Analysis of Energy Demand

The assignment will focus on data visualisation using pandas library.

KATE expects your code to define variables with specific names that correspond to certain things we are interested in.

KATE will run your notebook from top to bottom and check the latest value of those variables, so make sure you don't overwrite them.

- Remember to uncomment the line assigning the variable to your answer and don't change the variable or function names.
- Use copies of the original or previous DataFrames to make sure you do not overwrite them by mistake.

You will find instructions below about how to define each variable.

Once you're happy with your code, upload your notebook to KATE to check your feedback.

Importing Libraries

Run the cell below first, to import `pandas` and `matplotlib` `pyplot`. The `matplotlib_axes_logger.setLevel('ERROR')` code prevents some unnecessary warnings from showing.

In [1]:

```python
import pandas as pd

from matplotlib import pyplot as plt
from matplotlib.axes._axes import _log as matplotlib_axes_logger
matplotlib_axes_logger.setLevel('ERROR')
```

About the Datasets

In the following section, you will be analysing a datasets from the UK government detailing energy consumption across various sectors of industry.

The datasets include information about:

- Sector - sectors of industry
- Sub-Sector - a sector that is part of a larger sector
- Electricity - energy consumption measured in kilowatt hour (kWh)
- Natural Gas - energy consumption measured in kilowatt hour (kWh)
- Oil - energy consumption measured in kilowatt hour (kWh)
- District Heating - is a system for distributing heat generated in a centralised location through a system of insulated pipes, measured in kilowatt hour (kWh)
- Other - other energy sources measured in kilowatt hour (kWh)

Data Collection

We have written some code below to do some initial collation and cleaning of the datasets we'll be working with - see if you can follow along and understand what each line is doing.

Run the following cell to import and concatenate the datasets, assigning the result to DataFrame `data` :

In [2]:

```
df1 = pd.read_csv('data/heating_2018.csv')
df2 = pd.read_csv('data/hot_water_2018.csv')
df3 = pd.read_csv('data/catering_2018.csv')
data = pd.concat([df1, df2, df3], keys=['Heating', 'Hot Water', 'Catering'])
```

Running `data.head()` , `data.sample()` and `data.info()` will show us how the DataFrame is structured:

In [3]:

```
data.head()
```

Out[3]:

	level_0	Sector	Sub-Sector	Electricity	Natural Gas	Oil	District Heating	Other
0	Heating	Arts, leisure and community	Clubs & community centres	14	139	60	8.0	NaN
1	Heating	Arts, leisure and community	Leisure Centres	5	159	7	18.0	NaN
2	Heating	Arts, leisure and community	Museums	2	12	3	0.0	NaN
3	Heating	Arts, leisure and community	Places of Worship	29	377	110	13.0	NaN
4	Heating	Arts, leisure and community	Theatres	1	35	2	0.0	NaN

In [4]:

```
data.sample(5)
```

Out[4]:

	level_0	Sector	Sub-Sector	Electricity	Natural Gas	Oil	District Heating	Other
1	Hot Water	Arts, leisure and community	Leisure Centres	1	19	5	1.0	6.0
20	Hot Water	Hospitality	Restaurants & takeaways	6	12	27	0.0	0.0
35	Hot Water	Storage	Warehouses	9	12	9	0.0	3.0
26	Catering	Retail	Hairdressers	0	0	0	NaN	NaN
21	Catering	Military	Military civilian accommodation	1	1	0	NaN	NaN

In [5]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 108 entries, 0 to 35
Data columns (total 8 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   level_0            108 non-null    object 
 1   Sector             108 non-null    object 
 2   Sub-Sector         108 non-null    object 
 3   Electricity        108 non-null    int64  
 4   Natural Gas        108 non-null    int64  
 5   Oil                108 non-null    int64  
 6   District Heating   72 non-null     float64
 7   Other              36 non-null     float64
dtypes: float64(2), int64(3), object(3)
memory usage: 7.6+ KB
```

Data Processing

Q1. First of all, let's tidy up the `data` DataFrame:

- Use the `.rename()` method to change the name of the `level_0` column to `Use`
- Use the `.fillna()` method to update all `NaN` values to `0`
- Use the `.astype()` method to convert all numerical columns `['Electricity', 'Natural Gas', 'Oil', 'District Heating', 'Other']` to integers
- Use the `.sum(axis=1)` method to create a new column `Total` which contains the sum of all numerical columns

KATE will evaluate your updated version of `data` to check these changes have been made.

In [6]:

```
#add your code to update the `data` DataFrame below
#data.rename(columns = {'level_0':'Use'}, inplace = True)
data.rename(columns = {'level_0':'Use'}, inplace = True)
data.fillna(0, inplace = True)

data[['Electricity', 'Natural Gas', 'Oil', 'District Heating', 'Other']]=dat

data['Total'] = data.sum(axis=1)
data.head()
#data.info()
```

```
/kas/kloud/notebook/python3.7/site-packages/ipykernel_launcher.py:8: Future
Warning: Dropping of nuisance columns in DataFrame reductions (with 'numeri
c_only=None') is deprecated; in a future version this will raise TypeError.
Select only valid columns before calling the reduction.
```

Out[6]:

	Use	Sector	Sub-Sector	Electricity	Natural Gas	Oil	District Heating	Other	Total
0	Heating	Arts, leisure and community	Clubs & community centres	14	139	60	8	0	221
1	Heating	Arts, leisure and community	Leisure Centres	5	159	7	18	0	189
2	Heating	Arts, leisure and community	Museums	2	12	3	0	0	17
3	Heating	Arts, leisure and community	Places of Worship	29	377	110	13	0	529
4	Heating	Arts, leisure and community	Theatres	1	35	2	0	0	38

Data Grouping

Q2. Create a new DataFrame called `ss` , using `.groupby()` to group DataFrame `data` by column `'Sub-Sector'` , which contains the `.sum()` for each of the numerical (energy type) columns for each group:

See below code syntax for some guidance:

```
    ss = DataFrame_Name.groupby(by=...).sum()
```

In [7]:

```
#add your code below
grouped = data.groupby('Sub-Sector')
ss = grouped['Total'].sum()
ss = data.groupby(by='Sub-Sector').sum()
ss
```

Out[7]:

	Electricity	Natural Gas	Oil	District Heating	Other	Total
Sub-Sector						
Cafes	55	44	25	0	0	124
Clubs & community centres	29	166	84	8	0	287
Cold Stores	0	2	0	0	0	2
Fire and Ambulance stations	5	75	9	1	0	90
Hairdressers	14	11	9	0	0	34
Health Centres	10	109	4	0	0	123
Hospitals	48	1243	3	34	0	1328
Hotels	67	244	160	0	76	547
Large Distribution Centres	14	117	33	0	2	166
Large food shops	58	367	0	0	0	425
Large non-food shops	60	57	6	0	0	123
Law courts	1	21	4	0	0	26
Leisure Centres	7	178	12	19	6	222
Military civilian accommodation	1	11	0	1	0	13
Military offices	3	46	14	55	0	118
Military storage	0	55	6	51	0	112
Museums	2	13	4	0	0	19
Nurseries	5	45	17	0	0	67
Nursing Homes	4	24	9	0	0	37
Offices (private)	272	958	251	4	5	1490
Offices (public)	23	200	45	11	4	283
Places of Worship	53	414	154	13	0	634
Police stations	4	215	6	0	0	225
Prisons	4	126	32	0	0	162
Pubs	107	349	332	0	0	788
Restaurants & takeaways	342	176	394	0	0	912
Retail Warehouse	19	109	11	0	0	139
Showrooms	29	89	29	0	2	149
Small shops	272	154	106	0	0	532
State Primary schools	33	516	154	0	0	703
State Secondary schools	43	431	61	0	9	544
Stores	9	33	15	0	1	58
Theatres	2	37	3	0	1	43
Uni - Non-residential	20	308	0	46	0	374
Uni - Residential	9	85	16	39	0	149
Warehouses	56	404	651	0	3	1114

Q3. Create a new DataFrame called `use` , using `.groupby()` to group DataFrame `data` by column `'Use'` , which contains the `.sum()` for each of the numerical (energy type) columns for each group:

See below code syntax for some guidance:

```
use = DataFrame_Name.groupby(by=...).sum()
```

In [8]:

```
#add your code below
use = data.groupby(by='Use').sum()
use
```

Out[8]:

	Electricity	Natural Gas	Oil	District Heating	Other	Total
Use						
Catering	758	587	800	0	0	2145
Heating	762	6044	1602	265	0	8673
Hot Water	160	801	257	17	109	1344

Q4. Create a new DataFrame called `sector` , using `.groupby()` to group DataFrame `data` by column `'Sector'` , and make use of `.agg()` method on the `Total` column such that the new DataFrame has columns for `'sum'` , `'mean'` , and `'count'` of the values in `'Total'` :

- Use the `.sort_values()` method to sort the resulting DataFrame by `'sum'` , in *descending* order
- You may find this documentation page (https://pandas.pydata.org/pandas-docs/version/0.23.1/generated/pandas.core.groupby.DataFrameGroupBy.agg.html) useful

See below code syntax for some guidance:

```
sector = DataFrame_Name.groupby(by=...)['Total'].agg([...])
sector = sector.sort_values(by=..., ascending=...)
```

In [9]:

```
#add your code below
sector = data.groupby(by='Sector')['Total'].agg(['sum', 'mean', 'count'])
sector = sector.sort_values(by='sum', ascending=False)
sector
```

Out[9]:

	sum	mean	count
Sector			
Hospitality	2371	197.583333	12
Education	1837	122.466667	15
Offices	1773	295.500000	6
Health	1488	165.333333	9
Retail	1402	77.888889	18
Storage	1340	111.666667	12
Arts, leisure and community	1205	80.333333	15
Emergency Services	503	41.916667	12
Military	243	27.000000	9

You may want to submit your notebook to KATE to ensure your `data` , `ss` , and `use` and `sector` DataFrames are as expected before moving on to the visualisations.

Data Visualisation

Q5. Refer to the `ss` DataFrame.

Create a **histogram** from the `Electricity` column of `ss` DataFrame using the `.plot()` method: `ss['Electricity']`

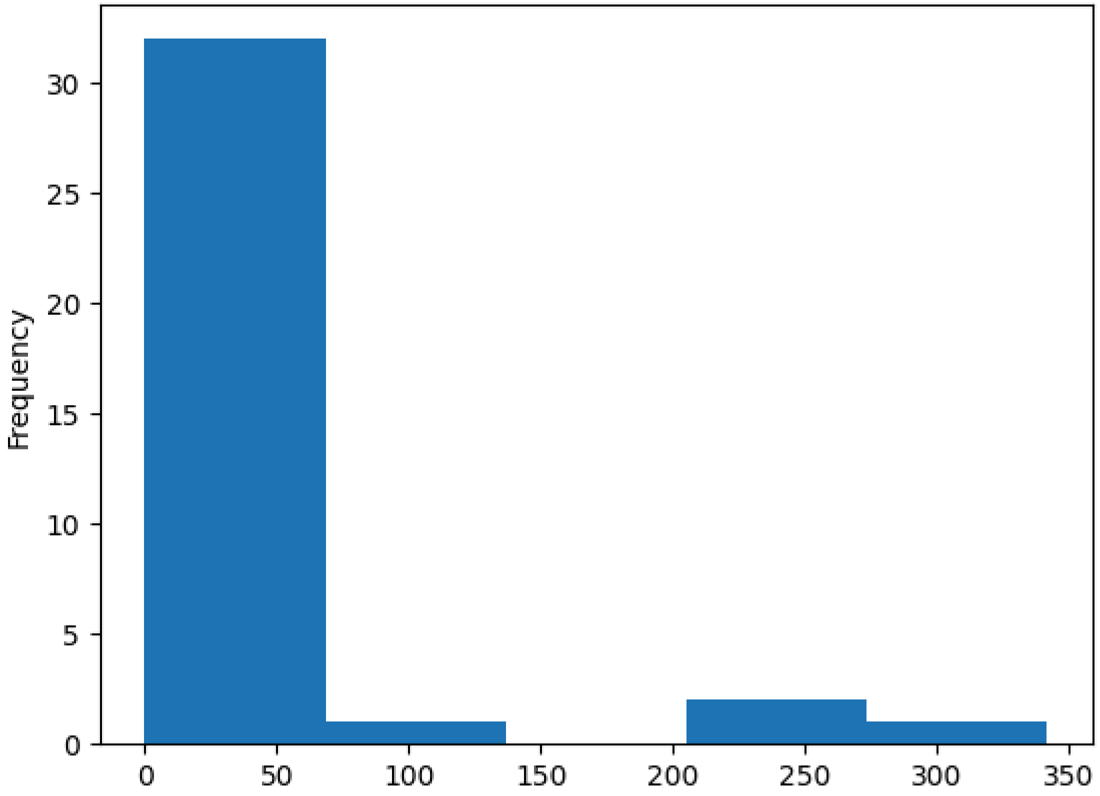
- The histogram should have 5 `bins`
- Assign the plot to the variable `elec_hist`
- Ensure your code cell starts with `plt.figure()`

See below code syntax for some guidance:

```
plt.figure()
elec_hist = DataFrame_Name.plot(kind='hist', bins=...);
```

We need to execute `plt.figure()` before creating each new plot in the notebook, otherwise the properties of previous plots will be overwritten in memory and KATE will not evaluate them correctly.

In [10]:
```
#add your code below
plt.figure()
elec_hist = ss['Electricity'].plot(kind='hist', bins=5);
```



Q6. Refer to the `ss` DataFrame.

Create a **scatter plot** of `Natural Gas` vs `Total` , to see the relationship between the two columns of `ss` DataFrame.

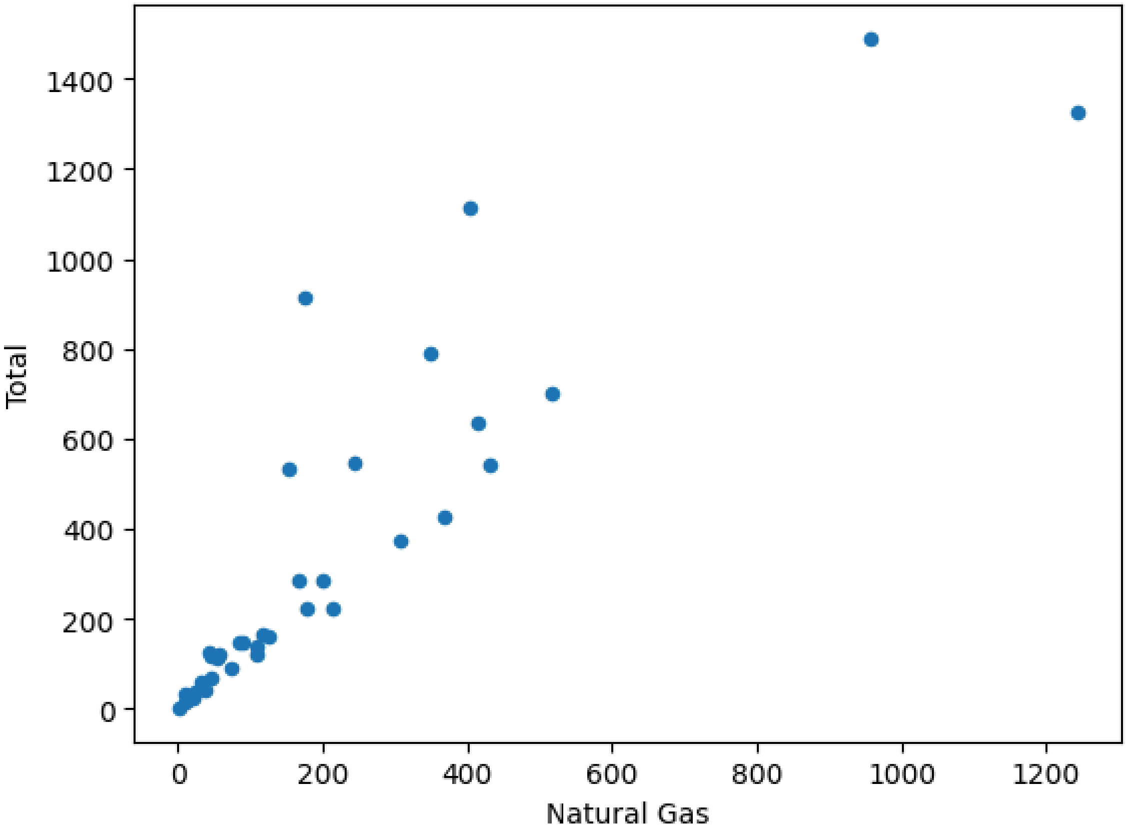
- Use the `.plot()` method on `ss` DataFrame
- Have `Natural Gas` on the `x-axis` and `Total` on the `y-axis`
- Assign the plot to the variable `gas_total`
- Ensure your code cell starts with `plt.figure()`

See below code syntax for some guidance:

```
plt.figure()
gas_total = DataFrame_Name.plot(x=..., y=..., kind='scatter');
```

```
In [11]: #add your code below
         plt.figure()
         gas_total = ss.plot(x= 'Natural Gas', y='Total', kind='scatter');
```

```
<Figure size 640x480 with 0 Axes>
```



Q7. Refer to the `sector` DataFrame.

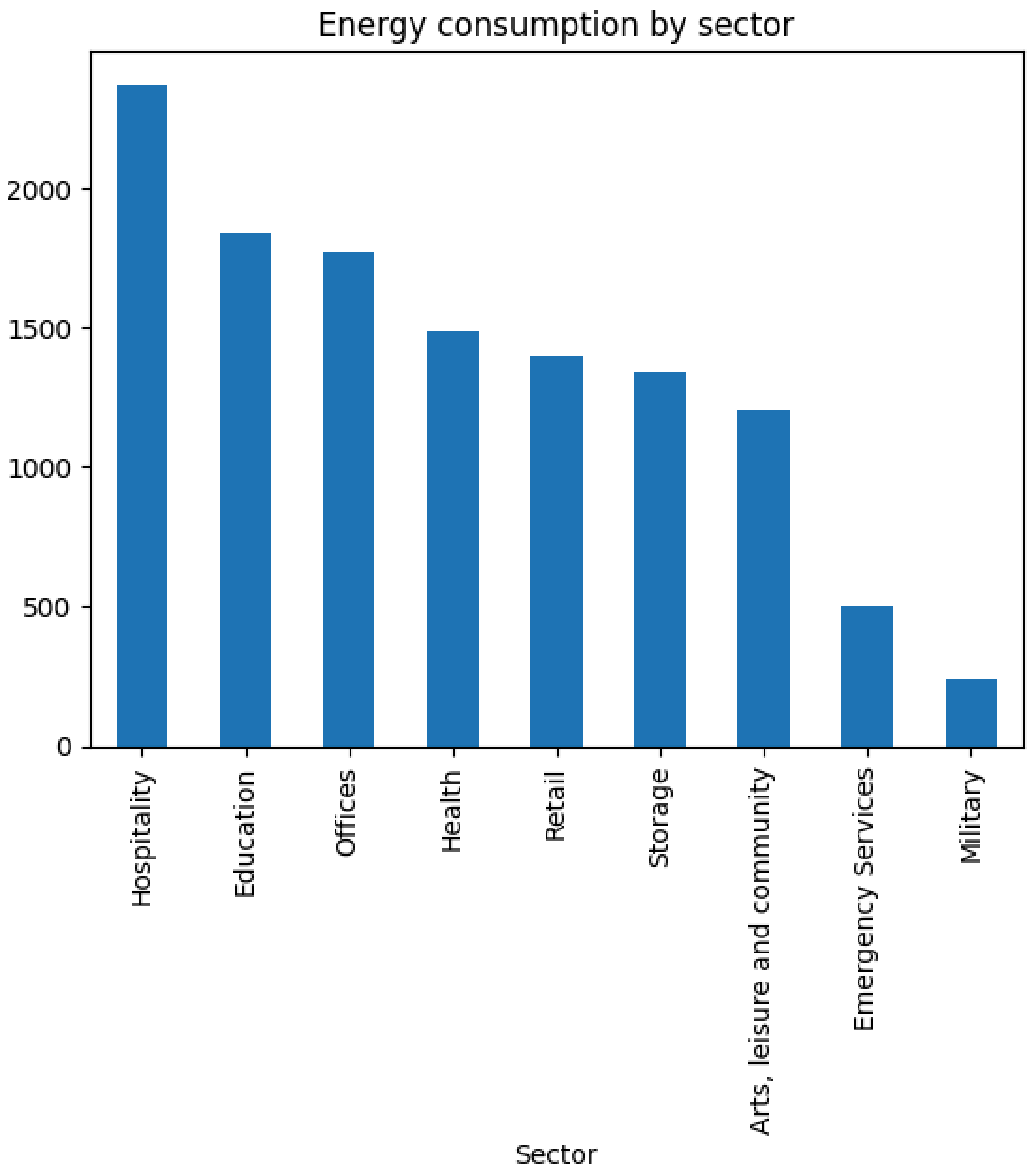
Create a **vertical bar chart** of the `'sum'` column of the `sector` DataFrame using the `.plot()` method: `sector['sum']`

- Add a title of `'Energy consumption by sector'` to the plot
- Assign the plot to the variable `sector_sum`
- Ensure your code cell starts with `plt.figure()`

See below code syntax for some guidance:

```
plt.figure()
sector_sum = DataFrame_Name.plot(kind='bar', title=...);
```

In [12]:
```
#add your code below
plt.figure()
sector_sum = sector['sum'].plot(kind='bar', title='Energy consumption by sec
```



Q8. Refer to the given `new_df_use` DataFrame, which is identical to the `use` DataFrame but excludes the `Total` column (see below for the code).

Create a *horizontal* and *stacked* bar chart from the `new_df_use` DataFrame, using the `.plot()` method:

- Assign the plot to the variable `use_type`
- Give it a `figsize` of `(12,12)`
- You may find [this page (https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.plot.barh.html)](https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.plot.barh.html) useful
- Ensure your code cell starts with `plt.figure()`

See below code syntax for some guidance:

```
plt.figure()
use_type = DataFrame_Name.plot.barh(stacked=True, figsize=(...));
```

Run the following code cell to create the DataFrame `new_df_use` :

In [13]:

```
new_df_use = use.loc[:, ['Electricity', 'Natural Gas', 'Oil', 'District Heat
new_df_use.head()
```

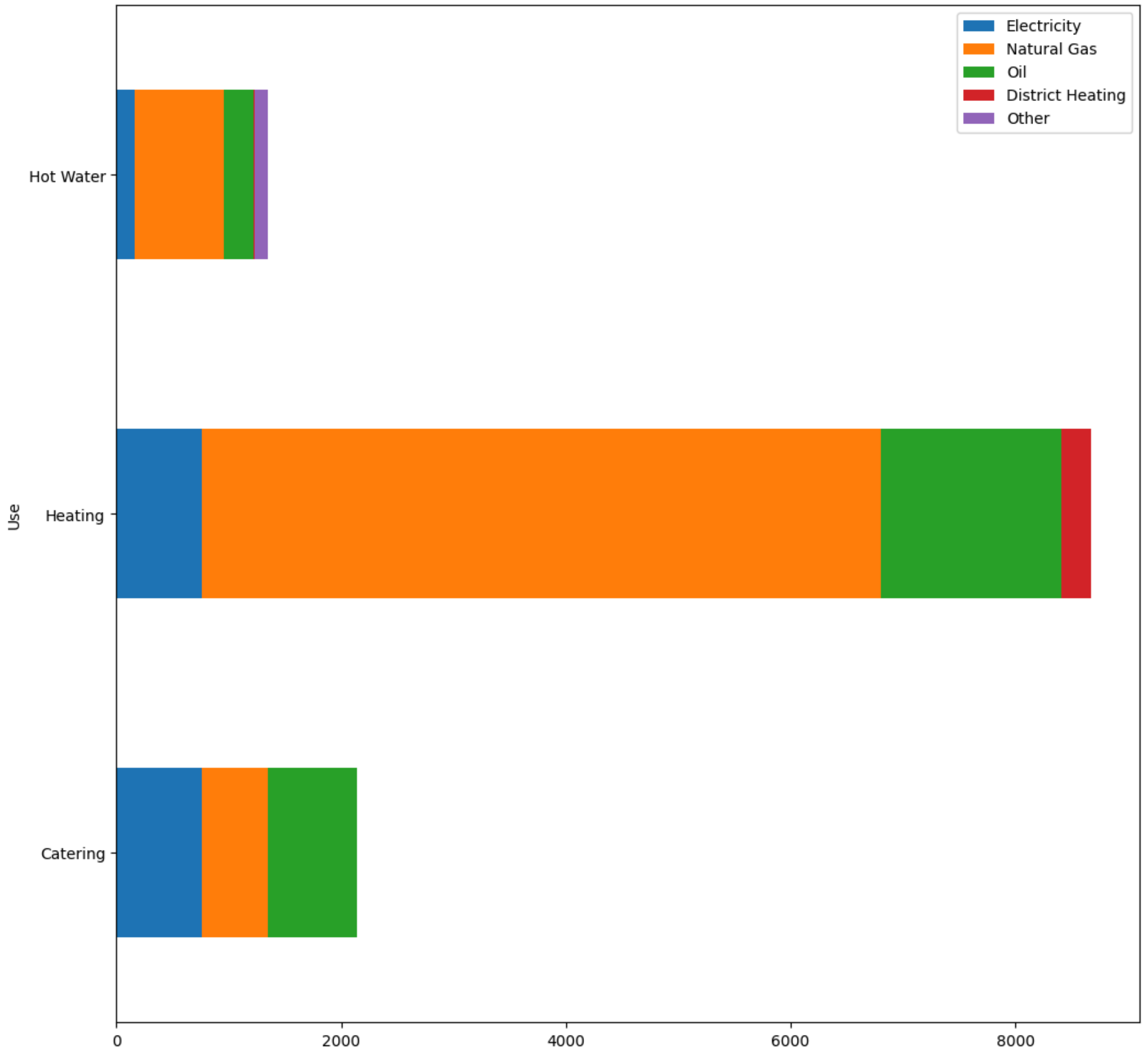
Out[13]:

	Electricity	Natural Gas	Oil	District Heating	Other
Use					
Catering	758	587	800	0	0
Heating	762	6044	1602	265	0
Hot Water	160	801	257	17	109

In [14]:

```
#add your code below
plt.figure()
use_type = new_df_use.plot.barh(stacked=True, figsize=(12,12));
```

```
<Figure size 640x480 with 0 Axes>
```



```
In [ ]:
```