Multivariate Linear Regression on ENB Dataset

In [1]:
```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, r2_score
import matplotlib.pyplot as plt
```

Load dataset

In [2]:
```
df = pd.read_csv("./dataset/energy_efficiency_data.csv")
```

In [3]:
```
# print first 5 rows
df.head()
```

Out[3]:

	Relative_Compactness	Surface_Area	Wall_Area	Roof_Area	Overall_Height	Orientati
0	0.98	514.5	294.0	110.25	7.0	
1	0.98	514.5	294.0	110.25	7.0	
2	0.98	514.5	294.0	110.25	7.0	
3	0.98	514.5	294.0	110.25	7.0	
4	0.90	563.5	318.5	122.50	7.0	

In [4]:
```
# check for missing values
df.isnull().sum()
```

Out[4]:
```
Relative_Compactness         0
Surface_Area                 0
Wall_Area                    0
Roof_Area                    0
Overall_Height               0
Orientation                  0
Glazing_Area                 0
Glazing_Area_Distribution    0
Heating_Load                 0
Cooling_Load                 0
dtype: int64
```

In [5]:
```
df.describe()
```

Out[5]:

	Relative_Compactness	Surface_Area	Wall_Area	Roof_Area	Overall_Height	Ori
count	768.000000	768.000000	768.000000	768.000000	768.00000	76
mean	0.764167	671.708333	318.500000	176.604167	5.25000	
std	0.105777	88.086116	43.626481	45.165950	1.75114	
min	0.620000	514.500000	245.000000	110.250000	3.50000	
25%	0.682500	606.375000	294.000000	140.875000	3.50000	
50%	0.750000	673.750000	318.500000	183.750000	5.25000	
75%	0.830000	741.125000	343.000000	220.500000	7.00000	
max	0.980000	808.500000	416.500000	220.500000	7.00000	

In [6]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 10 columns):
 #   Column                     Non-Null Count  Dtype  
---  ------                     --------------  -----  
 0   Relative_Compactness       768 non-null    float64
 1   Surface_Area               768 non-null    float64
 2   Wall_Area                  768 non-null    float64
 3   Roof_Area                  768 non-null    float64
 4   Overall_Height             768 non-null    float64
 5   Orientation                768 non-null    int64  
 6   Glazing_Area               768 non-null    float64
 7   Glazing_Area_Distribution  768 non-null    int64  
 8   Heating_Load               768 non-null    float64
 9   Cooling_Load               768 non-null    float64
dtypes: float64(8), int64(2)
memory usage: 60.1 KB
```

Select Features (X) and Target (y)

In [7]:

```
# Dataset has 8 features (columns 0 to 7) and 2 target variables (last 2 columns
X = df.iloc[:,:-2] # all rows, first 8 columns → features
y = df.iloc[:,8:] # all rows, last 2 columns → targets (Heating, Cooling load)
```

In [10]:

```
print("The shape of X (Features): ",X.shape)
print("The shape of y (target variables): ", y.shape)
```

```
The shape of X (Features):  (768, 8)
The shape of y (target variables):  (768, 2)
```

Split dataset into train and test samples

In [11]:

```
# 80% training and 20% testing
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2, rando
```

In [12]:

```
X_train.shape
```

Out[12]: (614, 8)

In [13]:
```
X_test.shape
```

Out[13]: (154, 8)

Train Multi-variate Linear Regression Model

In [14]:
```
model = LinearRegression()
```

In [15]:
```
model.fit(X_train, y_train)
```

Out[15]:

▾ LinearRegression

▶ Parameters

Make Predictions on test sample

In [16]:
```
y_pred = model.predict(X_test)
```

Evaluate the model performance

In [17]:
```
# Calculate error metrics
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print("\nMean Squared Error (MSE):", mse)
print("R² Score:", r2)
```

