Load Forecasting

Applied Time Series Analysis

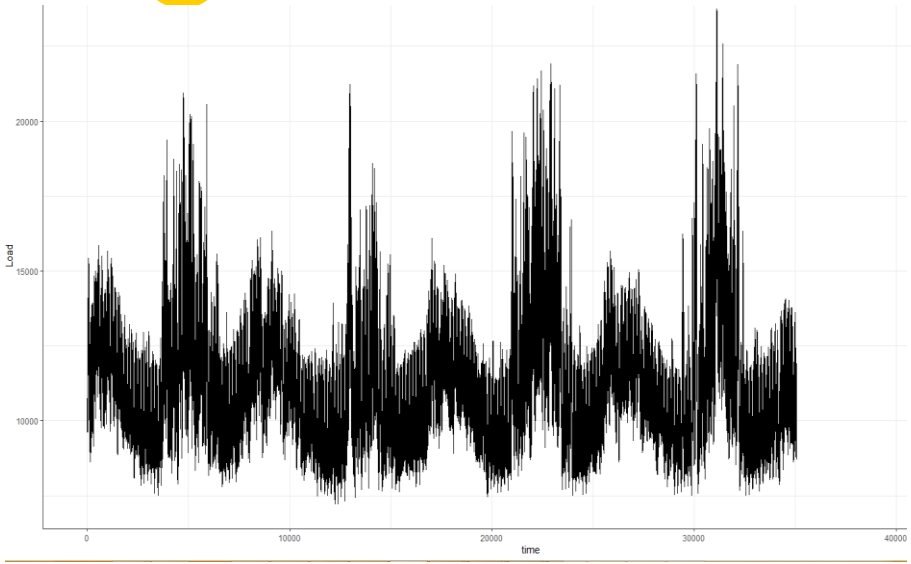
Karan Saxena
USC ID: 2102-1579-09

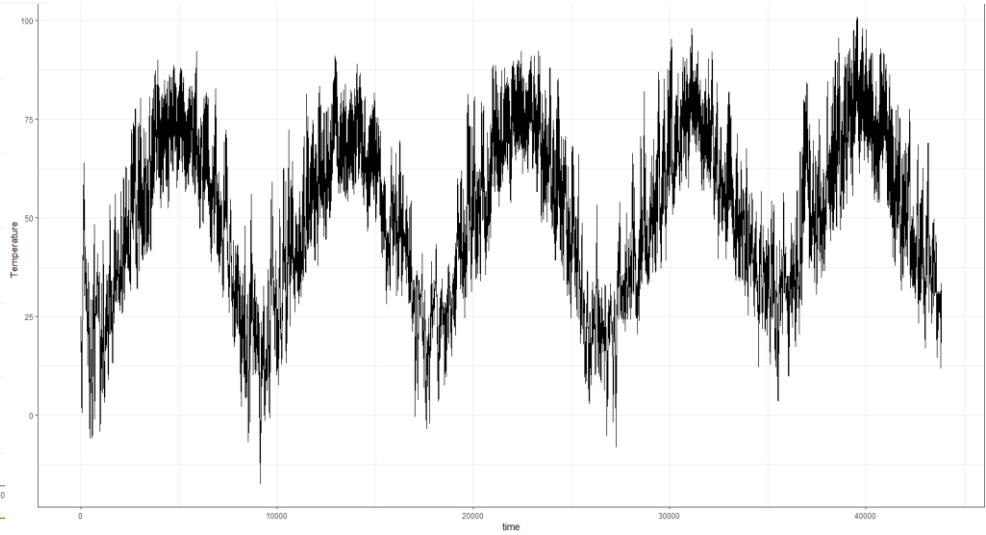
1 Business Problem

Business Problem

- To Accurately Predict the demand for Electricity
- Maximize Profit by buying the correct price for Electricity.
- Prevent the risk of buying electricity in real time at a higher price.

