In [1]:
```
import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

In [3]:
```
from statsmodels.tsa.statespace.sarimax import SARIMAX
from pmdarima import auto_arima
from statsmodels.tsa.seasonal import seasonal_decompose


```

In [7]:
```
from sklearn.metrics  import mean_absolute_percentage_error,mean_sq
```

In [8]:
```
import scipy.stats  as stats
```

In [9]:
```
df=pd.read_csv('RestaurantVisitors.csv',index_col='date',parse_date
```

In [10]:
```
df
```

Out[10]:

date	weekday	holiday	holiday_name	rest1	rest2	rest3	rest4	total
2016-01-01	Friday	1	New Year's Day	65.0	25.0	67.0	139.0	296.0
2016-01-02	Saturday	0	na	24.0	39.0	43.0	85.0	191.0
2016-01-03	Sunday	0	na	24.0	31.0	66.0	81.0	202.0
2016-01-04	Monday	0	na	23.0	18.0	32.0	32.0	105.0
2016-01-05	Tuesday	0	na	2.0	15.0	38.0	43.0	98.0
...	...	...	...	...	...	...	...	...
2017-05-27	Saturday	0	na	NaN	NaN	NaN	NaN	NaN
2017-05-28	Sunday	0	na	NaN	NaN	NaN	NaN	NaN
2017-05-29	Monday	1	Memorial Day	NaN	NaN	NaN	NaN	NaN
2017-05-30	Tuesday	0	na	NaN	NaN	NaN	NaN	NaN
2017-05-31	Wednesday	0	na	NaN	NaN	NaN	NaN	NaN

517 rows × 8 columns

In [11]:
```
df.index.freq='D'
```

In [12]:
```
df.tail()
```

Out[12]:

date	weekday	holiday	holiday_name	rest1	rest2	rest3	rest4	total
2017-05-27	Saturday	0	na	NaN	NaN	NaN	NaN	NaN
2017-05-28	Sunday	0	na	NaN	NaN	NaN	NaN	NaN
2017-05-29	Monday	1	Memorial Day	NaN	NaN	NaN	NaN	NaN
2017-05-30	Tuesday	0	na	NaN	NaN	NaN	NaN	NaN
2017-05-31	Wednesday	0	na	NaN	NaN	NaN	NaN	NaN

In [13]:
```
df1=df.dropna()
df1.tail()
```

Out[13]:

date	weekday	holiday	holiday_name	rest1	rest2	rest3	rest4	total
2017-04-18	Tuesday	0	na	30.0	30.0	13.0	18.0	91.0
2017-04-19	Wednesday	0	na	20.0	11.0	30.0	18.0	79.0
2017-04-20	Thursday	0	na	22.0	3.0	19.0	46.0	90.0
2017-04-21	Friday	0	na	38.0	53.0	36.0	38.0	165.0
