype(int)
df['state'] = df['state'].replace({'Andhra Pradesh.': 'Andhra Pradesh'})
df[['Month', 'Year']] = df['month'].str.split('-', n=1, expand=True)
df_diu = df[df["state"] == "Daman & Diu"]
df_dnh = df[df["state"] == "Dadra & Nagar Haveli"]

df_diu_sum = df_diu.groupby(["month", "Year", "region"]).sum()
df_dnh_sum = df_dnh.groupby(["month", "Year", "region"]).sum()
```

```
df_combined = df_diu_sum.add(df_dnh_sum, fill_value=0)

df_combined["state"] = "Dadra and Nagar Haveli and Dam"

df_combined.reset_index(inplace=True)
df_combined.drop('year', axis=1, inplace=True)
df_combined = df_combined[['id', 'month', 'region', 'state', 'coal', 'gas', 'diesel', 't

df = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Installed_Power_Capacity_Stat
df = df.drop(df[(df['state'] == 'Dadra & Nagar Haveli') | (df['state'] == 'Daman & Diu')
df = pd.concat([df, df_combined])
df.reset_index(drop=True, inplace=True)
df.head()
```

Out[41]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_total
0	1	Jan-2019	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	32.40	32.40
1	2	Jan-2019	Northern	Delhi	135.0	2208.40	0.0	2343.40	0.0	0.00	176.21	2519.61
2	3	Jan-2019	Northern	Haryana	5540.0	431.59	0.0	5971.59	0.0	0.00	411.99	6383.58
3	4	Jan-2019	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	9809.02	864.50	10673.52
4	5	Jan-2019	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3449.00	188.88	3812.88

In [42]:

```
df_jan2022 = df[df['month'].isin(['Jan-2022'])]
df_jan2022.head()
```

Out[42]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grar
1251	1426	Jan-2022	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	53.45	
1252	1427	Jan-2022	Northern	Delhi	0.0	2208.40	0.0	2208.40	0.0	0.00	263.12	
1253	1428	Jan-2022	Northern	Haryana	5330.0	431.59	0.0	5761.59	0.0	0.00	1086.88	
1254	1429	Jan-2022	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	10065.02	1031.82	1
1255	1430	Jan-2022	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3360.00	191.55	

In [44]:

```
df_new = df_jan2022[['state','grand_total']]
df_res = df_jan2022[['state','res']]
df_res.head()
```

Out[44]:

	state	res
1251	Chandigarh	53.45
1252	Delhi	263.12
1253	Haryana	1086.88
1254	Himachal Pradesh	1031.82
1255	Jammu and Kashmir	191.55

In [24]:
```
df_6 = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/Potential.csv")
df_6 = df_6[['state','Total']]
df_6.head()
```

Out[24]:

	state	Total
0	Andaman & Nicobar	15
1	Andhra Pradesh	84079
2	Arunachal Pradesh	10723
3	Assam	14182
4	Bihar	12719

In [46]:
```
df_new["state"].replace("Chhatisgarh", "Chhattisgarh",inplace = True)
df_new["state"].replace("Dadra and Nagar Haveli and Dam", "Dadra and Nagar Haveli",inpla

df_res["state"].replace("Chhatisgarh", "Chhattisgarh",inplace = True)
df_res["state"].replace("Dadra and Nagar Haveli and Dam", "Dadra and Nagar Haveli",inpla

df_6["state"].replace("Chhatisgarh", "Chhattisgarh",inplace = True)
df_6["state"].replace("Dadra and Nagar Haveli and Dam", "Dadra and Nagar Haveli",inplace
```

