

Competition Report

AyoungLeines

2025-04-23

Packages

```
library(tidyverse)
library(readxl)
library(ggplot2)
library(forecast)
library(Kendall)
library(tseries)
library(outliers)
library(smooth)
library(zoo)
library(kableExtra)
library(tsibble)
library(tibble)
library(forecastHybrid)
library(purrr)
library(tictoc)
library(janitor)
```

Directory

```
base_dir <- "D:/Geani/Box/Home Folder gnl13/Private/1 Academics/3 Time series/AyoungLeines_ENV797_TSA_F
data_dir <- file.path(base_dir, "Data")
output_dir <- file.path(base_dir, "Forecast")

file1 <- "load.xlsx"
file2 <- "temperature.xlsx"
file3 <- "relative_humidity.xlsx"
file4 <- "submission_template.xlsx"

file_path1 <- file.path(data_dir, file1)
file_path2 <- file.path(data_dir, file2)
file_path3 <- file.path(data_dir, file3)
file_path4 <- file.path(data_dir, file4)

load_raw <- read_excel(file_path1) %>% clean_names()
temp_raw <- read_excel(file_path2) %>% clean_names()
hum_raw <- read_excel(file_path3) %>% clean_names()
template <- read_excel(file_path4)
```

Wrangling data - Aggregate the hourly data to daily using averages

```
#Demand

# from wide (h1-h24) to long format, convert hour to integer
load_long <- load_raw %>%
  pivot_longer(
    cols      = starts_with("h"),
    names_to   = "hour",
    names_prefix= "h",
    values_to  = "load_kwh"
  ) %>%
  mutate(
    date      = as_date(date),
    hour      = as.integer(hour),
    meter_id  = factor(meter_id)
  )

# compute per-meter daily mean
daily_load <- load_long %>%
  group_by(meter_id, date) %>%
  summarise(
    daily_load_kwh = mean(load_kwh, na.rm = TRUE),
    .groups = "drop"
  )
```

```
# Temperature

# daily mean across all hours and stations
daily_temp <- temp_raw %>%
  pivot_longer(
    cols      = starts_with("t_ws"),
    names_to   = "station",
    names_prefix = "t_ws",
    values_to  = "temp_c"
  ) %>%
  mutate(date = as_date(date)) %>%
  group_by(date) %>%
  summarise(
    mean_temp_c = mean(temp_c, na.rm = TRUE),
    .groups = "drop"
  )

# Relative humidity
daily_hum <- hum_raw %>%
  pivot_longer(
    cols      = starts_with("rh_ws"),
    names_to   = "station",
    names_prefix = "rh_ws",
    values_to  = "rh_pct"
  ) %>%
  mutate(date = as_date(date)) %>%
  group_by(date) %>%
```

```

summarise(
  mean_rh_pct = mean(rh_pct, na.rm = TRUE),
  .groups     = "drop"
)

```

```

daily_data <- daily_load %>%
  inner_join(daily_temp, by = "date") %>%
  inner_join(daily_hum,  by = "date")

# total system demand per day, plus averaged covariates
agg_daily <- daily_data %>%
  group_by(date) %>%
  summarise(
    demand_kwh = sum(daily_load_kwh, na.rm = TRUE),
    temp_c      = mean(mean_temp_c,  na.rm = TRUE),
    rh_pct      = mean(mean_rh_pct,  na.rm = TRUE),
    .groups     = "drop"
  )

```

```

agg_daily %>%
  slice_head(n = 6) %>%
  kable(
    caption = "First six days of aggregated daily demand, temperature, and humidity",
    digits  = 2
  ) %>%
  kable_styling(full_width = FALSE)

```

Table 1: First six days of aggregated daily demand, temperature, and humidity

| date | demand_kwh | temp_c | rh_pct |
|------------|------------|--------|--------|
| 2005-01-01 | 2889.12 | 53.57 | 76.71 |
| 2005-01-02 | 2788.96 | 53.76 | 80.48 |
| 2005-01-03 | 2708.46 | 55.91 | 81.23 |
| 2005-01-04 | 2211.58 | 61.69 | 74.84 |
| 2005-01-05 | 2035.12 | 60.43 | 76.07 |
| 2005-01-06 | 2109.62 | 62.00 | 77.99 |

Define training and testing sets

```

train <- agg_daily %>%
  filter(date >= ymd("2005-01-01") & date <= ymd("2009-12-31"))

test <- agg_daily %>%
  filter(date >= ymd("2010-01-01") & date <= ymd("2010-02-28"))

full_train <- agg_daily %>%
  filter(date >= ymd("2005-01-01") & date <= ymd("2010-12-31"))

```

```

# 5.2 Construct msts objects with weekly and yearly seasonality
y_train <- msts(
  train$demand_kwh,
  seasonal.periods = c(7, 365.25),
  start            = c(2005, 1)
)

y_test <- msts(
  test$demand_kwh,
  seasonal.periods = c(7, 365.25),
  start            = c(2010, 1)
)

y_full <- msts(
  full_train$demand_kwh,
  seasonal.periods = c(7, 365.25),
  start            = c(2005, 1)
)

```

Forecasting until 2010

```

# 1) Forecast horizon
h <- length(y_test)

# 2) Fit each model

# ARIMA + Fourier + weather regressors
f_tr      <- fourier(y_train, K = c(2,6))
f_ts      <- fourier(y_train, K = c(2,6), h = h)
fit_reg   <- auto.arima(
  y_train,
  seasonal = FALSE,
  xreg      = cbind(f_tr, train$temp_c, train$rh_pct)
)
fc_reg    <- forecast(
  fit_reg,
  h       = h,
  xreg     = cbind(f_ts, test$temp_c, test$rh_pct)
)

# ETS with Box-Cox (lambda chosen to stabilize MAPE)
fc_ets_bc <- forecast(ets(y_train, lambda="auto"), h = h)

fc_naive  <- naive(y_train, h = h)
fc_tbats  <- forecast(tbats(y_train), h = h)

# TBATS with weather covariates
xreg_temp <- matrix(train$temp_c, ncol = 1)
xreg_test_temp <- matrix(test$temp_c, ncol = 1)
xreg_hum   <- matrix(train$rh_pct, ncol = 1)
xreg_test_hum <- matrix(test$rh_pct, ncol = 1)

```

```

xreg_both      <- cbind(train$temp_c, train$rh_pct)
xreg_test_both <- cbind(test$temp_c,  test$rh_pct)

fc_tbats_temp  <- forecast(tbats(y_train, xreg = xreg_temp), h = h, xreg = xreg_test_temp)
fc_tbats_hum   <- forecast(tbats(y_train, xreg = xreg_hum),  h = h, xreg = xreg_test_hum)
fc_tbats_both  <- forecast(tbats(y_train, xreg = xreg_both), h = h, xreg = xreg_test_both)

# 3) Extract accuracy metrics
models <- list(
  `ARIMA+F+Wx` = fc_reg,
  `ETS-BoxCox` = fc_ets_bc,
  Naive        = fc_naive,
  TBATS        = fc_tbats,
  `TBATS+Temp` = fc_tbats_temp,
  `TBATS+Hum`  = fc_tbats_hum
)

accuracy_tbl <- purrr::map_df(models, function(fit) {
  acc <- accuracy(fit, y_test)
  # if accuracy() returned two rows (train & test), use the test row
  idx <- if (nrow(acc) == 2) 2 else 1
  # pull out the six metrics we want
  acc[idx, c("ME", "RMSE", "MAE", "MAPE", "MASE", "ACF1"), drop=FALSE] %>%
    as_tibble(rownames = "dummy") %>%
    select(-dummy)
}, .id = "Model")

# 4) Render comparison table, sorted by MAPE
accuracy_tbl %>%
  arrange(MAPE) %>%
  kable(
    caption = "Forecast accuracy comparison (all models)",
    digits = 2
  ) %>%
  kable_styling(full_width = FALSE) %>%
  row_spec(1, bold = TRUE, background = "#F0F0F0") # highlight best MAPE

```

Table 2: Forecast accuracy comparison (all models)

| Model | ME | RMSE | MAE | MAPE | MASE | ACF1 |
|-------------------|---------------|----------------|---------------|--------------|-------------|-------------|
| ARIMA+F+Wx | 562.58 | 1007.86 | 800.76 | 14.95 | 1.04 | 0.65 |
| ETS-BoxCox | 485.94 | 1239.18 | 984.90 | 19.28 | 1.28 | 0.80 |
| Naive | 486.05 | 1239.22 | 984.94 | 19.28 | 1.28 | 0.80 |
| TBATS | 438.30 | 1244.69 | 1008.28 | 20.35 | 1.31 | 0.80 |
| TBATS+Temp | 438.30 | 1244.69 | 1008.28 | 20.35 | 1.31 | 0.80 |
| TBATS+Hum | 438.30 | 1244.69 | 1008.28 | 20.35 | 1.31 | 0.80 |

Forecasting until 2011- top 5 models - with all information

```
forecast_dates <- seq(as.Date("2011-01-01"), as.Date("2011-02-28"), by = "day")
h_future      <- length(forecast_dates) # 59
```

```
#Model 1: # ETS with Box-Cox (lambda chosen to stabilize MAPE)
fc_ets_bc_full <- forecast(ets(y_full, lambda="auto"), h = h_future)

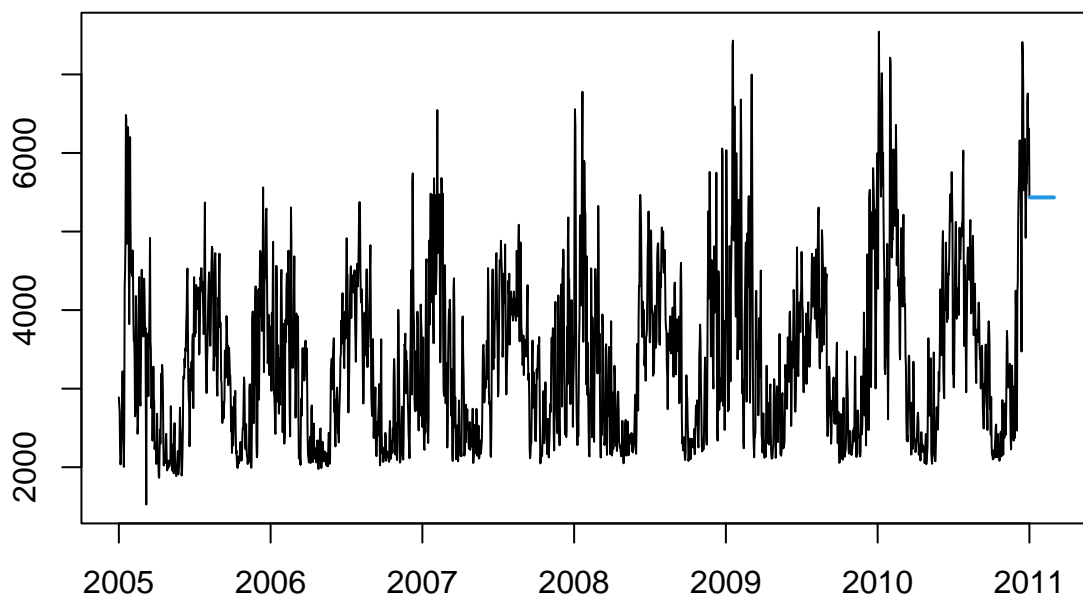
print(fc_ets_bc_full)
```

| ## | Point | Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|----|-----------|----------|----------|------------|----------|------------|
| ## | 2011.0027 | 5434.701 | 4095.479 | 7951.106 | 3614.502 | 10422.48 |
| ## | 2011.0055 | 5434.701 | 3709.794 | 9768.706 | 3164.111 | 16263.85 |
| ## | 2011.0082 | 5434.701 | 3457.804 | 11797.605 | 2885.135 | 27561.24 |
| ## | 2011.0110 | 5434.701 | 3269.399 | 14245.249 | 2683.988 | 61189.65 |
| ## | 2011.0137 | 5434.701 | 3118.904 | 17357.289 | 2527.699 | 1086869.88 |
| ## | 2011.0164 | 5434.701 | 2993.767 | 21521.223 | 2400.613 | NA |
| ## | 2011.0192 | 5434.701 | 2886.840 | 27437.657 | 2294.034 | NA |
| ## | 2011.0219 | 5434.701 | 2793.647 | 36546.352 | 2202.621 | NA |
| ## | 2011.0247 | 5434.701 | 2711.184 | 52358.137 | 2122.862 | NA |
| ## | 2011.0274 | 5434.701 | 2637.341 | 86170.280 | 2052.322 | NA |
| ## | 2011.0301 | 5434.701 | 2570.571 | 203285.559 | 1989.248 | NA |
| ## | 2011.0329 | 5434.701 | 2509.710 | NA | 1932.334 | NA |
| ## | 2011.0356 | 5434.701 | 2453.857 | NA | 1880.582 | NA |
| ## | 2011.0384 | 5434.701 | 2402.301 | NA | 1833.215 | NA |
| ## | 2011.0411 | 5434.701 | 2354.472 | NA | 1789.614 | NA |
| ## | 2011.0438 | 5434.701 | 2309.904 | NA | 1749.280 | NA |
| ## | 2011.0466 | 5434.701 | 2268.213 | NA | 1711.805 | NA |
| ## | 2011.0493 | 5434.701 | 2229.078 | NA | 1676.849 | NA |
| ## | 2011.0521 | 5434.701 | 2192.229 | NA | 1644.130 | NA |
| ## | 2011.0548 | 5434.701 | 2157.433 | NA | 1613.408 | NA |
| ## | 2011.0575 | 5434.701 | 2124.494 | NA | 1584.478 | NA |
| ## | 2011.0603 | 5434.701 | 2093.241 | NA | 1557.165 | NA |
| ## | 2011.0630 | 5434.701 | 2063.523 | NA | 1531.318 | NA |
| ## | 2011.0658 | 5434.701 | 2035.211 | NA | 1506.805 | NA |
| ## | 2011.0685 | 5434.701 | 2008.189 | NA | 1483.510 | NA |
| ## | 2011.0712 | 5434.701 | 1982.357 | NA | 1461.331 | NA |
| ## | 2011.0740 | 5434.701 | 1957.624 | NA | 1440.179 | NA |
| ## | 2011.0767 | 5434.701 | 1933.908 | NA | 1419.974 | NA |
| ## | 2011.0795 | 5434.701 | 1911.138 | NA | 1400.645 | NA |
| ## | 2011.0822 | 5434.701 | 1889.249 | NA | 1382.127 | NA |
| ## | 2011.0849 | 5434.701 | 1868.181 | NA | 1364.364 | NA |
| ## | 2011.0877 | 5434.701 | 1847.883 | NA | 1347.304 | NA |
| ## | 2011.0904 | 5434.701 | 1828.304 | NA | 1330.900 | NA |
| ## | 2011.0932 | 5434.701 | 1809.401 | NA | 1315.110 | NA |
| ## | 2011.0959 | 5434.701 | 1791.135 | NA | 1299.894 | NA |
| ## | 2011.0986 | 5434.701 | 1773.467 | NA | 1285.219 | NA |
| ## | 2011.1014 | 5434.701 | 1756.365 | NA | 1271.051 | NA |
| ## | 2011.1041 | 5434.701 | 1739.796 | NA | 1257.362 | NA |
| ## | 2011.1068 | 5434.701 | 1723.733 | NA | 1244.123 | NA |
| ## | 2011.1096 | 5434.701 | 1708.149 | NA | 1231.311 | NA |
| ## | 2011.1123 | 5434.701 | 1693.019 | NA | 1218.902 | NA |
| ## | 2011.1151 | 5434.701 | 1678.320 | NA | 1206.874 | NA |
| ## | 2011.1178 | 5434.701 | 1664.032 | NA | 1195.208 | NA |

