ADS506 Assignment 2.2 PJME_MW Time Series Data

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Assignment: Propose a Time Series Dataset for Your Final Project ### Data Source

The data source is the PJM Hourly Energy Consumption Data. The dataset contains the hourly power consumption data from PJM from 2005 to 2018. The dataset contains the following columns:

```
# Load necessary libraries
library(readr)
library(dplyr)
library(tsibble)
library(ggplot2)
library(feasts)
library(fable)
library(forecast)

# Load AEP consumption data
aep_data <- read_csv("/Users/home/Documents/GitHub/Energy-Consumption-Data/AEP_hourly.csv")

# Display the first few rows of the dataset
head(aep_data)
```

```
## # A tibble: 6 x 2
##   Datetime            AEP_MW
##   <dttm>               <dbl>
## 1 2004-12-31 01:00:00  13478
## 2 2004-12-31 02:00:00  12865
## 3 2004-12-31 03:00:00  12577
## 4 2004-12-31 04:00:00  12517
## 5 2004-12-31 05:00:00  12670
## 6 2004-12-31 06:00:00  13038
```

```
# Display the total number of rows and columns
dim(aep_data)
```

```
## [1] 121273      2
```

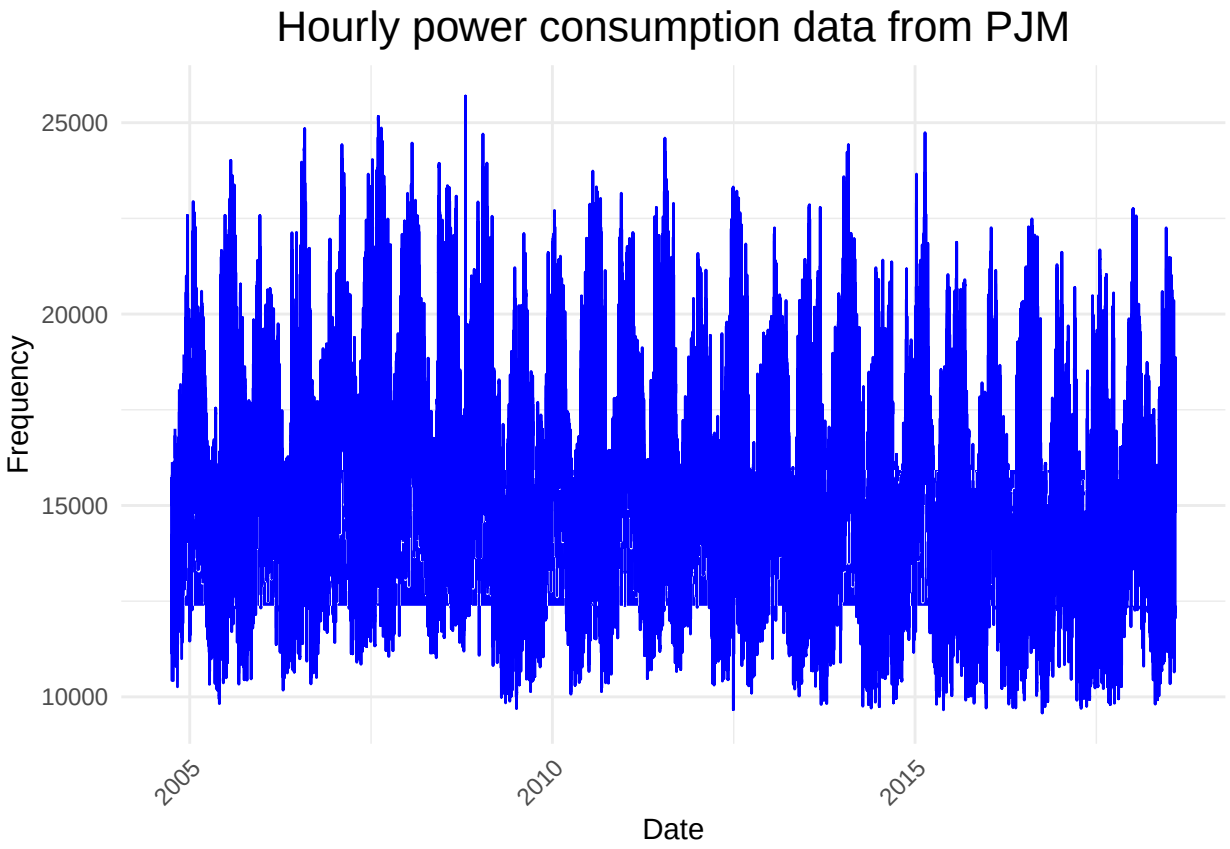
Data Source

Include public links to data if it is too large to upload (do not upload datasets larger than 50MB). **There is no need to upload the data (its under 40MB)** github repository