```
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\634403927.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\634403927.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\634403927.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
C:\Users\PC\AppData\Local\Temp\ipykernel_9000\634403927.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_
guide/indexing.html#returning-a-view-versus-a-copy
```

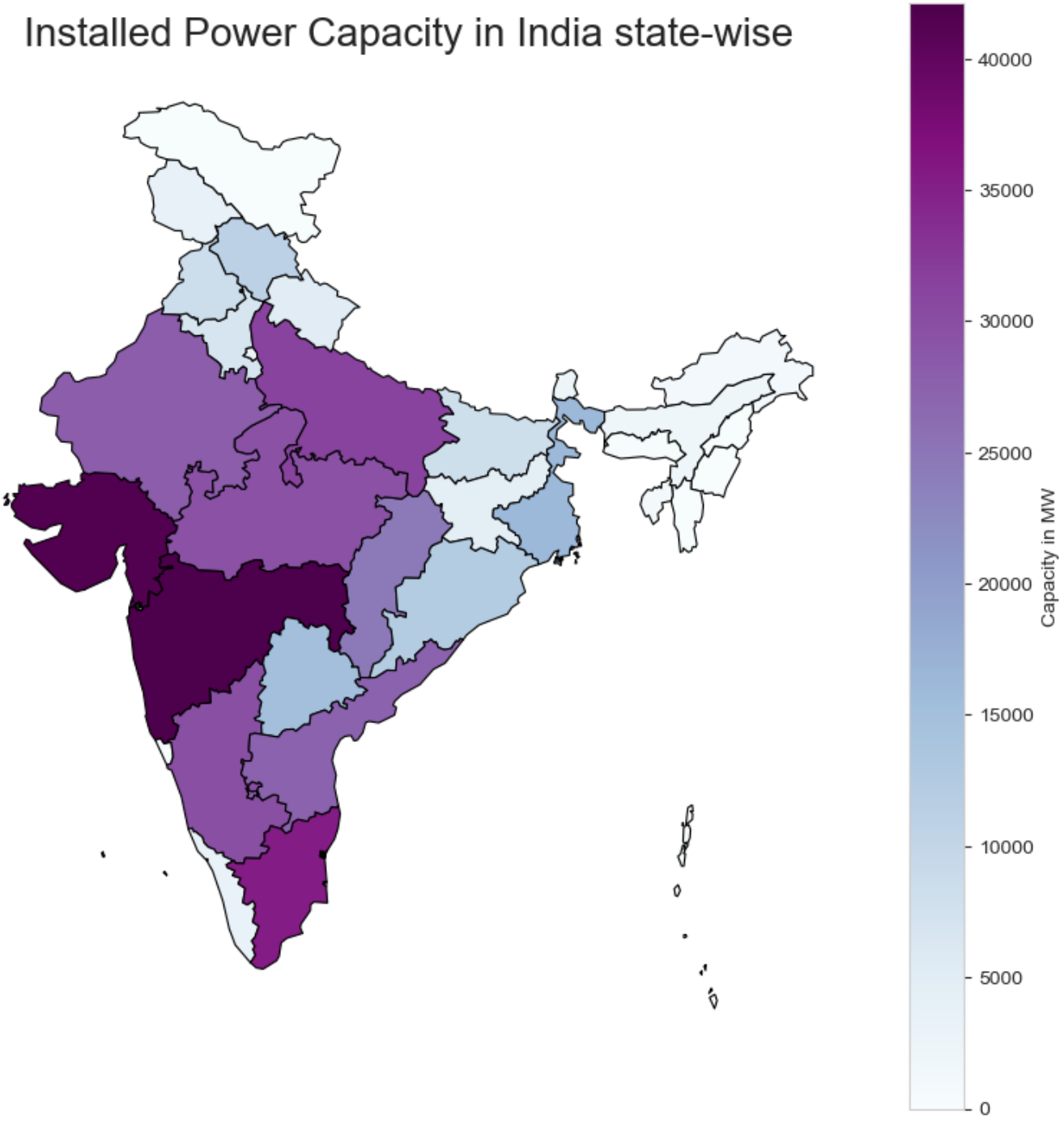
In [48]:
```
#Merging the data
merged = map_df.set_index('st_nm').join(df_new.set_index('state'))
merged['grand_total'] = merged['grand_total'].replace(np.nan, 0)

#Merging the data
merged_res = map_df.set_index('st_nm').join(df_res.set_index('state'))
merged_res['res'] = merged_res['res'].replace(np.nan, 0)

#Merging the data
merged_6= map_df.set_index('st_nm').join(df_6.set_index('state'))
merged_6['Total'] = merged_6['Total'].replace(np.nan, 0)
```

Plot VIII: Choropleth Map - India Total Installed Power Capacity

In [114…
```
fig, ax = plt.subplots(1, figsize=(10, 10))
```