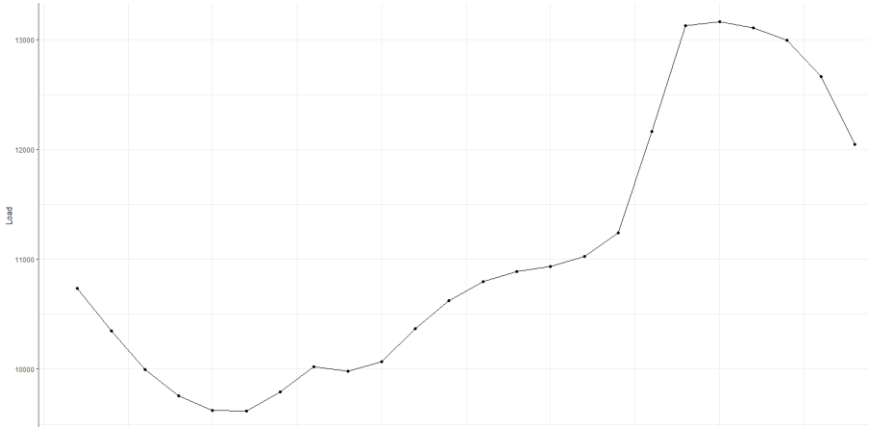
Load Vs Temp





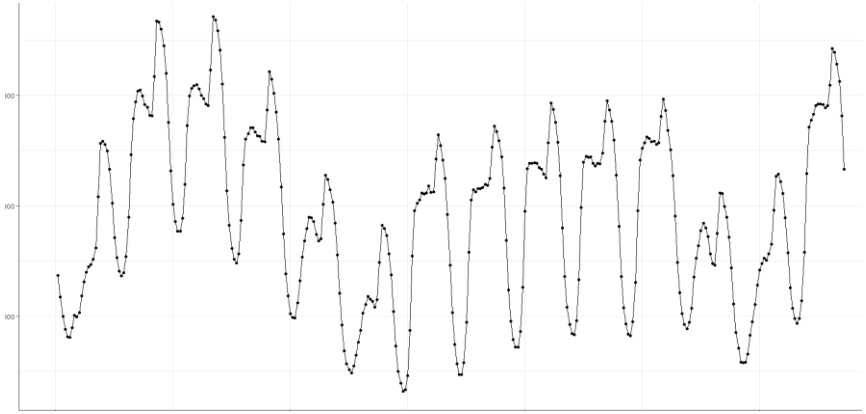
- Annual Seasonality
- Monthly Seasonality
- Weekly Seasonality
- Daily Seasonality

One Day Vs Two Weeks



One Day

Two Weeks



2 Models

Models Explored

1) Multiple Linear Regression
2) Multi Seasonal Time Series
    - -ARIMA
    - -ETS
    - -Naïve
3) Seasonal Naïve
4) Prophet
5) Neural Nets

