4. **Cross-tabulation**: To examine the relationship between categorical variables such as home ownership status and energy consumption profiles.
5. **ANOVA (Analysis of Variance)**: To assess significant differences in perceptions and behaviors between Generation Z and Millennials.
6. **Box-Cox Transformation**: Applied to normalize the data where necessary.

Ethical Considerations

The study was conducted in accordance with ethical guidelines for research involving human participants. Informed consent was obtained from all respondents, and data confidentiality was maintained throughout the study. Participants were assured that their responses would be anonymized and used solely for research purposes.

Limitations

The study acknowledges potential limitations, including self-report bias and the representativeness of the sample. Future research could expand the sample size and include additional demographic variables to enhance the generalizability of the findings.

In summary, this methodology outlines a rigorous approach to investigating generational differences in energy consumption and technology adoption, providing valuable insights to inform targeted strategies for promoting energy efficiency and sustainability.

Results and Discussions

Initial data preprocessing is done in the codded excel sheet and tabulation is completed. Further SPSS 2026 is used for baseline analysis and cross tabulation of data. All the tables shown in this report are generated with SPSS software.

In [1]:

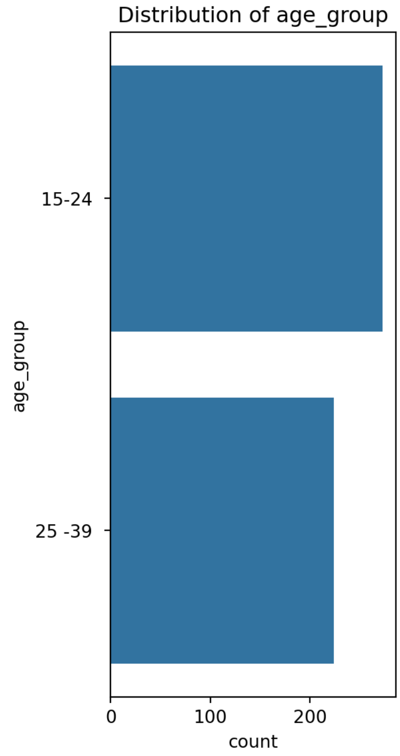
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Load the data
df = pd.read_csv("DatasetSM.csv")  # Replace 'DatasetSM.csv' with your actual file path

# Print the column names to check for any discrepancies
print(df.columns)

# Replace column names to match them to your request:
df.columns = ["Age Group", "Class", "Gender", "Mother tongue", "State", "Education", "Occupation",
             "Household income", "Average monthly Electricity Bill", "Payment mode", "Ownership",
             "Home size", "House type", "Consumption Profile", "Perception on Individual Usage",
             "Perception on Sharing Consumption information", "Perception on load control incentivised",
             "Perception on load control Self", "Perception on smart grid", "Perception on smart home appliances",
             "Perception on Solar PV and EV", "Perception on Vehicle to Grid", "Adoption of Roof top PV",
             "Percpective on RPV EV combination"]

# Data Cleaning
# Replace any spaces in column names with _ and make them all lowercase
df.columns = df.columns.str.replace(' ', '_').str.lower()

# Some specific changes based on unique values in your dataset:
df['household_income'] = df['household_income'].str.replace('0- 16000 (BPL- Urban)','< 1 Lakhs',regex=True)
df['household_income'] = df['household_income'].str.replace('< 1 Lakhs','<1 Lakhs',regex=True)
df['household_income'] = df['household_income'].str.replace('2.5 lakhs - 5  lakhs','2.5-5 Lakhs',regex=True)
df['household_income'] = df['household_income'].str.replace('7.5 - 10 Lakhs','7.5-10 Lakhs',regex=True)
df['household_income'] = df['household_income'].str.replace('Above 10 lakhs','>10 Lakhs',regex=True)
df['occupation'] = df['occupation'].str.replace('Student;Higher Education','Student and Higher Education',regex=True)
df['occupation'] = df['occupation'].str.replace('Student;Self Employed and Business','Student, Self Employed and Business',regex=True)
df['occupation'] = df['occupation'].str.replace('Employed (Govt. Sector and private)','Employed (Govt. Sector)',regex=True)
df['payment_mode'] = df['payment_mode'].str.replace('By Visiting Utility office -  Seeks others help','By Visiting Utility
         office',regex=True)
df['house_type'] = df['house_type'].str.replace('Some what Liberal','Somewhat Liberal',regex=True)


# Handle non-numeric values in numeric columns (eg. 'NR')
numeric_cols = ['average_monthly_electricity_bill', 'perception_on_individual_usage',
                  'perception_on_sharing_consumption_information',
                  'perception_on_load_control_incentivised', 'perception_on_load_control_self',
                   'perception_on_smart_grid', 'perception_on_smart_home_appliances',
                   'perception_on_solar_pv_and_ev', 'perception_on_vehicle_to_grid',
                   'adoption_of_roof_top_pv', 'percpective_on_rpv_ev_combination']

for col in numeric_cols:
    df[col] = pd.to_numeric(df[col], errors='coerce') # Replace 'errors='coerce'' with errors='raise' to identify if there are any
         errors while numeric conversion.
df.dropna(subset=numeric_cols, inplace=True) #Dropping all rows with null values for the numeric variables
```

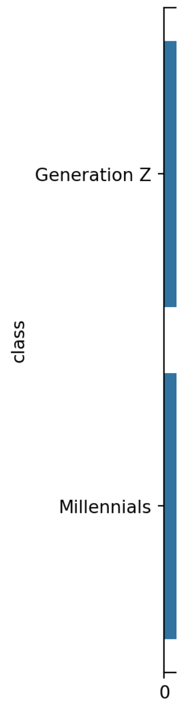
```
Index(['Age Group', 'Class', 'Gender', 'Mother tongue ', 'State', 'Education',
       'Occupation', 'Household income', 'Average monthly Electricity Bill',
       'Payment mode', 'Ownership', 'Home size', 'House type',
       'Consumption Profile', 'Perception on Individual Usage',
       'Perception on Sharing Consumption information',
       'Perception on load control incentivised',
```

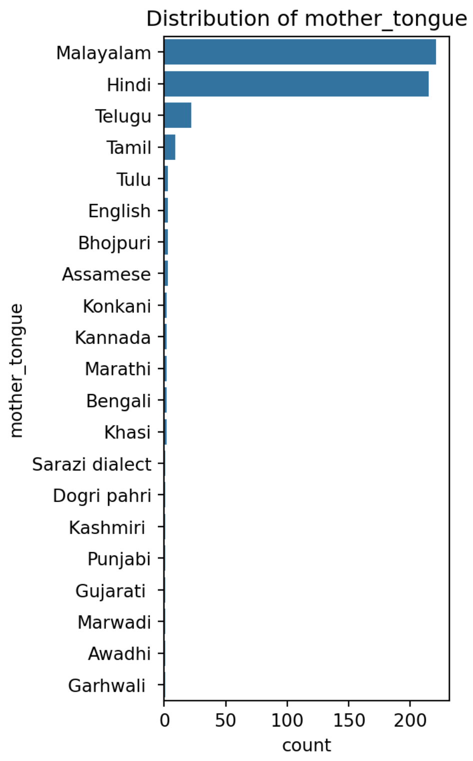
```
       'Perception on load control Self', 'Perception on smart grid',
       'Perception on smart home appliances', 'Perception on Solar PV and EV',
       'Perception on Vehicle to Grid', 'Adoption of Roof top PV',
       'Percpective on RPV EV combination'],
      dtype='object')
```

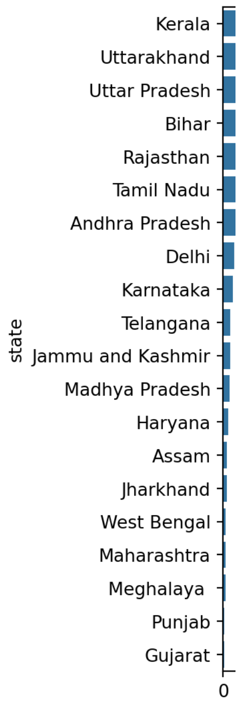
In [2]:

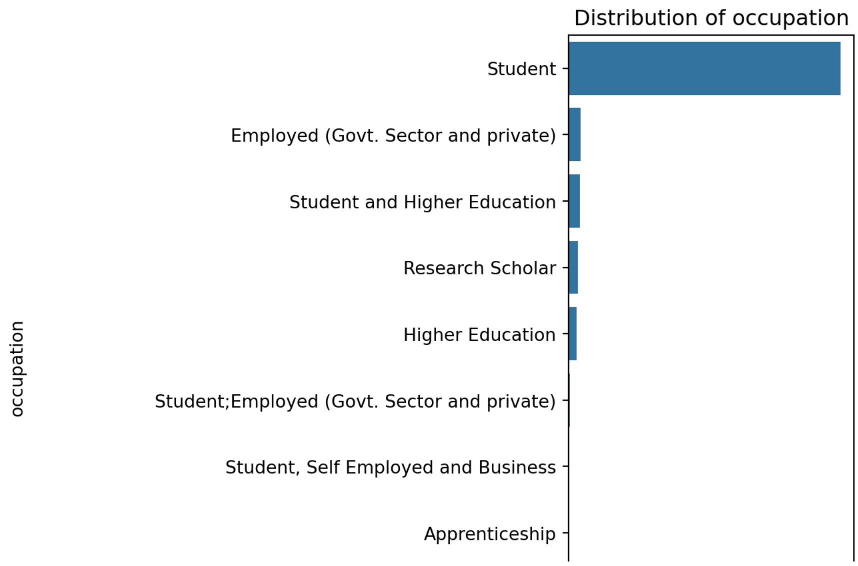
```
# --- Exploratory Data Analysis (EDA) ---

# 1. Distribution of Categorical Variables
def plot_categorical_distributions(df, cols, rows=3, cols_per_row=3):
    fig, axes = plt.subplots(rows, cols_per_row, figsize=(18, 6*rows))
    axes = axes.flatten()  # Convert axes into a flat list
    for i, col in enumerate(cols):
        sns.countplot(y=df[col], ax=axes[i], order=df[col].value_counts().index)
        axes[i].set_title(f"Distribution of {col}")
        axes[i].set_ylabel(col)  # Set y-axis label for better readability

    for j in range(i + 1, len(axes)): #Turn off unused axes
        axes[j].axis('off')

    plt.tight_layout()
    plt.show()