2017-04-22	Saturday	0	na	97.0	20.0	50.0	59.0	226.0

In [14]:
```
df1.info()
```

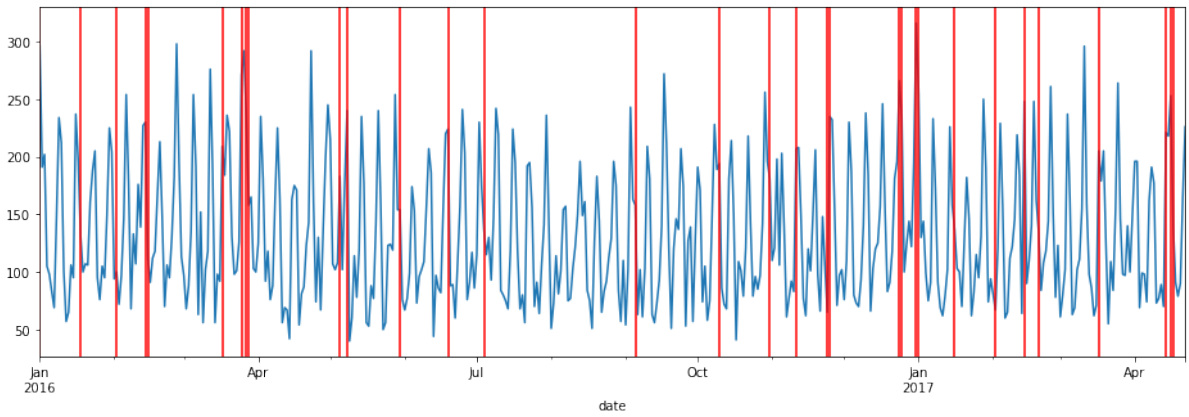
```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 478 entries, 2016-01-01 to 2017-04-22
Freq: D
Data columns (total 8 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   weekday       478 non-null    object 
 1   holiday       478 non-null    int64  
 2   holiday_name  478 non-null    object 
 3   rest1         478 non-null    float64
 4   rest2         478 non-null    float64
 5   rest3         478 non-null    float64
 6   rest4         478 non-null    float64
 7   total         478 non-null    float64
dtypes: float64(5), int64(1), object(2)
memory usage: 33.6+ KB
```

In [17]:
```
cols=['rest1','rest2','rest3','rest4','total']
for col in cols:
    df1[col]=df1[col].astype(int)
```

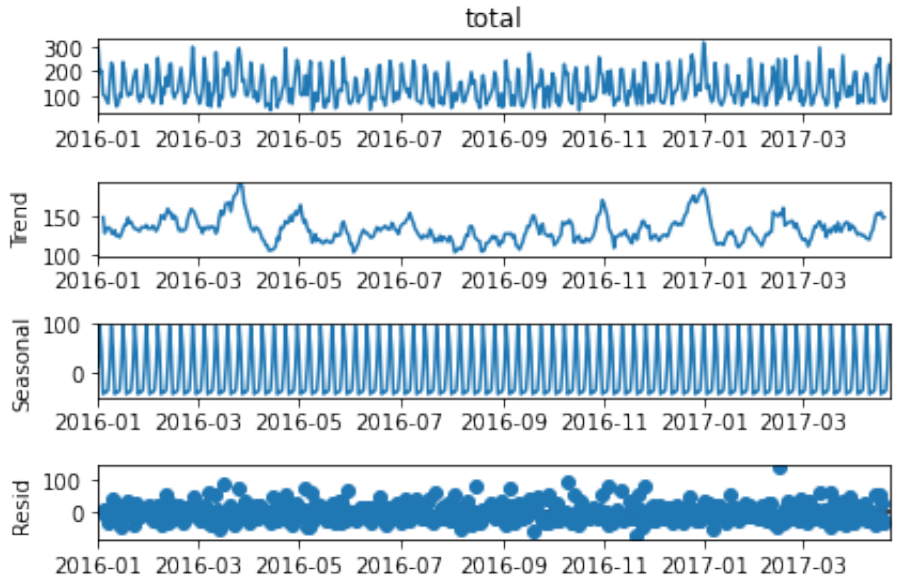
In [18]:
```
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 478 entries, 2016-01-01 to 2017-04-22
Freq: D
Data columns (total 8 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   weekday       478 non-null    object 
 1   holiday       478 non-null    int64  
 2   holiday_name  478 non-null    object 
 3   rest1         478 non-null    int64  
 4   rest2         478 non-null    int64  
 5   rest3         478 non-null    int64  
 6   rest4         478 non-null    int64  
 7   total         478 non-null    int64  
dtypes: int64(6), object(2)
memory usage: 33.6+ KB
```

In [19]:
```
ax=df1['total'].plot(figsize=(16,5))
for x in df1.query('holiday==1').index:
    ax.axvline(x=x,color='r')
```



In [20]:
```
result=seasonal_decompose(df1['total'])
result.plot();
```



In [21]:
```
auto_arima(df1['total'],seasonal=True,m=7,trace=True).summary()
```