Training Period

2008-2010

Testing Period

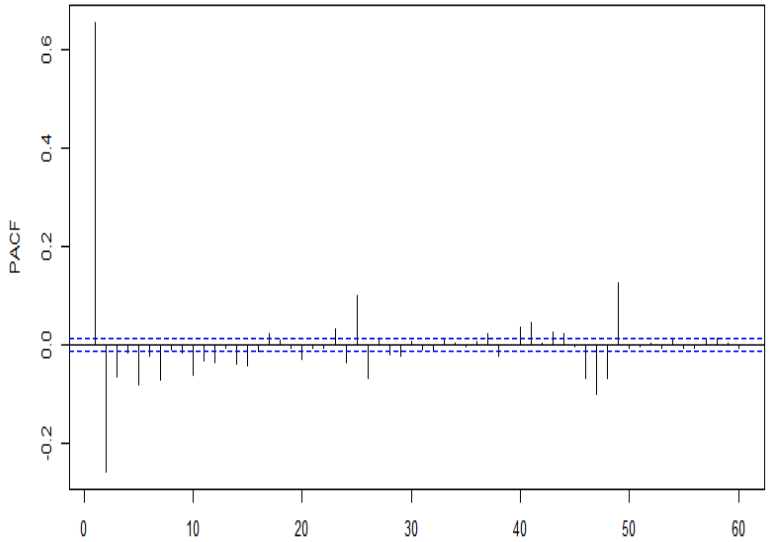
2011

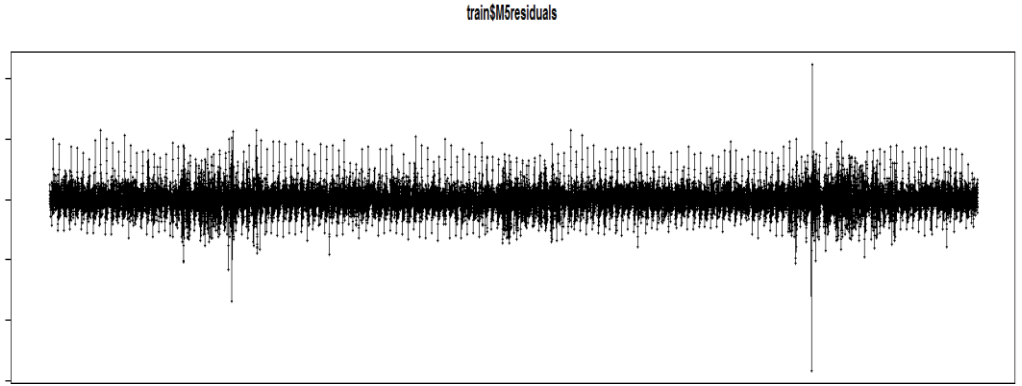
Adjusted- R-squared-> 0.9937

MAPE Testing Set -> 2.886

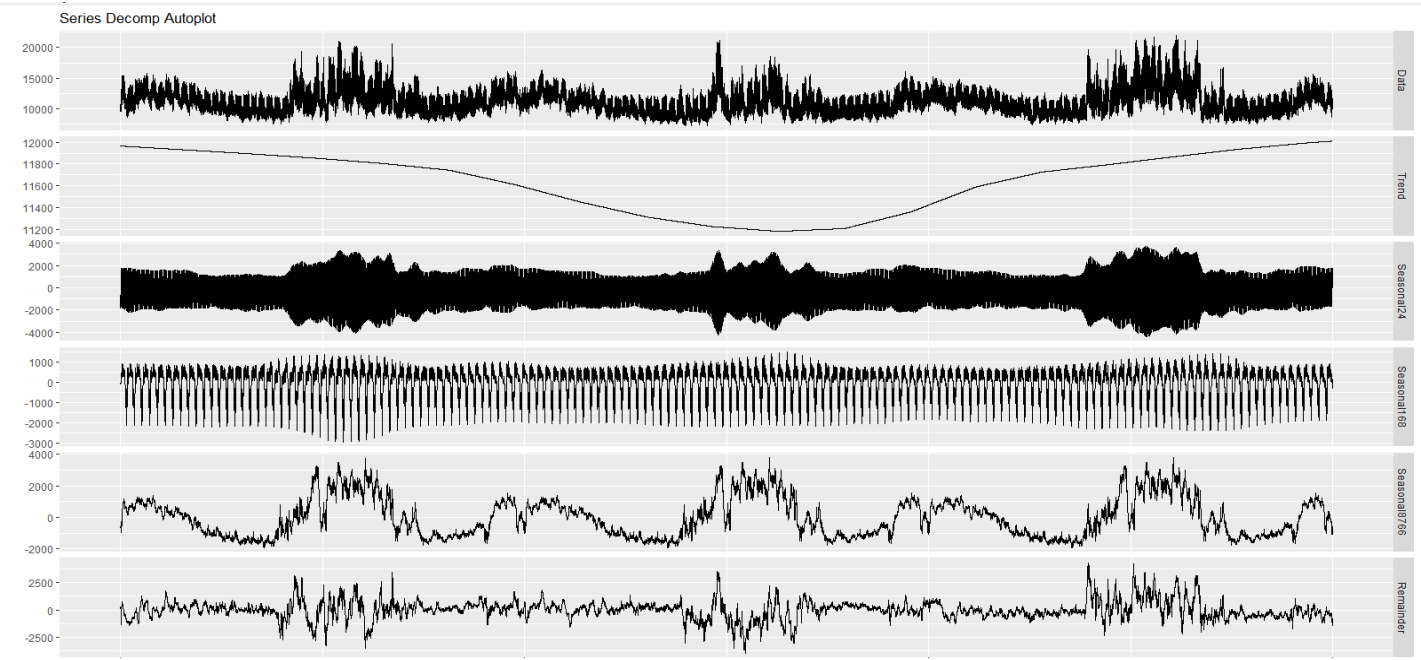
Multiple Linear Regression

```
M5 = lm(Load ~ trend + Weekday + Hour + Day*Hour + Weekday*Hour + Temperature*Hour + Temperature*Month
        + temp_sq + temp_cube +temp_sq*Hour +temp_cube*Hour+temp_sq*Month + temp_cube*Month
        + LoadLag1 + LoadLag24 + LoadLag25 + LoadLag48 + LoadLag49 + LoadLag50, data=train)
summary(M5)
```