categorical_cols = ['age_group', 'class', 'gender', 'mother_tongue', 'state', 'education', 'occupation', 'household_income', 'payment_mo
plot_categorical_distributions(df, categorical_cols, rows=5, cols_per_row=3)
```

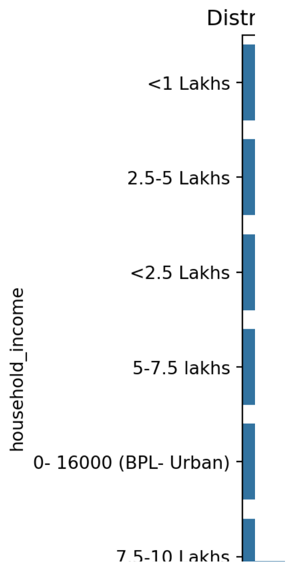

Distribution of age_group
15-24
25 -39
age_group
0
100
200
count

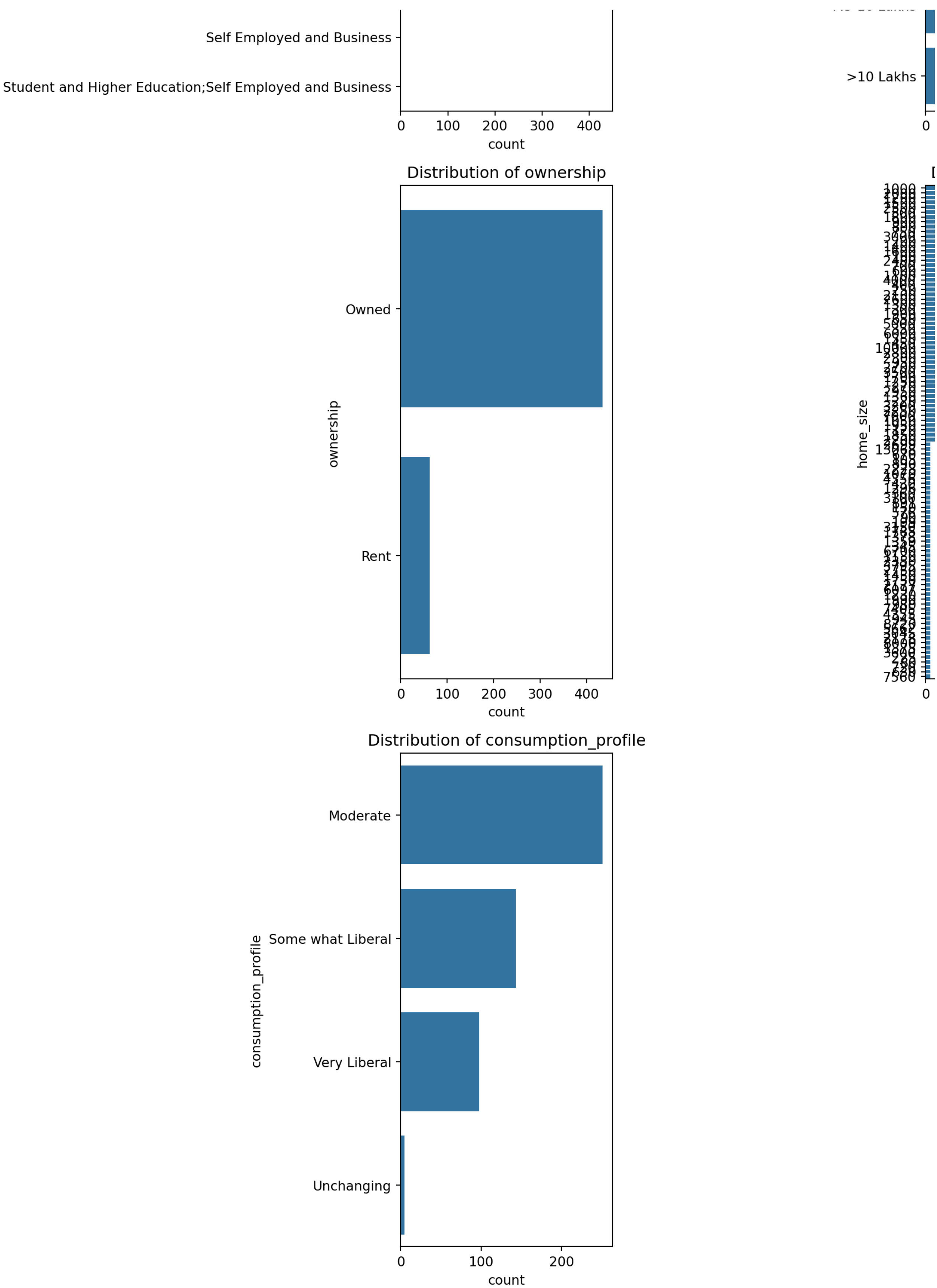

Generation Z
Millennials
class
0


Distribution of mother_tongue
Malayalam
Hindi
Telugu
Tamil
Tulu
English
Bhojpuri
Assamese
Konkani
Kannada
Marathi
Bengali
Khasi
Sarazi dialect
Dogri pahri
Kashmiri
Punjabi
Gujarati
Marwadi
Awadhi
Garhwali
mother_tongue
0
50
100
150
200
count


Kerala
Uttarakhand
Uttar Pradesh
Bihar
Rajasthan
Tamil Nadu
Andhra Pradesh
Delhi
Karnataka
Telangana
Jammu and Kashmir
Madhya Pradesh
Haryana
Assam
Jharkhand
West Bengal
Maharashtra
Meghalaya
Punjab
Gujarat
state
0


Distribution of occupation
Student
Employed (Govt. Sector and private)
Student and Higher Education
Research Scholar
Higher Education
Student;Employed (Govt. Sector and private)
Student, Self Employed and Business
Apprenticeship
occupation

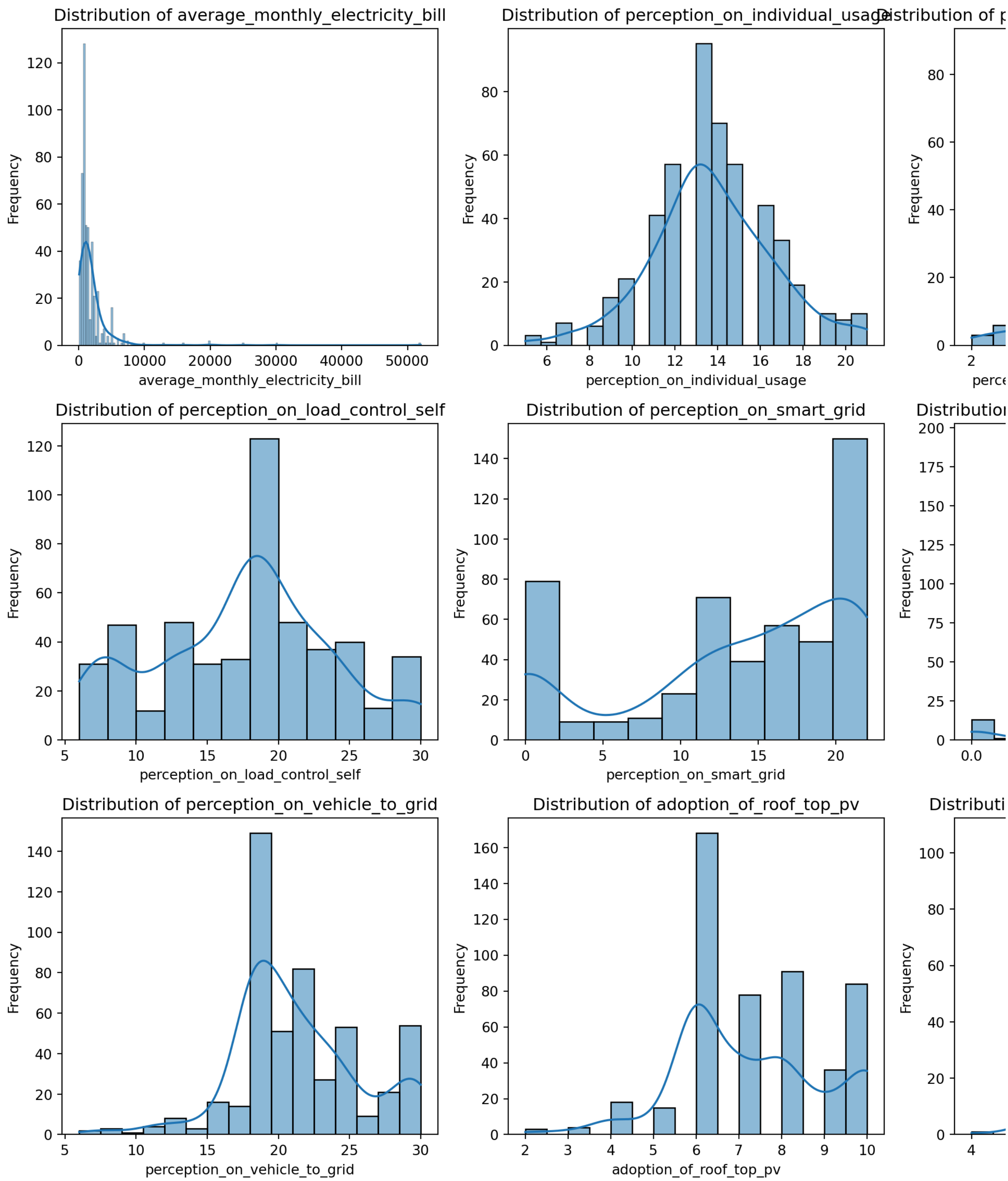

Distr
<1 Lakhs
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
0- 16000 (BPL- Urban)
household_income



In [3]:

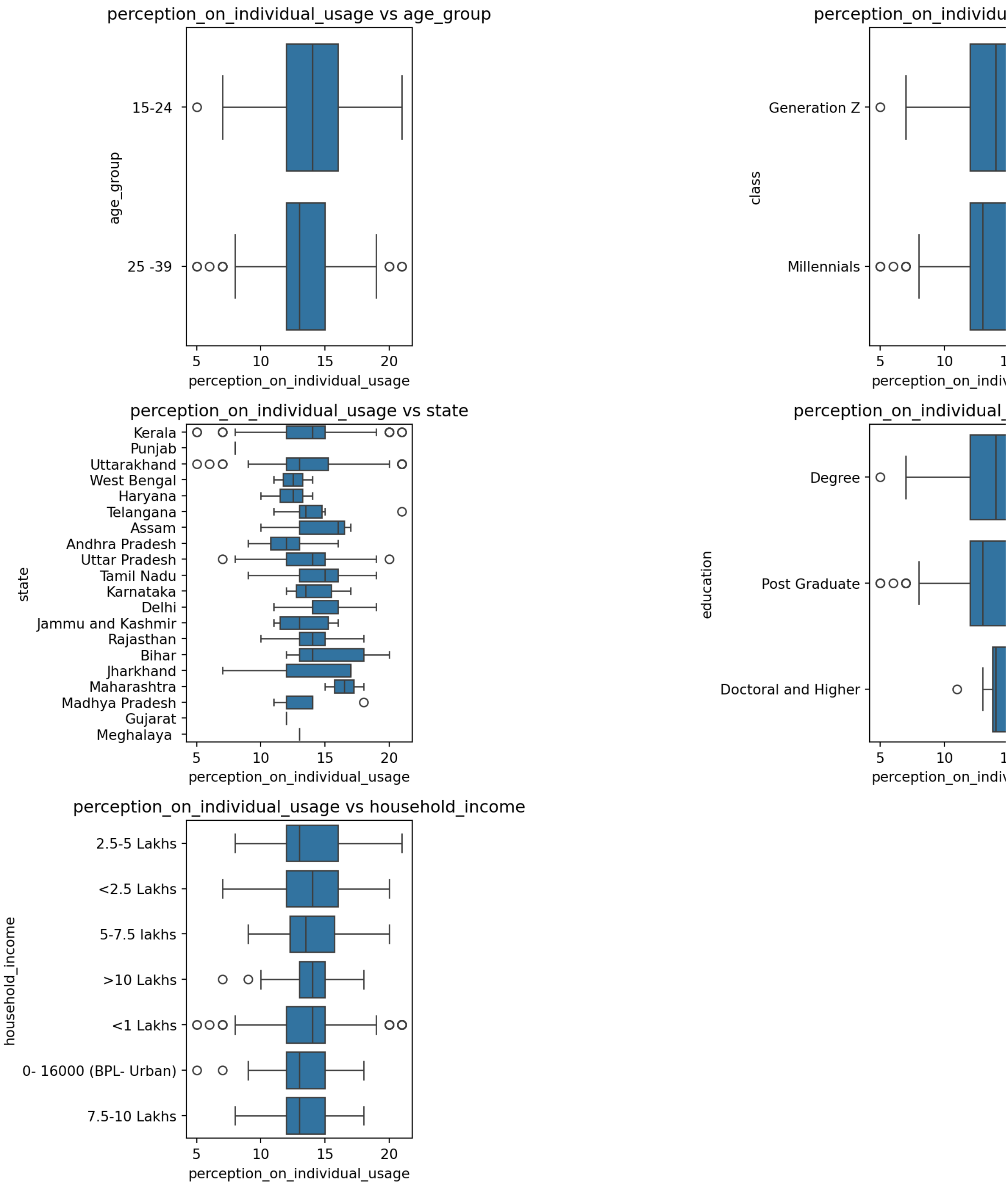
```python
# 2. Distribution of Numerical Variables
def plot_numerical_distributions(df, cols, rows=2, cols_per_row=3):
    fig, axes = plt.subplots(rows, cols_per_row, figsize=(18, 4*rows))
    axes = axes.flatten()  # Convert axes into a flat list
    for i, col in enumerate(cols):
        sns.histplot(df[col], ax=axes[i], kde=True)
        axes[i].set_title(f"Distribution of {col}")
        axes[i].set_ylabel("Frequency")

    for j in range(i + 1, len(axes)): #Turn off unused axes
        axes[j].axis('off')
```

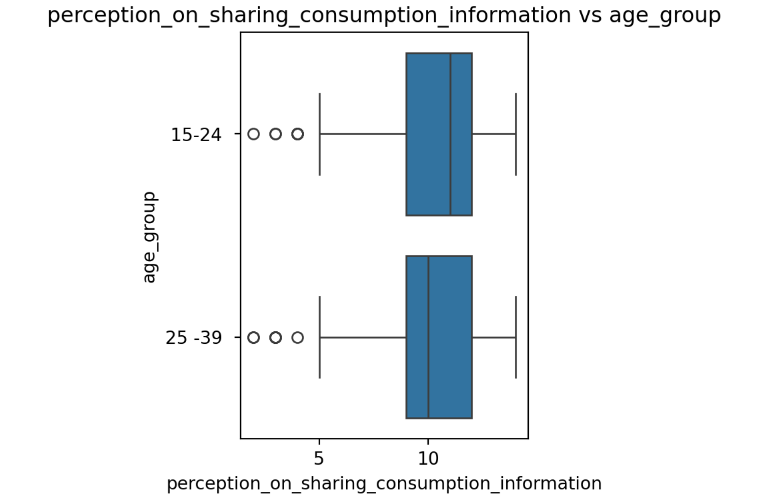
```python
    plt.tight_layout()
    plt.show()

numerical_perception_cols = ['average_monthly_electricity_bill', 'perception_on_individual_usage',
                  'perception_on_sharing_consumption_information',
                  'perception_on_load_control_incentivised', 'perception_on_load_control_self',
                   'perception_on_smart_grid', 'perception_on_smart_home_appliances',
                   'perception_on_solar_pv_and_ev', 'perception_on_vehicle_to_grid',
                   'adoption_of_roof_top_pv', 'percpective_on_rpv_ev_combination']
plot_numerical_distributions(df, numerical_perception_cols,rows=3, cols_per_row=4)
```

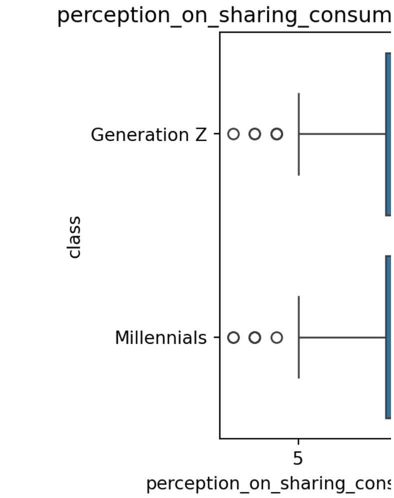


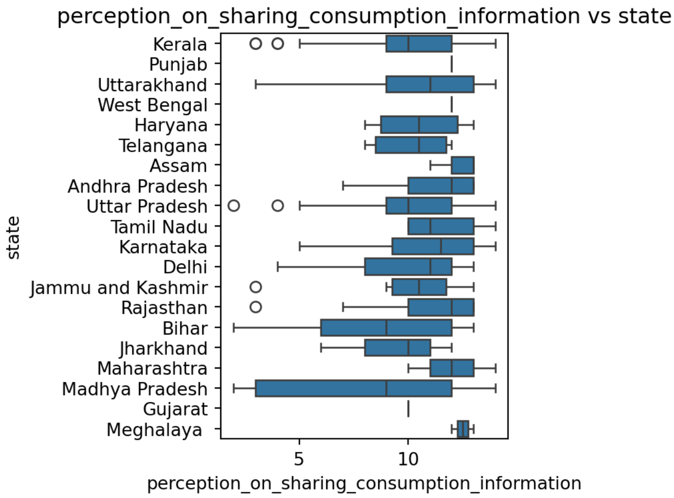
In [4]:
```python
# 3. Relationship between Numerical and Categorical Variables (using Boxplot)
def plot_boxplots(df, cat_cols, num_cols, rows=3, cols_per_row=3):
  for num_col in num_cols:
    fig, axes = plt.subplots(rows, cols_per_row, figsize=(18, 4*rows))
    axes = axes.flatten()
    for i, cat_col in enumerate(cat_cols):
          sns.boxplot(y=df[cat_col], x=df[num_col], ax=axes[i])
```

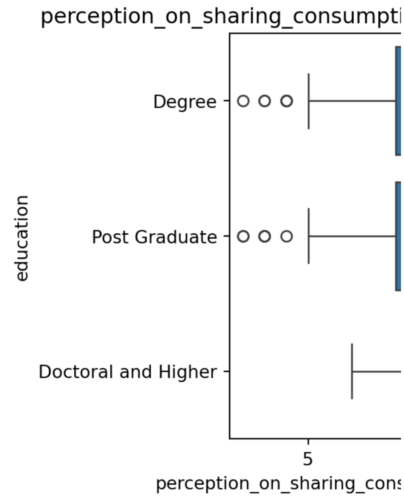
```
        axes[i].set_title(f"{num_col} vs {cat_col}")
        axes[i].set_xlabel(num_col)
        axes[i].set_ylabel(cat_col)

    for j in range(i + 1, len(axes)): #Turn off unused axes
        axes[j].axis('off')

    plt.tight_layout()
    plt.show()

cat_cols = ['age_group', 'class','gender', 'state', 'education', 'occupation', 'household_income'] #Can be extended
num_cols_box = ['perception_on_individual_usage',
                'perception_on_sharing_consumption_information',
                'perception_on_load_control_incentivised', 'perception_on_load_control_self',
                 'perception_on_smart_grid', 'perception_on_smart_home_appliances',
                 'perception_on_solar_pv_and_ev', 'perception_on_vehicle_to_grid',
                 'adoption_of_roof_top_pv', 'percpective_on_rpv_ev_combination'] #Can be extended.