```
ax.axis('off')
ax.set_title('Installed Power Capacity in India state-wise', fontdict={'fontsize': '20',
merged.plot(column='grand_total', cmap='BuPu', linewidth=0.8, ax=ax, edgecolor='0', lege
```

Out[114]: <AxesSubplot:title={'center':'Installed Power Capacity in India state-wise'}>



Plot IX: Choropleth Map - Installed Capacity State-wise

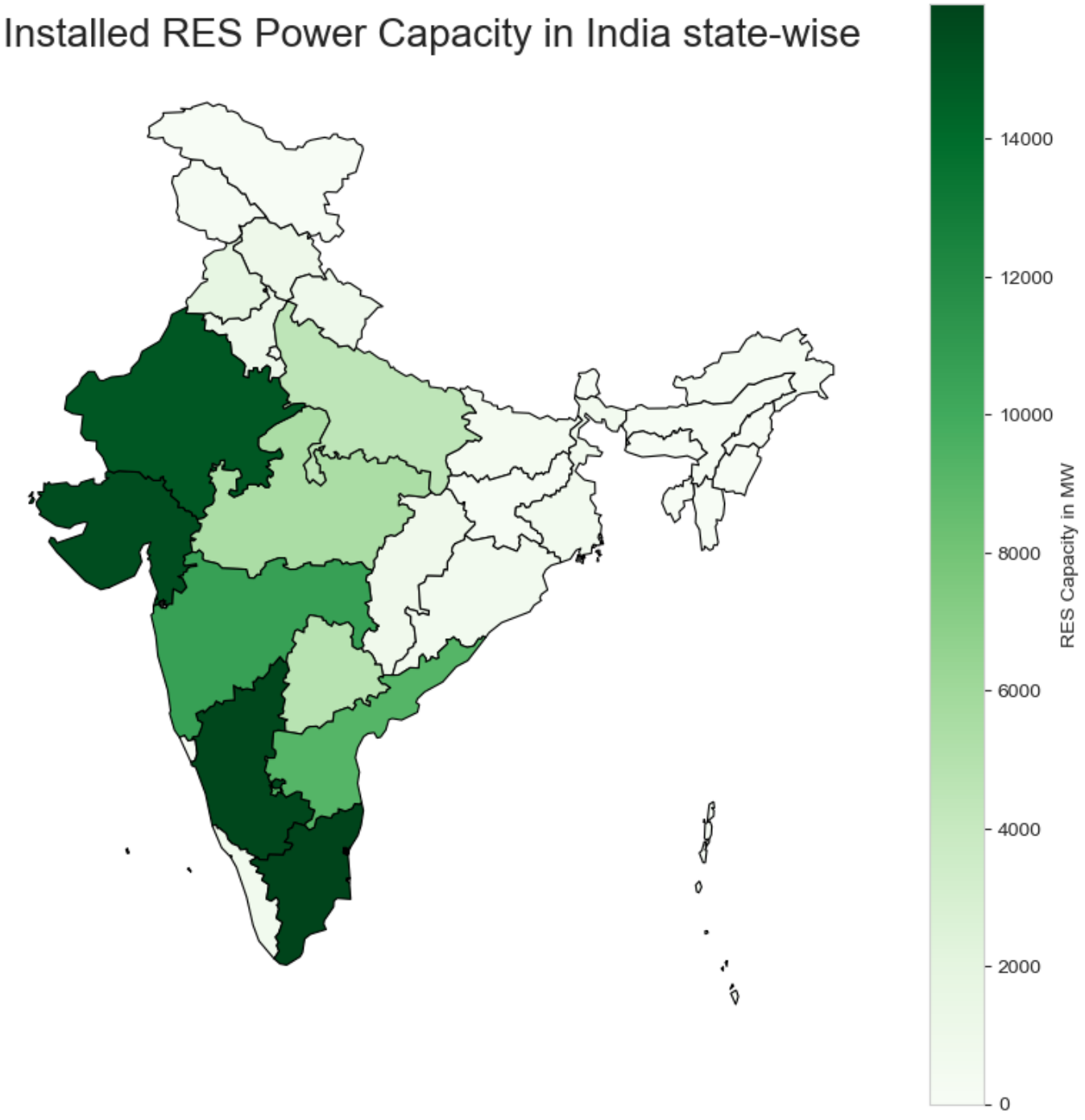
> A choropleth map is an effective way to visualize the distribution of data across geographic regions. A choropleth map showing the power installed capacity in India for the year 2022 would provide valuable insights into the regional distribution of power generation.
>
> The map would display the power installed capacity data for each state of India, with varying shades of colors indicating the level of installed capacity. The darker shades would represent higher installed capacity, while the lighter shades would represent lower installed capacity.

Some of the states that would be highlighted with the highest installed capacity include Maharashtra, Tamil Nadu, Gujarat, and Rajasthan. These states have invested significantly in renewable energy sources such as wind and solar power plants. On the other hand, states such as Bihar, Jharkhand, and Chhattisgarh would display lower installed capacity due to several factors, including a lack of resources and limited infrastructure.

Overall, the choropleth map would provide a clear visual representation of the power installed capacity across different states of India, indicating which regions are leading the way in power generation and which regions require more investment in the future.

In [49]:
```
fig, ax = plt.subplots(1, figsize=(10, 10))
ax.axis('off')
ax.set_title('Installed RES Power Capacity in India state-wise', fontdict={'fontsize': '
merged_res.plot(column='res', cmap='Greens', linewidth=0.8, ax=ax, edgecolor='0', legend
```

Out[49]:
```
<AxesSubplot:title={'center':'Installed RES Power Capacity in India state-wise'}>
```



Plot X: Line Charts - India Estimated Power Potential State-wise

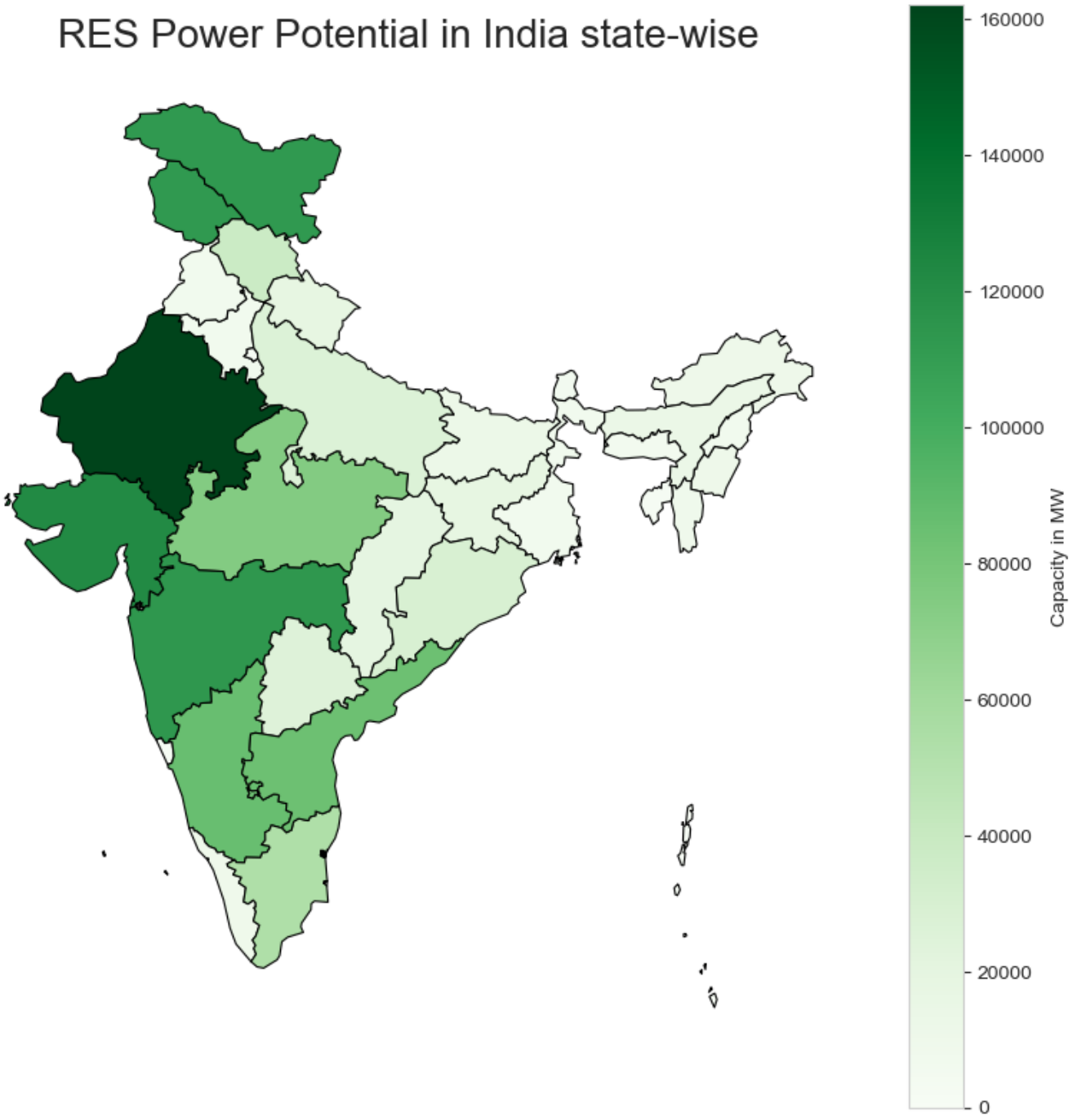
> Comparing two choropleth maps side by side can provide valuable insights into the current state of power generation in India. One map displays the potential of each state for power generation, while the other shows the current installed capacity of each state.
>
> The potential map would highlight the renewable energy resources available in each state, such as solar, wind, and hydropower potential. States such as Rajasthan, Gujarat, and Tamil Nadu would show high potential due to their abundant solar and wind resources, while states such as Jharkhand and Bihar would show lower potential due to their lack of these resources.
>
> Comparing the two maps side by side would reveal that some states with high potential have not yet fully tapped into their renewable energy resources. At the same time, some states with lower potential have made significant progress in developing their renewable energy infrastructure. This comparison could help policymakers and investors identify opportunities for further investment in renewable energy projects in the states with the highest potential and provide support for those states with lower potential that require assistance to increase their installed capacity.
>
> Overall, comparing the potential and installed capacity choropleth maps side by side can provide a comprehensive understanding of the current state of power generation in India and inform decision-making processes for future investment in renewable energy projects.

In [115…