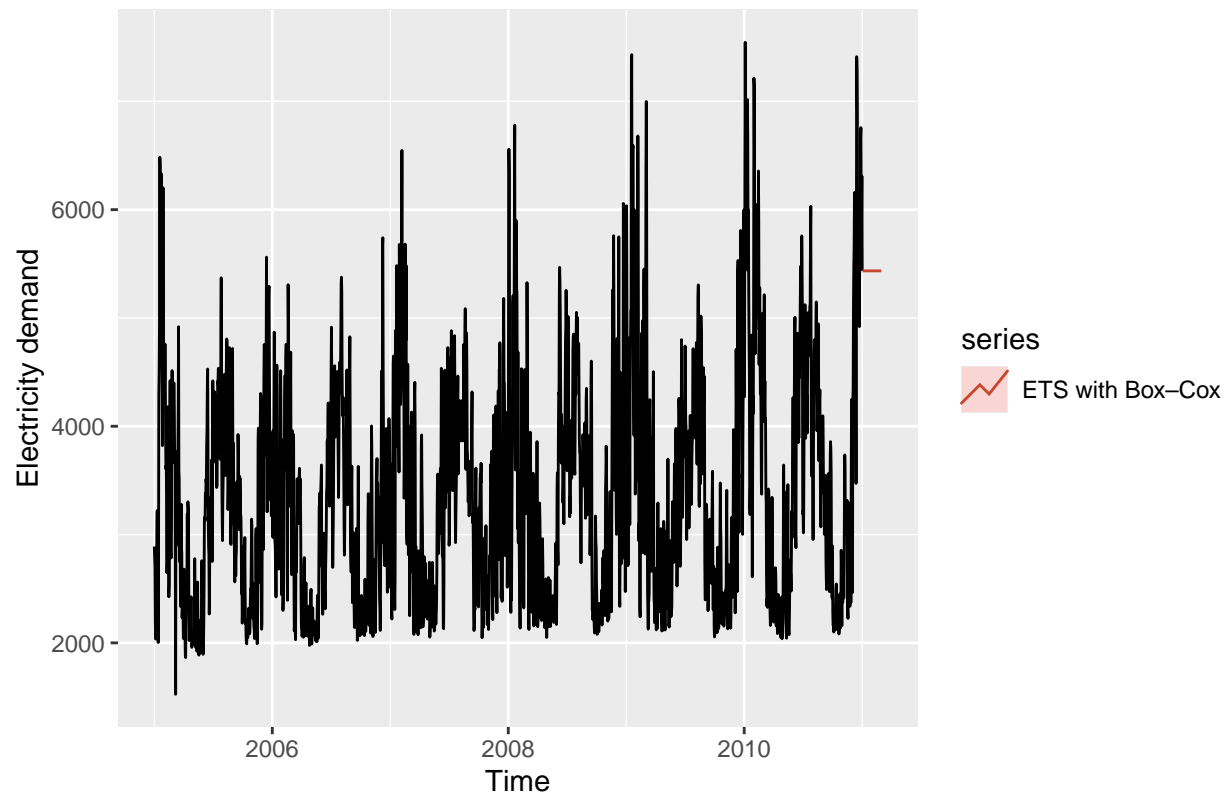
```
## 2011.1205      5434.701 1650.135      NA 1183.886      NA
## 2011.1233      5434.701 1636.609      NA 1172.890      NA
## 2011.1260      5434.701 1623.439      NA 1162.205      NA
## 2011.1288      5434.701 1610.608      NA 1151.817      NA
## 2011.1315      5434.701 1598.101      NA 1141.710      NA
## 2011.1342      5434.701 1585.904      NA 1131.873      NA
## 2011.1370      5434.701 1574.004      NA 1122.293      NA
## 2011.1397      5434.701 1562.388      NA 1112.959      NA
## 2011.1425      5434.701 1551.045      NA 1103.860      NA
## 2011.1452      5434.701 1539.964      NA 1094.987      NA
## 2011.1479      5434.701 1529.134      NA 1086.329      NA
## 2011.1507      5434.701 1518.546      NA 1077.879      NA
## 2011.1534      5434.701 1508.190      NA 1069.628      NA
## 2011.1562      5434.701 1498.058      NA 1061.567      NA
## 2011.1589      5434.701 1488.141      NA 1053.690      NA
## 2011.1616      5434.701 1478.432      NA 1045.990      NA
```

```
plot(fc_ets_bc_full)
```

Forecasts from ETS(A,N,N)

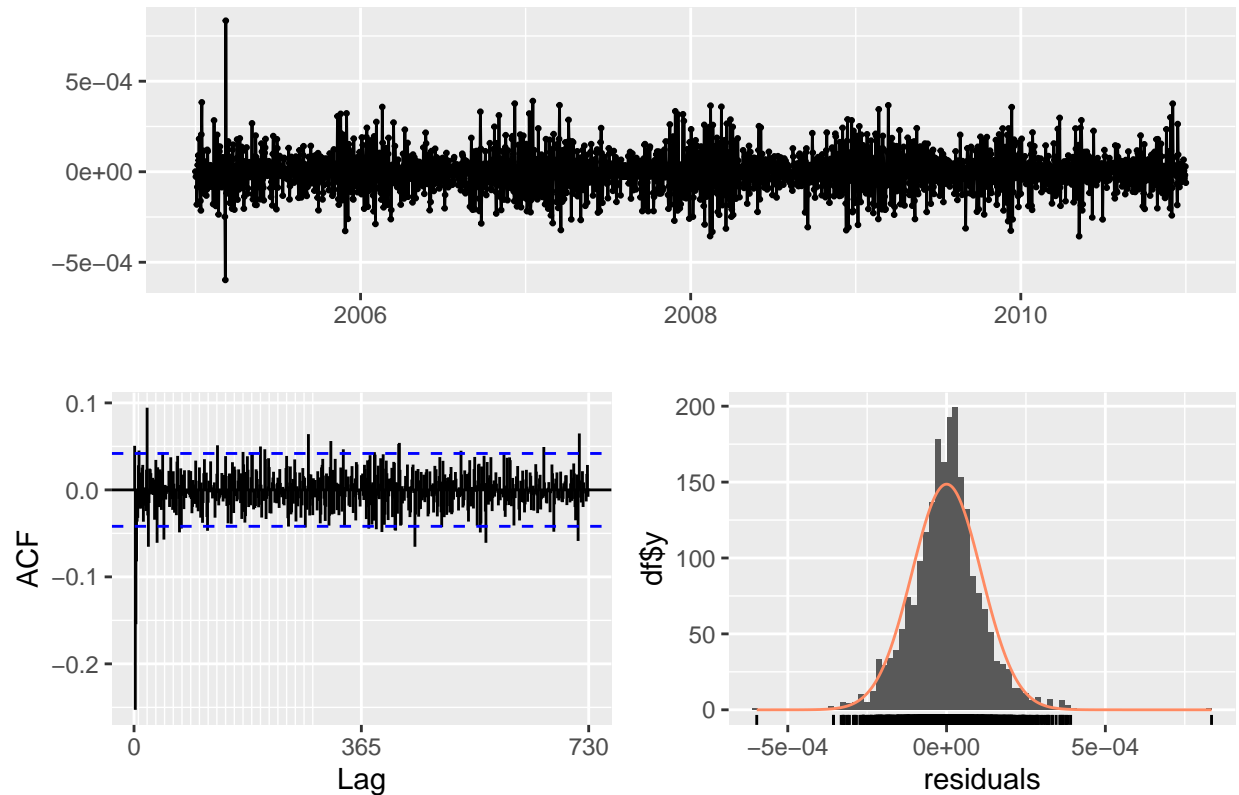


```
#Plot model + observed data
autoplot(y_full) +
  autolayer(fc_ets_bc_full, series="ETS with Box-Cox",PI=FALSE) +
  ylab("Electricity demand")
```



```
checkresiduals(fc_ets_bc_full)
```


Residuals from ETS(A,N,N)



```
##
##  Ljung-Box test
##
## data:  Residuals from ETS(A,N,N)
## Q* = 790.65, df = 438, p-value < 2.2e-16
##
## Model df: 0.   Total lags used: 438

# Export to CSV
submission <- template %>%
  mutate(
    date = format(forecast_dates, "%Y-%m-%d"),
    load = as.numeric(fc_ets_bc_full$mean)
  )
out_name <- "submission_final_ETS_with_Box-Cox.csv"
readr::write_csv(submission, file.path(output_dir, out_name))
```

#Model 2: Naive

```
fc_naive_full <- naive(y_full, h = h_future)
print(fc_naive_full)
```

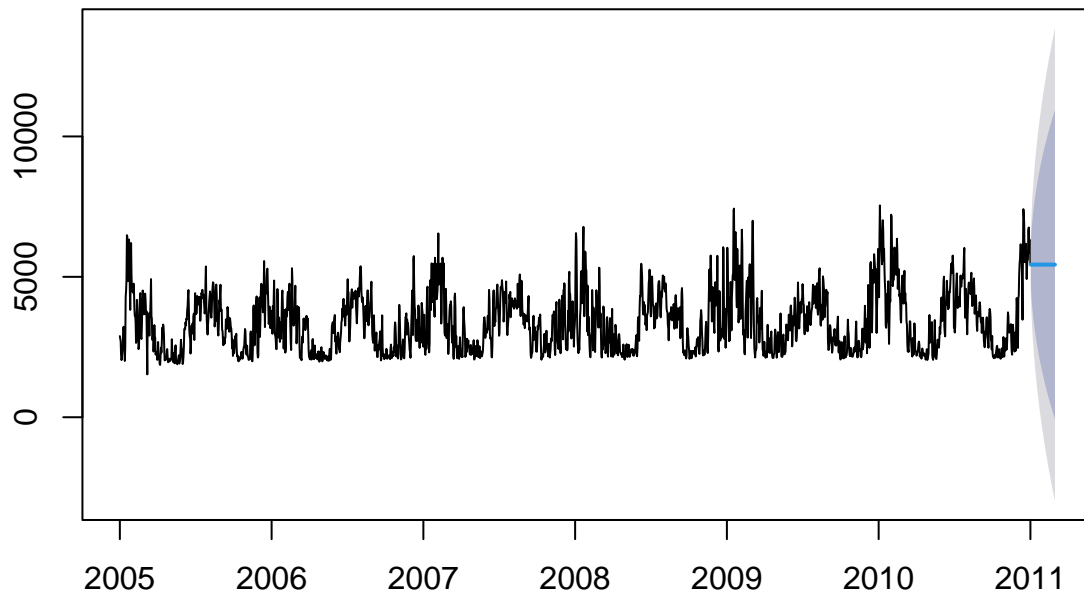
| | Point Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|--------------|----------------|------------|----------|------------|----------|
| ## 2011.0027 | 5434.625 | 4717.82576 | 6151.424 | 4338.37516 | 6530.875 |
| ## 2011.0055 | 5434.625 | 4420.91779 | 6448.332 | 3884.29361 | 6984.956 |