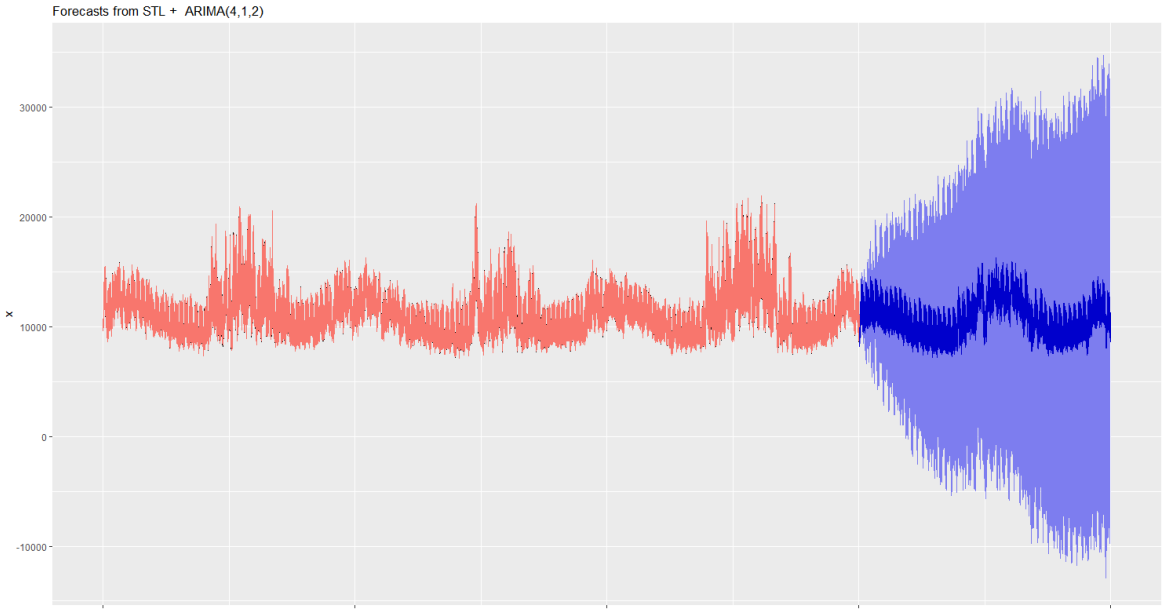




Multi Seasonality Decomposition

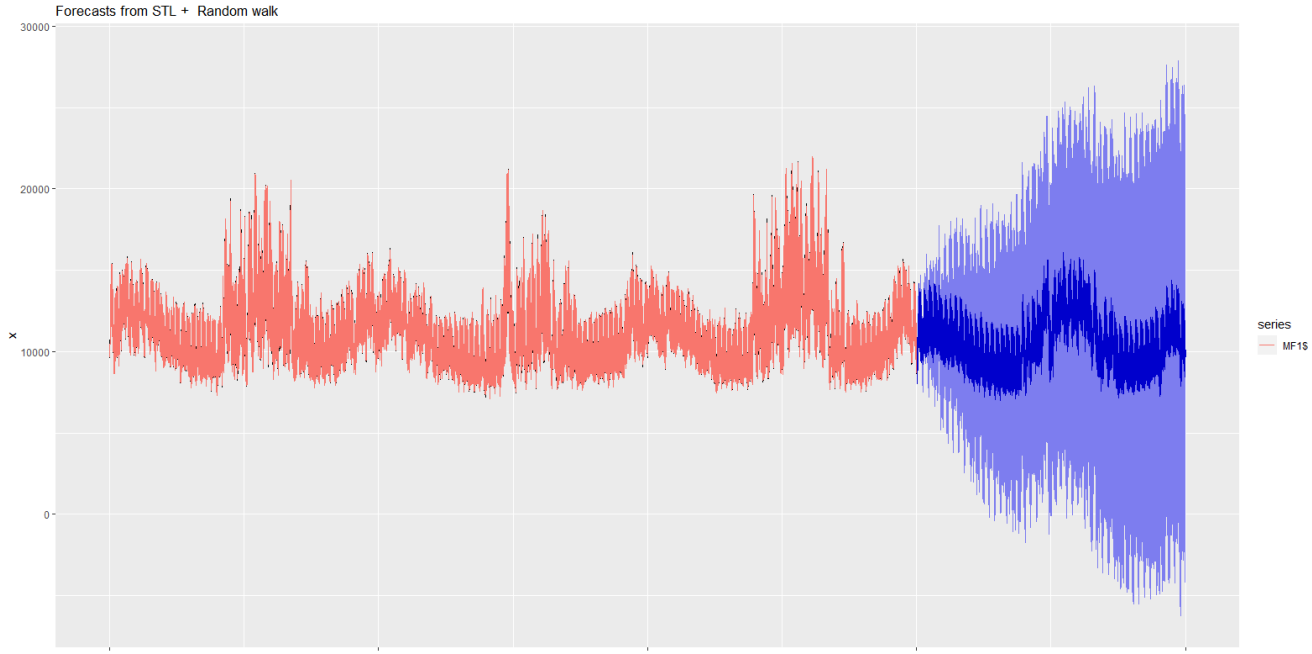


Multi Seasonality- Arima Model



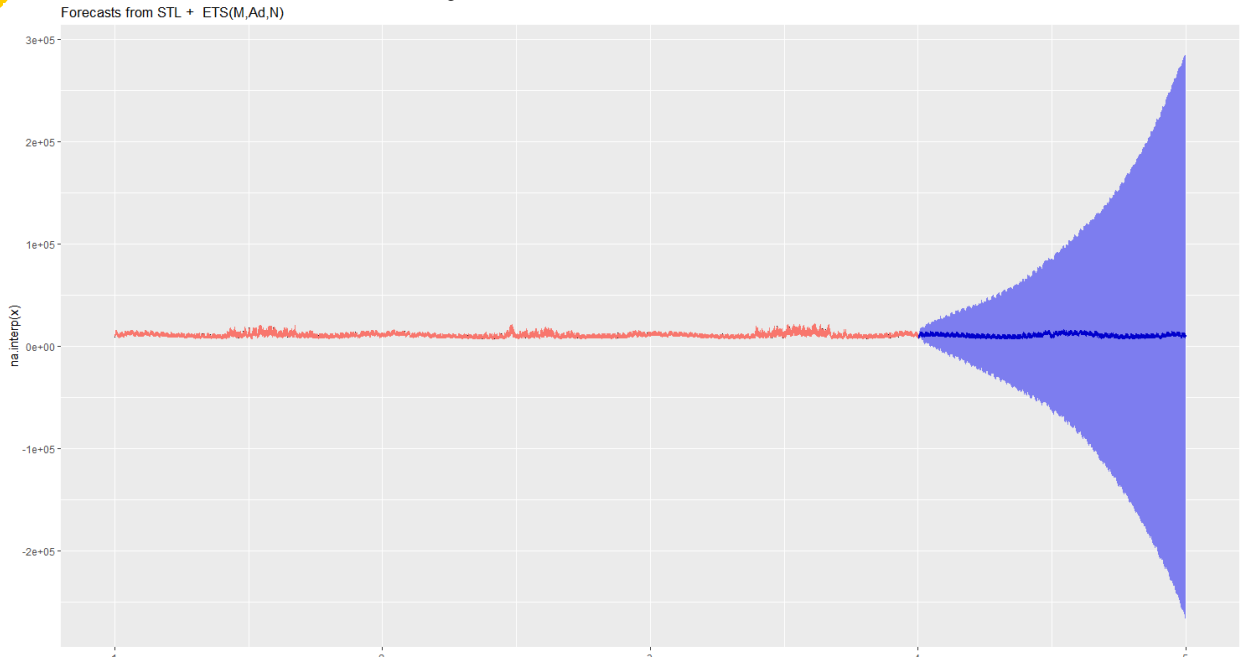
	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-0.02170903	57.99997	41.0828	-0.000218642	0.3549891	0.01850836	0.0005726639	NA
Test set	764.94630969	1782.87657	1184.0512	5.195655418	9.3135806	0.53343123	0.9772654173	2.898322