```
Performing stepwise search to minimize aic
 ARIMA(2,0,2)(1,0,1)[7] intercept   : AIC=inf, Time=1.03 sec
 ARIMA(0,0,0)(0,0,0)[7] intercept   : AIC=5269.484, Time=0.01 sec
 ARIMA(1,0,0)(1,0,0)[7] intercept   : AIC=4916.749, Time=0.34 sec
 ARIMA(0,0,1)(0,0,1)[7] intercept   : AIC=5049.644, Time=0.20 sec
 ARIMA(0,0,0)(0,0,0)[7]             : AIC=6126.084, Time=0.01 sec
 ARIMA(1,0,0)(0,0,0)[7] intercept   : AIC=5200.790, Time=0.06 sec
 ARIMA(1,0,0)(2,0,0)[7] intercept   : AIC=4845.442, Time=0.89 sec
 ARIMA(1,0,0)(2,0,1)[7] intercept   : AIC=inf, Time=1.14 sec
 ARIMA(1,0,0)(1,0,1)[7] intercept   : AIC=4816.600, Time=0.53 sec
 ARIMA(1,0,0)(0,0,1)[7] intercept   : AIC=5058.642, Time=0.25 sec
 ARIMA(1,0,0)(1,0,2)[7] intercept   : AIC=4951.803, Time=0.97 sec
 ARIMA(1,0,0)(0,0,2)[7] intercept   : AIC=4982.776, Time=0.45 sec
```