```
fig, ax = plt.subplots(1, figsize=(10, 10))
ax.axis('off')
ax.set_title('RES Power Potential in India state-wise', fontdict={'fontsize': '20', 'fon
merged_6.plot(column='Total', cmap='Greens', linewidth=0.8, ax=ax, edgecolor='0', legend
```

Out[115]:

```
<AxesSubplot:title={'center':'RES Power Potential in India state-wise'}>
```



In [51]:
```
df_3 = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/target.csv")
```

In [52]:
```
df_3.head()
```

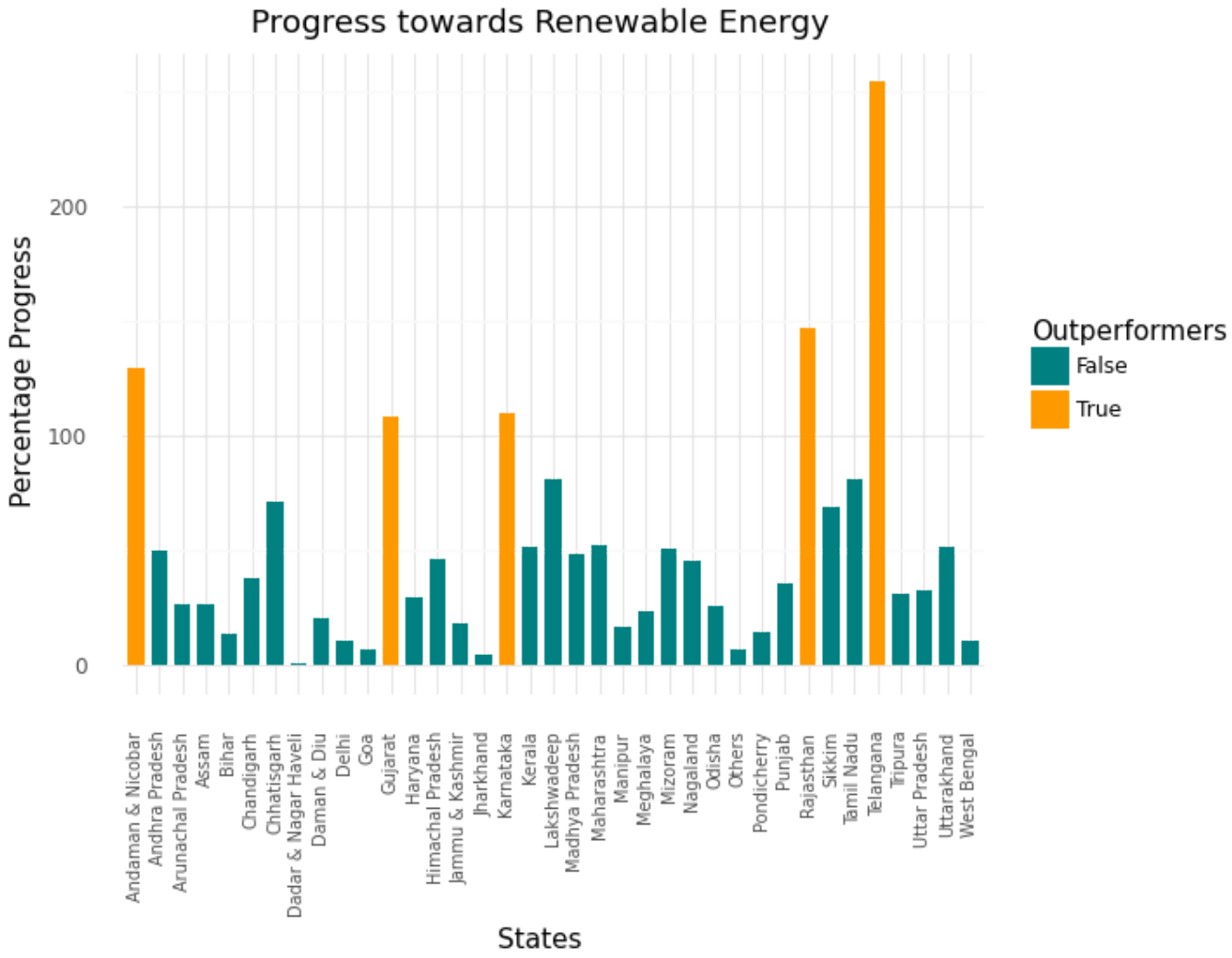
Out[52]:

	State	Installed as of December 2022	Target	% progress
0	India (total)	120848.29	174534	69.24
1	Andaman & Nicobar	35.16	27	130.22
2	Andhra Pradesh	9349.52	18477	50.60
3	Arunachal Pradesh	144.63	539	26.83
4	Assam	184.03	688	26.75

Plot XI: Bar Plot - Progress in Renewable Energy Sector

A bar plot showing the percentage target achieved by each state can provide a quick overview of how each state is performing in terms of power generation. In addition, highlighting the states that have outperformed their targets with an orange bar can help to identify the most successful states and areas that may require further investment and support.

In [53]:
```
df_2 = df_3[['State', '% progress']]
df_2 = df_2[df_2['State'] != 'India (total)']
melted_df_2 = df_2.melt(id_vars='State', var_name='Metric', value_name='Value')
melted_df_2['Highlight'] = melted_df_2['Value'] > 100
bar_plot = (ggplot(melted_df_2, aes(x='State', y='Value', fill='Highlight'))
            + geom_bar(stat='identity', position='dodge', width=0.7)
            + scale_fill_manual(values={True: custom_palette[1], False: custom_palette[0