| | | | | | |
|--------------|----------|------------|-----------|-------------|-----------|
| ## 2011.0082 | 5434.625 | 4193.09230 | 6676.158 | 3535.86458 | 7333.385 |
| ## 2011.0110 | 5434.625 | 4001.02652 | 6868.223 | 3242.12532 | 7627.125 |
| ## 2011.0137 | 5434.625 | 3831.81317 | 7037.437 | 2983.33584 | 7885.914 |
| ## 2011.0164 | 5434.625 | 3678.83261 | 7190.417 | 2749.37227 | 8119.878 |
| ## 2011.0192 | 5434.625 | 3538.15247 | 7331.098 | 2534.22055 | 8335.029 |
| ## 2011.0219 | 5434.625 | 3407.21058 | 7462.039 | 2333.96222 | 8535.288 |
| ## 2011.0247 | 5434.625 | 3284.22728 | 7585.023 | 2145.87549 | 8723.375 |
| ## 2011.0274 | 5434.625 | 3167.90677 | 7701.343 | 1967.97863 | 8901.271 |
| ## 2011.0301 | 5434.625 | 3057.27087 | 7811.979 | 1798.77561 | 9070.474 |
| ## 2011.0329 | 5434.625 | 2951.55959 | 7917.690 | 1637.10417 | 9232.146 |
| ## 2011.0356 | 5434.625 | 2850.16858 | 8019.081 | 1482.04000 | 9387.210 |
| ## 2011.0384 | 5434.625 | 2752.60783 | 8116.642 | 1332.83370 | 9536.416 |
| ## 2011.0411 | 5434.625 | 2658.47348 | 8210.777 | 1188.86763 | 9680.382 |
| ## 2011.0438 | 5434.625 | 2567.42804 | 8301.822 | 1049.62565 | 9819.624 |
| ## 2011.0466 | 5434.625 | 2479.18602 | 8390.064 | 914.67113 | 9954.579 |
| ## 2011.0493 | 5434.625 | 2393.50338 | 8475.747 | 783.63083 | 10085.619 |
| ## 2011.0521 | 5434.625 | 2310.16955 | 8559.080 | 656.18274 | 10213.067 |
| ## 2011.0548 | 5434.625 | 2229.00134 | 8640.249 | 532.04668 | 10337.203 |
| ## 2011.0575 | 5434.625 | 2149.83822 | 8719.412 | 410.97714 | 10458.273 |
| ## 2011.0603 | 5434.625 | 2072.53854 | 8796.711 | 292.75748 | 10576.493 |
| ## 2011.0630 | 5434.625 | 1996.97661 | 8872.273 | 177.19547 | 10692.055 |
| ## 2011.0658 | 5434.625 | 1923.04022 | 8946.210 | 64.11953 | 10805.130 |
| ## 2011.0685 | 5434.625 | 1850.62880 | 9018.621 | -46.62419 | 10915.874 |
| ## 2011.0712 | 5434.625 | 1779.65168 | 9089.598 | -155.17432 | 11024.424 |
| ## 2011.0740 | 5434.625 | 1710.02689 | 9159.223 | -261.65625 | 11130.906 |
| ## 2011.0767 | 5434.625 | 1641.67994 | 9227.570 | -366.18389 | 11235.434 |
| ## 2011.0795 | 5434.625 | 1574.54296 | 9294.707 | -468.86105 | 11338.111 |
| ## 2011.0822 | 5434.625 | 1508.55387 | 9360.696 | -569.78265 | 11439.033 |
| ## 2011.0849 | 5434.625 | 1443.65573 | 9425.594 | -669.03578 | 11538.286 |
| ## 2011.0877 | 5434.625 | 1379.79617 | 9489.454 | -766.70055 | 11635.951 |
| ## 2011.0904 | 5434.625 | 1316.92686 | 9552.323 | -862.85087 | 11732.101 |
| ## 2011.0932 | 5434.625 | 1255.00311 | 9614.247 | -957.55507 | 11826.805 |
| ## 2011.0959 | 5434.625 | 1193.98350 | 9675.266 | -1050.87650 | 11920.127 |
| ## 2011.0986 | 5434.625 | 1133.82956 | 9735.420 | -1142.87403 | 12012.124 |
| ## 2011.1014 | 5434.625 | 1074.50544 | 9794.745 | -1233.60244 | 12102.852 |
| ## 2011.1041 | 5434.625 | 1015.97772 | 9853.272 | -1323.11285 | 12192.363 |
| ## 2011.1068 | 5434.625 | 958.21518 | 9911.035 | -1411.45304 | 12280.703 |
| ## 2011.1096 | 5434.625 | 901.18855 | 9968.061 | -1498.66774 | 12367.918 |
| ## 2011.1123 | 5434.625 | 844.87041 | 10024.380 | -1584.79891 | 12454.049 |
| ## 2011.1151 | 5434.625 | 789.23499 | 10080.015 | -1669.88594 | 12539.136 |
| ## 2011.1178 | 5434.625 | 734.25804 | 10134.992 | -1753.96592 | 12623.216 |
| ## 2011.1205 | 5434.625 | 679.91674 | 10189.333 | -1837.07378 | 12706.324 |
| ## 2011.1233 | 5434.625 | 626.18951 | 10243.060 | -1919.24247 | 12788.492 |
| ## 2011.1260 | 5434.625 | 573.05602 | 10296.194 | -2000.50314 | 12869.753 |
| ## 2011.1288 | 5434.625 | 520.49699 | 10348.753 | -2080.88524 | 12950.135 |
| ## 2011.1315 | 5434.625 | 468.49418 | 10400.756 | -2160.41667 | 13029.667 |
| ## 2011.1342 | 5434.625 | 417.03031 | 10452.220 | -2239.12387 | 13108.374 |
| ## 2011.1370 | 5434.625 | 366.08896 | 10503.161 | -2317.03194 | 13186.282 |
| ## 2011.1397 | 5434.625 | 315.65452 | 10553.595 | -2394.16476 | 13263.415 |
| ## 2011.1425 | 5434.625 | 265.71217 | 10603.538 | -2470.54500 | 13339.795 |
| ## 2011.1452 | 5434.625 | 216.24776 | 10653.002 | -2546.19429 | 13415.444 |
| ## 2011.1479 | 5434.625 | 167.24784 | 10702.002 | -2621.13320 | 13490.383 |
| ## 2011.1507 | 5434.625 | 118.69956 | 10750.550 | -2695.38139 | 13564.631 |
| ## 2011.1534 | 5434.625 | 70.59065 | 10798.659 | -2768.95761 | 13638.208 |

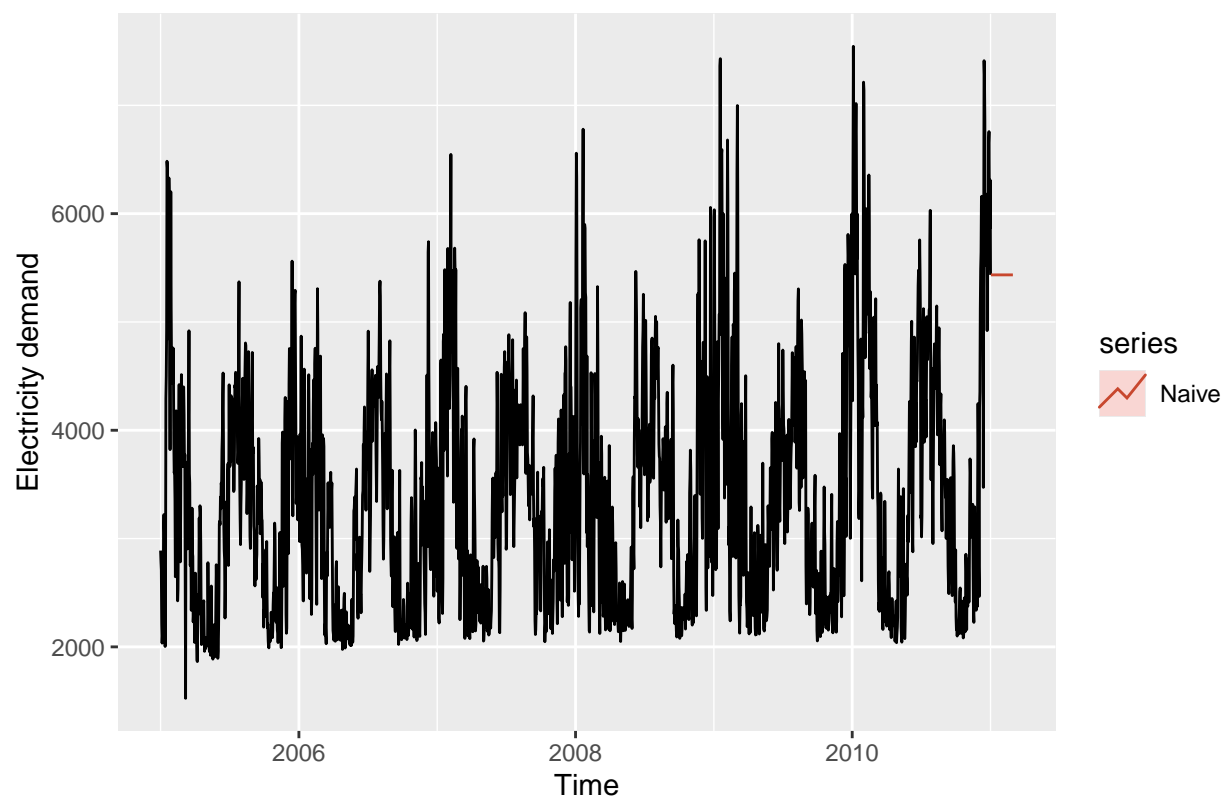
```
## 2011.1562      5434.625    22.90941 10846.341 -2841.87978 13711.130
## 2011.1589      5434.625   -24.35538 10893.605 -2914.16503 13783.415
## 2011.1616      5434.625   -71.21444 10940.464 -2985.82978 13855.080
```

```
plot(fc_naive_full)
```

Forecasts from Naive method

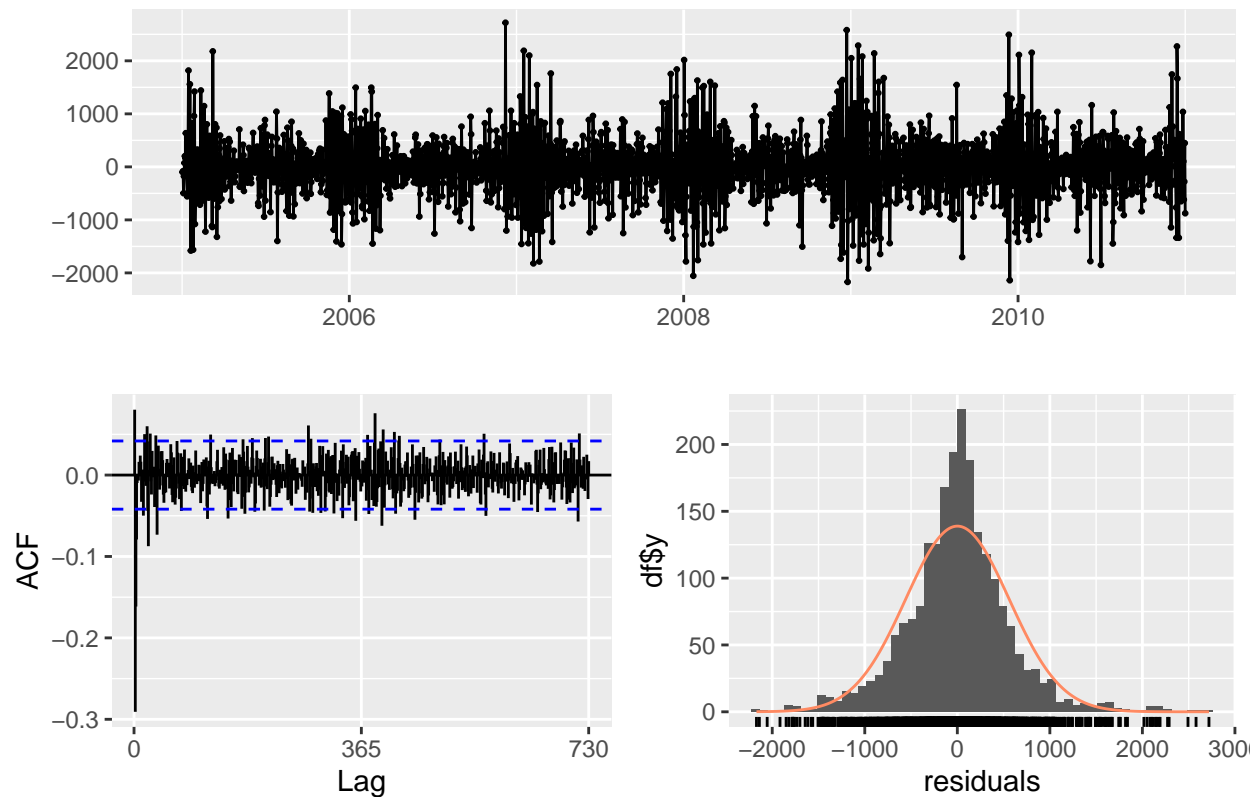


```
#Plot model + observed data
autoplot(y_full) +
  autolayer(fc_naive_full, series="Naive",PI=FALSE) +
  ylab("Electricity demand")
```



```
checkresiduals(fc_naive_full)
```