Multi Seasonality- Naïve Model



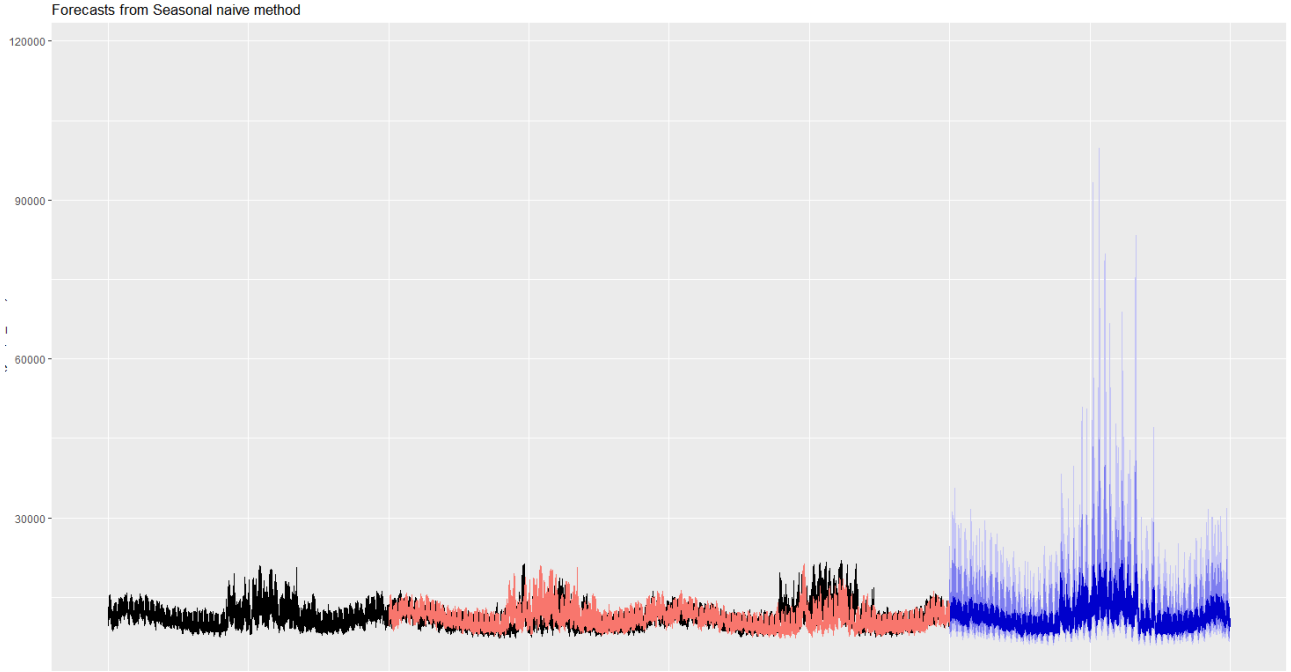
	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-0.05220057	78.49976	53.97093	-0.001875489	0.4605997	0.02431464	0.6653517	NA
Test set	955.43196482	1872.53829	1282.69164	6.895814328	10.1278701	0.57787009	0.9772574	3.05776