            + labs(title='Progress towards Renewable Energy', x='States', y='Percentage
            + theme_minimal()
            + theme(legend_position='right', axis_text_x=element_text(angle=90, size=7))
           )
print(bar_plot)
```



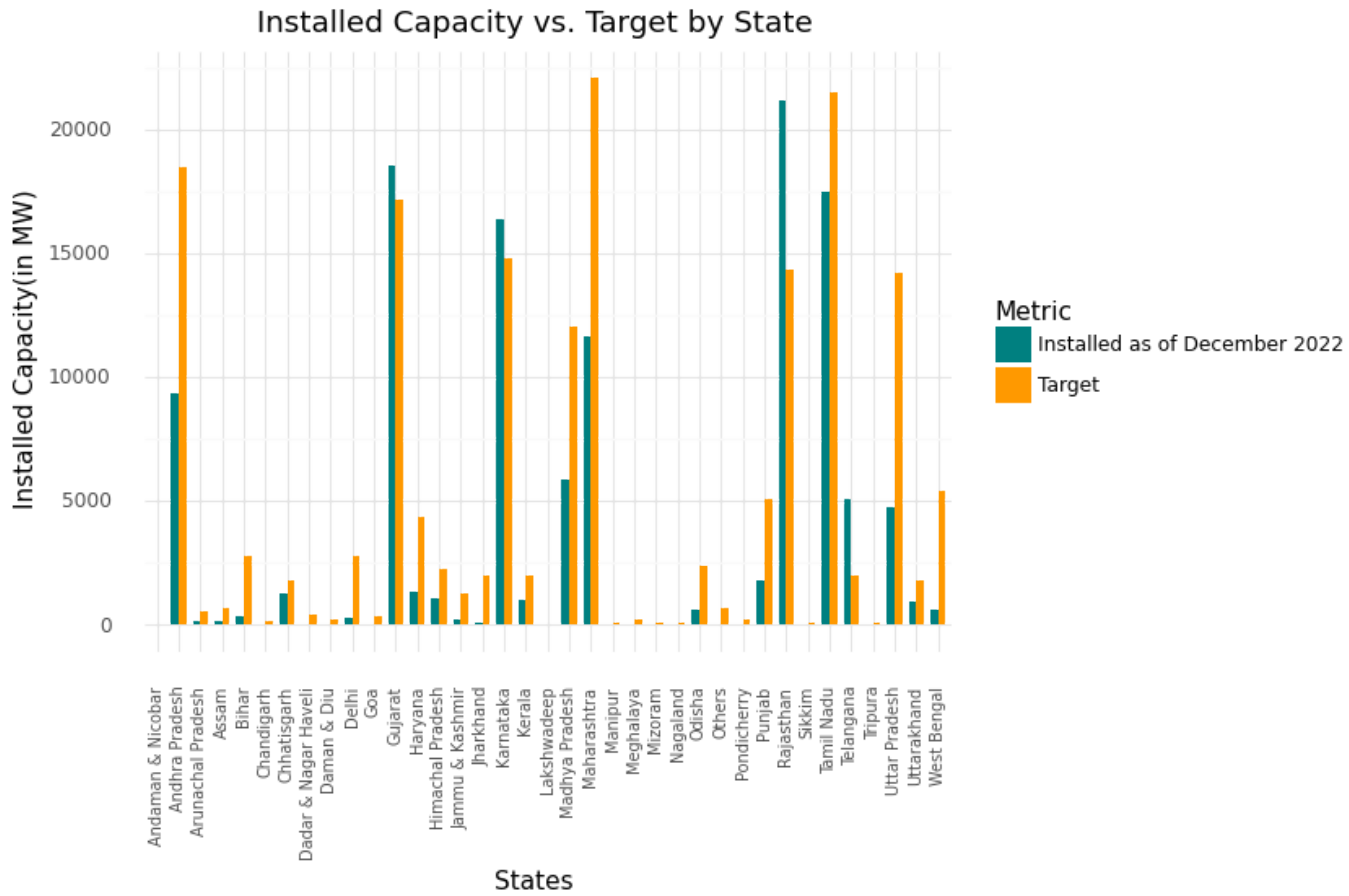
Plot XII: Bar Plot - Installed Capacity Vs State Target

A dodged bar plot is an excellent way to visualize the progress of different states in achieving their target for installed power capacity. The plot would display two bars side by side for each state, one representing the target set by the administration, and the other representing the actual installed capacity achieved by the state.

The plot would reveal the progress of each state in meeting its target and highlight the states that have exceeded their targets. States such as Tamil Nadu, Gujarat, and Maharashtra would display bars showing that they have surpassed their targets by a significant margin. On the other hand, states such as Jharkhand, Chhattisgarh, and Bihar would display bars indicating that they have fallen short of their targets.

Overall, a dodged bar plot showing the target given by the administration and the installed capacity achieved by each state would provide valuable insights into the progress of power generation in different states and help inform decision-making processes for future investment in the sector.

In [54]:
```
df_4 = df_3[['State','Installed as of December 2022','Target']]
df_4 = df_4[df_4['State'] != 'India (total)']
melted_df_4 = df_4.melt(id_vars='State', var_name='Metric', value_name='Value')