Residuals from Naive method



```
##
##  Ljung-Box test
##
## data:  Residuals from Naive method
## Q* = 888.66, df = 438, p-value < 2.2e-16
##
## Model df: 0.   Total lags used: 438

# Export to CSV
submission <- template %>%
  mutate(
    date = format(forecast_dates, "%Y-%m-%d"),
    load = as.numeric(fc_naive_full$mean)
  )
out_name <- "submission_final_Naive.csv"
readr::write_csv(submission, file.path(output_dir, out_name))

#Model 3: TBATS

fc_tbats_full <- forecast(tbats(y_full), h = h_future)
print(fc_tbats_full)

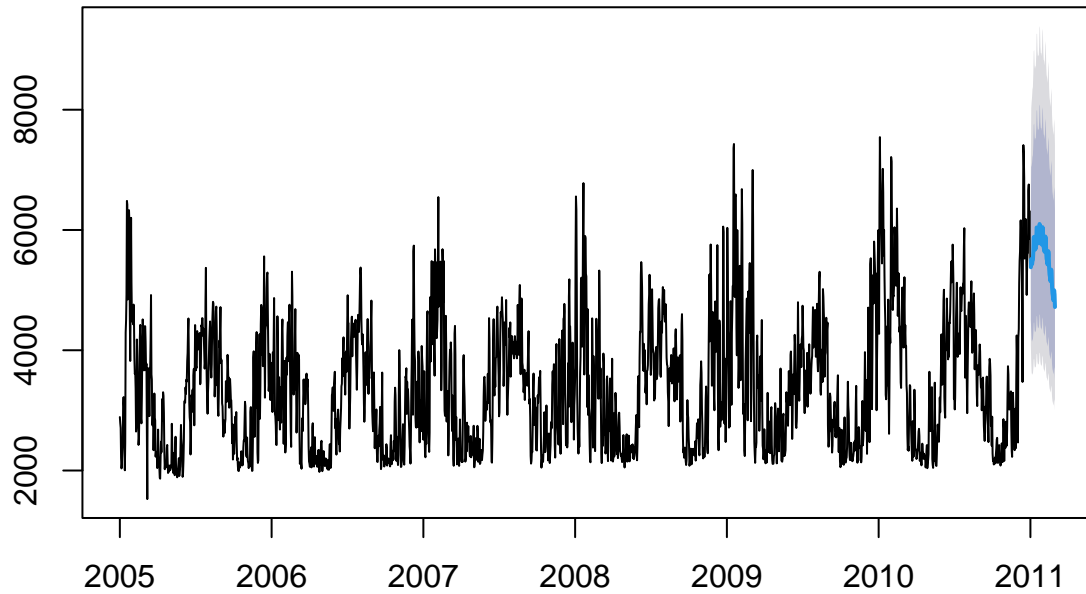
##           Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## 2011.0027      5380.085 4500.220 6431.809 4094.244 7069.322
## 2011.0055      5517.120 4318.157 7048.632 3792.779 8024.480
```

| | | | | | |
|--------------|----------|----------|----------|----------|----------|
| ## 2011.0082 | 5429.911 | 4170.880 | 7068.590 | 3627.191 | 8127.492 |
| ## 2011.0110 | 5431.497 | 4143.706 | 7119.079 | 3590.553 | 8215.164 |
| ## 2011.0137 | 5488.393 | 4174.928 | 7214.637 | 3612.029 | 8338.276 |
| ## 2011.0164 | 5502.866 | 4179.752 | 7244.364 | 3613.371 | 8379.185 |
| ## 2011.0192 | 5641.948 | 4281.575 | 7434.080 | 3699.650 | 8602.675 |
| ## 2011.0219 | 5876.817 | 4457.006 | 7748.428 | 3849.954 | 8969.423 |
| ## 2011.0247 | 5886.765 | 4462.254 | 7765.537 | 3853.437 | 8991.674 |
| ## 2011.0274 | 5719.353 | 4333.369 | 7548.151 | 3741.230 | 8742.081 |
| ## 2011.0301 | 5674.506 | 4297.585 | 7492.105 | 3709.511 | 8679.097 |
| ## 2011.0329 | 5702.158 | 4316.805 | 7531.617 | 3725.314 | 8726.710 |
| ## 2011.0356 | 5693.586 | 4308.633 | 7523.231 | 3717.493 | 8718.793 |
| ## 2011.0384 | 5817.851 | 4401.000 | 7690.345 | 3796.424 | 8914.255 |
| ## 2011.0411 | 6042.138 | 4568.961 | 7989.797 | 3940.533 | 9263.191 |
| ## 2011.0438 | 6035.782 | 4562.421 | 7984.425 | 3934.101 | 9258.824 |
| ## 2011.0466 | 5848.697 | 4419.302 | 7739.918 | 3809.915 | 8977.119 |
| ## 2011.0493 | 5787.844 | 4371.665 | 7662.290 | 3768.090 | 8888.863 |
| ## 2011.0521 | 5801.133 | 4380.058 | 7682.764 | 3774.574 | 8914.384 |
| ## 2011.0548 | 5777.578 | 4360.632 | 7654.446 | 3757.086 | 8883.294 |
| ## 2011.0575 | 5888.533 | 4442.730 | 7804.333 | 3827.070 | 9059.019 |
| ## 2011.0603 | 6099.819 | 4600.453 | 8087.322 | 3962.167 | 9389.322 |
| ## 2011.0630 | 6077.697 | 4582.050 | 8061.014 | 3945.534 | 9360.636 |
| ## 2011.0658 | 5874.103 | 4426.870 | 7793.950 | 3811.141 | 9052.340 |
| ## 2011.0685 | 5797.953 | 4367.842 | 7695.799 | 3759.575 | 8940.118 |
| ## 2011.0712 | 5796.233 | 4364.921 | 7696.378 | 3756.321 | 8942.549 |
| ## 2011.0740 | 5757.776 | 4334.343 | 7648.166 | 3729.270 | 8888.285 |
| ## 2011.0767 | 5853.211 | 4404.567 | 7777.789 | 3788.953 | 9040.682 |
| ## 2011.0795 | 6047.635 | 4549.217 | 8039.060 | 3912.633 | 9346.174 |
| ## 2011.0822 | 6010.266 | 4519.425 | 7992.360 | 3886.243 | 9293.710 |
| ## 2011.0849 | 5794.126 | 4355.250 | 7707.856 | 3744.319 | 8964.676 |
| ## 2011.0877 | 5704.534 | 4286.308 | 7591.499 | 3684.321 | 8831.087 |
| ## 2011.0904 | 5688.513 | 4272.693 | 7572.975 | 3671.900 | 8811.259 |
| ## 2011.0932 | 5636.700 | 4232.207 | 7506.775 | 3636.393 | 8735.946 |
| ## 2011.0959 | 5716.005 | 4290.188 | 7615.166 | 3685.500 | 8863.794 |
| ## 2011.0986 | 5891.483 | 4420.299 | 7851.777 | 3796.547 | 9140.945 |
| ## 2011.1014 | 5840.991 | 4380.796 | 7787.361 | 3761.882 | 9067.725 |
| ## 2011.1041 | 5617.573 | 4211.648 | 7492.309 | 3615.911 | 8725.897 |
| ## 2011.1068 | 5517.787 | 4135.304 | 7361.944 | 3549.671 | 8575.745 |
| ## 2011.1096 | 5489.650 | 4112.709 | 7327.087 | 3529.590 | 8536.798 |
| ## 2011.1123 | 5427.375 | 4064.559 | 7246.633 | 3487.588 | 8444.702 |
| ## 2011.1151 | 5491.567 | 4111.144 | 7334.994 | 3526.884 | 8549.308 |
| ## 2011.1178 | 5647.908 | 4226.672 | 7546.516 | 3625.306 | 8797.514 |
| ## 2011.1205 | 5587.656 | 4180.047 | 7468.750 | 3584.618 | 8708.546 |
| ## 2011.1233 | 5362.831 | 4010.361 | 7170.912 | 3438.423 | 8362.919 |
| ## 2011.1260 | 5256.980 | 3929.760 | 7031.955 | 3368.662 | 8202.458 |
| ## 2011.1288 | 5219.955 | 3900.663 | 6984.971 | 3343.074 | 8149.223 |
| ## 2011.1315 | 5150.960 | 3847.700 | 6895.163 | 3297.044 | 8046.000 |
| ## 2011.1342 | 5202.327 | 3884.674 | 6966.425 | 3328.094 | 8130.701 |
| ## 2011.1370 | 5340.965 | 3986.781 | 7154.616 | 3414.928 | 8351.914 |
| ## 2011.1397 | 5274.970 | 3936.084 | 7068.787 | 3370.853 | 8253.312 |
| ## 2011.1425 | 5054.418 | 3770.113 | 6775.744 | 3228.082 | 7912.715 |
| ## 2011.1452 | 4946.868 | 3688.545 | 6633.987 | 3157.630 | 7748.667 |
| ## 2011.1479 | 4904.658 | 3655.750 | 6579.759 | 3128.957 | 7686.798 |
| ## 2011.1507 | 4832.918 | 3600.971 | 6485.867 | 3081.479 | 7578.562 |
| ## 2011.1534 | 4874.508 | 3630.664 | 6544.015 | 3106.302 | 7647.949 |

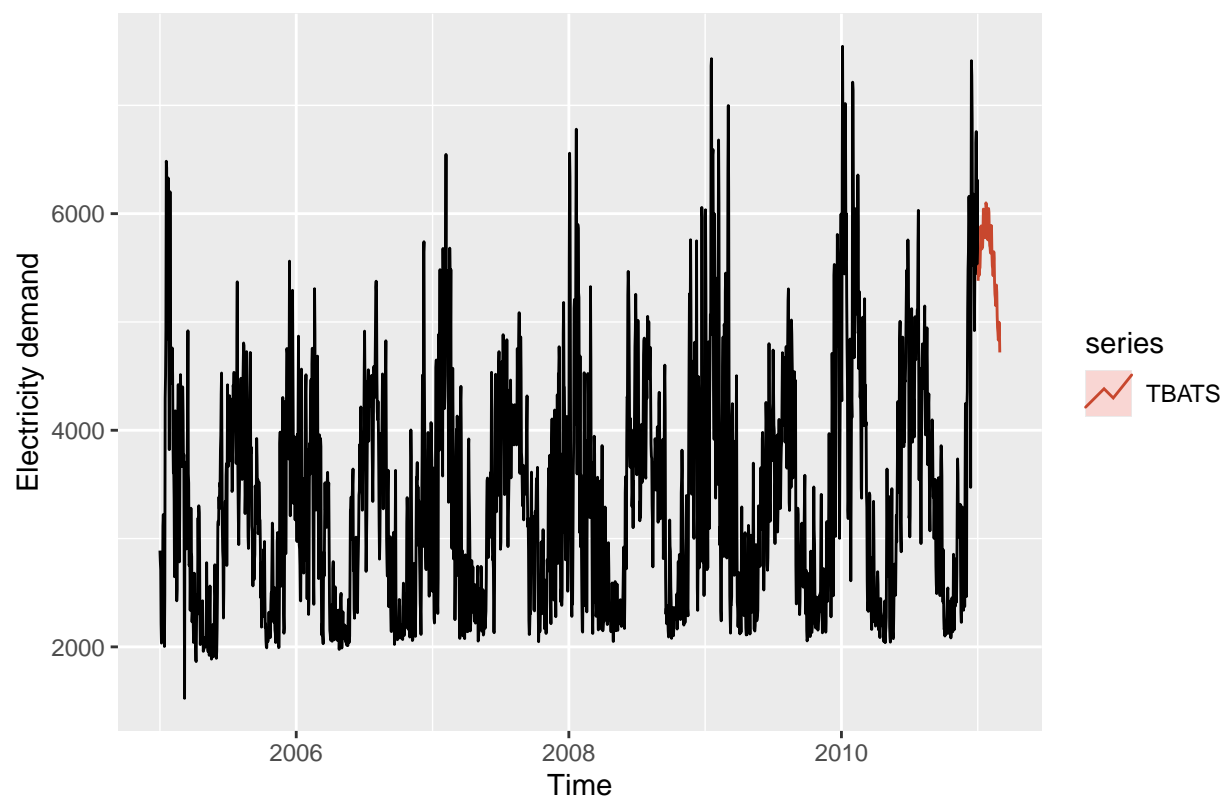
```
## 2011.1562      4998.020 3721.347 6712.196 3183.292 7845.965
## 2011.1589      4930.330 3669.618 6623.686 3138.442 7743.986
## 2011.1616      4718.870 3510.936 6341.933 3002.143 7416.024
```

```
plot(fc_tbats_full)
```

Forecasts from TBATS(0.001, {1,2}, −, {<7,2>, <365.25,2>})

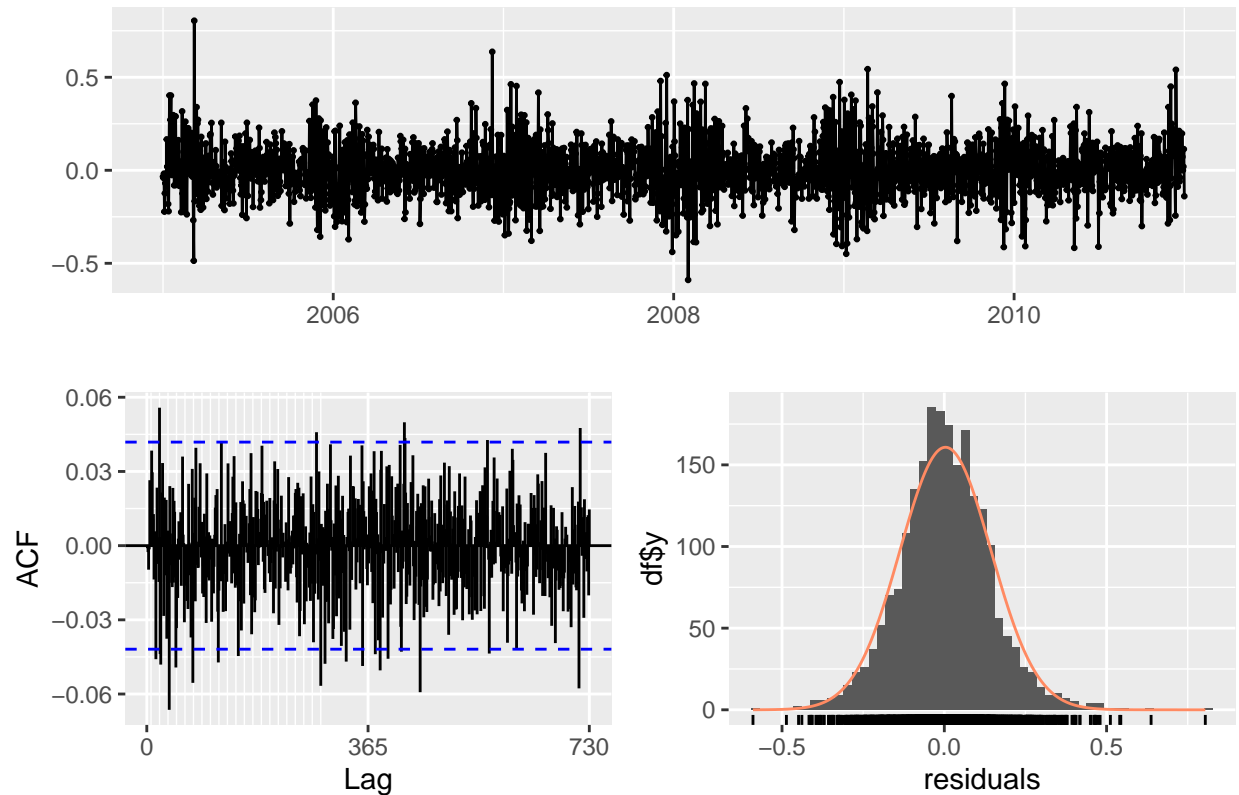


```
#Plot model + observed data
autoplot(y_full) +
  autolayer(fc_tbats_full, series="TBATS",PI=FALSE) +
  ylab("Electricity demand")
```



```
checkresiduals(fc_tbats_full)
```