Time Series Plot

```
# Check for duplicates
duplicates <- aep_data %>%
    group_by(Datetime) %>%
    filter(n() > 1)

# Remove duplicates if any
aep_data <- aep_data %>%
    distinct(Datetime, .keep_all = TRUE)
```

```
# Convert to tsibble for time series structure
aep_data_ts <- aep_data %>%
    as_tsibble(index = Datetime)

# Time series plot for Adjusted Close prices
ggplot(aep_data_ts, aes(x = Datetime, y = `AEP_MW`)) +
    geom_line(color = "blue") +
    labs(
        title = "Hourly power consumption data from PJM",
        x = "Date",
        y = "Frequency"
    ) +
    theme_minimal() +
    theme(
        plot.title = element_text(hjust = 0.5, size = 16),
        axis.text.x = element_text(angle = 45, hjust = 1)
    )
```



Discussion

The hourly power consumption data from PJM reveals notable fluctuations over time, capturing trends that reflect varying levels of energy demand influenced by seasonality, time of day, and economic factors. From 2005 onwards, we observe a periodic increase in energy demand during summer and winter months, likely driven by seasonal heating and cooling needs. These patterns highlight the strong influence of temperature and weather conditions on energy usage.

Energy demand also reflects broader economic activities. Periods of economic growth are often marked by increased industrial and residential energy consumption, whereas economic downturns can lead to reduced demand. This dataset offers insights into how external factors, such as economic slowdowns, regulatory changes, and shifts in energy efficiency practices, can directly impact consumption patterns.

Predicting future consumption trends from this dataset can provide valuable insights for energy providers, policymakers, and businesses. Accurate forecasts help ensure resource availability, support grid stability, and inform pricing strategies. However, energy demand is inherently variable, affected by unpredictable factors like extreme weather events and changes in consumer behavior. Adding contextual data, such as temperature records or economic indicators, would likely improve forecast accuracy and provide a more comprehensive understanding of the factors driving energy consumption.

Assignment: Propose a Time Series Dataset for Your Final Project

```
##     Datetime                         AEP_MW
##  Min.   :2004-10-01 01:00:00.00   Min.   : 9581
##  1st Qu.:2008-03-17 14:00:00.00   1st Qu.:13630
##  Median :2011-09-02 02:00:00.00   Median :15310
##  Mean   :2011-09-02 01:55:58.41   Mean   :15500
##  3rd Qu.:2015-02-16 15:00:00.00   3rd Qu.:17200
##  Max.   :2018-08-03 00:00:00.00   Max.   :25695
```