plot_boxplots(df, cat_cols, num_cols_box, rows=3, cols_per_row=3)
```

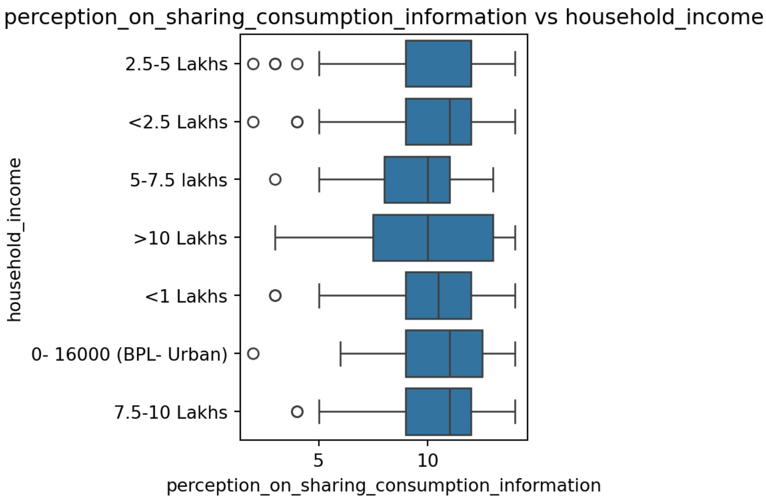


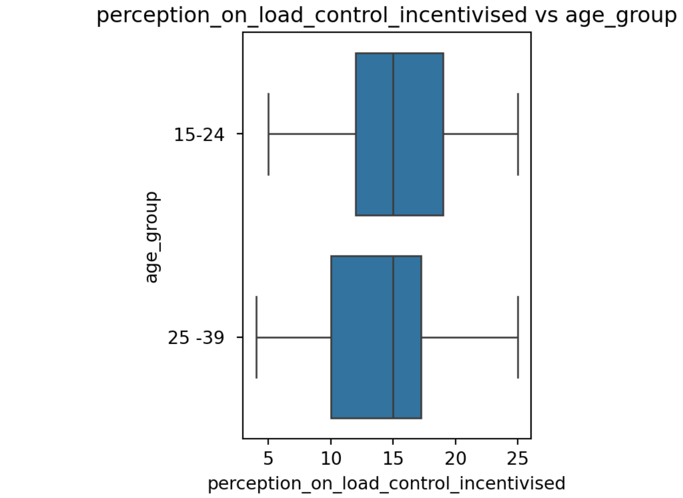

perception_on_sharing_consumption_information vs age_group
age_group
15-24
25 -39
5
10
perception_on_sharing_consumption_information

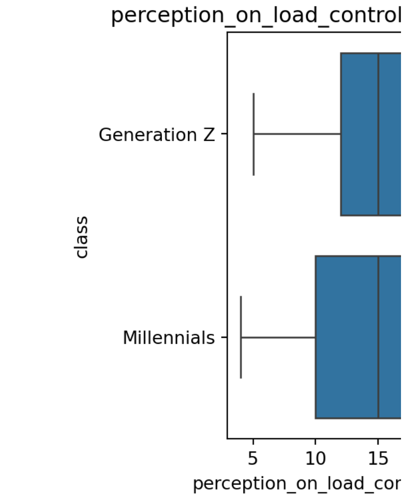

perception_on_sharing_consum
class
Generation Z
Millennials
5
perception_on_sharing_cons

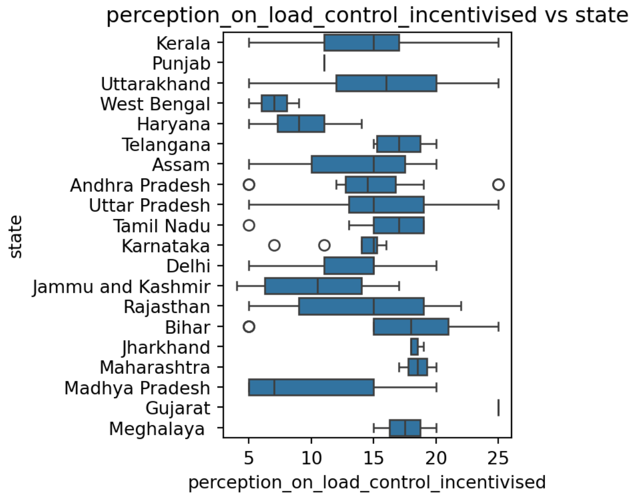

perception_on_sharing_consumption_information vs state
state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
5
10
perception_on_sharing_consumption_information

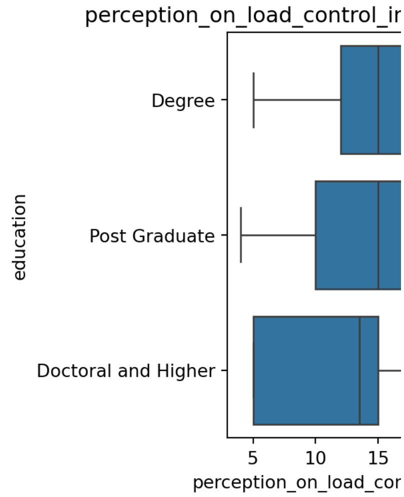

perception_on_sharing_consumpti
education
Degree
Post Graduate
Doctoral and Higher
5
perception_on_sharing_cons

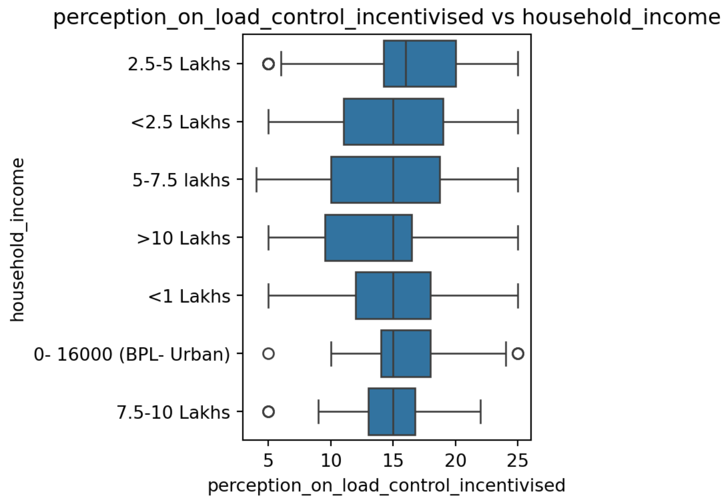

perception_on_sharing_consumption_information vs household_income
household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
5
10
perception_on_sharing_consumption_information

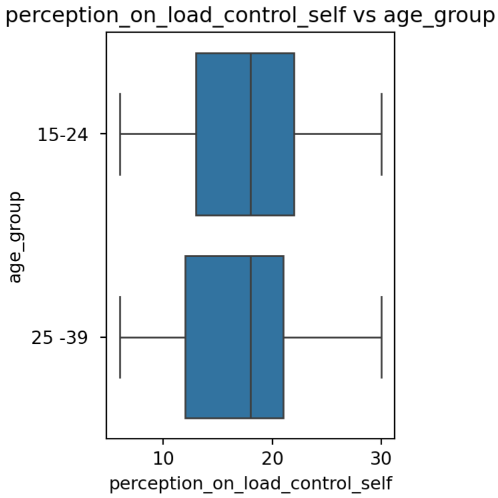

perception_on_load_control_incentivised vs age_group
15-24
25 -39
age_group
5
10
15
20
25
perception_on_load_control_incentivised

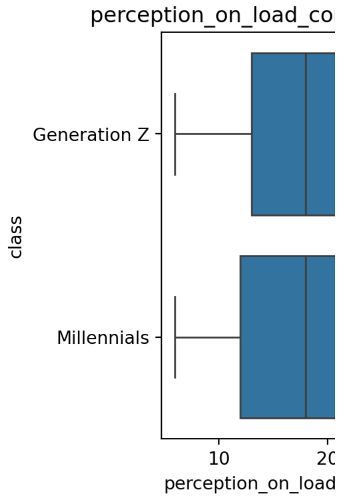

perception_on_load_control
Generation Z
Millennials
class
5
10
15
perception_on_load_cor

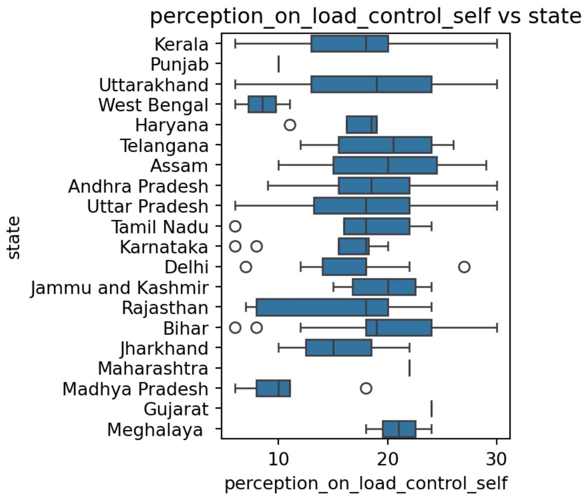

perception_on_load_control_incentivised vs state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
state
5
10
15
20
25
perception_on_load_control_incentivised

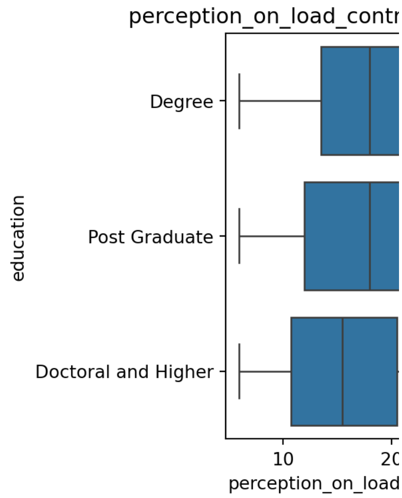

perception_on_load_control_ir
Degree
Post Graduate
Doctoral and Higher
education
5
10
15
perception_on_load_cor


perception_on_load_control_incentivised vs household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
household_income
5
10
15
20
25
perception_on_load_control_incentivised

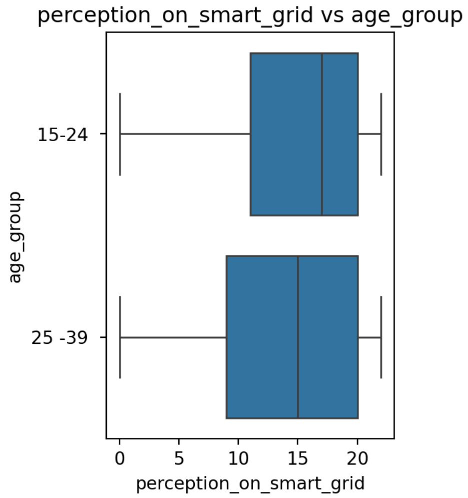

perception_on_load_control_self vs age_group
15-24
25 -39
age_group
10
20
30
perception_on_load_control_self

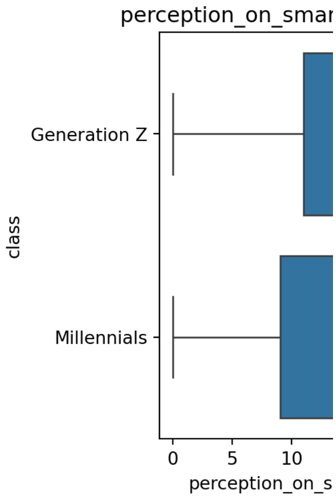

perception_on_load_co
Generation Z
Millennials
class
10
20
perception_on_load

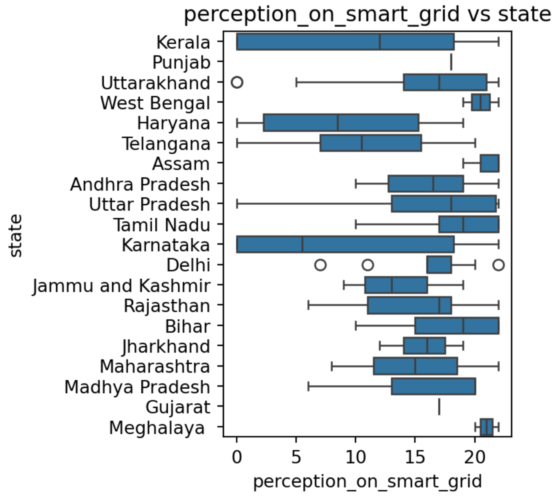

perception_on_load_control_self vs state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
state
10
20
30
perception_on_load_control_self

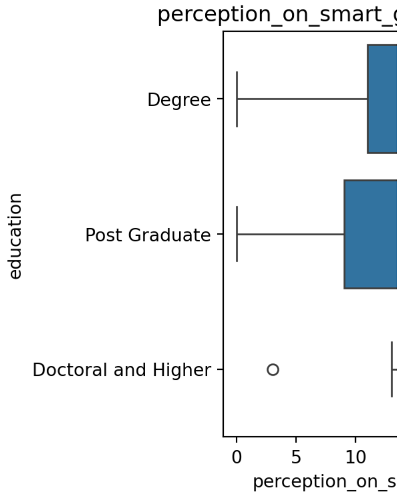

perception_on_load_contr
Degree
Post Graduate
Doctoral and Higher
education
10
20
perception_on_load

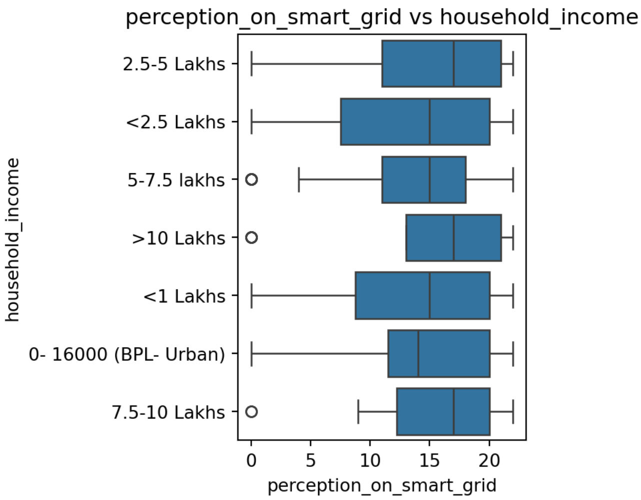

perception_on_load_control_self vs household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
household_income
10
20
30
perception_on_load_control_self

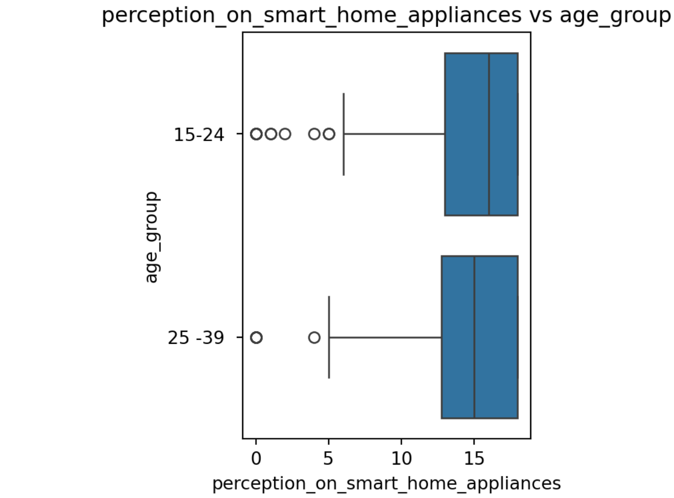

perception_on_smart_grid vs age_group
15-24
25 -39
age_group
0 5 10 15 20
perception_on_smart_grid

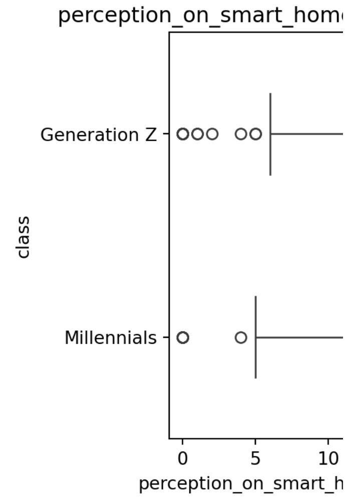

perception_on_smar
Generation Z
Millennials
class
0 5 10
perception_on_s

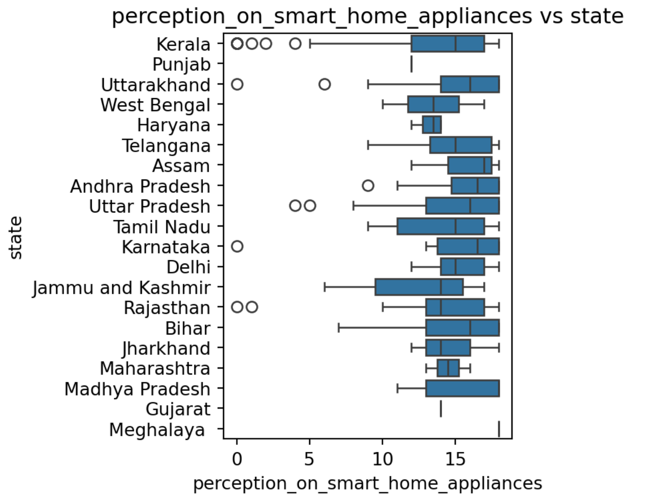

perception_on_smart_grid vs state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
state
0 5 10 15 20
perception_on_smart_grid

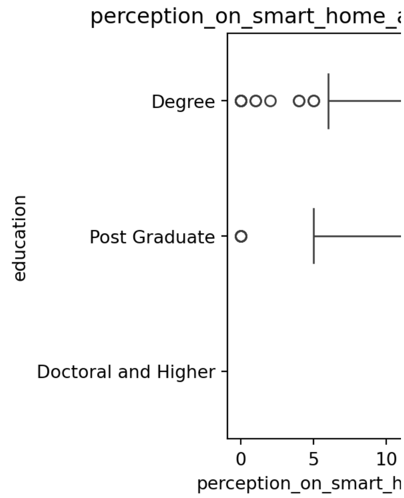

perception_on_smart_(
Degree
Post Graduate
Doctoral and Higher
education
0 5 10
perception_on_s

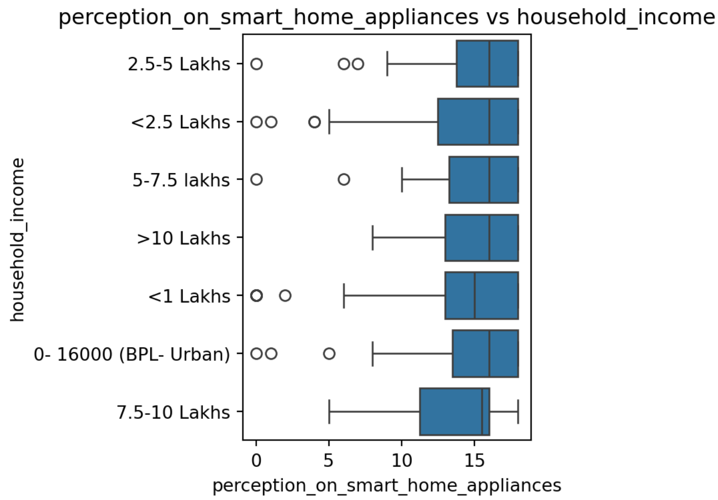

perception_on_smart_grid vs household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