bar_plot = (ggplot(melted_df_4, aes(x='State', y='Value', fill='Metric'))
            + geom_bar(stat='identity', position='dodge', width=0.7)
            + scale_fill_manual(values=custom_palette)
            + labs(title='Installed Capacity vs. Target by State', x='States', y='Instal
            + theme_minimal()
            + theme(legend_position='right', axis_text_x=element_text(angle=90, size=7))
           )
print(bar_plot)
```



In [81]:
```
df_5 = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/GDP_data_statewise.csv")
```

In [82]:
```
df_5.head()
```

Out[82]:

Rank	state	GDP in Indian	GDP in US Dollars	NSDP in Indian	NSDP in US Dollars

			Rupees (Lakh)	(Billion)	Rupees (Lakh)	(Billion)
0	33	Andaman and Nicobar Islands	9,71,923	1.2	8,70,221	1.1
1	8	Andhra Pradesh	9,71,22,422	120.0	8,70,06,430	110.0
2	31	Arunachal Pradesh	28,04,613	3.5	25,64,801	3.2
3	18	Assam	3,35,23,811	42.0	2,99,56,920	38.0
4	14	Bihar	5,94,01,640	74.0	5,43,37,663	68.0

In [109…
```
df_6 = df_5[["state", "GDP in Indian Rupees (Lakh)"]]
df_6.head()
```

Out[109]:

	state	GDP in Indian Rupees (Lakh)
0	Andaman and Nicobar Islands	9,71,923
1	Andhra Pradesh	9,71,22,422
2	Arunachal Pradesh	28,04,613
3	Assam	3,35,23,811
4	Bihar	5,94,01,640

In [110…
```
df_jan2020 = df[df['month'].isin(['Jan-2020'])]
df_jan2020.head()
```

Out[110]:

	id	month	region	state	coal	gas	diesel	thermal_total	nuclear	hydro	res	grand_to
408	433	Jan-2020	Northern	Chandigarh	0.0	0.00	0.0	0.00	0.0	0.00	36.99	36
409	434	Jan-2020	Northern	Delhi	0.0	2208.40	0.0	2208.40	0.0	0.00	208.12	2416
410	435	Jan-2020	Northern	Haryana	5540.0	431.59	0.0	5971.59	0.0	0.00	531.30	6502
411	436	Jan-2020	Northern	Himachal Pradesh	0.0	0.00	0.0	0.00	0.0	9809.02	951.64	10760
412	437	Jan-2020	Northern	Jammu and Kashmir	0.0	175.00	0.0	175.00	0.0	3360.00	199.78	3734

In [111…
```
df_jan2020 = df_jan2020[['state','grand_total']]
df_jan2020.head()
```

Out[111]:

	state	grand_total
408	Chandigarh	36.99
409	Delhi	2416.52
410	Haryana	6502.89
411	Himachal Pradesh	10760.66
412	Jammu and Kashmir	3734.78

In [113…
```
merged_df = pd.merge(df_6, df_jan2020, on='state')
merged_df['GDP in Indian Rupees (Lakh)'] = pd.to_numeric(merged_df['GDP in Indian Rupees
```