```
 ARIMA(1,0,0)(2,0,2)[7] intercept   : AIC=inf, Time=1.24 sec
 ARIMA(0,0,0)(1,0,1)[7] intercept   : AIC=4770.490, Time=0.49 sec
 ARIMA(0,0,0)(0,0,1)[7] intercept   : AIC=5093.130, Time=0.09 sec
 ARIMA(0,0,0)(1,0,0)[7] intercept   : AIC=4926.360, Time=0.23 sec
 ARIMA(0,0,0)(2,0,1)[7] intercept   : AIC=4975.347, Time=1.11 sec
 ARIMA(0,0,0)(1,0,2)[7] intercept   : AIC=4968.926, Time=0.74 sec
 ARIMA(0,0,0)(0,0,2)[7] intercept   : AIC=5010.582, Time=0.29 sec
 ARIMA(0,0,0)(2,0,0)[7] intercept   : AIC=4859.638, Time=1.22 sec
 ARIMA(0,0,0)(2,0,2)[7] intercept   : AIC=inf, Time=1.07 sec
 ARIMA(0,0,1)(1,0,1)[7] intercept   : AIC=inf, Time=0.62 sec
 ARIMA(1,0,1)(1,0,1)[7] intercept   : AIC=inf, Time=0.73 sec
 ARIMA(0,0,0)(1,0,1)[7]             : AIC=inf, Time=0.14 sec

Best model:  ARIMA(0,0,0)(1,0,1)[7] intercept
Total fit time: 13.897 seconds
```

Out[21]:

SARIMAX Results

Dep. Variable:	y	**No. Observations:**	478
Model:	SARIMAX(1, 0, [1], 7)	**Log Likelihood**	-2381.245
Date:	Tue, 26 Apr 2022	**AIC**	4770.490
Time:	06:55:33	**BIC**	4787.169
Sample:	0	**HQIC**	4777.048
	- 478		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
intercept	4.0723	1.600	2.545	0.011	0.936	7.209
ar.S.L7	0.9680	0.012	81.909	0.000	0.945	0.991
ma.S.L7	-0.7313	0.051	-14.451	0.000	-0.830	-0.632
sigma2	1248.4033	75.522	16.530	0.000	1100.384	1396.423

Ljung-Box (L1) (Q):	14.32	**Jarque-Bera (JB):**	59.98
Prob(Q):	0.00	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.87	**Skew:**	0.71
Prob(H) (two-sided):	0.38	**Kurtosis:**	4.01

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

In [22]:
```
train=df1.iloc[:436]
test=df1.iloc[436:]
len(test)
```

Out[22]: 42

In [23]:
```
model=SARIMAX(train['total'],order=(0,0,0),seasonal_order=(1,0,1,7)
model.summary()
```

```
RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            3     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  5.01719D+00    |proj g|=  8.65114D-02

At iterate    5    f=  4.98913D+00    |proj g|=  3.10711D-02

At iterate   10    f=  4.97484D+00    |proj g|=  1.66063D-02

At iterate   15    f=  4.96669D+00    |proj g|=  5.66525D-04

At iterate   20    f=  4.96644D+00    |proj g|=  2.66764D-06

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    3     20     24      1     0     0   2.668D-06   4.966D+00
  F =   4.9664421023955105