```
Mean Squared Error (MSE): 9.523307751573416
R² Score: 0.9027048110077098
```

Compare Predictions with Actual Values

In [19]:
```
print("\nFirst 5 Predictions:\n", y_pred[:5])
print("\nFirst 5 Actual Values:\n", y_test.values[:5])
```

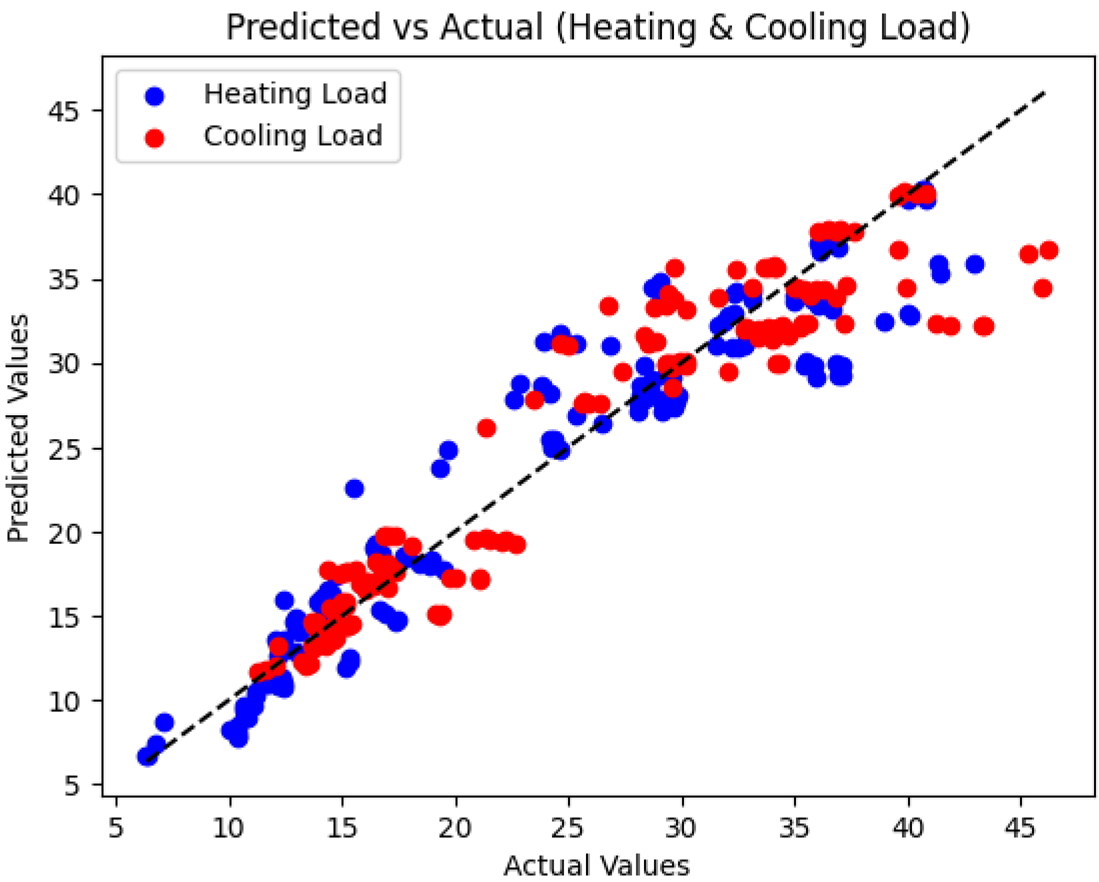
```
First 5 Predictions:
 [[18.86296033 19.75455641]
 [14.04938012 16.77160938]
 [31.31560297 32.02497722]
 [35.90050966 36.70240832]
 [15.33519734 17.27670437]]

First 5 Actual Values:
 [[16.47 16.9 ]
 [13.17 16.39]
 [32.82 32.78]
 [41.32 46.23]
 [16.69 19.76]]
```

Visualization

In [20]:

```
# Scatter plot: Predicted vs Actual for Heating Load (first target)
plt.scatter(y_test.iloc[:,0], y_pred[:,0], color="blue", label="Heating Load")
plt.scatter(y_test.iloc[:,1], y_pred[:,1], color="red", label="Cooling Load")
plt.plot([y_test.min().min(), y_test.max().max()],
         [y_test.min().min(), y_test.max().max()],
         color="black", linestyle="--")  # perfect prediction line
plt.xlabel("Actual Values")
plt.ylabel("Predicted Values")
plt.title("Predicted vs Actual (Heating & Cooling Load)")
plt.legend()
plt.show()
```



In [24]:

```
import numpy as np
# Loop through each target separately
target_names = ["Heating Load", "Cooling Load"]

for i, name in enumerate(target_names):
    mse_i = mean_squared_error(y_test.iloc[:, i], y_pred[:, i])
    r2_i = r2_score(y_test.iloc[:, i], y_pred[:, i])
    print(f"\n{name}:")
    print(f"  MSE: {mse_i:.2f}")
    print(f"  RMSE: {np.sqrt(mse_i):.2f}")
    print(f"  R²: {r2_i:.4f}")
```

```
Heating Load:
  MSE: 9.15
  RMSE: 3.03
  R²: 0.9122

Cooling Load:
  MSE: 9.89
  RMSE: 3.15
  R²: 0.8932
```

In [22]:

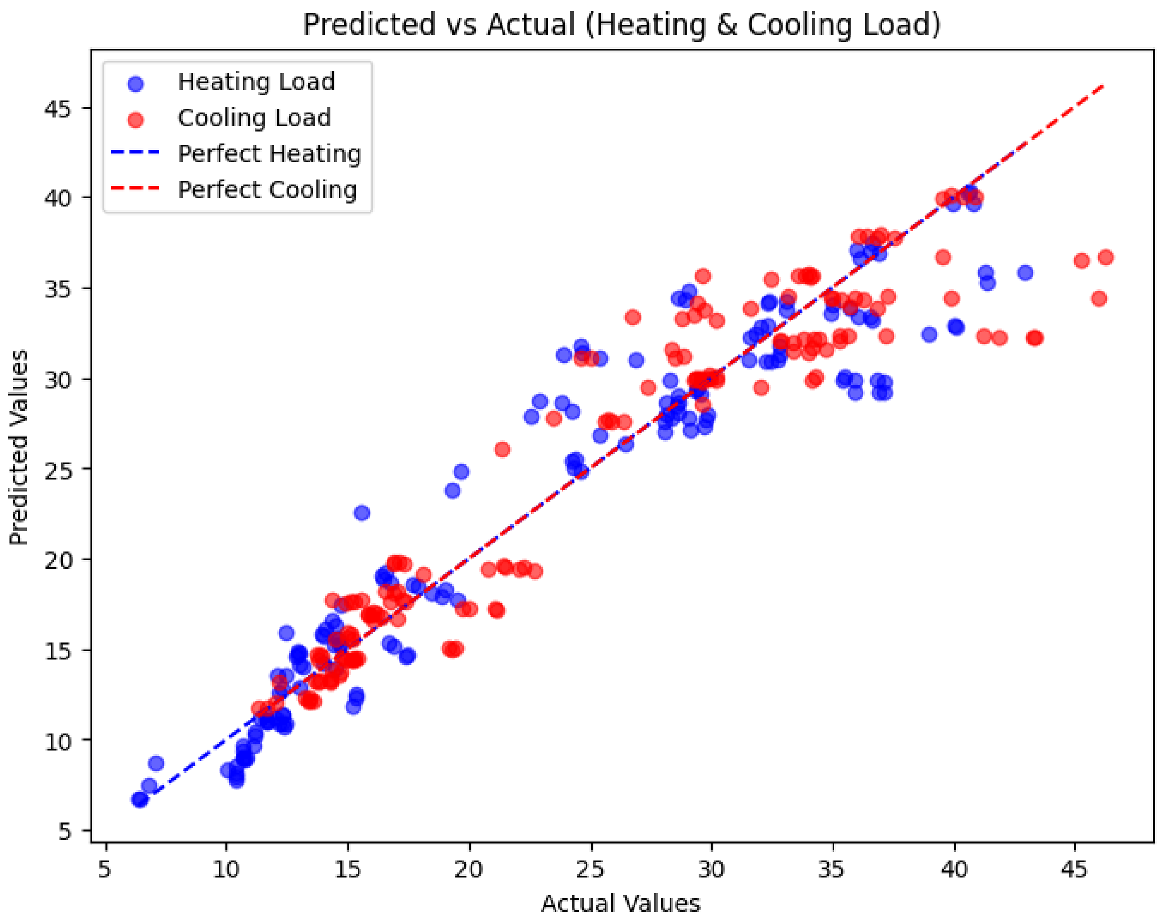
```python
plt.figure(figsize=(8,6))

# Scatter plots for actual vs predicted
plt.scatter(y_test.iloc[:,0], y_pred[:,0], color="blue", alpha=0.6, label="Heati
plt.scatter(y_test.iloc[:,1], y_pred[:,1], color="red", alpha=0.6, label="Coolin

# Heating load perfect line
plt.plot([y_test.iloc[:,0].min(), y_test.iloc[:,0].max()],
         [y_test.iloc[:,0].min(), y_test.iloc[:,0].max()],
         color="blue", linestyle="--", label="Perfect Heating")

# Cooling load perfect line
plt.plot([y_test.iloc[:,1].min(), y_test.iloc[:,1].max()],
         [y_test.iloc[:,1].min(), y_test.iloc[:,1].max()],
         color="red", linestyle="--", label="Perfect Cooling")

# Labels and title
plt.xlabel("Actual Values")
plt.ylabel("Predicted Values")
plt.title("Predicted vs Actual (Heating & Cooling Load)")
plt.legend()
plt.show()
```



Predicted vs Actual (Heating & Cooling Load)
Heating Load
Cooling Load
Perfect Heating
Perfect Cooling
Predicted Values
Actual Values
5
10
15
20
25
30
35
40
45