Residuals from TBATS(0.001, {1,2}, -, {<7,2>, <365.25,2>})



```
##
##  Ljung-Box test
##
## data:  Residuals from TBATS(0.001, {1,2}, -, {<7,2>, <365.25,2>})
## Q* = 437.14, df = 438, p-value = 0.5027
##
## Model df: 0.   Total lags used: 438
```

```
# Export to CSV
submission <- template %>%
  mutate(
    date = format(forecast_dates, "%Y-%m-%d"),
    load = as.numeric(fc_tbats_full$mean)
  )
out_name <- "submission_final_TBATS.csv"
readr::write_csv(submission, file.path(output_dir, out_name))
```

#Model 4-6: TBATS + regressors

```
-- 1) Forecast temp & humidity into 2011 (no drift/mean) --#
fit_temp <- auto.arima(full_train$temp_c, seasonal=FALSE,
  allowdrift=FALSE, allowmean=FALSE)
fit_hum  <- auto.arima(full_train$rh_pct, seasonal=FALSE,
  allowdrift=FALSE, allowmean=FALSE)
```

```

fc_temp <- forecast(fit_temp, h = h_future)$mean
fc_hum  <- forecast(fit_hum, h = h_future)$mean

##-- 2) Build xreg matrices - just the covariates --#
# Historical (2005-2010):
xreg_full_temp <- matrix(full_train$temp_c, ncol=1)
xreg_full_hum  <- matrix(full_train$rh_pct, ncol=1)
xreg_full_both <- cbind(full_train$temp_c, full_train$rh_pct)

# Future (2011):
xreg_future_temp <- matrix(fc_temp, ncol=1)
xreg_future_hum  <- matrix(fc_hum, ncol=1)
xreg_future_both <- cbind(as.numeric(fc_temp), as.numeric(fc_hum))

# Model 4: TBATS + Temp
fit_tb_temp_full <- tbats(y_full, xreg = xreg_full_temp)
fc_tbats_temp_full <- forecast(fit_tb_temp_full,
                              h = h_future,
                              xreg = xreg_future_temp)

print(fc_tbats_temp_full)

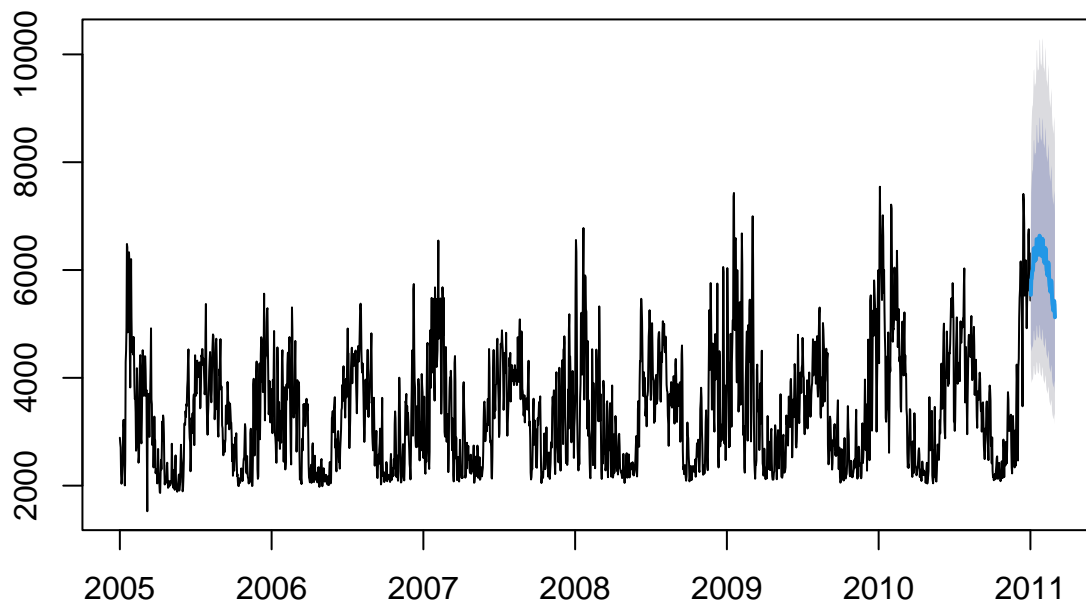
```

| ## | Point | Forecast | Lo 80 | Hi 80 | Lo 95 | Hi 95 |
|----|-----------|----------|----------|----------|----------|-----------|
| ## | 2011.0027 | 5539.938 | 4631.264 | 6626.897 | 4212.228 | 7286.146 |
| ## | 2011.0055 | 5823.408 | 4555.477 | 7444.244 | 4000.187 | 8477.625 |
| ## | 2011.0082 | 5838.615 | 4487.720 | 7596.156 | 3904.159 | 8731.567 |
| ## | 2011.0110 | 5949.202 | 4551.732 | 7775.724 | 3950.214 | 8959.770 |
| ## | 2011.0137 | 5991.887 | 4579.571 | 7839.754 | 3972.163 | 9038.580 |
| ## | 2011.0164 | 5996.749 | 4578.487 | 7854.341 | 3969.020 | 9060.423 |
| ## | 2011.0192 | 6143.125 | 4685.347 | 8054.470 | 4059.410 | 9296.422 |
| ## | 2011.0219 | 6397.117 | 4873.989 | 8396.223 | 4220.524 | 9696.213 |
| ## | 2011.0247 | 6406.109 | 4875.788 | 8416.737 | 4219.768 | 9725.233 |
| ## | 2011.0274 | 6221.596 | 4730.475 | 8182.742 | 4091.773 | 9460.020 |
| ## | 2011.0301 | 6171.773 | 4687.774 | 8125.560 | 4052.632 | 9399.024 |
| ## | 2011.0329 | 6201.652 | 4705.643 | 8173.269 | 4065.874 | 9459.341 |
| ## | 2011.0356 | 6192.060 | 4693.569 | 8168.967 | 4053.249 | 9459.475 |
| ## | 2011.0384 | 6328.028 | 4791.749 | 8356.852 | 4135.805 | 9682.260 |
| ## | 2011.0411 | 6573.677 | 4972.710 | 8690.076 | 4289.688 | 10073.747 |
| ## | 2011.0438 | 6566.744 | 4962.450 | 8689.684 | 4278.549 | 10078.681 |
| ## | 2011.0466 | 6361.758 | 4802.712 | 8426.898 | 4138.622 | 9779.093 |
| ## | 2011.0493 | 6294.974 | 4747.531 | 8346.800 | 4088.900 | 9691.286 |
| ## | 2011.0521 | 6309.433 | 4753.679 | 8374.345 | 4092.027 | 9728.418 |
| ## | 2011.0548 | 6283.603 | 4729.499 | 8348.381 | 4069.064 | 9703.376 |
| ## | 2011.0575 | 6405.093 | 4816.149 | 8518.261 | 4141.434 | 9906.042 |
| ## | 2011.0603 | 6636.562 | 4985.251 | 8834.851 | 4284.596 | 10279.605 |
| ## | 2011.0630 | 6612.384 | 4962.190 | 8811.355 | 4262.549 | 10257.624 |
| ## | 2011.0658 | 6389.327 | 4790.092 | 8522.488 | 4112.576 | 9926.504 |
| ## | 2011.0685 | 6305.797 | 4722.839 | 8419.317 | 4052.732 | 9811.425 |
| ## | 2011.0712 | 6303.822 | 4716.746 | 8424.913 | 4045.409 | 9823.028 |
| ## | 2011.0740 | 6261.675 | 4680.645 | 8376.746 | 4012.376 | 9771.910 |
| ## | 2011.0767 | 6366.160 | 4754.123 | 8524.810 | 4073.266 | 9949.754 |
| ## | 2011.0795 | 6579.136 | 4908.407 | 8818.548 | 4203.296 | 10297.876 |
| ## | 2011.0822 | 6538.257 | 4873.204 | 8772.219 | 4171.018 | 10249.010 |

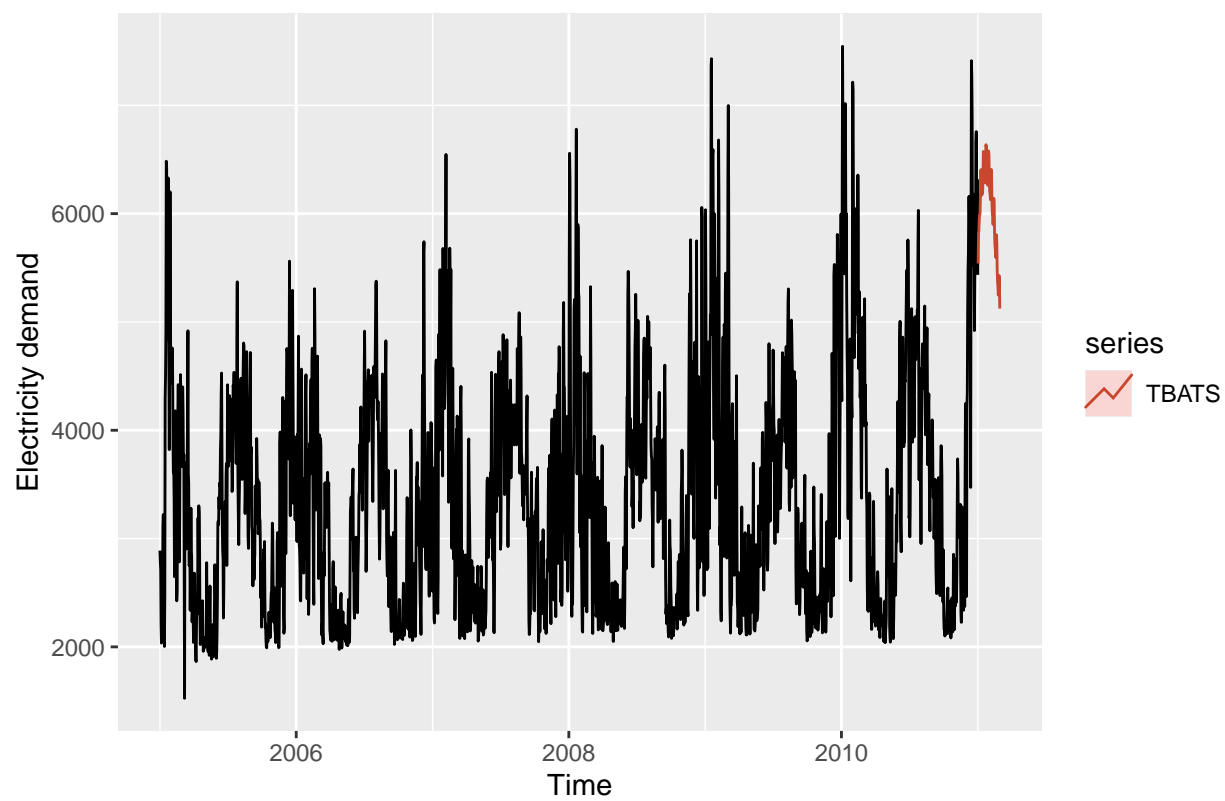
| | | | | | |
|--------------|----------|----------|----------|----------|-----------|
| ## 2011.0849 | 6301.490 | 4692.221 | 8462.683 | 4014.071 | 9892.396 |
| ## 2011.0877 | 6203.254 | 4614.645 | 8338.747 | 3945.704 | 9752.470 |
| ## 2011.0904 | 6185.622 | 4597.129 | 8323.005 | 3928.736 | 9738.991 |
| ## 2011.0932 | 6128.860 | 4550.599 | 8254.501 | 3887.008 | 9663.712 |
| ## 2011.0959 | 6215.662 | 4610.658 | 8379.381 | 3936.324 | 9814.856 |
| ## 2011.0986 | 6407.841 | 4748.702 | 8646.663 | 4052.142 | 10133.018 |
| ## 2011.1014 | 6352.599 | 4703.316 | 8580.225 | 4011.405 | 10060.191 |
| ## 2011.1041 | 6107.928 | 4517.913 | 8257.526 | 3851.358 | 9686.656 |
| ## 2011.1068 | 5998.565 | 4432.854 | 8117.294 | 3776.970 | 9526.890 |
| ## 2011.1096 | 5967.679 | 4405.899 | 8083.072 | 3752.141 | 9491.433 |
| ## 2011.1123 | 5899.488 | 4351.484 | 7998.182 | 3703.967 | 9396.401 |
| ## 2011.1151 | 5969.720 | 4399.182 | 8100.952 | 3742.719 | 9521.837 |
| ## 2011.1178 | 6140.882 | 4521.105 | 8340.976 | 3844.554 | 9808.791 |
| ## 2011.1205 | 6074.975 | 4468.441 | 8259.104 | 3797.908 | 9717.276 |
| ## 2011.1233 | 5828.862 | 4283.459 | 7931.821 | 3638.906 | 9336.769 |
| ## 2011.1260 | 5712.914 | 4194.388 | 7781.202 | 3561.502 | 9163.937 |
| ## 2011.1288 | 5672.323 | 4160.761 | 7733.020 | 3531.231 | 9111.624 |
| ## 2011.1315 | 5596.811 | 4101.610 | 7637.073 | 3479.340 | 9002.940 |
| ## 2011.1342 | 5652.985 | 4138.989 | 7720.785 | 3509.348 | 9106.032 |
| ## 2011.1370 | 5804.699 | 4246.193 | 7935.232 | 3598.506 | 9363.478 |
| ## 2011.1397 | 5732.539 | 4189.599 | 7843.711 | 3548.836 | 9259.938 |
| ## 2011.1425 | 5491.223 | 4009.603 | 7520.329 | 3394.742 | 8882.422 |
| ## 2011.1452 | 5373.485 | 3920.089 | 7365.735 | 3317.368 | 8703.990 |
| ## 2011.1479 | 5327.252 | 3882.858 | 7308.949 | 3284.293 | 8641.011 |
| ## 2011.1507 | 5248.781 | 3822.223 | 7207.770 | 3231.466 | 8525.451 |
| ## 2011.1534 | 5294.240 | 3851.867 | 7276.725 | 3254.980 | 8611.104 |
| ## 2011.1562 | 5429.333 | 3946.618 | 7469.093 | 3333.468 | 8842.939 |
| ## 2011.1589 | 5355.357 | 3889.373 | 7373.900 | 3283.566 | 8734.360 |
| ## 2011.1616 | 5124.122 | 3718.131 | 7061.780 | 3137.520 | 8368.591 |

```
plot(fc_tbats_temp_full)
```