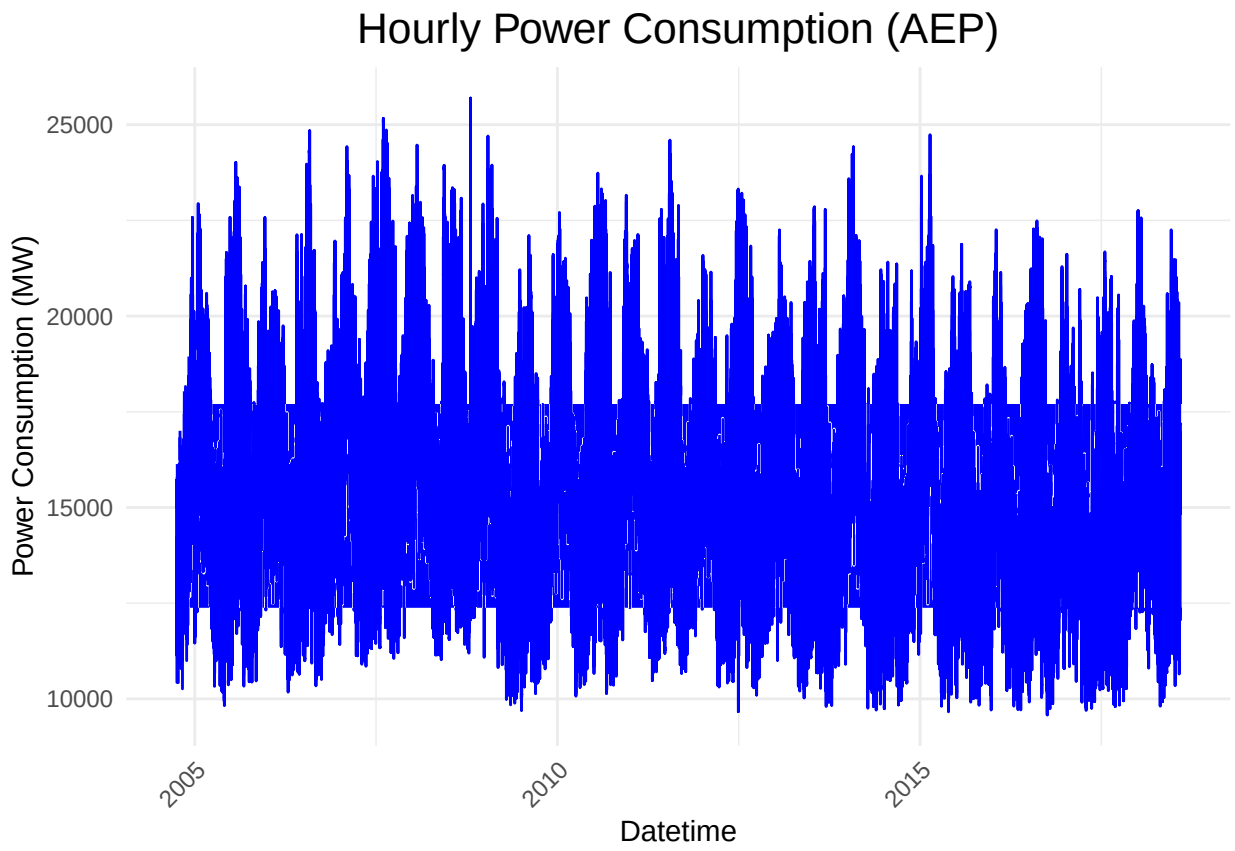
```
## # A tibble: 6 x 2
##   Datetime            AEP_MW
##   <dttm>               <dbl>
## 1 2004-12-31 01:00:00  13478
## 2 2004-12-31 02:00:00  12865
## 3 2004-12-31 03:00:00  12577
## 4 2004-12-31 04:00:00  12517
## 5 2004-12-31 05:00:00  12670
## 6 2004-12-31 06:00:00  13038
```

```
## Number of missing values: 0
```

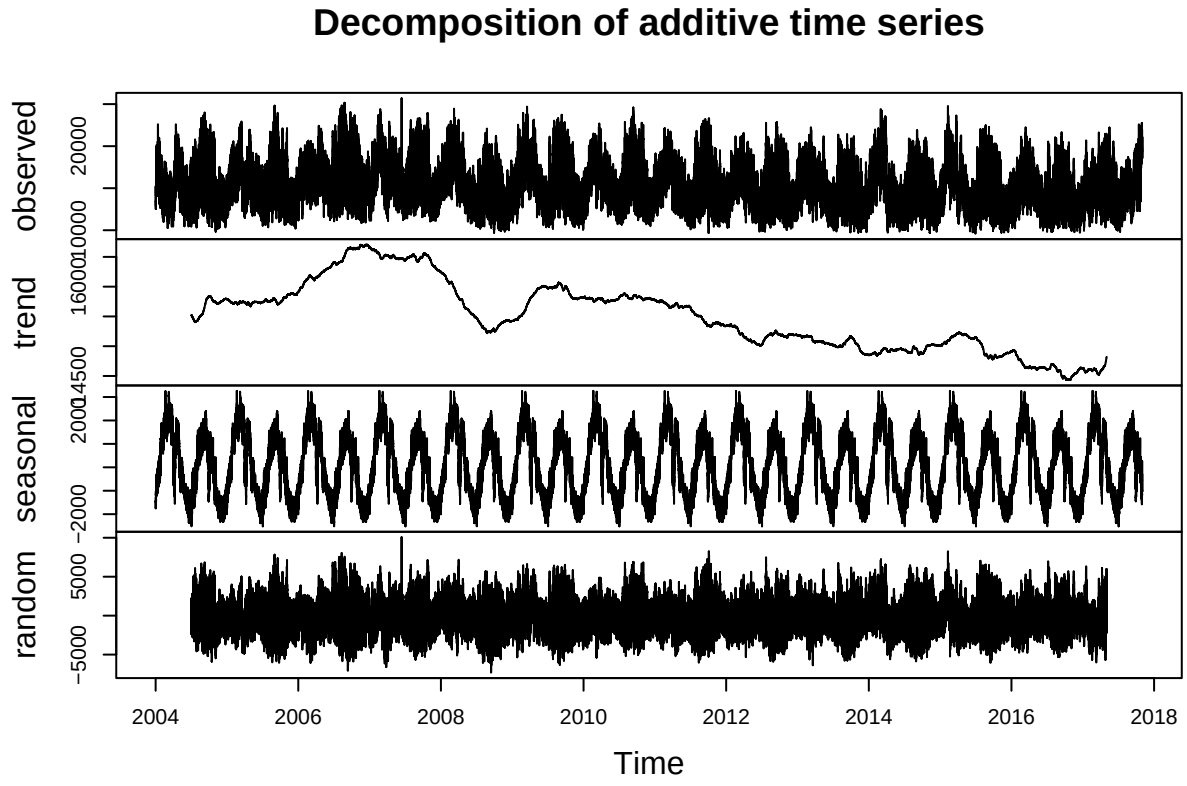
```
## Number of missing timestamps: 27
```

```
## [1] 1099188000 1112497200 1130637600 1143946800 1162087200 1173582000
```

```
## Number of missing values after interpolation: 0
```