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL

 This problem is unconstrained.
```

Out[23]:

SARIMAX Results

Dep. Variable:	total	**No. Observations:**	436
Model:	SARIMAX(1, 0, [1], 7)	**Log Likelihood**	-2165.369

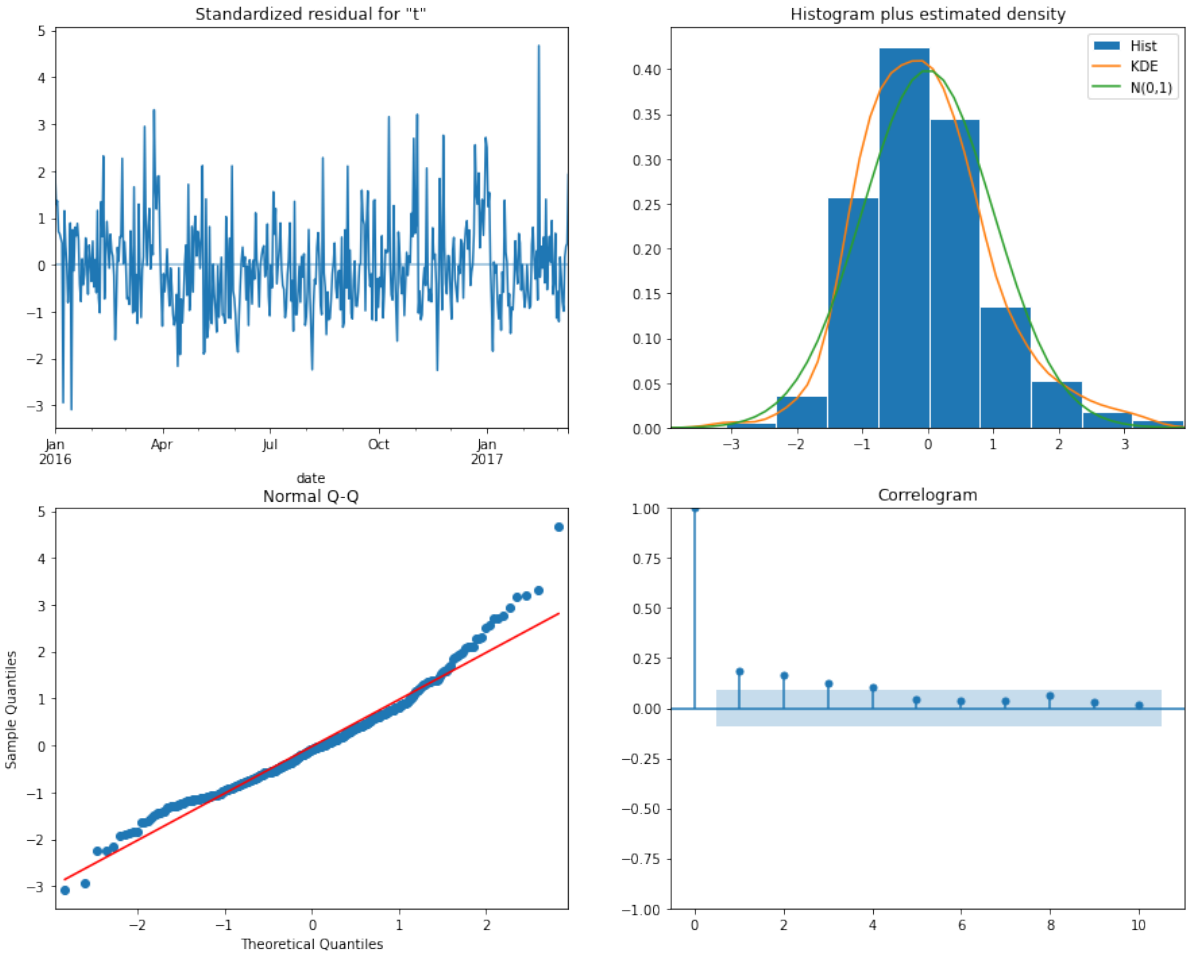
Date:	Tue, 26 Apr 2022	**AIC**	4336.738
Time:	06:55:45	**BIC**	4348.970
Sample:	01-01-2016	**HQIC**	4341.565
	- 03-11-2017		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.S.L7	0.9999	9.58e-05	1.04e+04	0.000	1.000	1.000
ma.S.L7	-0.9383	0.024	-39.198	0.000	-0.985	-0.891
sigma2	1111.8065	58.739	18.928	0.000	996.680	1226.932

Ljung-Box (L1) (Q):	15.40	**Jarque-Bera (JB):**	83.56
Prob(Q):	0.00	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.96	**Skew:**	0.72
Prob(H) (two-sided):	0.81	**Kurtosis:**	4.59

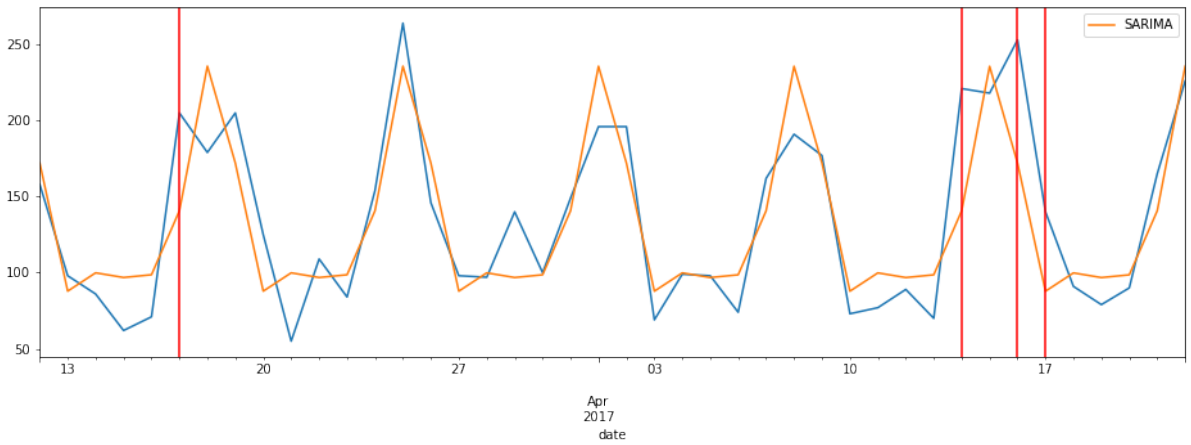
Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

In [24]:
```
model.plot_diagnostics(figsize=(15,12));
```



In [25]:
```
start=len(train)
end=start+len(test)-1
predictions=model.predict(start=start,end=end,dynamic=False).rename
```

In [26]:
```
ax=test['total'].plot(figsize=(16,5))
predictions.plot(legend=True)
for x in test.query('holiday==1').index:
    ax.axvline(x=x,color='r')
```



In [28]:
```
mean_absolute_percentage_error(test['total'],predictions)
```

Out[28]:
```
0.20157016526303326
```

In [29]:
```
modelExog=SARIMAX(train['total'],exog=train['holiday'],order=(0,0,0
modelExog.summary()
```