Forecasts from TBATS(0, {0,3}, -, {<7,2>, <365.25,2>})

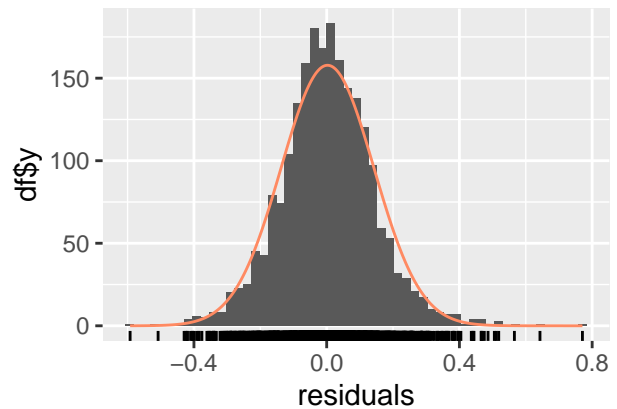
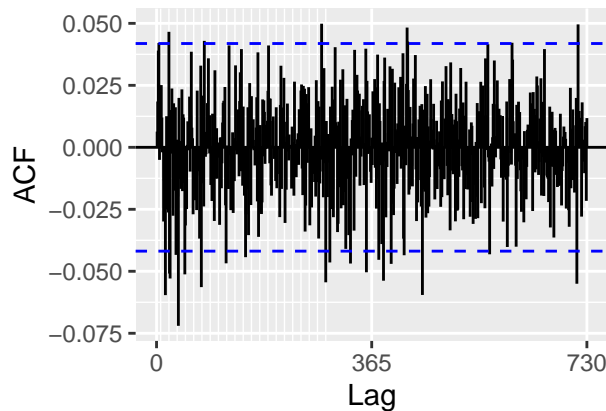
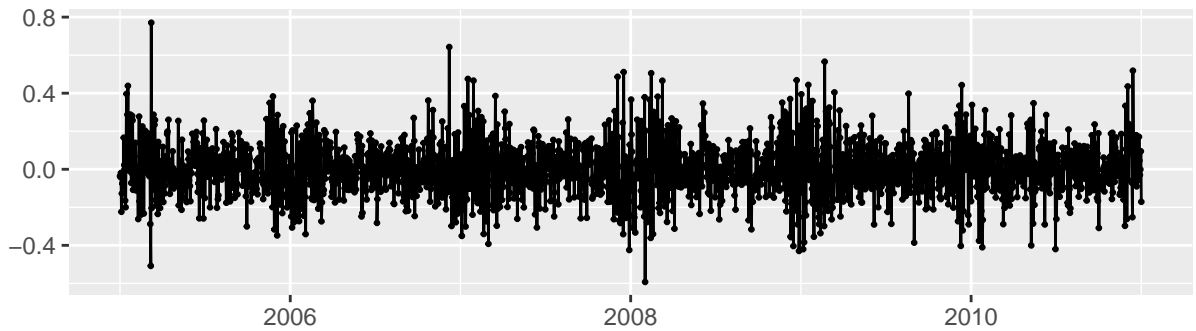


```
#Plot model + observed data
autoplot(y_full) +
  autolayer(fc_tbats_temp_full, series="TBATS",PI=FALSE) +
  ylab("Electricity demand")
```



```
checkresiduals(fc_tbats_temp_full)
```

Residuals from TBATS(0, {0,3}, -, {<7,2>, <365.25,2>})



```
##
##  Ljung-Box test
##
## data:  Residuals from TBATS(0, {0,3}, -, {<7,2>, <365.25,2>})
## Q* = 451.67, df = 438, p-value = 0.3157
##
## Model df: 0.   Total lags used: 438
```

```
# Export to CSV
submission <- template %>%
  mutate(
    date = format(forecast_dates, "%Y-%m-%d"),
    load = as.numeric(fc_tbats_temp_full$mean)
  )
out_name <- "submission_final_TBATS_temp.csv"
readr::write_csv(submission, file.path(output_dir, out_name))
```

```
# Model TBATS + Hum
fit_tb_hum_full <- tbats(y_full, xreg = xreg_full_hum)
fc_tbats_hum_full <- forecast(fit_tb_hum_full,
                              h = h_future,
                              xreg = xreg_future_hum)

print(fc_tbats_hum_full)
```

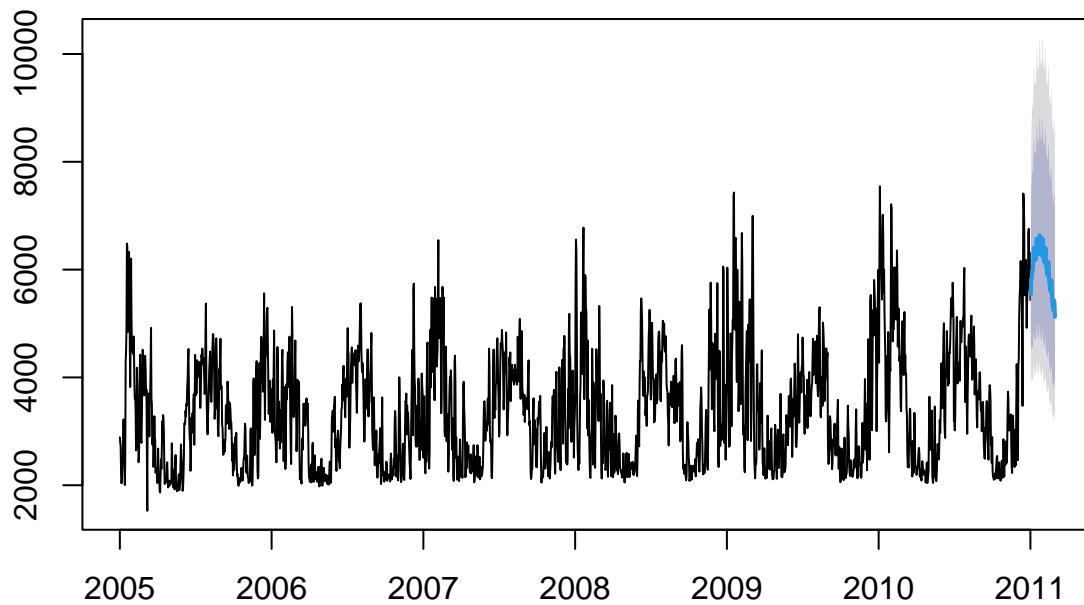
```
##           Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
```

| | | | | | |
|--------------|----------|----------|----------|----------|-----------|
| ## 2011.0027 | 5539.938 | 4631.264 | 6626.897 | 4212.228 | 7286.146 |
| ## 2011.0055 | 5823.408 | 4555.477 | 7444.244 | 4000.187 | 8477.625 |
| ## 2011.0082 | 5838.615 | 4487.720 | 7596.156 | 3904.159 | 8731.567 |
| ## 2011.0110 | 5949.202 | 4551.732 | 7775.724 | 3950.214 | 8959.770 |
| ## 2011.0137 | 5991.887 | 4579.571 | 7839.754 | 3972.163 | 9038.580 |
| ## 2011.0164 | 5996.749 | 4578.487 | 7854.341 | 3969.020 | 9060.423 |
| ## 2011.0192 | 6143.125 | 4685.347 | 8054.470 | 4059.410 | 9296.422 |
| ## 2011.0219 | 6397.117 | 4873.989 | 8396.223 | 4220.524 | 9696.213 |
| ## 2011.0247 | 6406.109 | 4875.788 | 8416.737 | 4219.768 | 9725.233 |
| ## 2011.0274 | 6221.596 | 4730.475 | 8182.742 | 4091.773 | 9460.020 |
| ## 2011.0301 | 6171.773 | 4687.774 | 8125.560 | 4052.632 | 9399.024 |
| ## 2011.0329 | 6201.652 | 4705.643 | 8173.269 | 4065.874 | 9459.341 |
| ## 2011.0356 | 6192.060 | 4693.569 | 8168.967 | 4053.249 | 9459.475 |
| ## 2011.0384 | 6328.028 | 4791.749 | 8356.852 | 4135.805 | 9682.260 |
| ## 2011.0411 | 6573.677 | 4972.710 | 8690.076 | 4289.688 | 10073.747 |
| ## 2011.0438 | 6566.744 | 4962.450 | 8689.684 | 4278.549 | 10078.681 |
| ## 2011.0466 | 6361.758 | 4802.712 | 8426.898 | 4138.622 | 9779.093 |
| ## 2011.0493 | 6294.974 | 4747.531 | 8346.800 | 4088.900 | 9691.286 |
| ## 2011.0521 | 6309.433 | 4753.679 | 8374.345 | 4092.027 | 9728.418 |
| ## 2011.0548 | 6283.603 | 4729.499 | 8348.381 | 4069.064 | 9703.376 |
| ## 2011.0575 | 6405.093 | 4816.149 | 8518.261 | 4141.434 | 9906.042 |
| ## 2011.0603 | 6636.562 | 4985.251 | 8834.851 | 4284.596 | 10279.605 |
| ## 2011.0630 | 6612.384 | 4962.190 | 8811.355 | 4262.549 | 10257.624 |
| ## 2011.0658 | 6389.327 | 4790.092 | 8522.488 | 4112.576 | 9926.504 |
| ## 2011.0685 | 6305.797 | 4722.839 | 8419.317 | 4052.732 | 9811.425 |
| ## 2011.0712 | 6303.822 | 4716.746 | 8424.913 | 4045.409 | 9823.028 |
| ## 2011.0740 | 6261.675 | 4680.645 | 8376.746 | 4012.376 | 9771.910 |
| ## 2011.0767 | 6366.160 | 4754.123 | 8524.810 | 4073.266 | 9949.754 |
| ## 2011.0795 | 6579.136 | 4908.407 | 8818.548 | 4203.296 | 10297.876 |
| ## 2011.0822 | 6538.257 | 4873.204 | 8772.219 | 4171.018 | 10249.010 |
| ## 2011.0849 | 6301.490 | 4692.221 | 8462.683 | 4014.071 | 9892.396 |
| ## 2011.0877 | 6203.254 | 4614.645 | 8338.747 | 3945.704 | 9752.470 |
| ## 2011.0904 | 6185.622 | 4597.129 | 8323.005 | 3928.736 | 9738.991 |
| ## 2011.0932 | 6128.860 | 4550.599 | 8254.501 | 3887.008 | 9663.712 |
| ## 2011.0959 | 6215.662 | 4610.658 | 8379.381 | 3936.324 | 9814.856 |
| ## 2011.0986 | 6407.841 | 4748.702 | 8646.663 | 4052.142 | 10133.018 |
| ## 2011.1014 | 6352.599 | 4703.316 | 8580.225 | 4011.405 | 10060.191 |
| ## 2011.1041 | 6107.928 | 4517.913 | 8257.526 | 3851.358 | 9686.656 |
| ## 2011.1068 | 5998.565 | 4432.854 | 8117.294 | 3776.970 | 9526.890 |
| ## 2011.1096 | 5967.679 | 4405.899 | 8083.072 | 3752.141 | 9491.433 |
| ## 2011.1123 | 5899.488 | 4351.484 | 7998.182 | 3703.967 | 9396.401 |
| ## 2011.1151 | 5969.720 | 4399.182 | 8100.952 | 3742.719 | 9521.837 |
| ## 2011.1178 | 6140.882 | 4521.105 | 8340.976 | 3844.554 | 9808.791 |
| ## 2011.1205 | 6074.975 | 4468.441 | 8259.104 | 3797.908 | 9717.276 |
| ## 2011.1233 | 5828.862 | 4283.459 | 7931.821 | 3638.906 | 9336.769 |
| ## 2011.1260 | 5712.914 | 4194.388 | 7781.202 | 3561.502 | 9163.937 |
| ## 2011.1288 | 5672.323 | 4160.761 | 7733.020 | 3531.231 | 9111.624 |
| ## 2011.1315 | 5596.811 | 4101.610 | 7637.073 | 3479.340 | 9002.940 |
| ## 2011.1342 | 5652.985 | 4138.989 | 7720.785 | 3509.348 | 9106.032 |
| ## 2011.1370 | 5804.699 | 4246.193 | 7935.232 | 3598.506 | 9363.478 |
| ## 2011.1397 | 5732.539 | 4189.599 | 7843.711 | 3548.836 | 9259.938 |
| ## 2011.1425 | 5491.223 | 4009.603 | 7520.329 | 3394.742 | 8882.422 |
| ## 2011.1452 | 5373.485 | 3920.089 | 7365.735 | 3317.368 | 8703.990 |
| ## 2011.1479 | 5327.252 | 3882.858 | 7308.949 | 3284.293 | 8641.011 |

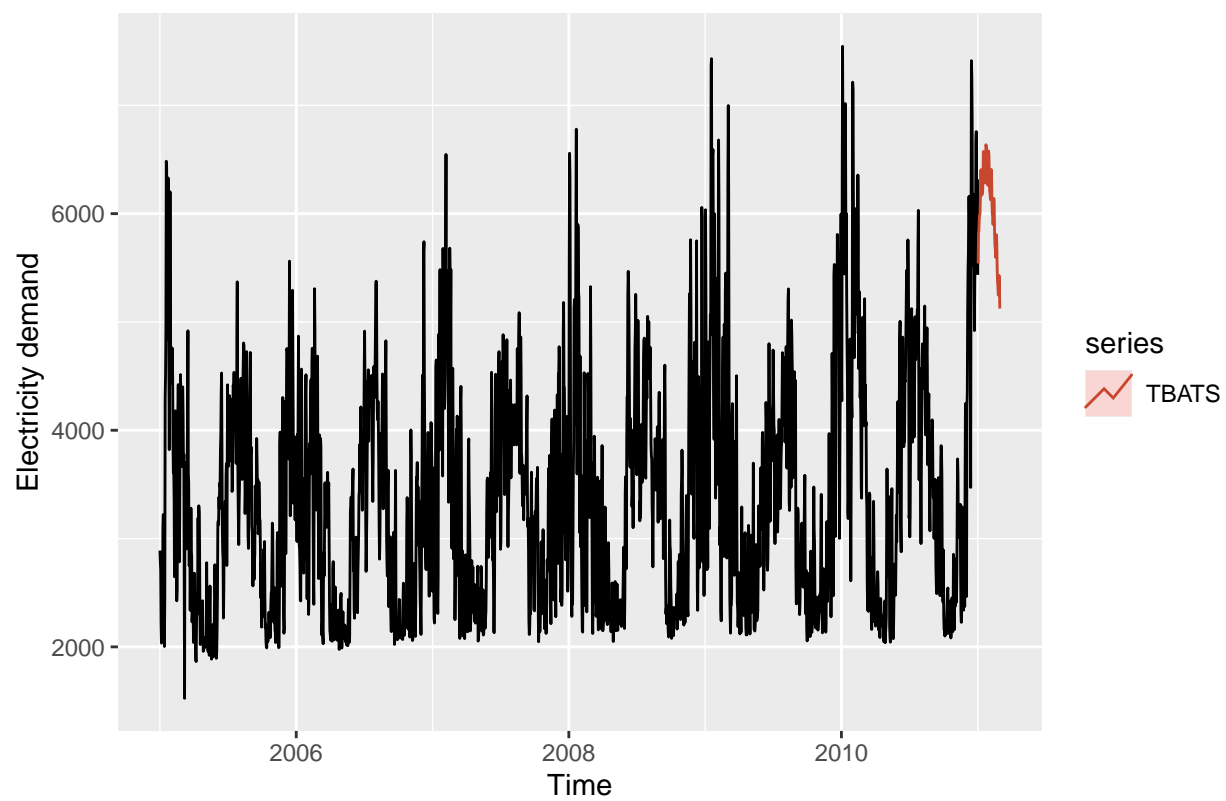
```
## 2011.1507      5248.781 3822.223 7207.770 3231.466 8525.451
## 2011.1534      5294.240 3851.867 7276.725 3254.980 8611.104
## 2011.1562      5429.333 3946.618 7469.093 3333.468 8842.939
## 2011.1589      5355.357 3889.373 7373.900 3283.566 8734.360
## 2011.1616      5124.122 3718.131 7061.780 3137.520 8368.591
```

```
plot(fc_tbats_hum_full)
```

Forecasts from TBATS(0, {0,3}, –, {<7,2>, <365.25,2>})

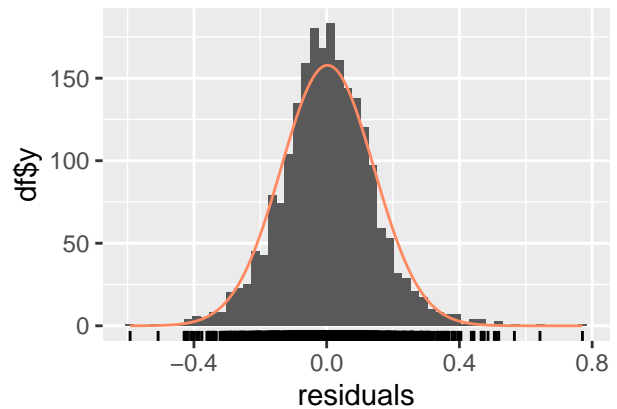
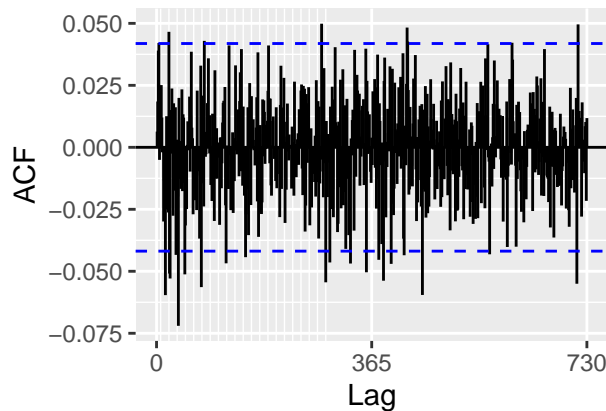
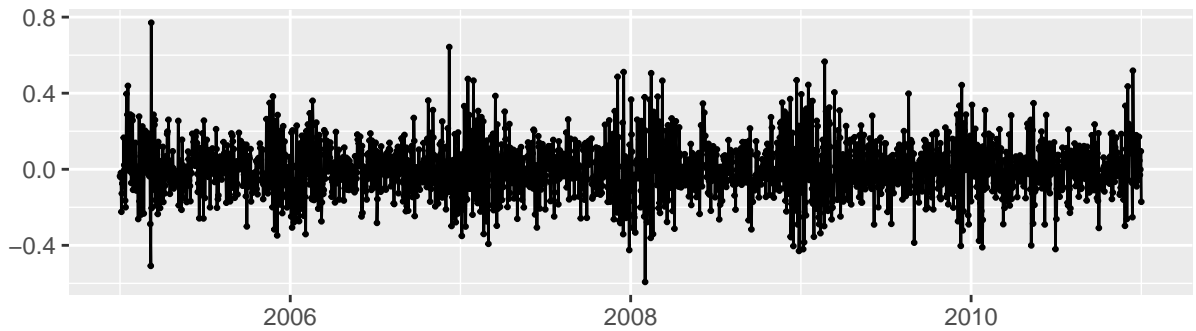


```
#Plot model + observed data
autoplot(y_full) +
  autolayer(fc_tbats_hum_full, series="TBATS",PI=FALSE) +
  ylab("Electricity demand")
```

```
checkresiduals(fc_tbats_hum_full)
```

Residuals from TBATS(0, {0,3}, -, {<7,2>, <365.25,2>})



```
##
##  Ljung-Box test
##
## data:  Residuals from TBATS(0, {0,3}, -, {<7,2>, <365.25,2>})
## Q* = 451.67, df = 438, p-value = 0.3157
##
## Model df: 0.   Total lags used: 438
```

```
# Export to CSV
submission <- template %>%
  mutate(
    date = format(forecast_dates, "%Y-%m-%d"),
    load = as.numeric(fc_tbats_hum_full$mean)
  )
out_name <- "submission_final_TBATS_hum.csv"
readr::write_csv(submission, file.path(output_dir, out_name))
```

```
# Model 6: TBATS + Both
fit_tb_both_full <- tbats(y_full, xreg = xreg_full_both)
fc_tbats_both_full <- forecast(fit_tb_both_full,
                              h = h_future,
                              xreg = xreg_future_both)

print(fc_tbats_both_full)
```

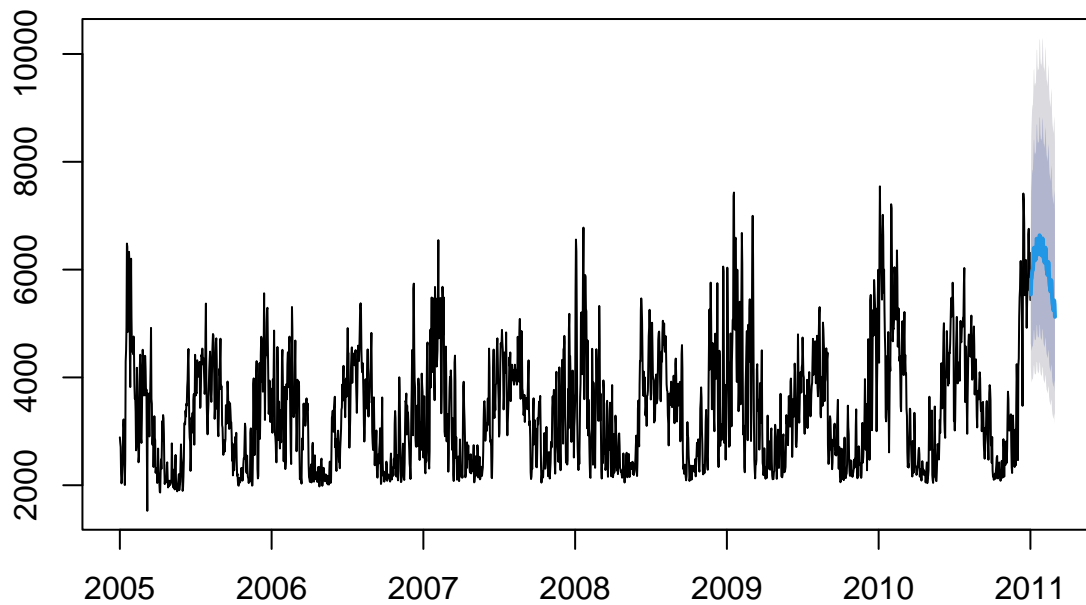
```
##           Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
```

| | | | | | |
|--------------|----------|----------|----------|----------|-----------|
| ## 2011.0027 | 5539.938 | 4631.264 | 6626.897 | 4212.228 | 7286.146 |
| ## 2011.0055 | 5823.408 | 4555.477 | 7444.244 | 4000.187 | 8477.625 |
| ## 2011.0082 | 5838.615 | 4487.720 | 7596.156 | 3904.159 | 8731.567 |
| ## 2011.0110 | 5949.202 | 4551.732 | 7775.724 | 3950.214 | 8959.770 |
| ## 2011.0137 | 5991.887 | 4579.571 | 7839.754 | 3972.163 | 9038.580 |
| ## 2011.0164 | 5996.749 | 4578.487 | 7854.341 | 3969.020 | 9060.423 |
| ## 2011.0192 | 6143.125 | 4685.347 | 8054.470 | 4059.410 | 9296.422 |
| ## 2011.0219 | 6397.117 | 4873.989 | 8396.223 | 4220.524 | 9696.213 |
| ## 2011.0247 | 6406.109 | 4875.788 | 8416.737 | 4219.768 | 9725.233 |
| ## 2011.0274 | 6221.596 | 4730.475 | 8182.742 | 4091.773 | 9460.020 |
| ## 2011.0301 | 6171.773 | 4687.774 | 8125.560 | 4052.632 | 9399.024 |
| ## 2011.0329 | 6201.652 | 4705.643 | 8173.269 | 4065.874 | 9459.341 |
| ## 2011.0356 | 6192.060 | 4693.569 | 8168.967 | 4053.249 | 9459.475 |
| ## 2011.0384 | 6328.028 | 4791.749 | 8356.852 | 4135.805 | 9682.260 |
| ## 2011.0411 | 6573.677 | 4972.710 | 8690.076 | 4289.688 | 10073.747 |
| ## 2011.0438 | 6566.744 | 4962.450 | 8689.684 | 4278.549 | 10078.681 |
| ## 2011.0466 | 6361.758 | 4802.712 | 8426.898 | 4138.622 | 9779.093 |
| ## 2011.0493 | 6294.974 | 4747.531 | 8346.800 | 4088.900 | 9691.286 |
| ## 2011.0521 | 6309.433 | 4753.679 | 8374.345 | 4092.027 | 9728.418 |
| ## 2011.0548 | 6283.603 | 4729.499 | 8348.381 | 4069.064 | 9703.376 |
| ## 2011.0575 | 6405.093 | 4816.149 | 8518.261 | 4141.434 | 9906.042 |
| ## 2011.0603 | 6636.562 | 4985.251 | 8834.851 | 4284.596 | 10279.605 |
| ## 2011.0630 | 6612.384 | 4962.190 | 8811.355 | 4262.549 | 10257.624 |
| ## 2011.0658 | 6389.327 | 4790.092 | 8522.488 | 4112.576 | 9926.504 |
| ## 2011.0685 | 6305.797 | 4722.839 | 8419.317 | 4052.732 | 9811.425 |
| ## 2011.0712 | 6303.822 | 4716.746 | 8424.913 | 4045.409 | 9823.028 |
| ## 2011.0740 | 6261.675 | 4680.645 | 8376.746 | 4012.376 | 9771.910 |
| ## 2011.0767 | 6366.160 | 4754.123 | 8524.810 | 4073.266 | 9949.754 |
| ## 2011.0795 | 6579.136 | 4908.407 | 8818.548 | 4203.296 | 10297.876 |
| ## 2011.0822 | 6538.257 | 4873.204 | 8772.219 | 4171.018 | 10249.010 |
| ## 2011.0849 | 6301.490 | 4692.221 | 8462.683 | 4014.071 | 9892.396 |
| ## 2011.0877 | 6203.254 | 4614.645 | 8338.747 | 3945.704 | 9752.470 |
| ## 2011.0904 | 6185.622 | 4597.129 | 8323.005 | 3928.736 | 9738.991 |
| ## 2011.0932 | 6128.860 | 4550.599 | 8254.501 | 3887.008 | 9663.712 |
| ## 2011.0959 | 6215.662 | 4610.658 | 8379.381 | 3936.324 | 9814.856 |
| ## 2011.0986 | 6407.841 | 4748.702 | 8646.663 | 4052.142 | 10133.018 |
| ## 2011.1014 | 6352.599 | 4703.316 | 8580.225 | 4011.405 | 10060.191 |
| ## 2011.1041 | 6107.928 | 4517.913 | 8257.526 | 3851.358 | 9686.656 |
| ## 2011.1068 | 5998.565 | 4432.854 | 8117.294 | 3776.970 | 9526.890 |
| ## 2011.1096 | 5967.679 | 4405.899 | 8083.072 | 3752.141 | 9491.433 |
| ## 2011.1123 | 5899.488 | 4351.484 | 7998.182 | 3703.967 | 9396.401 |
| ## 2011.1151 | 5969.720 | 4399.182 | 8100.952 | 3742.719 | 9521.837 |
| ## 2011.1178 | 6140.882 | 4521.105 | 8340.976 | 3844.554 | 9808.791 |
| ## 2011.1205 | 6074.975 | 4468.441 | 8259.104 | 3797.908 | 9717.276 |
| ## 2011.1233 | 5828.862 | 4283.459 | 7931.821 | 3638.906 | 9336.769 |
| ## 2011.1260 | 5712.914 | 4194.388 | 7781.202 | 3561.502 | 9163.937 |
| ## 2011.1288 | 5672.323 | 4160.761 | 7733.020 | 3531.231 | 9111.624 |
| ## 2011.1315 | 5596.811 | 4101.610 | 7637.073 | 3479.340 | 9002.940 |
| ## 2011.1342 | 5652.985 | 4138.989 | 7720.785 | 3509.348 | 9106.032 |
| ## 2011.1370 | 5804.699 | 4246.193 | 7935.232 | 3598.506 | 9363.478 |
| ## 2011.1397 | 5732.539 | 4189.599 | 7843.711 | 3548.836 | 9259.938 |
| ## 2011.1425 | 5491.223 | 4009.603 | 7520.329 | 3394.742 | 8882.422 |
| ## 2011.1452 | 5373.485 | 3920.089 | 7365.735 | 3317.368 | 8703.990 |
| ## 2011.1479 | 5327.252 | 3882.858 | 7308.949 | 3284.293 | 8641.011 |

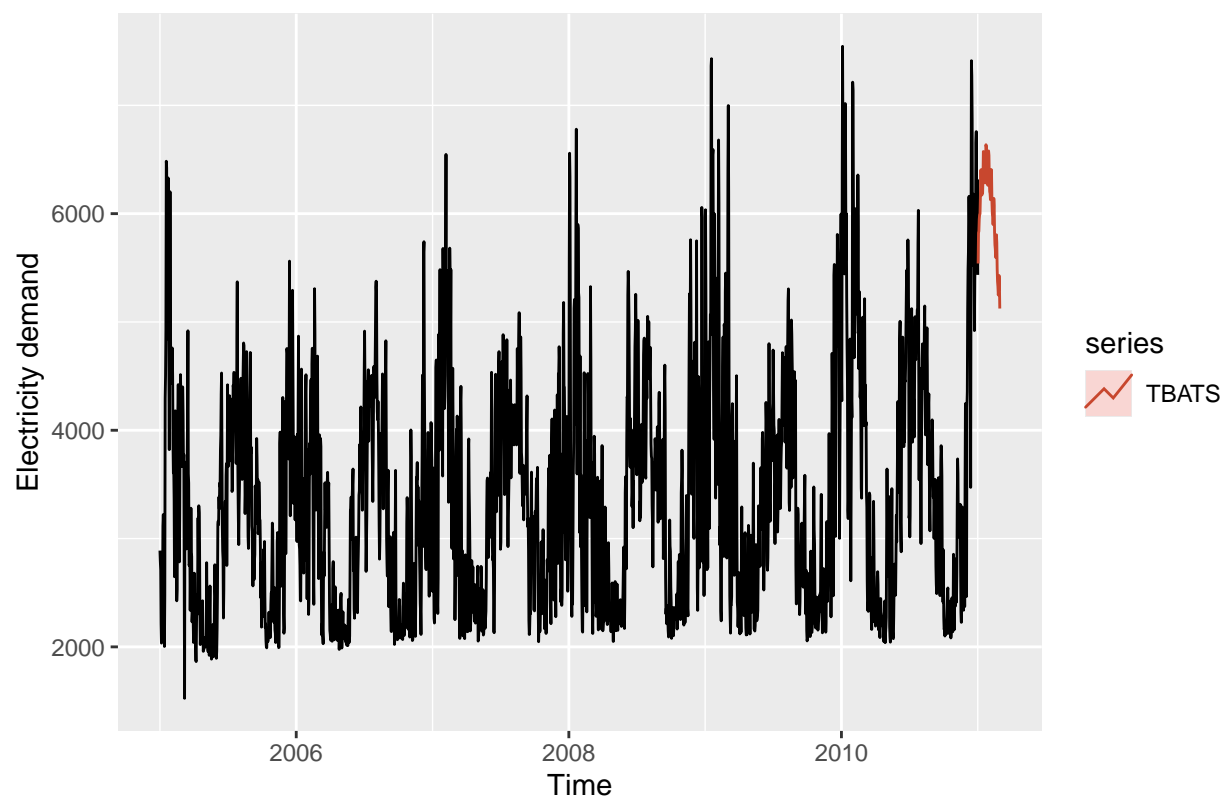
```
## 2011.1507      5248.781 3822.223 7207.770 3231.466 8525.451
## 2011.1534      5294.240 3851.867 7276.725 3254.980 8611.104
## 2011.1562      5429.333 3946.618 7469.093 3333.468 8842.939
## 2011.1589      5355.357 3889.373 7373.900 3283.566 8734.360
## 2011.1616      5124.122 3718.131 7061.780 3137.520 8368.591
```

```
plot(fc_tbats_both_full)
```

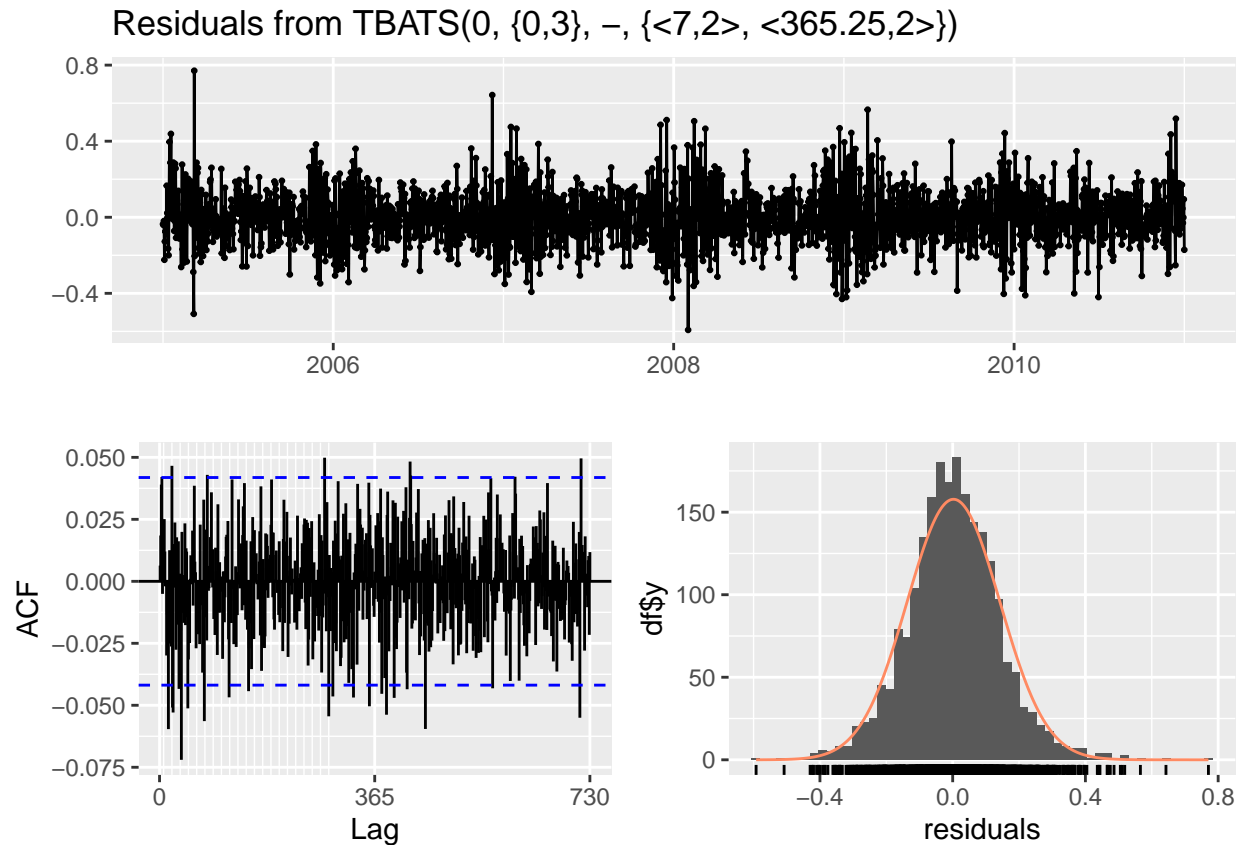
Forecasts from TBATS(0, {0,3}, –, {<7,2>, <365.25,2>})



```
#Plot model + observed data
autoplot(y_full) +
  autolayer(fc_tbats_both_full, series="TBATS",PI=FALSE) +
  ylab("Electricity demand")
```



```
checkresiduals(fc_tbats_both_full)
```



```
##
##  Ljung-Box test
##
## data:  Residuals from TBATS(0, {0,3}, -, {<7,2>, <365.25,2>})
## Q* = 451.67, df = 438, p-value = 0.3157
##
## Model df: 0.   Total lags used: 438
```

```
# Export to CSV
submission <- template %>%
  mutate(
    date = format(forecast_dates, "%Y-%m-%d"),
    load = as.numeric(fc_tbats_both_full$mean)
  )
out_name <- "submission_final_TBATS_both.csv"
readr::write_csv(submission, file.path(output_dir, out_name))
```

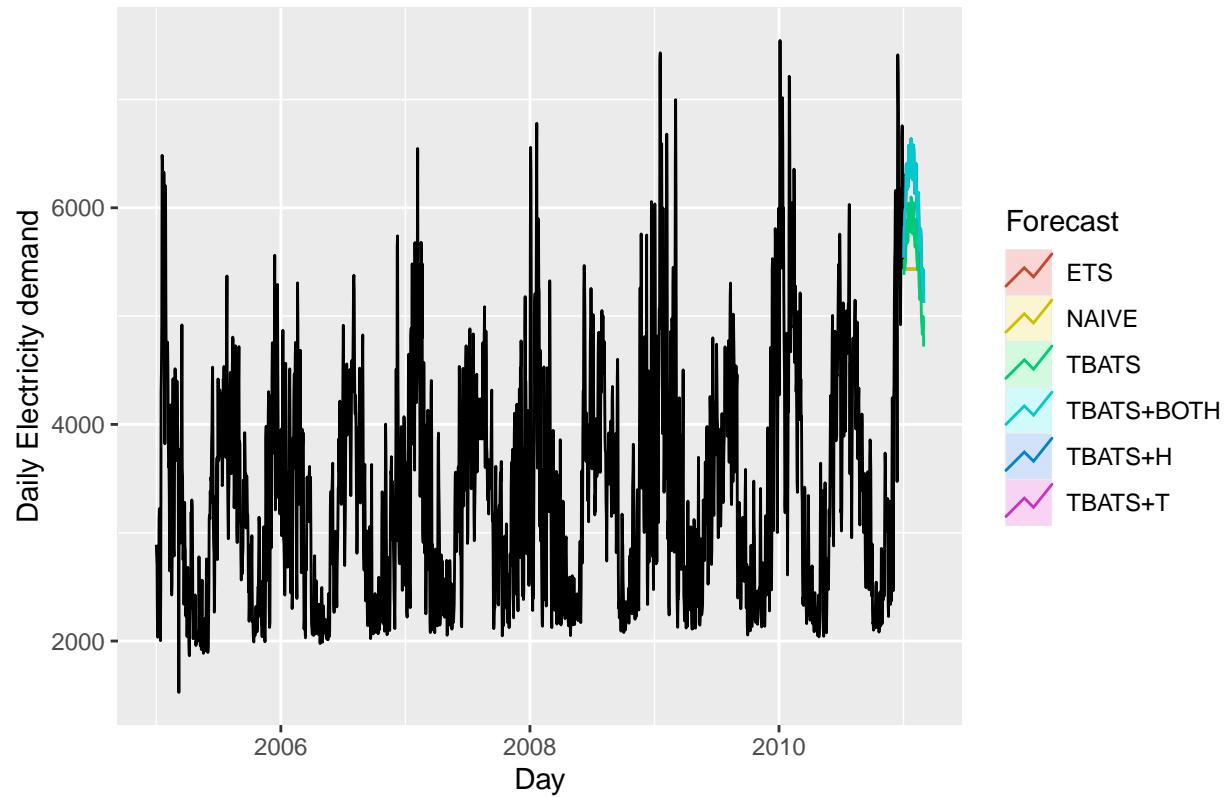
Graph

```
autoplot(y_full) +
  autolayer(fc_ets_bc_full, PI=FALSE, series="ETS") +
  autolayer(fc_naive_full, PI=FALSE, series="NAIVE") +
  autolayer(fc_tbats_full, PI=FALSE, series="TBATS") +
```

```

autolayer(fc_tbats_temp_full,PI=FALSE, series="TBATS+T") +
autolayer(fc_tbats_hum_full,PI=FALSE, series="TBATS+H") +
autolayer(fc_tbats_both_full,PI=FALSE, series="TBATS+BOTH") +
xlab("Day") + ylab("Daily Electricity demand") +
guides(colour=guide_legend(title="Forecast"))

```



Conclusions