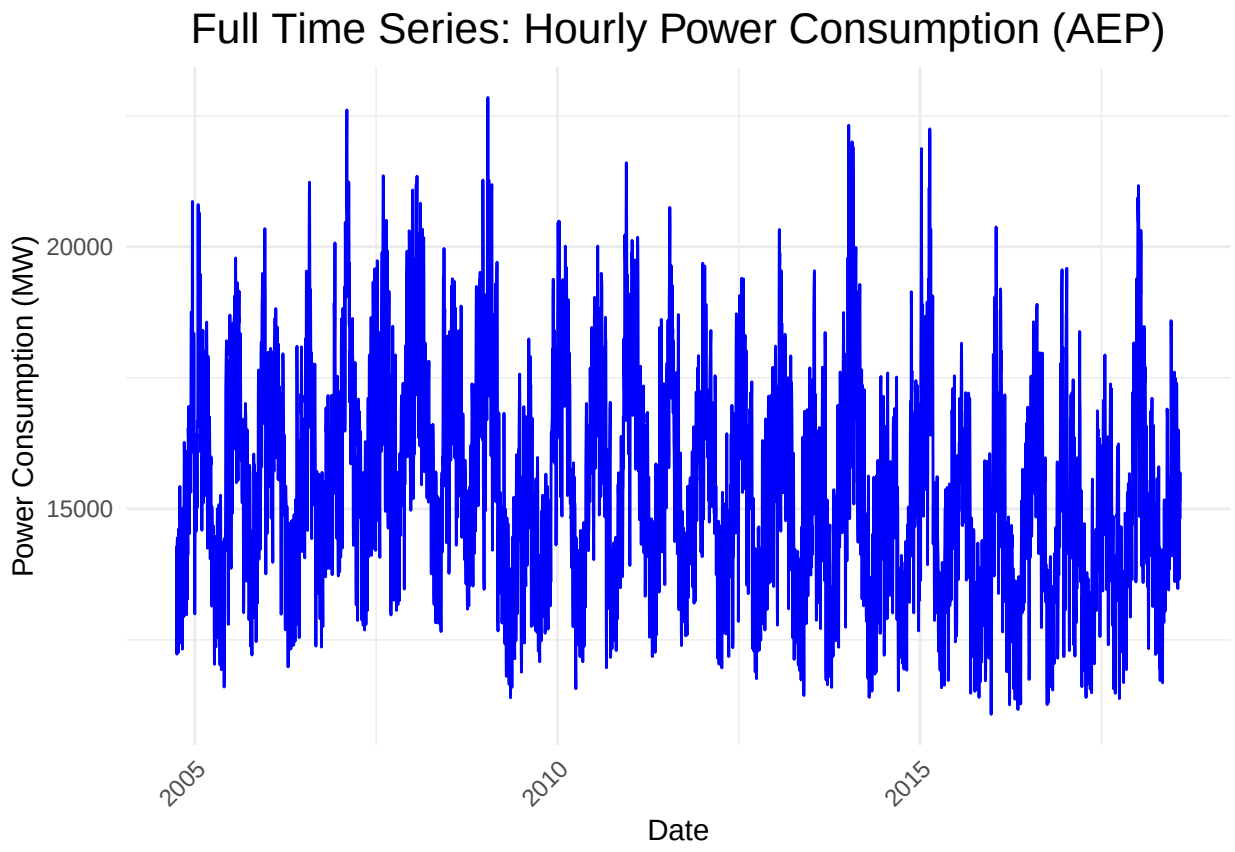
```
## Number of missing values in AEP_MW: 0

## Number of missing timestamps: 27

## # A tsibble: 121,269 x 2 [1h] <UTC>
##    Datetime            AEP_MW
##    <dttm>               <dbl>
##  1 2004-10-01 01:00:00  12379
##  2 2004-10-01 02:00:00  11935
##  3 2004-10-01 03:00:00  11692
##  4 2004-10-01 04:00:00  11597
##  5 2004-10-01 05:00:00  11681
##  6 2004-10-01 06:00:00  12280
##  7 2004-10-01 07:00:00  13692
##  8 2004-10-01 08:00:00  14618
##  9 2004-10-01 09:00:00  14903
## 10 2004-10-01 10:00:00  15118
## # i 121,259 more rows

## [1] "numeric"

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    9581   13630   15310   15500   17200   25695
```