household_income
0 5 10 15 20
perception_on_smart_grid

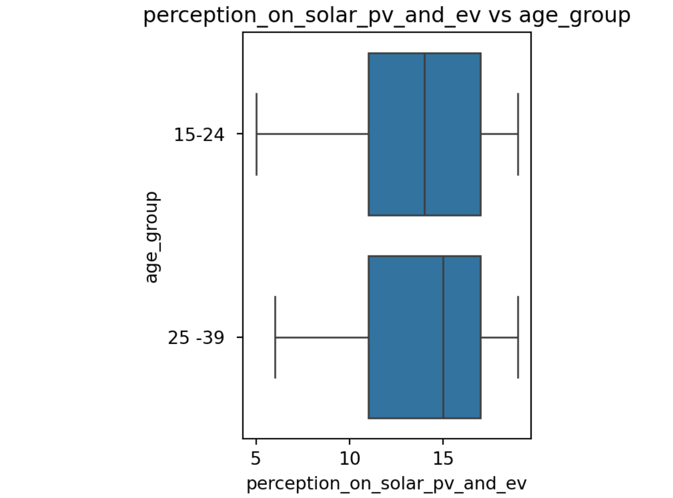

perception_on_smart_home_appliances vs age_group
age_group
15-24
25 -39
0
5
10
15
perception_on_smart_home_appliances

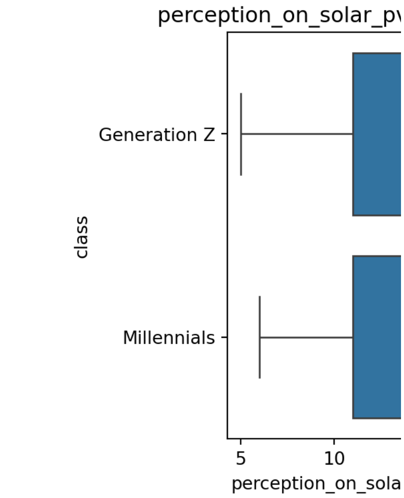

perception_on_smart_hom
class
Generation Z
Millennials
0
5
10
perception_on_smart_h

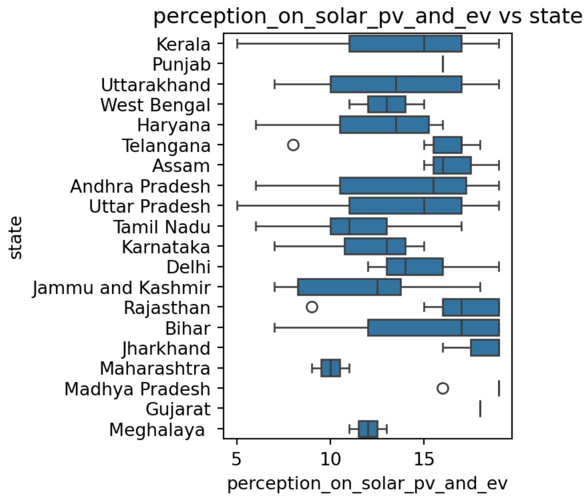

perception_on_smart_home_appliances vs state
state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
0
5
10
15
perception_on_smart_home_appliances

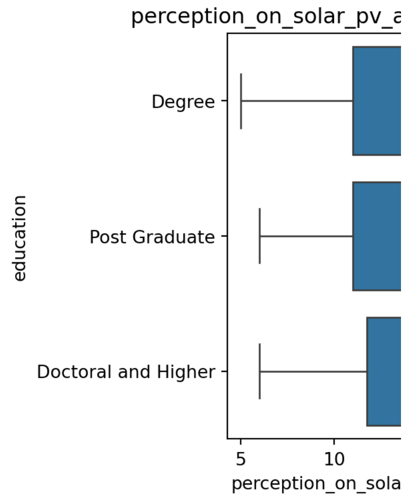

perception_on_smart_home_a
education
Degree
Post Graduate
Doctoral and Higher
0
5
10
perception_on_smart_h

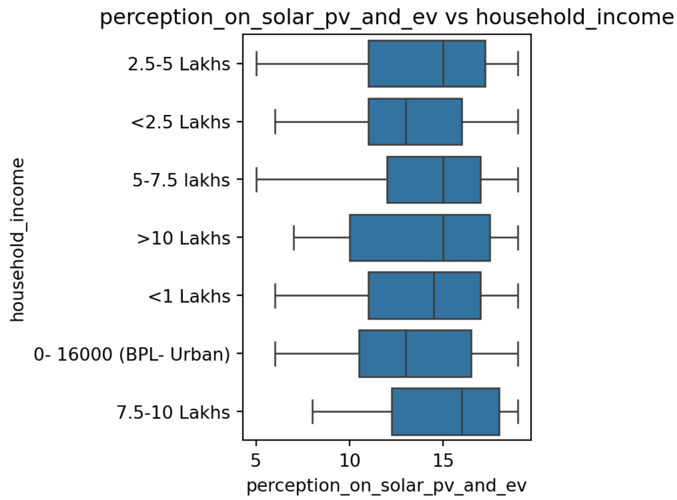

perception_on_smart_home_appliances vs household_income
household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
0
5
10
15
perception_on_smart_home_appliances

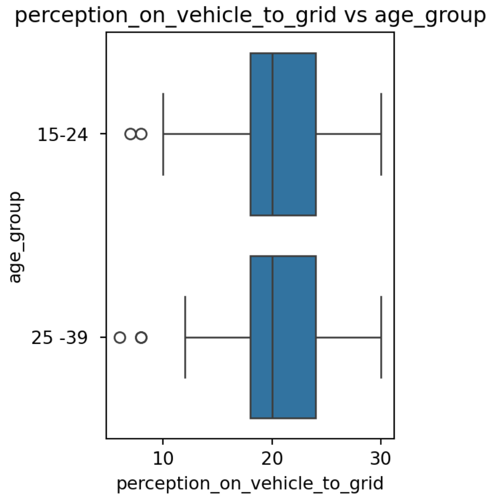

perception_on_solar_pv_and_ev vs age_group
15-24
25 -39
age_group
5
10
15
perception_on_solar_pv_and_ev

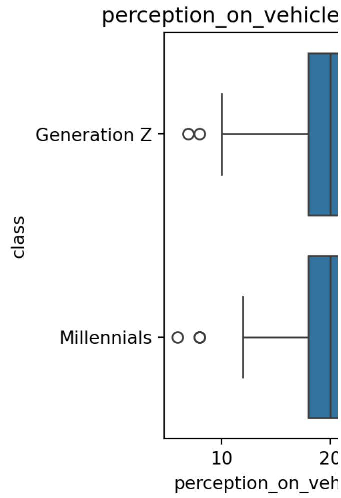

perception_on_solar_pv
Generation Z
Millennials
class
5
10
perception_on_sola

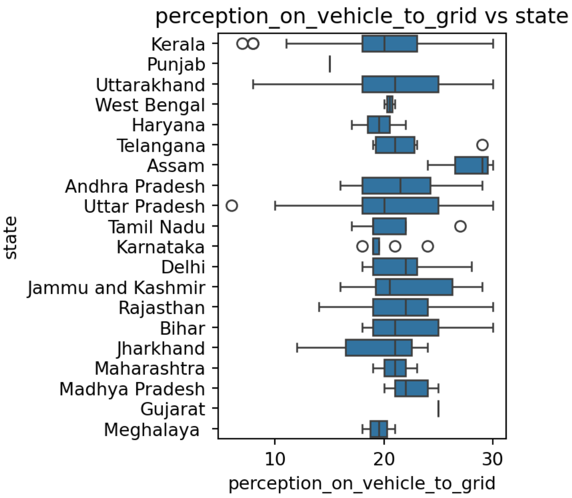

perception_on_solar_pv_and_ev vs state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
state
5
10
15
perception_on_solar_pv_and_ev

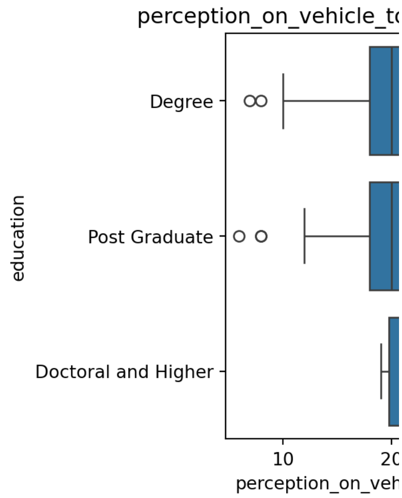

perception_on_solar_pv_a
Degree
Post Graduate
Doctoral and Higher
education
5
10
perception_on_sola

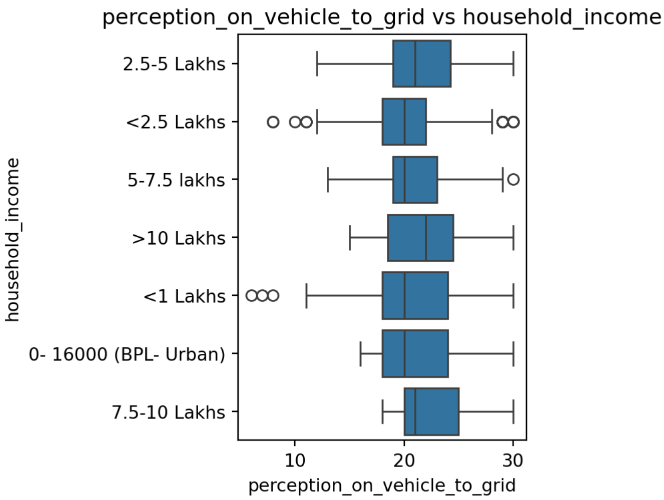

perception_on_solar_pv_and_ev vs household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
household_income
5
10
15
perception_on_solar_pv_and_ev

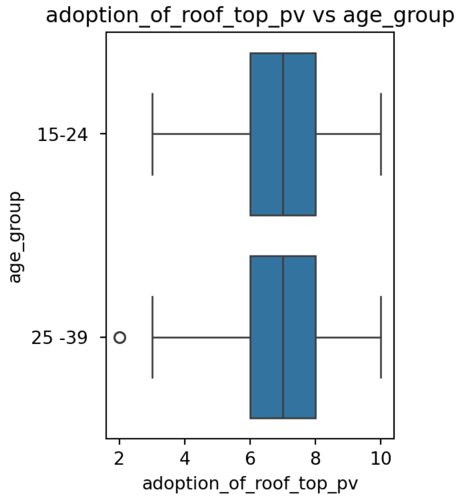

perception_on_vehicle_to_grid vs age_group
15-24
25 -39
age_group
10
20
30
perception_on_vehicle_to_grid

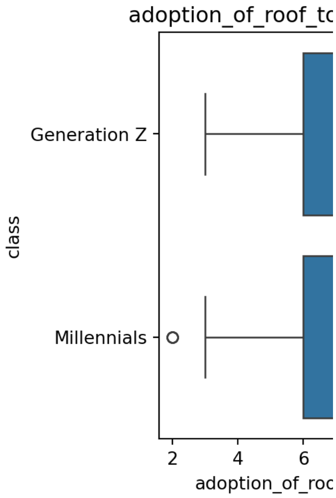

perception_on_vehicle
Generation Z
Millennials
class
10
perception_on_veh

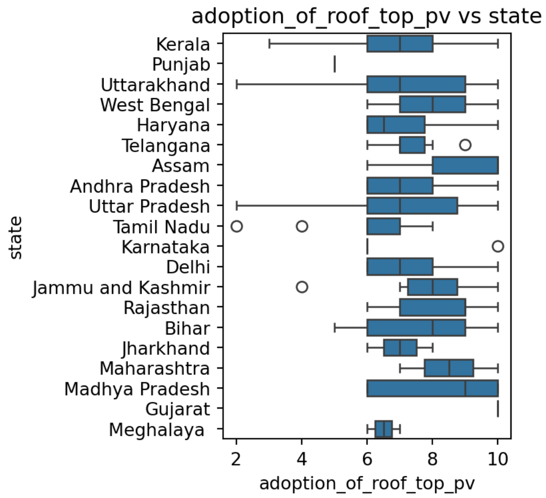

perception_on_vehicle_to_grid vs state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
state
10
20
30
perception_on_vehicle_to_grid

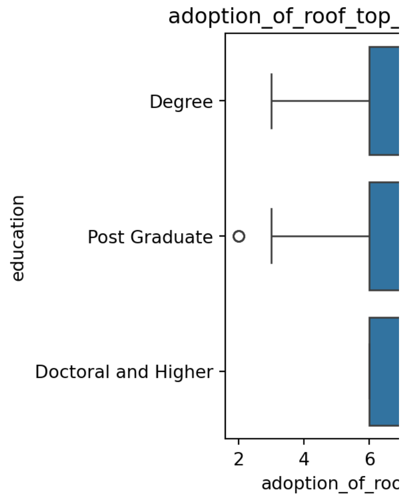

Degree
Post Graduate
Doctoral and Higher
education
10
perception_on_veh

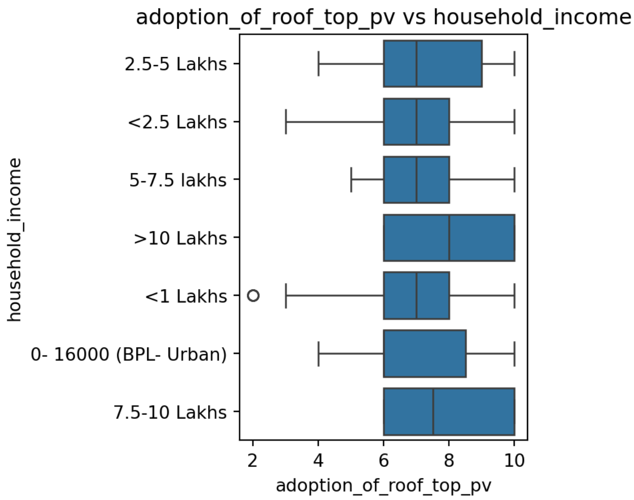

perception_on_vehicle_to_grid vs household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
household_income
10
20
30
perception_on_vehicle_to_grid

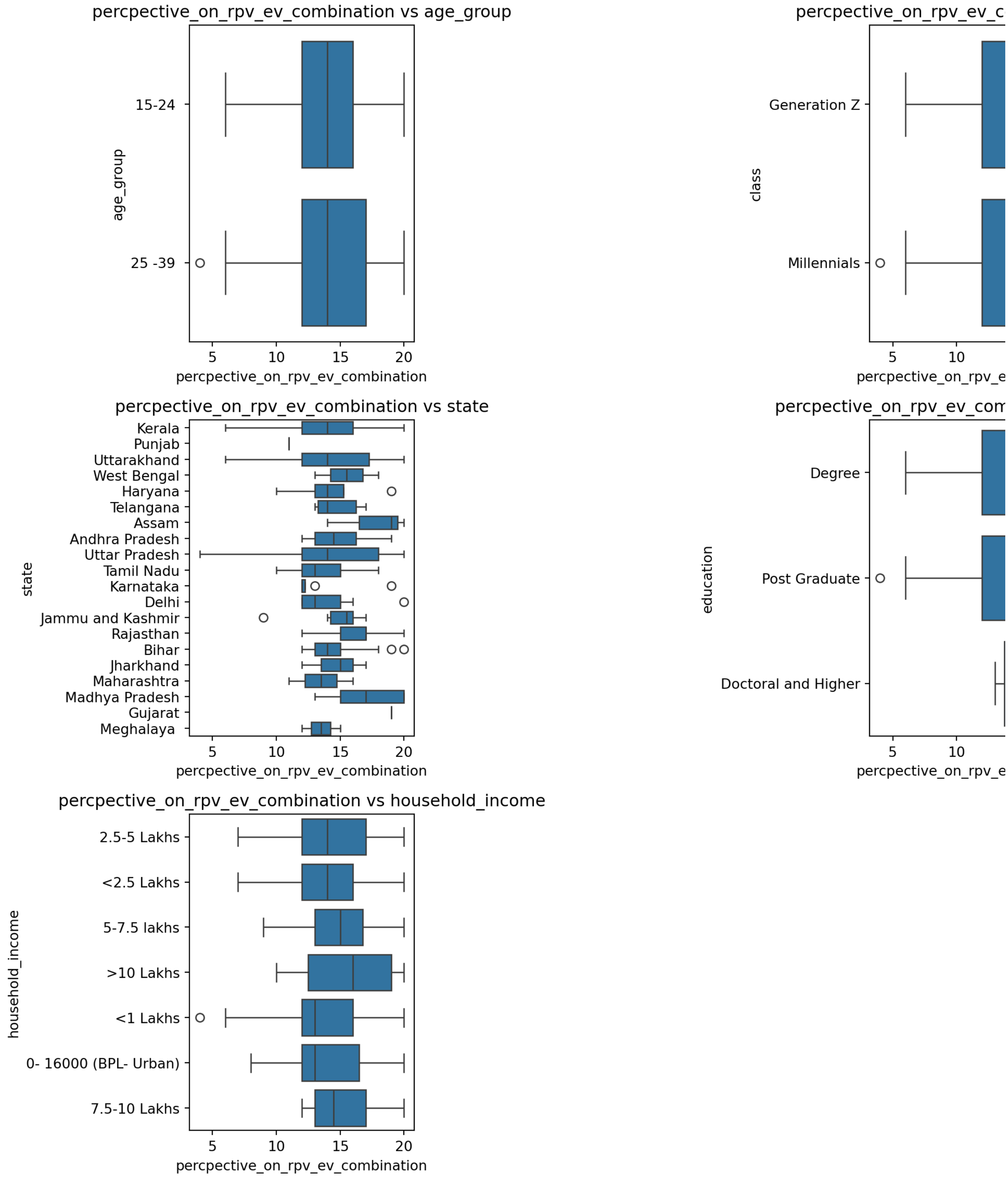

adoption_of_roof_top_pv vs age_group
15-24
25 -39
age_group
2
4
6
8
10
adoption_of_roof_top_pv


adoption_of_roof_tc
Generation Z
Millennials
class
2
4
6
adoption_of_roc


adoption_of_roof_top_pv vs state
Kerala
Punjab
Uttarakhand
West Bengal
Haryana
Telangana
Assam
Andhra Pradesh
Uttar Pradesh
Tamil Nadu
Karnataka
Delhi
Jammu and Kashmir
Rajasthan
Bihar
Jharkhand
Maharashtra
Madhya Pradesh
Gujarat
Meghalaya
state
2
4
6
8
10
adoption_of_roof_top_pv

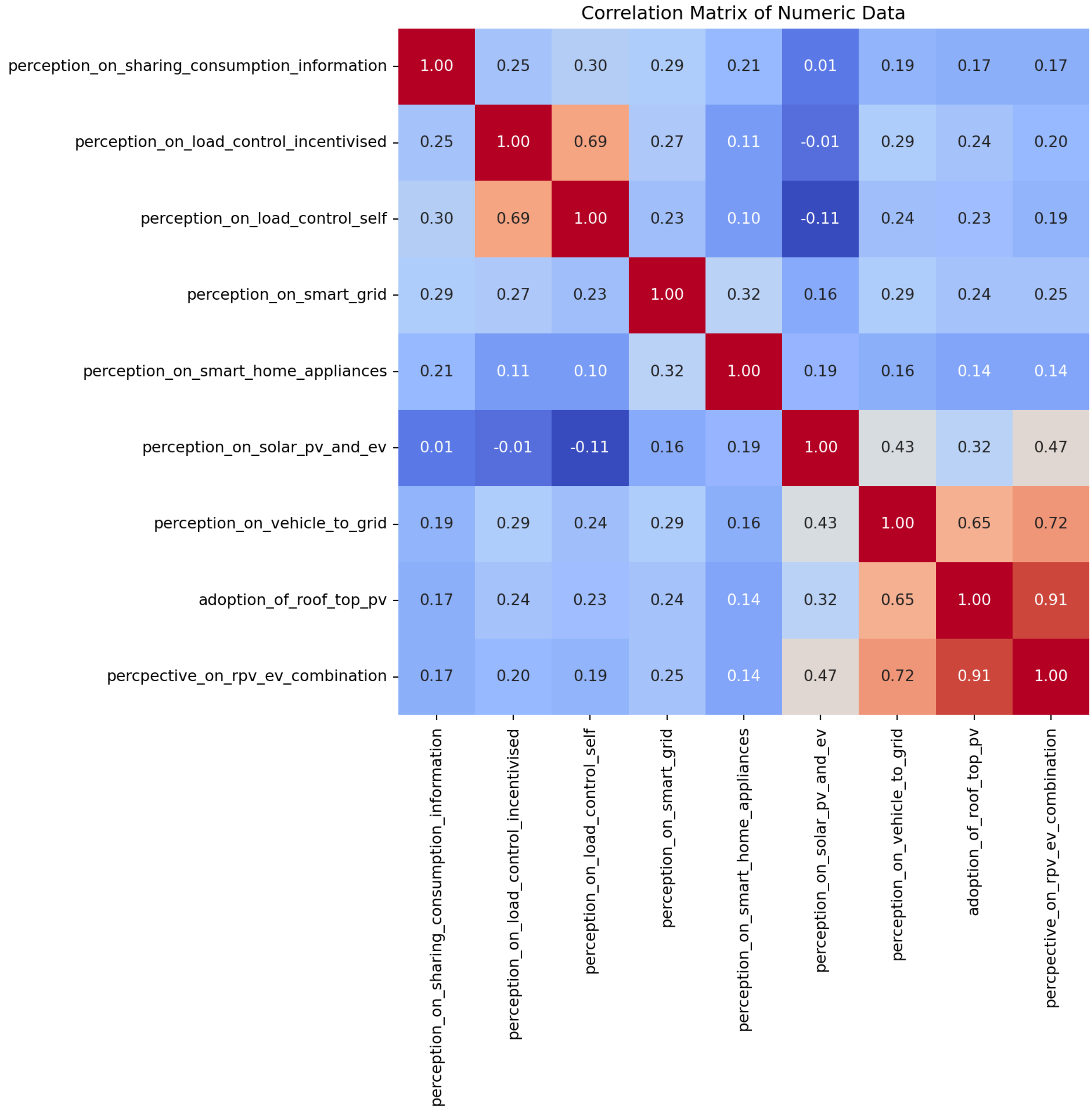

adoption_of_roof_top_
Degree
Post Graduate
Doctoral and Higher
education
2
4
6
adoption_of_roc


adoption_of_roof_top_pv vs household_income
2.5-5 Lakhs
<2.5 Lakhs
5-7.5 lakhs
>10 Lakhs
<1 Lakhs
0- 16000 (BPL- Urban)
7.5-10 Lakhs
household_income
2
4
6
8
10
adoption_of_roof_top_pv



In [5]:

```
numeric_perception_cols = [                 'perception_on_sharing_consumption_information',
                  'perception_on_load_control_incentivised', 'perception_on_load_control_self',
                   'perception_on_smart_grid', 'perception_on_smart_home_appliances',
                   'perception_on_solar_pv_and_ev', 'perception_on_vehicle_to_grid',
                   'adoption_of_roof_top_pv', 'percpective_on_rpv_ev_combination']
#4. Pairwise correlation between numeric data
def plot_corr_matrix(df, cols):
  corr_matrix = df[cols].corr()
  plt.figure(figsize=(10, 8))
  sns.heatmap(corr_matrix, annot=True, cmap='coolwarm', fmt=".2f")
  plt.title('Correlation Matrix of Numeric Data')
  plt.show()
plot_corr_matrix(df, numeric_perception_cols)
```

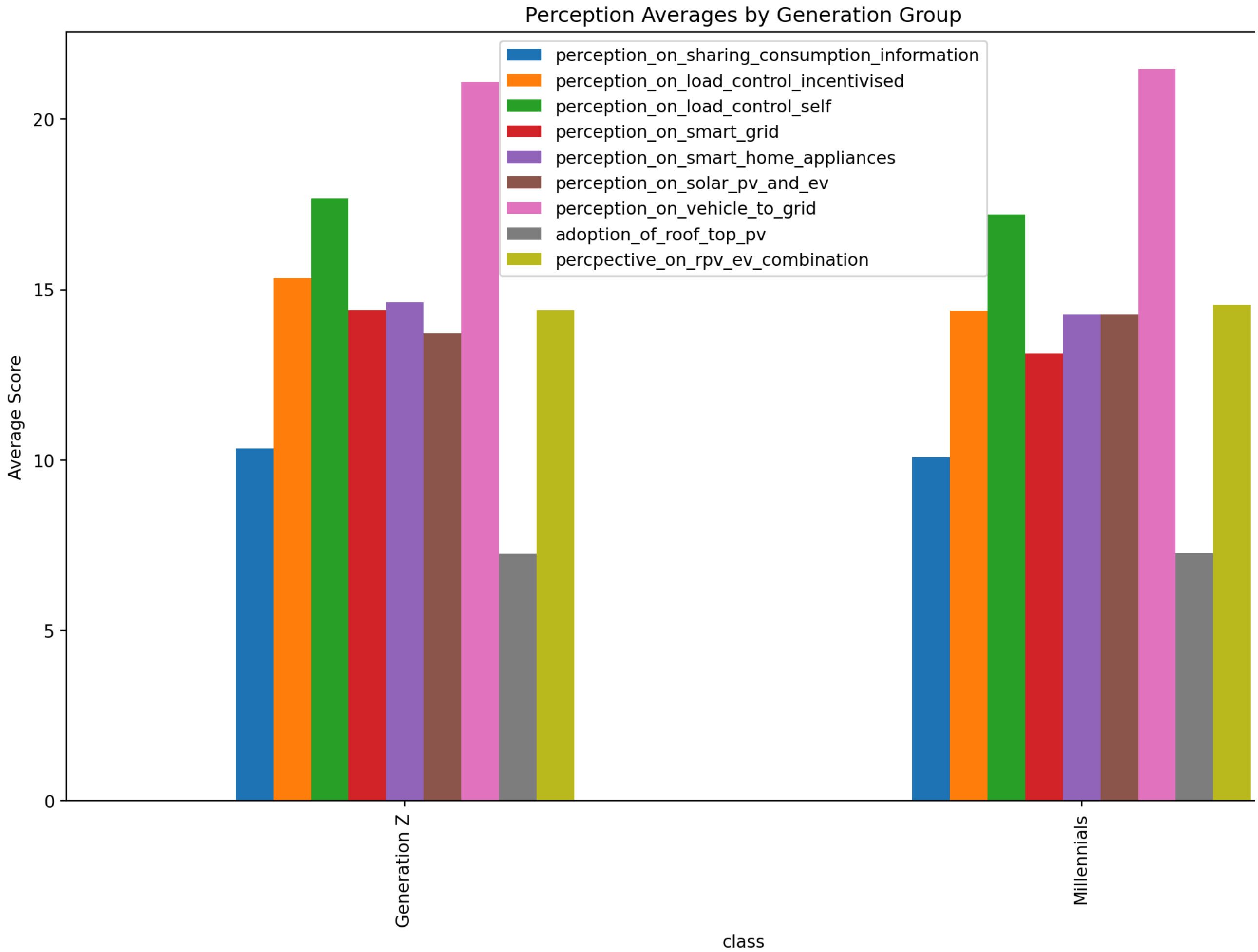


In [6]:

```
# --- Demographic Analysis with Perceptions ---

# 1. Perceptions by Generation
def analyze_by_generation(df):
    gen_group = df.groupby('class')[numeric_perception_cols].mean().round(2)
    print("\nAverage Perceptions by Generation Group:\n", gen_group)
    gen_group.plot(kind='bar', figsize=(14,8))
    plt.title("Perception Averages by Generation Group")
    plt.ylabel("Average Score")
    plt.show()

analyze_by_generation(df)
```

```
Average Perceptions by Generation Group:
               perception_on_sharing_consumption_information  \
class
Generation Z                                           10.34
Millennials                                            10.10

              perception_on_load_control_incentivised  \
class
Generation Z                                     15.33
Millennials                                      14.38

              perception_on_load_control_self  perception_on_smart_grid  \
class
Generation Z                            17.69                     14.40
```

```
Millennials                             17.20                     13.13

              perception_on_smart_home_appliances  \
class                                                
Generation Z                                 14.63   
Millennials                                  14.26   

              perception_on_solar_pv_and_ev  perception_on_vehicle_to_grid  \
class                                                                        
Generation Z                          13.72                          21.10   
Millennials                           14.26                          21.48   

              adoption_of_roof_top_pv  percpective_on_rpv_ev_combination  
class                                                                     
Generation Z                     7.26                              14.40  
Millennials                      7.27                              14.55  
```



In [7]:

```python
# 2. Perceptions by State
def analyze_by_state(df):
    state_group = df.groupby('state')[numeric_perception_cols].mean().round(2)
    print("\nAverage Perceptions by State:\n", state_group)
    state_group.plot(kind='bar',figsize=(14,8))
    plt.title("Perception Averages by State")
    plt.ylabel("Average Score")
    plt.show()

analyze_by_state(df)
```

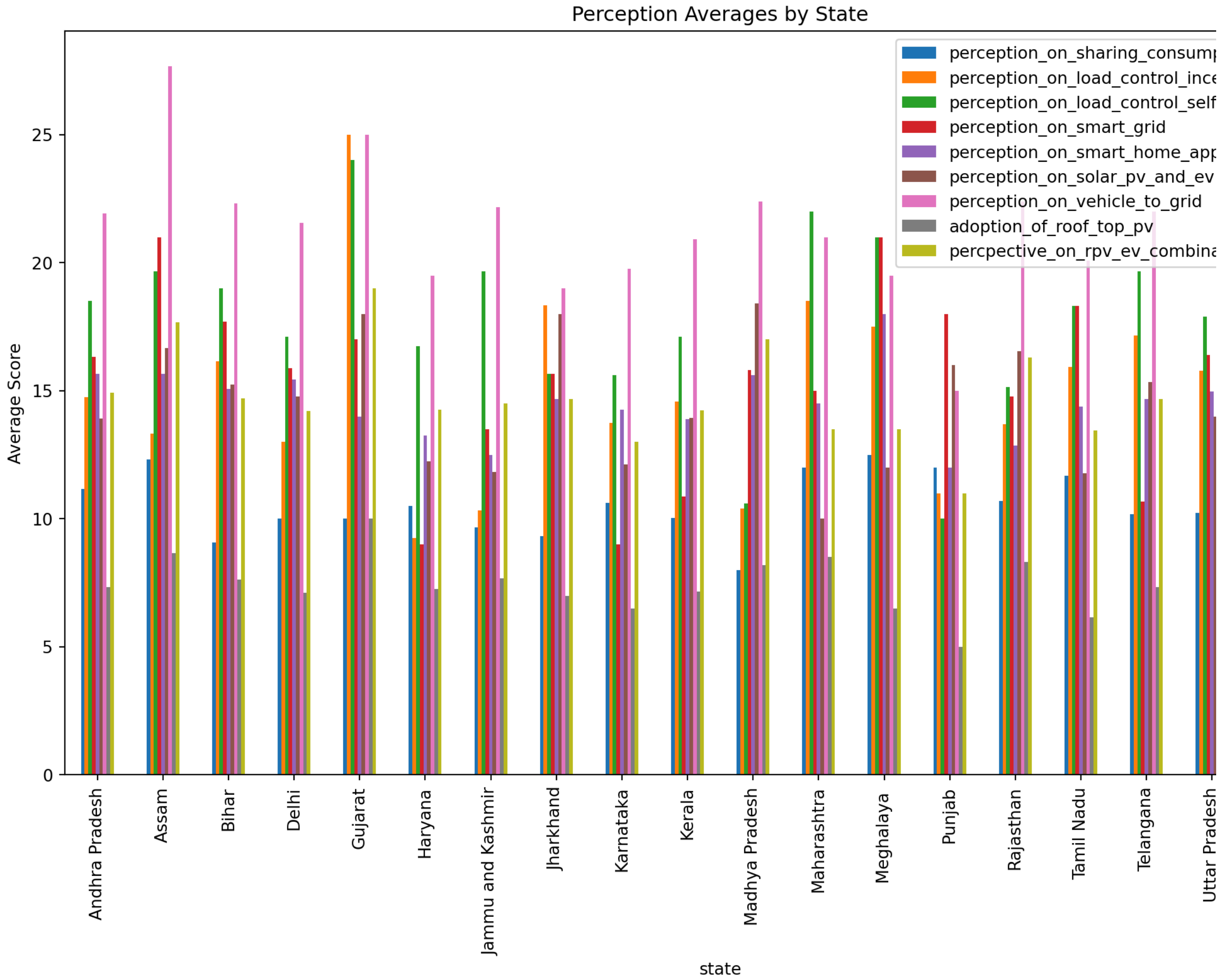
```
Average Perceptions by State:
                     perception_on_sharing_consumption_information  \
state                                                               
Andhra Pradesh                                               11.17   
Assam                                                        12.33   
Bihar                                                         9.08   
Delhi                                                        10.00   
Gujarat                                                      10.00   
Haryana                                                      10.50   
Jammu and Kashmir                                             9.67   
Jharkhand                                                     9.33   
Karnataka                                                    10.62   
```