```
merged_df = merged_df.nlargest(15, 'grand_total')
merged_df.head()
```

Out[113]:

	state	GDP in Indian Rupees (Lakh)	grand_total
15	Maharashtra	281855457	42195.54
7	Gujarat	163024012	36605.53
25	Tamil Nadu	179722872	33222.38
12	Karnataka	162892793	29222.76
28	Uttar Pradesh	168781799	28079.45

In [91]:
```
merged_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 15 entries, 15 to 8
Data columns (total 3 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   state                         15 non-null     object
 1   GDP in Indian Rupees (Lakh)   15 non-null     int64
 2   grand_total                   15 non-null     float64
dtypes: float64(1), int64(1), object(1)
memory usage: 480.0+ bytes
```

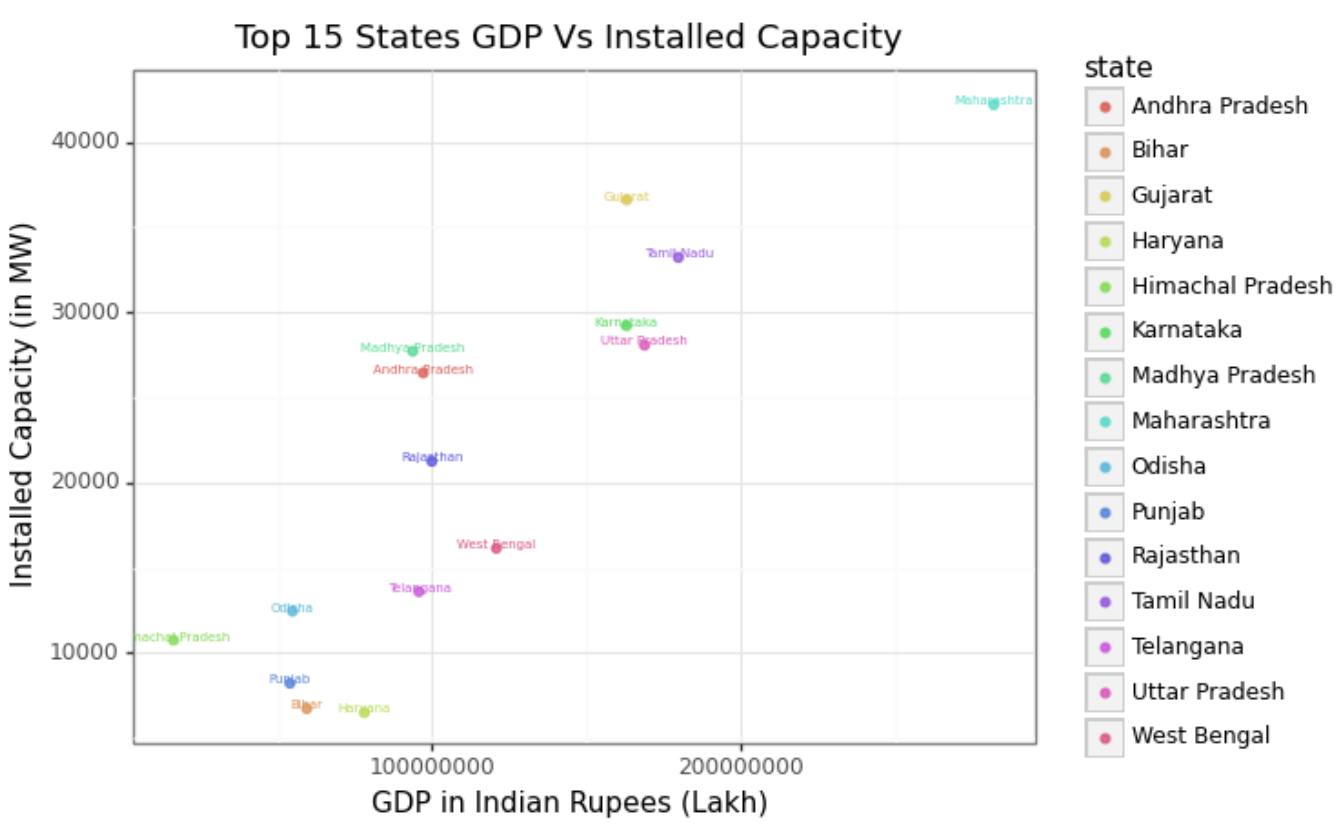
In [114…
```
merged_df['GDP in Indian Rupees (Lakh)'] = merged_df['GDP in Indian Rupees (Lakh)'].asty
merged_df['grand_total'] = merged_df['grand_total'].astype(float)
```

Plot XIII: Scatter Plot to show a positive correlation between GDP and Installed Power Capacity

> A scatter plot can be used to visualize the relationship between installed capacity and GDP of states in India. A positive correlation between the two variables suggests that as the installed capacity increases, so does the GDP.
>
> The plot would display each state as a point with the installed capacity on the y-axis and GDP on the x-axis. The size of the point would represent the population of the state, and each point would be color-coded according to the region of the country in which it is located.
>
> A positive correlation between installed capacity and GDP would be evident if the points on the scatter plot tend to cluster around a line that slopes upward from left to right. A line of best fit could be drawn to visualize this trend, making it easy to see how the two variables are related.

In [93]:
```
from plotnine import *
ggplot(merged_df, aes(x='GDP in Indian Rupees (Lakh)', y='grand_total',  color='state'))
    + geom_point(alpha=0.8) \
    + geom_text(aes(label='state'), size=5, nudge_x=20000, nudge_y=200) \
    + labs(title='Top 15 States GDP Vs Installed Capacity', x='GDP in Indian Rupees (Lak
    + scale_size(range=[1,20]) \
    + theme_bw()
```