Multi Seasonality- ETS Model



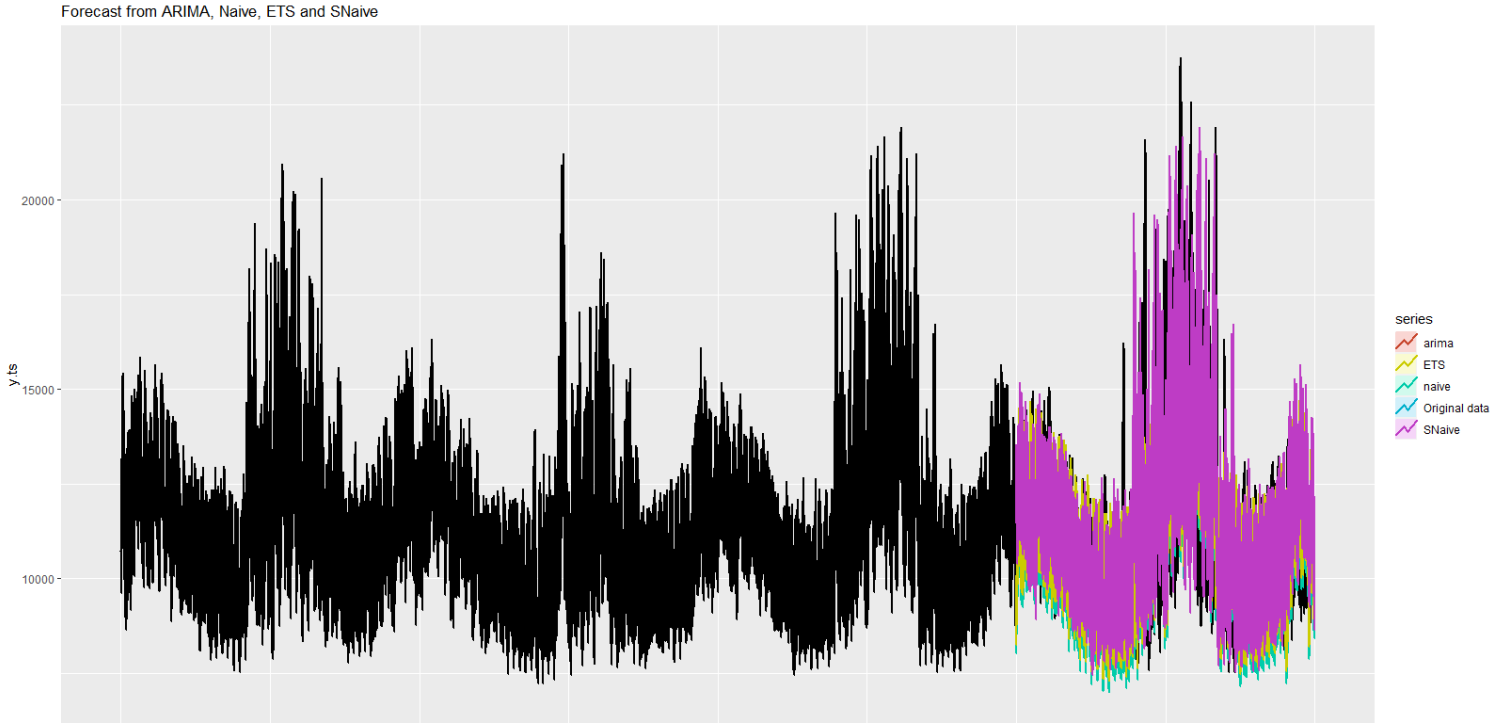
	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-0.01098346	59.7062	41.91302	0.001299585	0.3621474	0.01888239	0.008703314	NA
Test set	645.68098262	1735.0250	1134.83590	4.131384288	8.9238864	0.51125907	0.977271519	2.82373

Seasonal Naïve Model



	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1	Theil's U
Training set	-25.27392	2873.095	2219.689	-3.402390	19.57466	1.0000000	0.9647256	NA
Test set	-175.29521	2900.011	2214.835	-4.299109	19.37397	0.9978133	0.9632845	5.863695