```
Kerala                                                    10.03
Madhya Pradesh                                             8.00
Maharashtra                                               12.00
Meghalaya                                                 12.50
Punjab                                                    12.00
Rajasthan                                                 10.69
Tamil Nadu                                                11.69
Telangana                                                 10.17
Uttar Pradesh                                             10.24
Uttarakhand                                               10.44
West Bengal                                               12.00

                   perception_on_load_control_incentivised  \
state
Andhra Pradesh                                       14.75
Assam                                                13.33
Bihar                                                16.15
Delhi                                                13.00
Gujarat                                              25.00
Haryana                                               9.25
Jammu and Kashmir                                    10.33
Jharkhand                                            18.33
Karnataka                                            13.75
Kerala                                               14.57
Madhya Pradesh                                       10.40
Maharashtra                                          18.50
Meghalaya                                            17.50
Punjab                                               11.00
Rajasthan                                            13.69
Tamil Nadu                                           15.92
Telangana                                            17.17
Uttar Pradesh                                        15.79
Uttarakhand                                          15.60
West Bengal                                           7.00

                   perception_on_load_control_self  perception_on_smart_grid  \
state
Andhra Pradesh                               18.50                     16.33
Assam                                        19.67                     21.00
Bihar                                        19.00                     17.69
Delhi                                        17.11                     15.89
Gujarat                                      24.00                     17.00
Haryana                                      16.75                      9.00
Jammu and Kashmir                            19.67                     13.50
Jharkhand                                    15.67                     15.67
Karnataka                                    15.62                      9.00
Kerala                                       17.10                     10.86
Madhya Pradesh                               10.60                     15.80
Maharashtra                                  22.00                     15.00
Meghalaya                                    21.00                     21.00
Punjab                                       10.00                     18.00
Rajasthan                                    15.15                     14.77
Tamil Nadu                                   18.31                     18.31
Telangana                                    19.67                     10.67
Uttar Pradesh                                17.90                     16.40
Uttarakhand                                  18.15                     16.80
West Bengal                                   8.50                     20.50

                   perception_on_smart_home_appliances  \
state
Andhra Pradesh                                   15.67
Assam                                            15.67
Bihar                                            15.08
Delhi                                            15.44
Gujarat                                          14.00
Haryana                                          13.25
Jammu and Kashmir                                12.50
Jharkhand                                        14.67
Karnataka                                        14.25
Kerala                                           13.88
Madhya Pradesh                                   15.60
Maharashtra                                      14.50
Meghalaya                                        18.00
Punjab                                           12.00
Rajasthan                                        12.85
Tamil Nadu                                       14.38
Telangana                                        14.67
Uttar Pradesh                                    14.96
Uttarakhand                                      15.36
West Bengal                                      13.50
```

state	perception_on_solar_pv_and_ev \
Andhra Pradesh	13.92
Assam	16.67
Bihar	15.23
Delhi	14.78
Gujarat	18.00
Haryana	12.25
Jammu and Kashmir	11.83
Jharkhand	18.00
Karnataka	12.12
Kerala	13.94
Madhya Pradesh	18.40
Maharashtra	10.00
Meghalaya	12.00
Punjab	16.00
Rajasthan	16.54
Tamil Nadu	11.77
Telangana	15.33
Uttar Pradesh	13.99
Uttarakhand	13.61
West Bengal	13.00

state	perception_on_vehicle_to_grid	adoption_of_roof_top_pv \
Andhra Pradesh	21.92	7.33
Assam	27.67	8.67
Bihar	22.31	7.62
Delhi	21.56	7.11
Gujarat	25.00	10.00
Haryana	19.50	7.25
Jammu and Kashmir	22.17	7.67
Jharkhand	19.00	7.00
Karnataka	19.75	6.50
Kerala	20.91	7.17
Madhya Pradesh	22.40	8.20
Maharashtra	21.00	8.50
Meghalaya	19.50	6.50
Punjab	15.00	5.00
Rajasthan	22.38	8.31
Tamil Nadu	20.08	6.15
Telangana	22.00	7.33
Uttar Pradesh	21.24	7.33
Uttarakhand	21.89	7.31
West Bengal	20.50	8.00

state	percpective_on_rpv_ev_combination
Andhra Pradesh	14.92
Assam	17.67
Bihar	14.69
Delhi	14.22
Gujarat	19.00
Haryana	14.25
Jammu and Kashmir	14.50
Jharkhand	14.67
Karnataka	13.00
Kerala	14.24
Madhya Pradesh	17.00
Maharashtra	13.50
Meghalaya	13.50
Punjab	11.00
Rajasthan	16.31
Tamil Nadu	13.46
Telangana	14.67
Uttar Pradesh	14.67
Uttarakhand	14.54
West Bengal	15.50



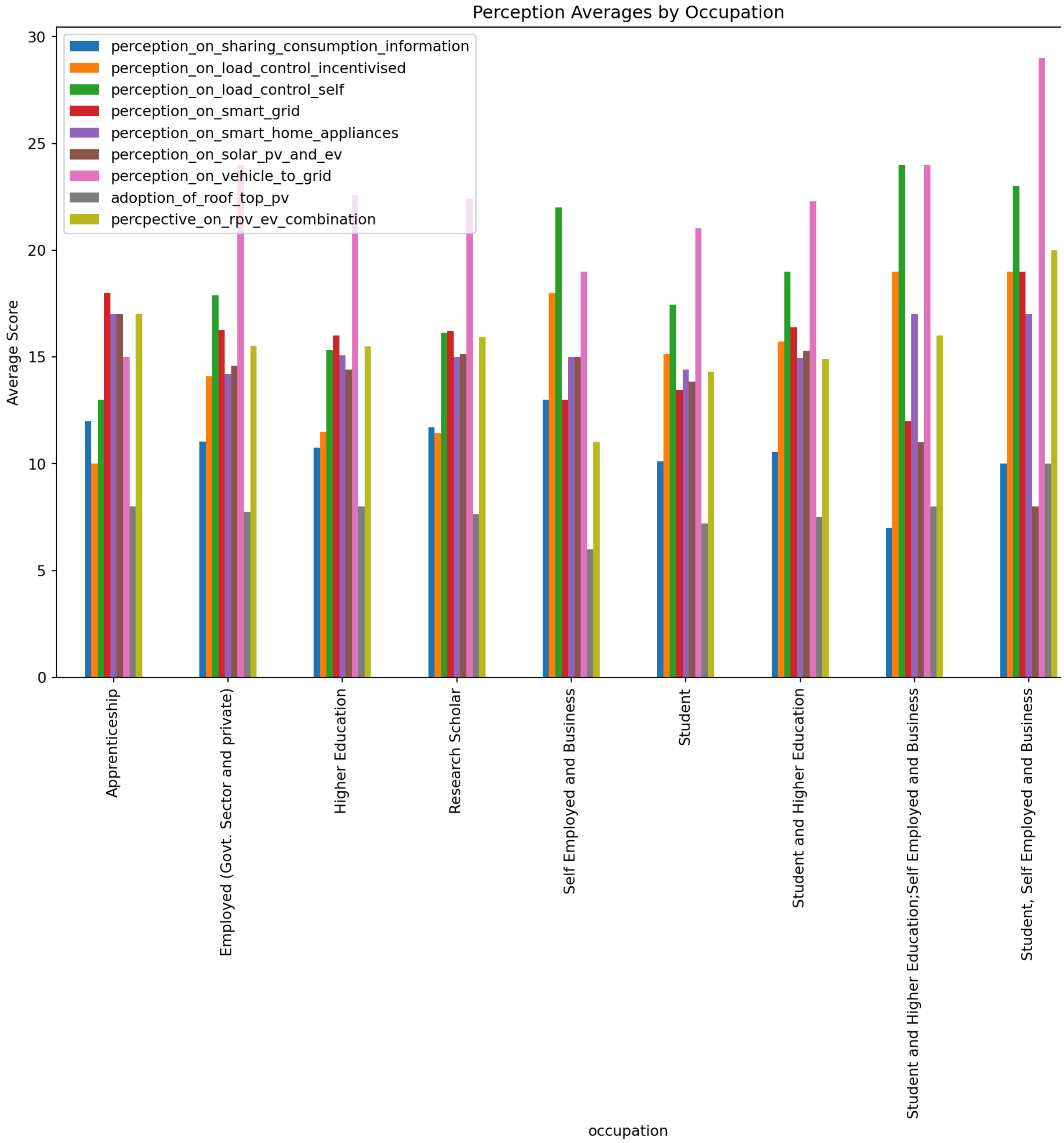
In [8]:

```
# 3. Perceptions by Occupation
def analyze_by_occupation(df):
  occupation_group = df.groupby('occupation')[numeric_perception_cols].mean().round(2)
  print("\nAverage Perceptions by Occupation:\n", occupation_group)
  occupation_group.plot(kind='bar',figsize=(14,8))
  plt.title("Perception Averages by Occupation")
  plt.ylabel("Average Score")
  plt.show()
analyze_by_occupation(df)
```

```
Average Perceptions by Occupation:
                                                     perception_on_sharing_consumption_information  \
occupation
Apprenticeship                                                                               12.00
Employed (Govt. Sector and private)                                                          11.05
Higher Education                                                                             10.75
Research Scholar                                                                             11.71
Self Employed and Business                                                                   13.00
Student                                                                                      10.11
Student and Higher Education                                                                 10.56
Student and Higher Education;Self Employed and ...                                            7.00
Student, Self Employed and Business                                                          10.00
Student;Employed (Govt. Sector and private)                                                  11.00

                                                    perception_on_load_control_incentivised  \
occupation
Apprenticeship                                                                        10.00
Employed (Govt. Sector and private)                                                   14.11
Higher Education                                                                      11.50
Research Scholar                                                                      11.43
Self Employed and Business                                                            18.00
Student                                                                               15.12
Student and Higher Education                                                          15.72
Student and Higher Education;Self Employed and ...                                    19.00
Student, Self Employed and Business                                                   19.00
Student;Employed (Govt. Sector and private)                                           10.00
```

```
                                                  perception_on_load_control_self  \
occupation
Apprenticeship                                                               13.00
Employed (Govt. Sector and private)                                          17.89
Higher Education                                                             15.33
Research Scholar                                                             16.14
Self Employed and Business                                                   22.00
Student                                                                      17.46
Student and Higher Education                                                 19.00
Student and Higher Education;Self Employed and ...                           24.00
Student, Self Employed and Business                                          23.00
Student;Employed (Govt. Sector and private)                                  17.50

                                                  perception_on_smart_grid  \
occupation
Apprenticeship                                                        18.00
Employed (Govt. Sector and private)                                   16.26
Higher Education                                                      16.00
Research Scholar                                                      16.21
Self Employed and Business                                            13.00
Student                                                               13.46
Student and Higher Education                                          16.39
Student and Higher Education;Self Employed and ...                    12.00
Student, Self Employed and Business                                   19.00
Student;Employed (Govt. Sector and private)                           13.50

                                                  perception_on_smart_home_appliances  \
occupation
Apprenticeship                                                                   17.00
Employed (Govt. Sector and private)                                              14.21
Higher Education                                                                 15.08
Research Scholar                                                                 15.00
Self Employed and Business                                                       15.00
Student                                                                          14.40
Student and Higher Education                                                     14.94
Student and Higher Education;Self Employed and ...                               17.00
Student, Self Employed and Business                                              17.00
Student;Employed (Govt. Sector and private)                                      15.50

                                                  perception_on_solar_pv_and_ev  \
occupation
Apprenticeship                                                             17.00
Employed (Govt. Sector and private)                                        14.58
Higher Education                                                           14.42
Research Scholar                                                           15.14
Self Employed and Business                                                 15.00
Student                                                                    13.84
Student and Higher Education                                               15.28
Student and Higher Education;Self Employed and ...                         11.00
Student, Self Employed and Business                                         8.00
Student;Employed (Govt. Sector and private)                                14.50

                                                  perception_on_vehicle_to_grid  \
occupation
Apprenticeship                                                             15.00
Employed (Govt. Sector and private)                                        24.00
Higher Education                                                           22.58
Research Scholar                                                           22.43
Self Employed and Business                                                 19.00
Student                                                                    21.02
Student and Higher Education                                               22.28
Student and Higher Education;Self Employed and ...                         24.00
Student, Self Employed and Business                                        29.00
Student;Employed (Govt. Sector and private)                                24.00

                                                  adoption_of_roof_top_pv  \
occupation
Apprenticeship                                                       8.00
Employed (Govt. Sector and private)                                  7.74
Higher Education                                                     8.00
Research Scholar                                                     7.64
Self Employed and Business                                           6.00
Student                                                              7.19
Student and Higher Education                                         7.50
Student and Higher Education;Self Employed and ...                   8.00
Student, Self Employed and Business                                 10.00
Student;Employed (Govt. Sector and private)                          7.50

                                                  percpective_on_rpv_ev_combination
occupation
```

```
Apprenticeship                                                  17.00
Employed (Govt. Sector and private)                             15.53
Higher Education                                                15.50
Research Scholar                                                15.93
Self Employed and Business                                      11.00
Student                                                         14.31
Student and Higher Education                                    14.89
Student and Higher Education;Self Employed and ...              16.00
Student, Self Employed and Business                             20.00
Student;Employed (Govt. Sector and private)                     15.50
```

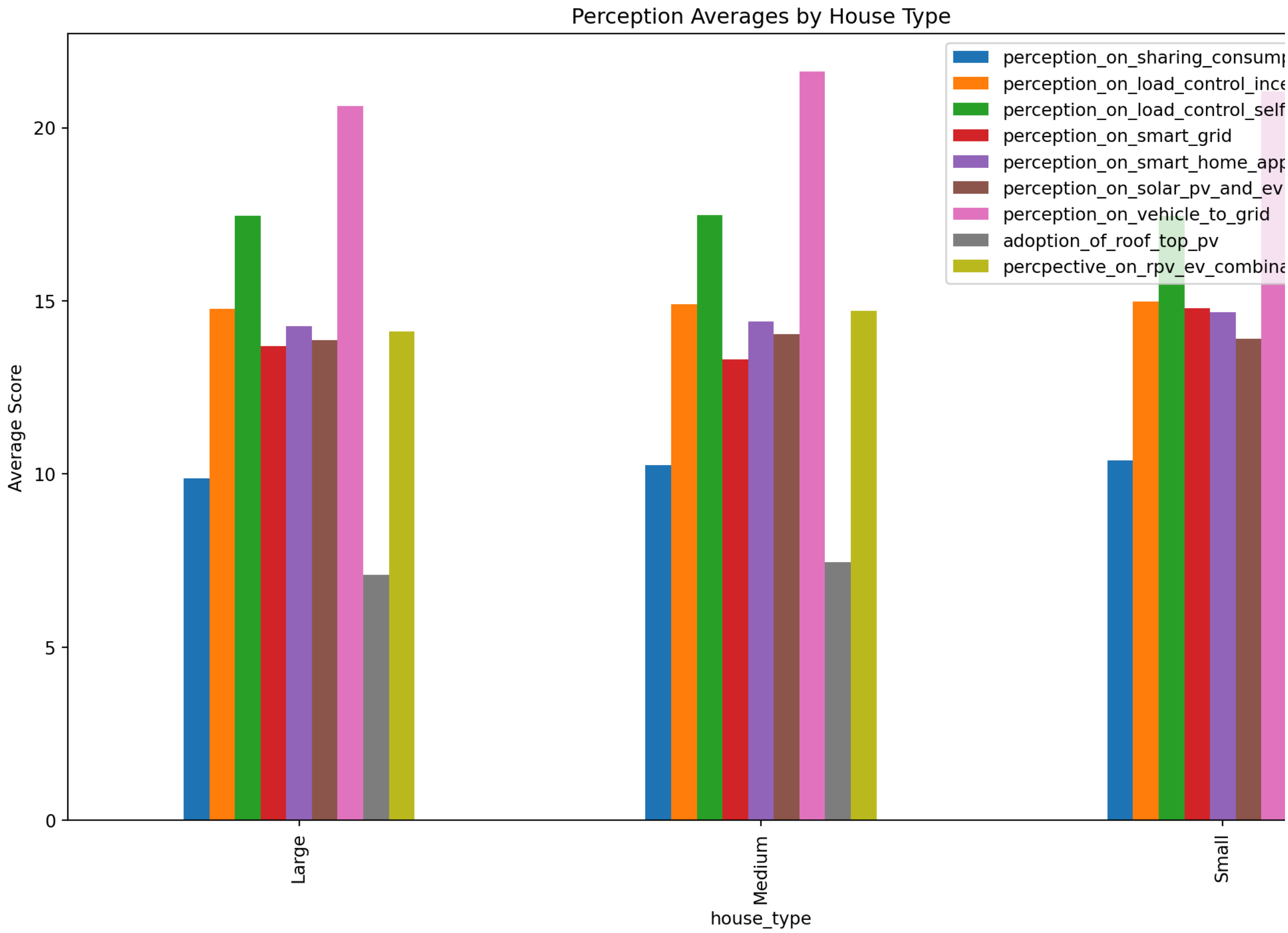


In [9]:

```python
#4. Perceptions by House-type
def analyze_by_house_type(df):
  house_type_group = df.groupby('house_type')[numeric_perception_cols].mean().round(2)
  print("\nAverage Perceptions by House Type:\n", house_type_group)
  house_type_group.plot(kind='bar',figsize=(14,8))
  plt.title("Perception Averages by House Type")
  plt.ylabel("Average Score")
  plt.show()

analyze_by_house_type(df)
```

```
Average Perceptions by House Type:
             perception_on_sharing_consumption_information  \
```

```
house_type
Large                                          9.88
Medium                                        10.26
Small                                         10.40

           perception_on_load_control_incentivised  \
house_type
Large                                        14.77
Medium                                       14.90
Small                                        14.98

           perception_on_load_control_self  perception_on_smart_grid  \
house_type
Large                                17.45                     13.70
Medium                               17.48                     13.30
Small                                17.45                     14.79

           perception_on_smart_home_appliances  \
house_type
Large                                    14.27
Medium                                   14.41
Small                                    14.68

           perception_on_solar_pv_and_ev  perception_on_vehicle_to_grid  \
house_type
Large                              13.86                          20.63
Medium                             14.04                          21.63
Small                              13.91                          21.05

           adoption_of_roof_top_pv  percpective_on_rpv_ev_combination
house_type
Large                         7.09                              14.12
Medium                        7.45                              14.72
Small                         7.06                              14.26
```



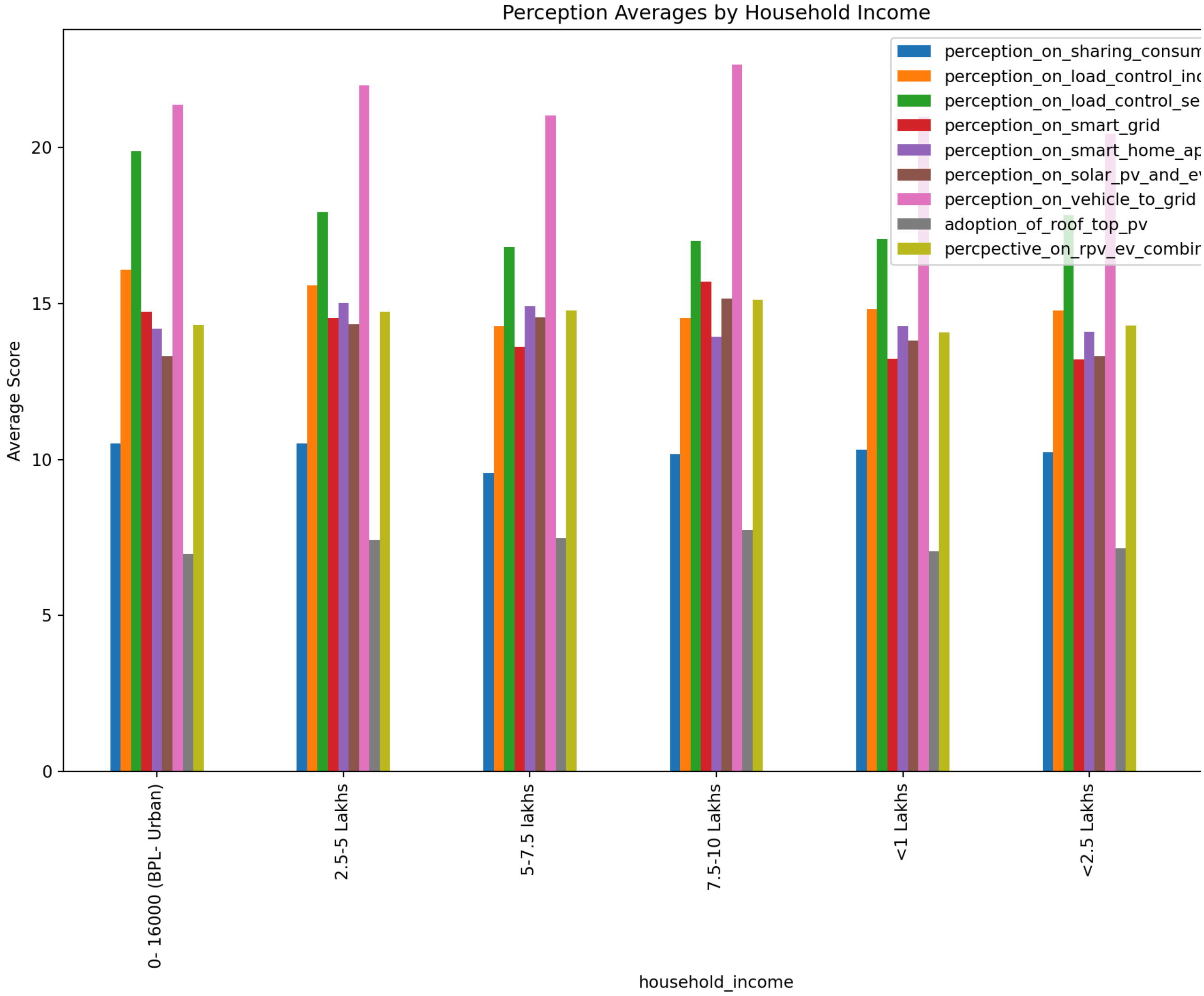
In [10]:

```python
#5. Perceptions by Household Income
def analyze_by_household_income(df):
    income_group = df.groupby('household_income')[numeric_perception_cols].mean().round(2)
    print("\nAverage Perceptions by Household Income:\n", income_group)
    income_group.plot(kind='bar', figsize=(14, 8))
    plt.title("Perception Averages by Household Income")
    plt.ylabel("Average Score")
```

```python
    plt.show()

analyze_by_household_income(df)
```

```
Average Perceptions by Household Income:
                       perception_on_sharing_consumption_information  \
household_income
0- 16000 (BPL- Urban)                                         10.51
2.5-5 Lakhs                                                   10.51
5-7.5 lakhs                                                    9.57
7.5-10 Lakhs                                                  10.18
<1 Lakhs                                                      10.32
<2.5 Lakhs                                                    10.23
>10 Lakhs                                                      9.74

                      perception_on_load_control_incentivised  \
household_income
0- 16000 (BPL- Urban)                                   16.09
2.5-5 Lakhs                                             15.59
5-7.5 lakhs                                             14.28
7.5-10 Lakhs                                            14.53
<1 Lakhs                                                14.81
<2.5 Lakhs                                              14.78
>10 Lakhs                                               13.61

                      perception_on_load_control_self  \
household_income
0- 16000 (BPL- Urban)                           19.89
2.5-5 Lakhs                                     17.93
5-7.5 lakhs                                     16.81
7.5-10 Lakhs                                    17.00
<1 Lakhs                                        17.06
<2.5 Lakhs                                      17.84
>10 Lakhs                                       15.91

                      perception_on_smart_grid  \
household_income
0- 16000 (BPL- Urban)                    14.74
2.5-5 Lakhs                              14.53
5-7.5 lakhs                              13.61
7.5-10 Lakhs                             15.71
<1 Lakhs                                 13.22
<2.5 Lakhs                               13.20
>10 Lakhs                                14.48

                      perception_on_smart_home_appliances  \
household_income
0- 16000 (BPL- Urban)                               14.20
2.5-5 Lakhs                                         15.02
5-7.5 lakhs                                         14.91
7.5-10 Lakhs                                        13.94
<1 Lakhs                                            14.28
<2.5 Lakhs                                          14.10
>10 Lakhs                                           15.22

                      perception_on_solar_pv_and_ev  \
household_income
0- 16000 (BPL- Urban)                         13.31
2.5-5 Lakhs                                   14.34
5-7.5 lakhs                                   14.56
7.5-10 Lakhs                                  15.15
<1 Lakhs                                      13.82
<2.5 Lakhs                                    13.31
>10 Lakhs                                     13.96

                      perception_on_vehicle_to_grid  adoption_of_roof_top_pv  \
household_income
0- 16000 (BPL- Urban)                         21.37                     6.97
2.5-5 Lakhs                                   21.99                     7.41
5-7.5 lakhs                                   21.04                     7.48
7.5-10 Lakhs                                  22.65                     7.74
<1 Lakhs                                      20.99                     7.05
<2.5 Lakhs                                    20.44                     7.16
>10 Lakhs                                     22.17                     8.04

                      percpective_on_rpv_ev_combination
household_income
0- 16000 (BPL- Urban)                             14.31
2.5-5 Lakhs                                       14.73
5-7.5 lakhs                                       14.78
```

```
7.5-10 Lakhs                                         15.12
<1 Lakhs                                             14.07
<2.5 Lakhs                                           14.29
>10 Lakhs                                            15.78
```



In [11]:

```python
#Example: Hypothesis testing to check if significant difference exists between perceptions of two different age groups
from scipy import stats
def hypothesis_testing(df, var, age1, age2):
    age_group1 = df[df['class'] == age1][var]
    age_group2 = df[df['class'] == age2][var]
    t_stat, p_val = stats.ttest_ind(age_group1, age_group2, equal_var=False, nan_policy='omit')
    print(f"\nT-test result between {age1} and {age2} for perception on {var}:")
    print("T-statistic:", t_stat)
    print("P-value:", p_val)
    alpha = 0.05
    if p_val < alpha:
        print(f"Reject null hypothesis. Significant difference in {var} between {age1} and {age2}")
    else:
        print(f"Failed to reject null hypothesis. No significant difference in {var} between {age1} and {age2}")
hypothesis_testing(df, 'perception_on_smart_grid', 'Generation Z', 'Millennials')
```

```
T-test result between Generation Z and Millennials for perception on perception_on_smart_grid:
T-statistic: 1.8748124234100918
P-value: 0.061441521579950545
Failed to reject null hypothesis. No significant difference in perception_on_smart_grid between Generation Z and Millennials
```

In [12]:

```python
#6. Further analysis

#You can further conduct ANOVA test to compare differences among three or more group's data
# Example: ANOVA test for the above:
import statsmodels.api as sm
from statsmodels.formula.api import ols
def anova_test_by_state(df, var):
    model = ols(f'{var} ~ C(state)', data=df).fit()
    anova_table = sm.stats.anova_lm(model, typ=2)
    print(f"\nANOVA test result by class for {var}:")
```

```
    print(anova_table)


anova_test_by_state(df, 'perception_on_smart_grid')
```

```
ANOVA test result by class for perception_on_smart_grid:
                sum_sq     df         F        PR(>F)
C(state)   4623.740753   19.0  5.022068  6.099431e-11
Residual  23114.029871  477.0       NaN           NaN
```

In [13]:

```
for col in numeric_cols:
    df[col] = pd.to_numeric(df[col], errors='coerce') # Replace 'errors='coerce'' with errors='raise' to identify if there are any
        errors while numeric conversion.
df.dropna(subset=numeric_cols, inplace=True) #Dropping all rows with null values for the numeric variables


# --- ANOVA Test ---

def anova_test_by_class(df, var):
    model = ols(f'{var} ~ C(age_group)', data=df).fit()
    anova_table = sm.stats.anova_lm(model, typ=2)
    print(f"\nANOVA test result for {var} across Class:")
    print(anova_table)

# Perform ANOVA for each perception variable
for col in numeric_cols[1:]:  # Exclude 'average_monthly_electricity_bill' from ANOVA test as it is not a perception variable
    anova_test_by_class(df, col)
```

```
ANOVA test result for perception_on_individual_usage across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)    69.634448    1.0  8.551152  0.003611
Residual      4030.924908  495.0       NaN       NaN

ANOVA test result for perception_on_sharing_consumption_information across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)     6.968479    1.0  1.052943  0.305331
Residual      3275.957074  495.0       NaN       NaN

ANOVA test result for perception_on_load_control_incentivised across Class:
                    sum_sq     df         F    PR(>F)
C(age_group)    111.093808    1.0  3.883281  0.049326
Residual      14161.075206  495.0       NaN       NaN

ANOVA test result for perception_on_load_control_self across Class:
                    sum_sq     df        F    PR(>F)
C(age_group)     29.810272    1.0  0.76791  0.381289
Residual      19215.891941  495.0      NaN       NaN

ANOVA test result for perception_on_smart_grid across Class:
                    sum_sq     df         F    PR(>F)
C(age_group)    197.250363    1.0  3.545283  0.060301
Residual      27540.520261  495.0       NaN       NaN

ANOVA test result for perception_on_smart_home_appliances across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)    17.281697    1.0  1.072206  0.300953
Residual      7978.352106  495.0       NaN       NaN

ANOVA test result for perception_on_solar_pv_and_ev across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)    35.523455    1.0  2.701995  0.100858
Residual      6507.824634  495.0       NaN       NaN

ANOVA test result for perception_on_vehicle_to_grid across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)    18.071738    1.0  0.912597  0.339893
Residual      9802.258242  495.0       NaN       NaN

ANOVA test result for adoption_of_roof_top_pv across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)     0.018459    1.0  0.006153  0.937508
Residual      1484.923191  495.0       NaN       NaN

ANOVA test result for percpective_on_rpv_ev_combination across Class:
                   sum_sq     df         F    PR(>F)
C(age_group)     2.629122    1.0  0.272997  0.601562
Residual      4767.137477  495.0       NaN       NaN
```