```
C:\Users\PC\anaconda3\lib\site-packages\plotnine\guides\guides.py:187: PlotnineWarning:
Cannot generate legend for the 'size' aesthetic. Make sure you have mapped a variable to
it
```



Out[93]: <ggplot: (124160913186)>

In [16]:
```
df_ind = pd.read_csv("C:/Users/PC/Desktop/Work/DVProject/Power/RES_individual.csv")
```

Plot XIV: Interactive Line Charts Using Plotly - Solar, Wind, Bio-energy and Small Hydo growth over Top 3 Renewable Energy Leader States

> A line chart can be used to visualize the growth of solar and wind energy capacity in Gujarat, Rajasthan, and Tamil Nadu over the past two years. The line chart would display each state as a separate line with the solar and wind energy capacity on the y-axis and time on the x-axis.
>
> The line chart would show the growth in solar and wind energy capacity in each state over the past two years. The line for each state would be color-coded to make it easy to distinguish between them. The chart would also include a legend to identify the different lines.

In [17]:
```
df_7 = df_ind[df_ind['State'] == 'Gujarat']
df_7.head()
```

Out[17]:

	State	Date	Solar	Wind	Small hydro	Bioenergy
57	Gujarat	2019-03	2440.13	6073.07	61.30	77.3
94	Gujarat	2019-04	2493.85	6102.67	61.30	77.3
131	Gujarat	2019-05	2564.14	6290.47	61.30	77.3
168	Gujarat	2019-06	2622.21	6563.07	62.35	77.3
205	Gujarat	2019-07	2647.72	6860.77	62.35	77.3

In [18]:
```
import plotly.graph_objs as go
import pandas as pd
```

In [19]:
```
# Create a trace for each energy source
solar_trace = go.Scatter(x=df_7['Date'], y=df_7['Solar'], name='Solar', line=dict(color=
wind_trace = go.Scatter(x=df_7['Date'], y=df_7['Wind'], name='Wind', line=dict(color='bl
hydro_trace = go.Scatter(x=df_7['Date'], y=df_7['Small hydro'], name='Small Hydro', line
bio_trace = go.Scatter(x=df_7['Date'], y=df_7['Bioenergy'], name='Bioenergy', line=dict(

# Create a list of traces
traces = [solar_trace, wind_trace, hydro_trace, bio_trace]


# Define the layout for the plot
layout =  go.Layout(title=dict(text='Gujarat Renewable Energy Capacity in India', x=0.5)
                    xaxis=dict(title='Month-Year'),
                    yaxis=dict(title='RES Installed Capacity (in MW)'))

# Create the figure and plot the traces
fig = go.Figure(data=traces, layout=layout)
fig.show()
```

In [20]:
```
df_8 = df_ind[df_ind['State'] == 'Rajasthan']
# Create a trace for each energy source
solar_trace = go.Scatter(x=df_7['Date'], y=df_8['Solar'], name='Solar', line=dict(color=
wind_trace = go.Scatter(x=df_7['Date'], y=df_8['Wind'], name='Wind', line=dict(color='bl
hydro_trace = go.Scatter(x=df_7['Date'], y=df_8['Small hydro'], name='Small Hydro', line
bio_trace = go.Scatter(x=df_7['Date'], y=df_8['Bioenergy'], name='Bioenergy', line=dict(

# Create a list of traces
traces = [solar_trace, wind_trace, hydro_trace, bio_trace]

# Define the layout for the plot
```

```
layout =  go.Layout(title=dict(text='Rajasthan Renewable Energy Capacity in India', x=0.
                   xaxis=dict(title='Month-Year'),
                   yaxis=dict(title='RES Installed Capacity (in MW)'))

# Create the figure and plot the traces
fig = go.Figure(data=traces, layout=layout)
fig.show()
```

In [21]:

```
df_9 = df_ind[df_ind['State'] == 'Tamil Nadu']
# Create a trace for each energy source
solar_trace = go.Scatter(x=df_7['Date'], y=df_9['Solar'], name='Solar', line=dict(color=
wind_trace = go.Scatter(x=df_7['Date'], y=df_9['Wind'], name='Wind', line=dict(color='bl
hydro_trace = go.Scatter(x=df_7['Date'], y=df_9['Small hydro'], name='Small Hydro', line
bio_trace = go.Scatter(x=df_7['Date'], y=df_9['Bioenergy'], name='Bioenergy', line=dict(

# Create a list of traces
traces = [solar_trace, wind_trace, hydro_trace, bio_trace]

# Define the layout for the plot
layout =  go.Layout(title=dict(text='Tamil Nadu Renewable Energy Capacity in India', x=0
                   xaxis=dict(title='Month-Year'),
                   yaxis=dict(title='RES Installed Capacity (in MW)'))

# Create the figure and plot the traces
fig = go.Figure(data=traces, layout=layout)
fig.show()
```

In [ ]: