Project Linear Regression

In this notebook a linear regression algortihm will be used to predict the units ordered for a specific medication type

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split,cross_val_score, cross_val_predict
from sklearn import metrics
%matplotlib inline
```

Dataset

Below you can see the dataset in it's current state

In [2]:

```
df = pd.read_csv("../pharmacy_with_pop_2020.csv")
df.head()
```

Out[2]:

	Delivery Date	Pharmacy No	Pharmacy Post	YOB	Gender	CNK	Product Name	ATC	Units	Price	Contribution	Age	Age Group	Province	ATC_Classification	Medication_
0	2017-01-01	7341765	21	1923	1	5520523	WACHTHONORARIUM		0	4.90	0.00	94	90-94	Antwerp	Unknown	Unk
1	2017-01-01	7341765	21	1925	1	1799931	ZALDIAR 37,5 MG/325 MG FILMOMH TABL 20	N02AJ13	20	9.26	3.62	92	90-94	Antwerp	Nervous system	Analgesic
2	2017-01-01	8272695	16	1930	2	1719400	VASEXTEN CAPS BLIST 28 X 10 MG	C08CA12	28	19.22	4.98	87	85-89	Flemish Brabant	Cardiovascular system	Calcium ch blc
3	2017-01-01	8272695	16	1933	2	5520523	WACHTHONORARIUM		0	4.90	0.00	84	80-84	Flemish Brabant	Unknown	Unk
4	2017-01-01	9111423	10	1931	1	1750132	AACIDEXAM 5MG/ML OPL INJ FL INJ 1 X 1ML	H02AB02	1	6.15	0.39	86	85-89	Brussels	Systemic hormonal preparations, excluding repr...	Corticoste sys

Selecting properties

Below you can select the prefered medication type and frequency (Y, M, W, D)

In [26]:

```
MedicationType = 'Psychoanaleptics'
Frequency= 'M'
Province = 'Antwerp'
```

After selecting a medication type, it will be filtered from the dataset

In [27]:

```
is_Med = df['Medication_Type'] == MedicationType
df2 = df[is_Med]
df2.head()
```

Out[27]:

	Delivery Date	Pharmacy No	Pharmacy Post	YOB	Gender	CNK	Product Name	ATC	Units	Price	Contribution	Age	Age Group	Province	ATC_Classification	Medication_T
40	2017-01-01	7641438	40	1970	2	3183092	CYMBALTA 60 MG MAAGSAPRESIST. CAPS 98 X 60 MG	N06AX21	98	53.30	13.67	47	45-49	Liege	Nervous system	Psychoanale
838	2017-01-01	9123123	86	1899	0	126987	REDOMEX DIFFUCAPS CAPS 40 X 25 MG	N06AA09	40	7.22	0.91	118	100+	West Flanders	Nervous system	Psychoanale
839	2017-01-01	7056201	89	1899	0	127019	REDOMEX DIFFUCAPS CAPS 40 X 50 MG	N06AA09	40	8.83	0.89	118	100+	West Flanders	Nervous system	Psychoanale
978	2017-01-01	7067208	20	1899	0	1390343	SERLAIN 50 MG COMP PELL 30 X 50 MG	N06AB06	30	14.96	2.14	118	100+	Antwerp	Nervous system	Psychoanale
1269	2017-01-01	7122399	30	1899	0	1625672	FLUOXETINE EG CAPS 56 X 20 MG	N06AB03	56	25.74	4.26	118	100+	Flemish Brabant	Nervous system	Psychoanale

In [28]:

```
is_Prov = df['Province'] == Province
df2 = df2[is_Prov]
```

```
D:\Anaconda\lib\site-packages\ipykernel_launcher.py:2: UserWarning: Boolean Series key will be reindexed to match DataFrame index.
```

In [29]:

```
df2['Delivery Date'] = df2['Delivery Date'].astype('datetime64[ns]')
df2.head()
```

Out[29]:

Delivery Date	Pharmacy No	Pharmacy Post	YOB	Gender	CNK	Product Name	ATC	Units	Price	Contribution	Age	Age Group	Province	ATC_Classification	Medication_T

	Delivery Date	Pharmacy No	Pharmacy Post	YOB	Gender	CNK	Product Name	ATC	Units	Price	Contribution	Age	Age Group	Province	ATC_Classification	Medication_
978	2017-01-01	7067208	20	1899	0	1390343	SERLAIN 50 MG COMP PELL 30 X 50 MG	N06AB06	30	14.96	2.14	118	100+	Antwerp	Nervous system	Psychoanale
2435	2017-01-01	3790968	21	1899	0	2967065	SERLAIN 50 MG COMP PELL 100 X 50 MG	N06AB06	100	32.58	5.24	118	100+	Antwerp	Nervous system	Psychoanale
2483	2017-01-01	7084071	20	1899	0	2999860	SIPRALEXA 10 MG TABL 98 X 10 MG	N06AB10	98	26.78	9.88	118	100+	Antwerp	Nervous system	Psychoanale
2592	2017-01-01	7084071	20	1899	0	3179959	DEANXIT 10 MG FILMOMH TABL 30 X 10 MG/0,5 MG	N06CA02	30	6.28	6.28	118	100+	Antwerp	Nervous system	Psychoanale
2607	2017-01-01	7122423	20	1899	0	3183092	CYMBALTA 60 MG MAAGSAPRESIST. CAPS 98 X 60 MG	N06AX21	98	53.30	8.12	118	100+	Antwerp	Nervous system	Psychoanale

Create a new dataframe

Now it has to create a new dataframe to sum the units on the selected frequency

In [30]:

```
res = df2.set_index('Delivery Date').groupby([pd.Grouper(freq=Frequency), 'Total Population', 'Age Group'])['Units'].sum().reset_index()

print(res)
```

```
    Delivery Date  Total Population Age Group   Units
0      2017-01-31             270.0      100+     566
1      2017-01-31            2778.0     95-99    2062
2      2017-01-31           13563.0     90-94   10990
3      2017-01-31           34356.0     85-89   30608
4      2017-01-31           53729.0     80-84   49862
..            ...               ...       ...     ...
869    2020-07-31          120343.0     45-49   66628
870    2020-07-31          121504.0     30-34   32988
871    2020-07-31          123123.0     35-39   41350
872    2020-07-31          128978.0     50-54   91270
873    2020-07-31          132846.0     55-59  111436

[874 rows x 4 columns]
```

In [31]:

```
res['Month'] = 0
res['Month'] = pd.DatetimeIndex(res['Delivery Date']).month
res.head()
```

Out[31]:

	Delivery Date	Total Population	Age Group	Units	Month
0	2017-01-31	270.0	100+	566	1
1	2017-01-31	2778.0	95-99	2062	1
2	2017-01-31	13563.0	90-94	10990	1
3	2017-01-31	34356.0	85-89	30608	1
4	2017-01-31	53729.0	80-84	49862	1

Converting the age groups

To be able to use the age groups it has to be converted to numerical data, so we do that by changing '0-4' to a 1, '5-9' to a 2, etc.

In [32]:

```
res['Age'] = 0
res['Age'] = res['Age Group'].map( {'0-4': 1, '5-9': 2, '10-14': 3, '15-19': 4, '20-24': 5, '25-29': 6, '30-34': 7, '35-39': 8, '40-44': 9, '45-49
res.head(5)
```

Out[32]:

	Delivery Date	Total Population	Age Group	Units	Month	Age
0	2017-01-31	270.0	100+	566	1	20
1	2017-01-31	2778.0	95-99	2062	1	20
2	2017-01-31	13563.0	90-94	10990	1	19
3	2017-01-31	34356.0	85-89	30608	1	18
4	2017-01-31	53729.0	80-84	49862	1	17

In [ ]:

In [33]:

```
res['Total Population'] = res['Total Population'].astype(float)
res.dtypes
res = res.reset_index()
res.head()
```

Out[33]:

	index	Delivery Date	Total Population	Age Group	Units	Month	Age
0	0	2017-01-31	270.0	100+	566	1	20
1	1	2017-01-31	2778.0	95-99	2062	1	20

	index	Delivery Date	Total Population	Age Group	Units	Month	Age
2	2	2017-01-31	13563.0	90-94	10990	1	19
3	3	2017-01-31	34356.0	85-89	30608	1	18
4	4	2017-01-31	53729.0	80-84	49862	1	17

Swapping column placement

To normalize the data it is easier when the columns that are to be normalized are al next to each other so Age Group and Age are swapped

In [34]:

```
cols = list(res.columns)
a, b = cols.index('Age Group'), cols.index('Age')
cols[b], cols[a] = cols[a], cols[b]
res = res[cols]
```

Normalizing the data

To make sure that the data shares a common scale we use the minmaxscaler to normalize the data

In [35]:

```
from sklearn.preprocessing import MinMaxScaler
minmax = MinMaxScaler()
res[[i for i in list(res.columns)[2:5]]] = minmax.fit_transform(res[[i for i in list(res.columns)[2:5]]])
print(res)
```

```
     index Delivery Date  Total Population       Age     Units  Month  \
0        0    2017-01-31          0.000385  1.000000  0.003593      1   
1        1    2017-01-31          0.018964  1.000000  0.013437      1   
2        2    2017-01-31          0.098855  0.947368  0.072185      1   
3        3    2017-01-31          0.252882  0.894737  0.201277      1   
4        4    2017-01-31          0.396390  0.842105  0.327973      1   
..     ...           ...               ...       ...       ...    ...   
869    869    2020-07-31          0.889841  0.473684  0.438297      7   
870    870    2020-07-31          0.898441  0.315789  0.216938      7   
871    871    2020-07-31          0.910434  0.368421  0.271962      7   
872    872    2020-07-31          0.953806  0.526316  0.600447      7   
873    873    2020-07-31          0.982459  0.578947  0.733145      7   

    Age Group  
0        100+  
1       95-99  
2       90-94  
3       85-89  
4       80-84  
..        ...  
869     45-49  
870     30-34  
871     35-39  
872     50-54  
873     55-59  

[874 rows x 7 columns]
```

Creating the model

After all the preprocessing the model can be made, we use Total Population and Age to predict the Units

Multiple Linear Regression

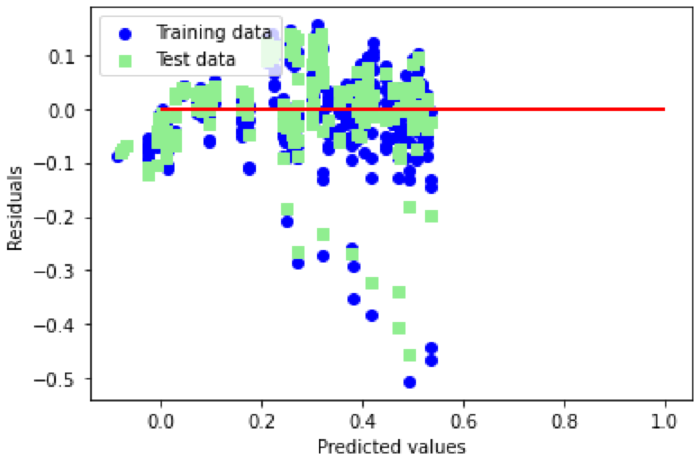
In [36]:

```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
X = res[['Total Population', 'Age']].values
y = res['Units'].values
X_train, X_test, y_train, y_test = train_test_split(
     X, y, test_size=0.3, random_state=0
)
slr = LinearRegression()
slr.fit(X_train, y_train)
y_train_pred = slr.predict(X_train)
y_test_pred = slr.predict(X_test)
print('Slope: %.3f' % slr.coef_[0])
print('Intercept: %.3f' % slr.intercept_)
```

```
Slope: 0.831
Intercept: -0.706
```

In [37]:

```
plt.scatter(y_train_pred, y_train_pred - y_train,
    c='blue', marker='o', label='Training data'
)
plt.scatter(y_test_pred,  y_test_pred - y_test,
    c='lightgreen', marker='s', label='Test data'
)
plt.xlabel('Predicted values')
plt.ylabel('Residuals')
plt.legend(loc='upper left')
plt.hlines(y=0, xmin=-0, xmax=1, lw=2, color='red')
plt.show()
```



Measuring accuracy

After making the model we can check it's accuracy and visualize it by plotting a bar chart

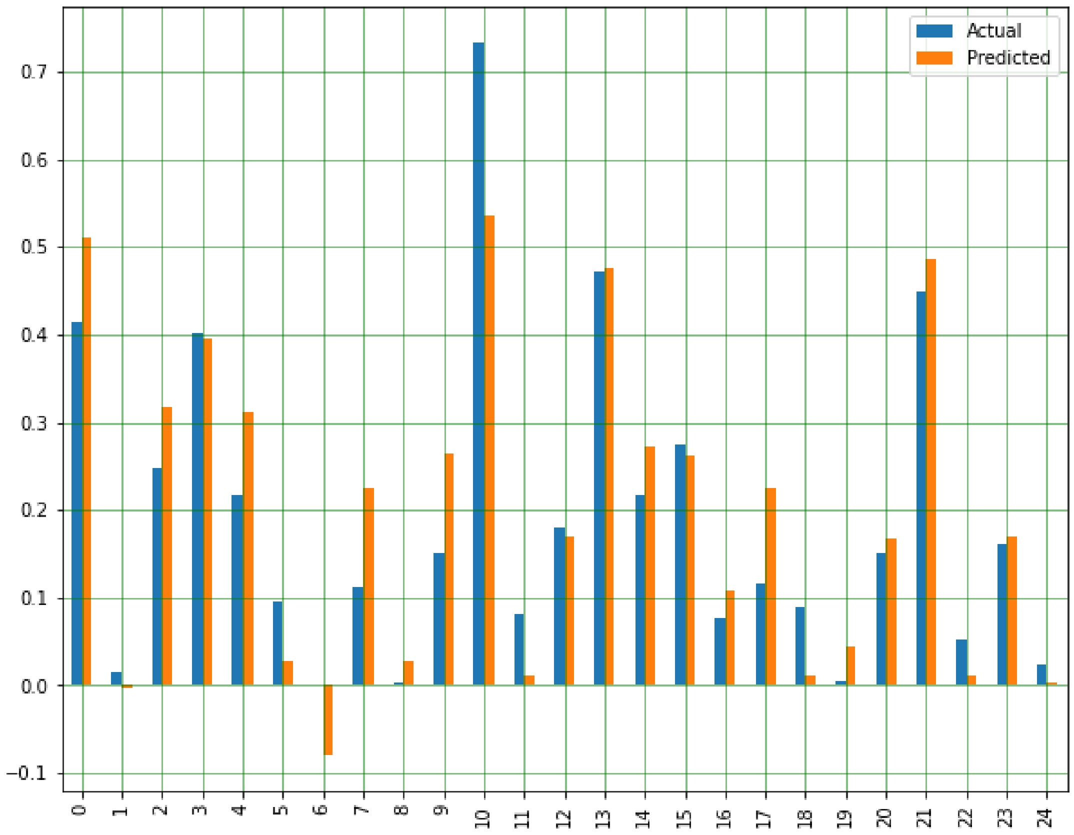
In [38]:

```
from sklearn.metrics import median_absolute_error
from sklearn.metrics import mean_squared_error
from sklearn.metrics import r2_score
print("Mean Squared Error: ",mean_squared_error(y_test, y_test_pred))
errors = abs(y_test_pred-y_test)
print('Mean Absolute Error:', round(np.mean(errors), 2))
print('R2 score: ',r2_score(y_test, y_test_pred))
#print('Median Absolute Error: ',median_absolute_error(y_test, y_test_pred))
print('Linear Regression Accuracy: ', slr.score(X_test,y_test)*100)

y_pred_kf_lr = cross_val_predict(slr, X, y, cv=15 )

#Mutiple Linear Regression Accuracy with cross validation (KFold method)
accuracy_lf = metrics.r2_score(y, y_pred_kf_lr)
print('Cross-Predicted(KFold) Mutiple Linear Regression Accuracy: ', accuracy_lf*100)
```

```
Mean Squared Error:  0.006835606428476987
Mean Absolute Error: 0.06
R2 score:  0.8213313151698411
Linear Regression Accuracy:  82.13313151698412
Cross-Predicted(KFold) Mutiple Linear Regression Accuracy:  82.92948083861829
```

In [39]:

```
df1 = pd.DataFrame({'Actual': y_test, 'Predicted': y_test_pred})
df2 = df1.head(25)
df2.plot(kind='bar',figsize=(10,8))
plt.grid(which='major', linestyle='-', linewidth='0.5', color='green')
plt.grid(which='minor', linestyle=':', linewidth='0.5', color='black')
plt.show()
```



Gradient Boosting Regression

In [47]:

```
from sklearn.ensemble import GradientBoostingRegressor

X = res[['Total Population', 'Age']].values
y = res['Units'].values
X_train, X_test, y_train, y_test = train_test_split(
     X, y, test_size=0.3, random_state=0
)
gbr = GradientBoostingRegressor()
gbr.fit(X_train, y_train)
y_train_pred = gbr.predict(X_train)
y_test_pred = gbr.predict(X_test)
#print('Slope: %.3f' % slr.coef_[0])
#print('Intercept: %.3f' % slr.intercept_)
```

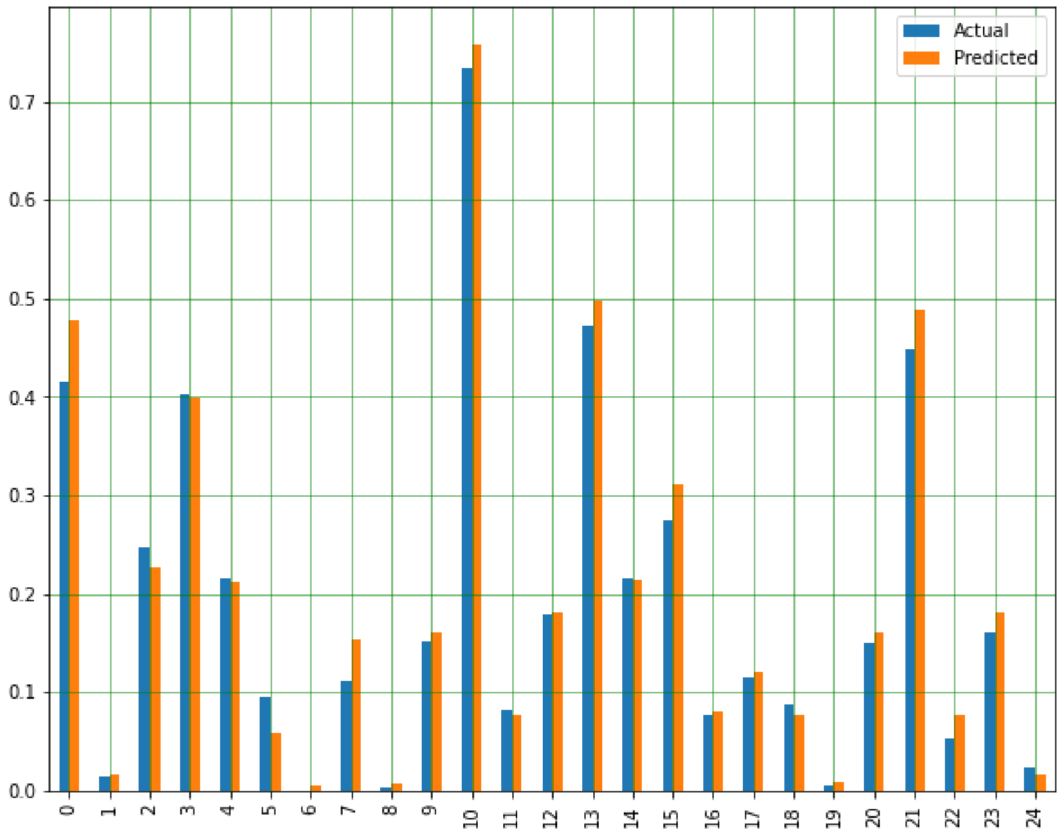
Measuring accuracy

After making the model we can check it's accuracy and visualize it by plotting a bar chart

In [41]:

```
#After making the model we can check it's accuracy and visualize it by plotting a bar chart

print("Mean Squared Error: ",mean_squared_error(y_test, y_test_pred))
errors = abs(y_test_pred-y_test)
print('Mean Absolute Error:', round(np.mean(errors), 2))
print('R2 score: ',r2_score(y_test, y_test_pred))
#print('Median Absolute Error: ',median_absolute_error(y_test, y_test_pred))
print('Gradient Boosting Regression Accuracy: ', gbr.score(X_test,y_test)*100)

y_pred_kf_gbr = cross_val_predict(gbr, X, y, cv=15 )

#Mutiple Linear Regression Accuracy with cross validation (KFold method)
accuracy_gbr = metrics.r2_score(y, y_pred_kf_gbr)
print('Cross-Predicted(KFold) Gradient Boosting Regression Accuracy: ', accuracy_gbr*100)
df1 = pd.DataFrame({'Actual': y_test, 'Predicted': y_test_pred})
df2 = df1.head(25)
df2.plot(kind='bar',figsize=(10,8))
plt.grid(which='major', linestyle='-', linewidth='0.5', color='green')
plt.grid(which='minor', linestyle=':', linewidth='0.5', color='black')
plt.show()
```

```
Mean Squared Error:  0.002947393490868686
Mean Absolute Error: 0.03
R2 score:  0.9229611996827894
Gradient Boosting Regression Accuracy:  92.29611996827894
Cross-Predicted(KFold) Gradient Boosting Regression Accuracy:  91.29400006973245
```



Random Forest Regression

In [49]:

```
from sklearn.ensemble import RandomForestRegressor

X = res[['Total Population', 'Age']].values
y = res['Units'].values
X_train, X_test, y_train, y_test = train_test_split(
     X, y, test_size=0.3, random_state=0
)

rbf = RandomForestRegressor()
rbf.fit(X_train, y_train)
y_train_pred = rbf.predict(X_train)
y_test_pred = rbf.predict(X_test)
```

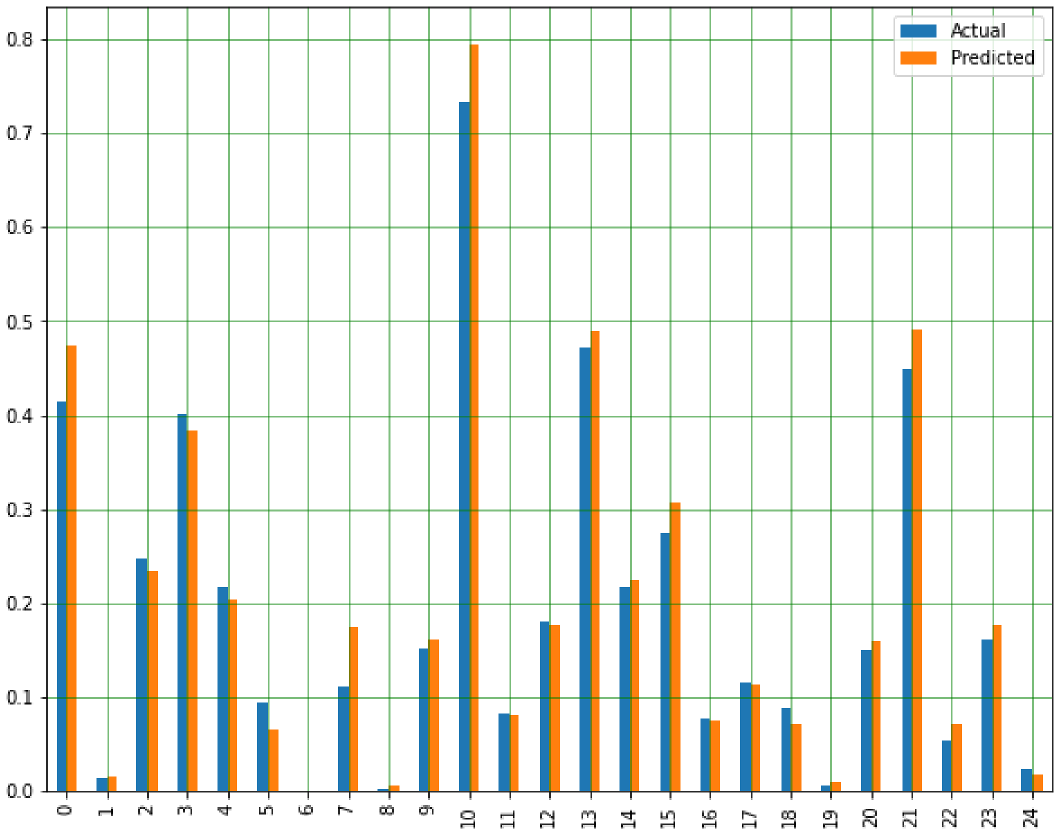
Measuring accuracy

After making the model we can check it's accuracy and visualize it by plotting a bar chart

In [43]:

```
print("Mean Squared Error: ",mean_squared_error(y_test, y_test_pred))
errors = abs(y_test_pred-y_test)
print('Mean Absolute Error:', round(np.mean(errors), 2))
print('R2 score: ',r2_score(y_test, y_test_pred))
#print('Median Absolute Error: ',median_absolute_error(y_test, y_test_pred))
print('Random Forest Regression Accuracy: ', rbf.score(X_test,y_test)*100)

y_pred_kf_rbf = cross_val_predict(rbf, X, y, cv=15 )

#Mutiple Linear Regression Accuracy with cross validation (KFold method)
accuracy_rbf = metrics.r2_score(y, y_pred_kf_rbf)
print('Cross-Predicted(KFold) Random Forest Regression Accuracy: ', accuracy_rbf*100)

df1 = pd.DataFrame({'Actual': y_test, 'Predicted': y_test_pred})
df2 = df1.head(25)
df2.plot(kind='bar',figsize=(10,8))
plt.grid(which='major', linestyle='-', linewidth='0.5', color='green')
plt.grid(which='minor', linestyle=':', linewidth='0.5', color='black')
plt.show()
```

```
Mean Squared Error:  0.0027799435387319224
Mean Absolute Error: 0.03
R2 score:  0.9273379968311026
Random Forest Regression Accuracy:  92.73379968311026
Cross-Predicted(KFold) Random Forest Regression Accuracy:  90.92974004846775
```



Decision Tree Regression

In [44]:

```
from sklearn.tree import DecisionTreeRegressor
X = res[['Total Population', 'Age']].values
y = res['Units'].values
X_train, X_test, y_train, y_test = train_test_split(
     X, y, test_size=0.3, random_state=0
)
dtr = DecisionTreeRegressor()
dtr.fit(X_train, y_train)
y_train_pred = dtr.predict(X_train)
y_test_pred = dtr.predict(X_test)
```

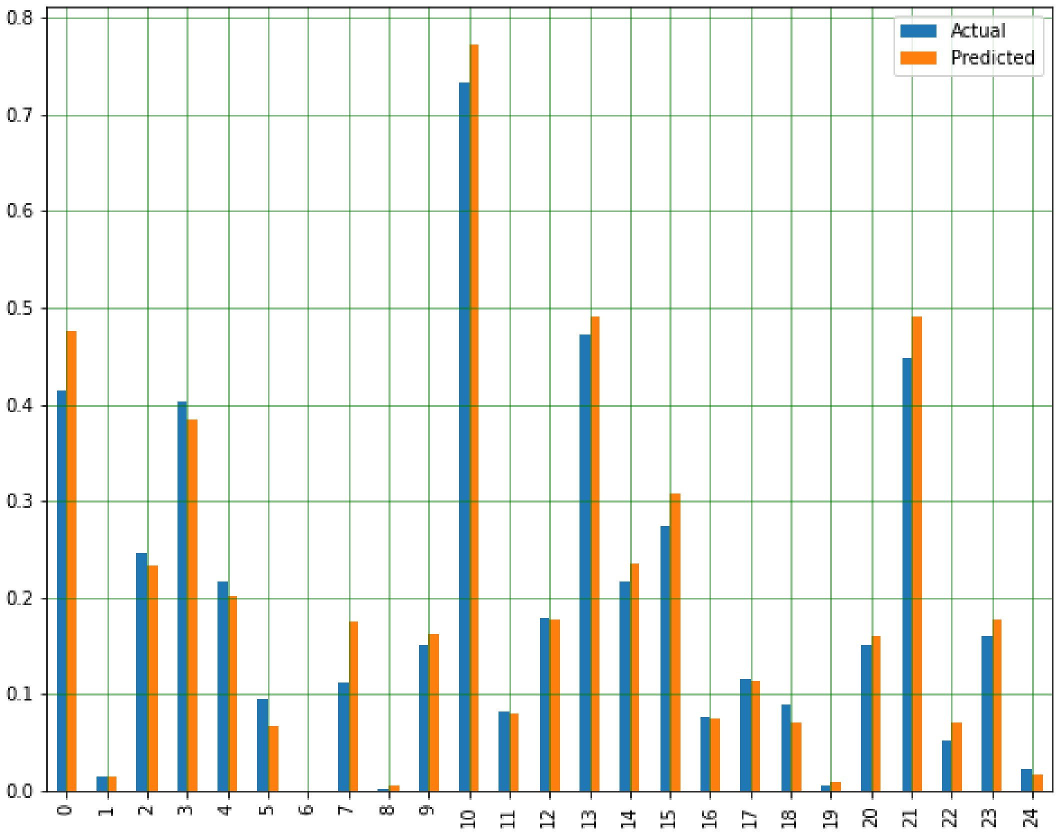
Measuring accuracy

After making the model we can check it's accuracy and visualize it by plotting a bar chart

In [45]:

```
print("Mean Squared Error: ",mean_squared_error(y_test, y_test_pred))
errors = abs(y_test_pred-y_test)
print('Mean Absolute Error:', round(np.mean(errors), 2))
print('R2 score: ',r2_score(y_test, y_test_pred))
#print('Median Absolute Error: ',median_absolute_error(y_test, y_test_pred))
print('Decision Tree Accuracy: ', dtr.score(X_test,y_test)*100)

y_pred_kf_dtr = cross_val_predict(dtr, X, y, cv=15 )

#Mutiple Linear Regression Accuracy with cross validation (KFold method)
accuracy_dtr = metrics.r2_score(y, y_pred_kf_dtr)
print('Cross-Predicted(KFold) Decision Tree Regression Accuracy: ', accuracy_dtr*100)

df1 = pd.DataFrame({'Actual': y_test, 'Predicted': y_test_pred})
df2 = df1.head(25)
df2.plot(kind='bar',figsize=(10,8))
plt.grid(which='major', linestyle='-', linewidth='0.5', color='green')
plt.grid(which='minor', linestyle=':', linewidth='0.5', color='black')
plt.show()
```

```
Mean Squared Error:  0.0027293923925480893
Mean Absolute Error: 0.03
R2 score:  0.9286592997615486
Decision Tree Accuracy:  92.86592997615486
Cross-Predicted(KFold) Decision Tree Regression Accuracy:  90.7617443067702
```


Actual
Predicted