```
 This problem is unconstrained.

RUNNING THE L-BFGS-B CODE

           * * *

Machine precision = 2.220D-16
 N =            4     M =           10

At X0         0 variables are exactly at the bounds

At iterate    0    f=  5.24304D+00    |proj g|=  7.49269D-02

At iterate    5    f=  5.09816D+00    |proj g|=  9.66459D-03

At iterate   10    f=  4.81986D+00    |proj g|=  1.11454D-02

At iterate   15    f=  4.81298D+00    |proj g|=  2.51383D-04

At iterate   20    f=  4.81287D+00    |proj g|=  8.62111D-05

           * * *

Tit   = total number of iterations
Tnf   = total number of function evaluations
Tnint = total number of segments explored during Cauchy searches
Skip  = number of BFGS updates skipped
Nact  = number of active bounds at final generalized Cauchy point
Projg = norm of the final projected gradient
F     = final function value

           * * *

   N    Tit     Tnf  Tnint  Skip  Nact     Projg        F
    4     23     27      1     0     0   4.105D-06   4.813D+00
  F =   4.8128709766911708

CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL
```

Out[29]:

SARIMAX Results

Dep. Variable:	total	**No. Observations:**	436
Model:	SARIMAX(1, 0, [1], 7)	**Log Likelihood**	-2098.412
Date:	Tue, 26 Apr 2022	**AIC**	4204.823

Time:	06:56:42	**BIC**	4221.134
Sample:	01-01-2016	**HQIC**	4211.260
	- 03-11-2017		
Covariance Type:	opg		

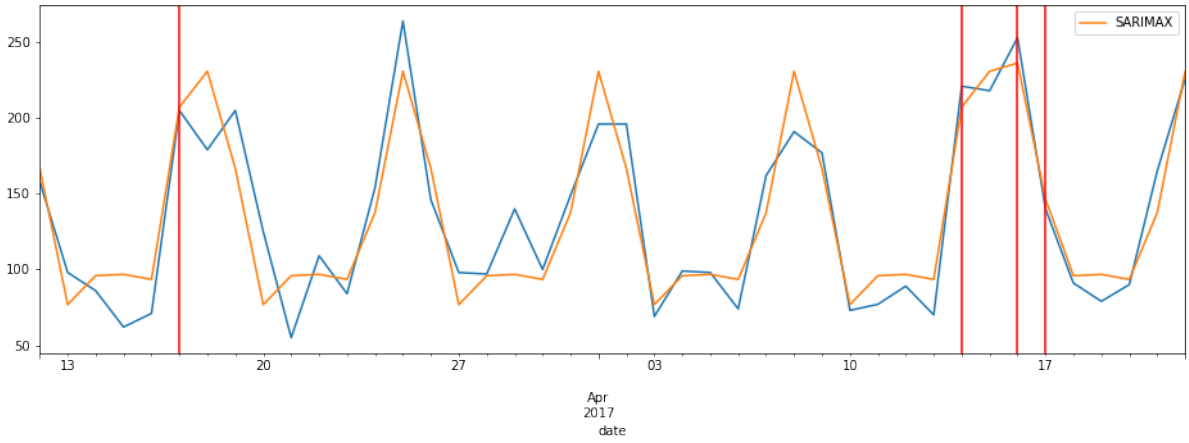
	coef	std err	z	P>|z|	[0.025	0.975]
holiday	69.6423	3.968	17.550	0.000	61.865	77.420
ar.S.L7	0.9999	7.57e-05	1.32e+04	0.000	1.000	1.000
ma.S.L7	-0.9429	0.023	-40.396	0.000	-0.989	-0.897
sigma2	813.5453	47.380	17.171	0.000	720.681	906.409

Ljung-Box (L1) (Q):	15.58	**Jarque-Bera (JB):**	20.71
Prob(Q):	0.00	**Prob(JB):**	0.00
Heteroskedasticity (H):	1.00	**Skew:**	0.23
Prob(H) (two-sided):	1.00	**Kurtosis:**	3.96

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

In [30]:
```
predictionsExog=modelExog.predict(start=start,end=end,exog=test['ho
```

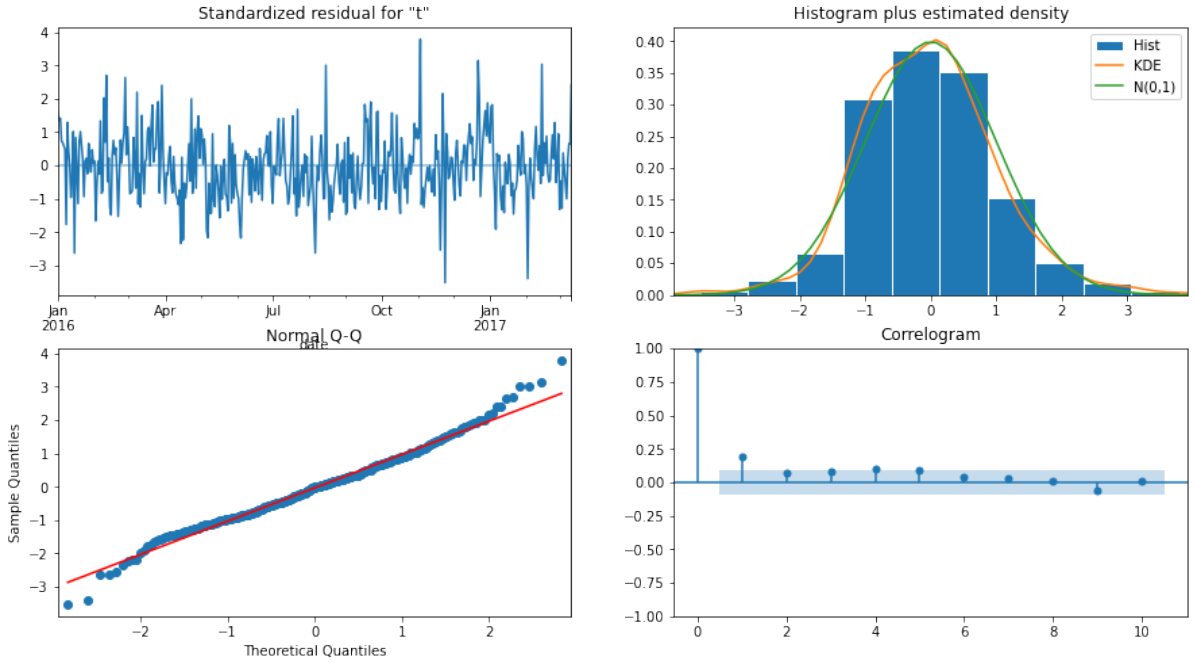
In [31]:
```
ax=test['total'].plot(figsize=(16,5))
predictionsExog.plot(legend=True)
for x in test.query('holiday==1').index:
    ax.axvline(x=x,color='r')
```



In [32]:
```
mean_absolute_percentage_error(test['total'],predictionsExog)
```

Out[32]: 0.16142983735081276

In [33]:
```
modelExog.plot_diagnostics(figsize=(15,8));
```



In [ ]:
```

```