Accuracy Comparison Graph



Prophet Model

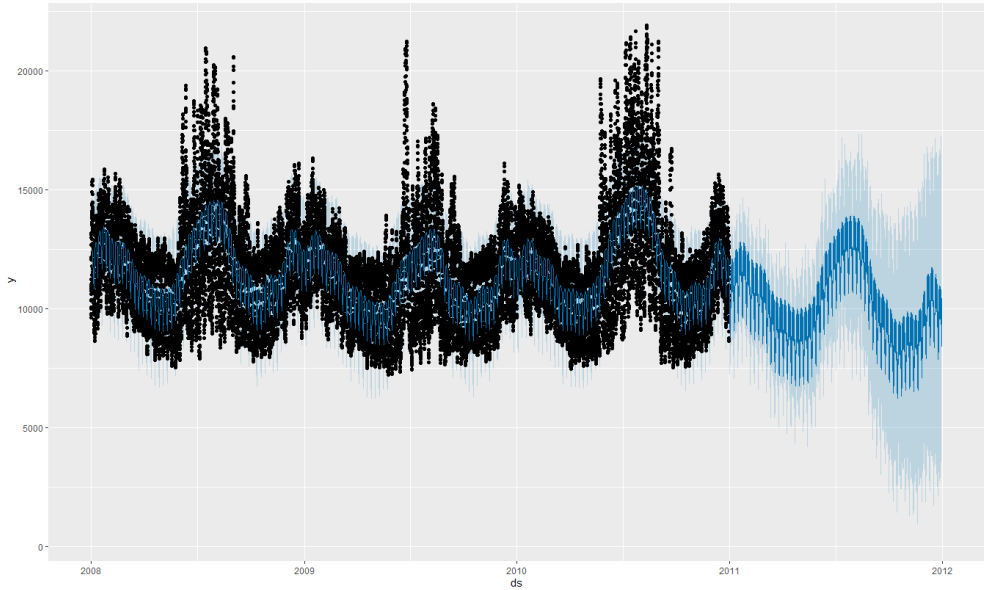
```
m= prophet()
m = add_regressor(m, 'temp')
m = add_regressor(m, 'temp_sq')
m= add_regressor(m, 'temp_cube')
m = add_country_holidays(m, country_name = 'US')

m = prophet(train2, yearly.seasonality = T,daily.seasonality = T, weekly.seasonality = T,
            holidays.prior.scale = .05)

summary(m)

future <- make_future_dataframe(m, periods = 24*365,freq= 3600)
tail(future)
forecast <- predict(m, future)
tail(forecast[c('ds', 'yhat', 'yhat_lower', 'yhat_upper')])

plot(m, forecast)
```



Neural Net Modelling

```
ns=2 # Non Seasonal
s=1 # Seasonal
hl=1 # Hidden Layer

Results = data.frame(p=NA,P=NA,size=NA,RMSE=NA,MAPE=NA)

for (i in ns) {
  for (j in s){
    for (k in hl){
      NN= nnetar(head(y.ts,n_train),p=i,P=j,size=k,lamda='auto')
      NNF= forecast(NN,h= n_test)
      Results = rbind(Results,c(i,j,k,accuracy(NNF,tail(y.ts,n_test))[2,'RMSE'],accuracy(NNF,tail(y.ts,n_test))[2,'MAPE']))
      print(c(i,j,k))
    }
  }
}
```

```
  p  P size     RMSE     MAPE
1 NA NA   NA       NA       NA
2  1  1    1 9045.286 73.12878
3  1  1    2 9305.538 75.12563
4  1  2    1 9636.749 78.89838
5  1  2    2 8841.049 71.79365
6  2  1    1 2573.014 14.75794
7  2  1    2 2483.373 15.05607
8  2  2    1 2531.018 14.73291
9  2  2    2 2499.054 15.38223
>
```

MAPE All Model Testing Set(2011)

MODEL	Testing MAPE (2011)
Multiple Linear Regression	2.886
MSTS-ARIMA	9.31
MSTS-Naïve	10.12
MSTS-ETS	8.92
Seasonal Naïve	19.37
Neural Net	14.74

Champion Model is Regression

Champion Model Forecast- Regression