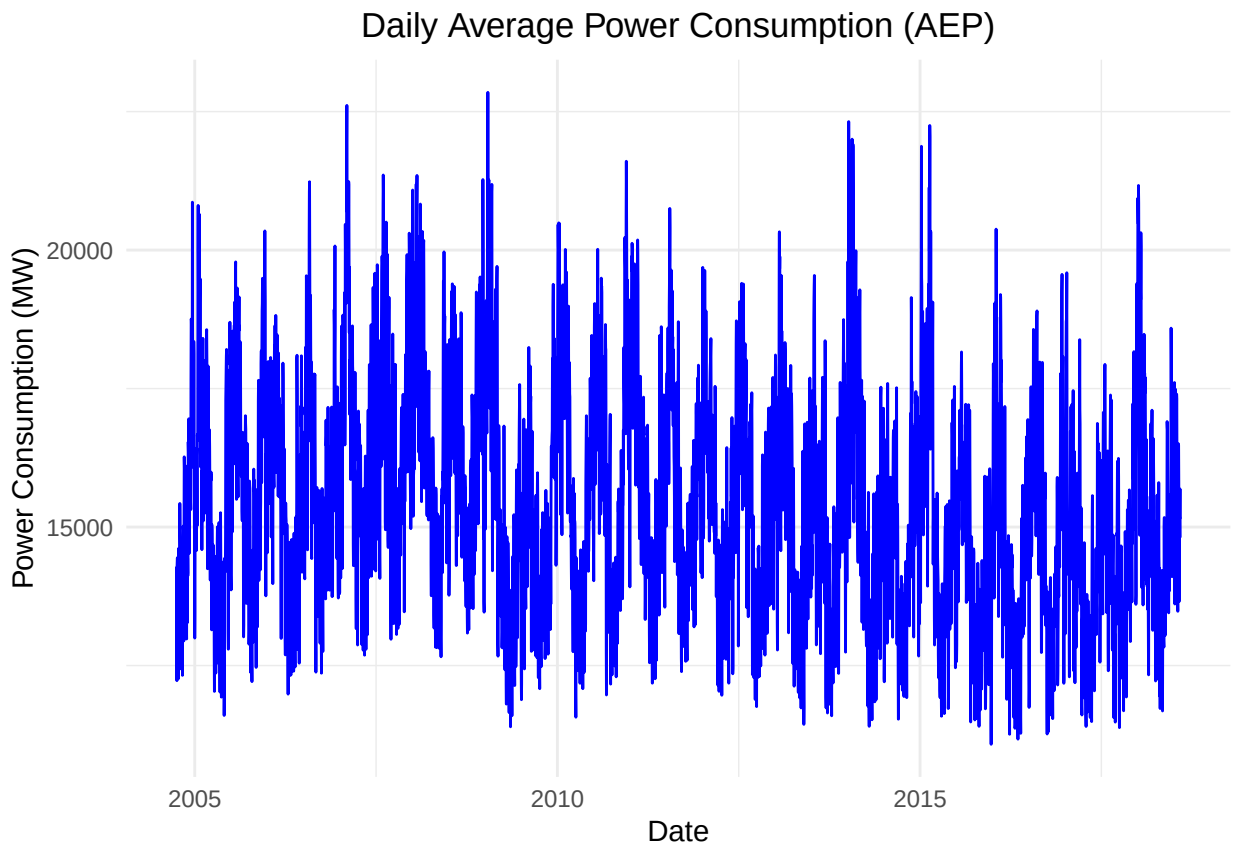


Lets proceed with the ARIMA of the time series data

```
## # A tibble: 6 x 2
##   Datetime            AEP_MW
##   <dttm>               <dbl>
## 1 2004-12-31 01:00:00  13478
## 2 2004-12-31 02:00:00  12865
## 3 2004-12-31 03:00:00  12577
## 4 2004-12-31 04:00:00  12517
## 5 2004-12-31 05:00:00  12670
## 6 2004-12-31 06:00:00  13038
```

```
## [1] 121273      2
```





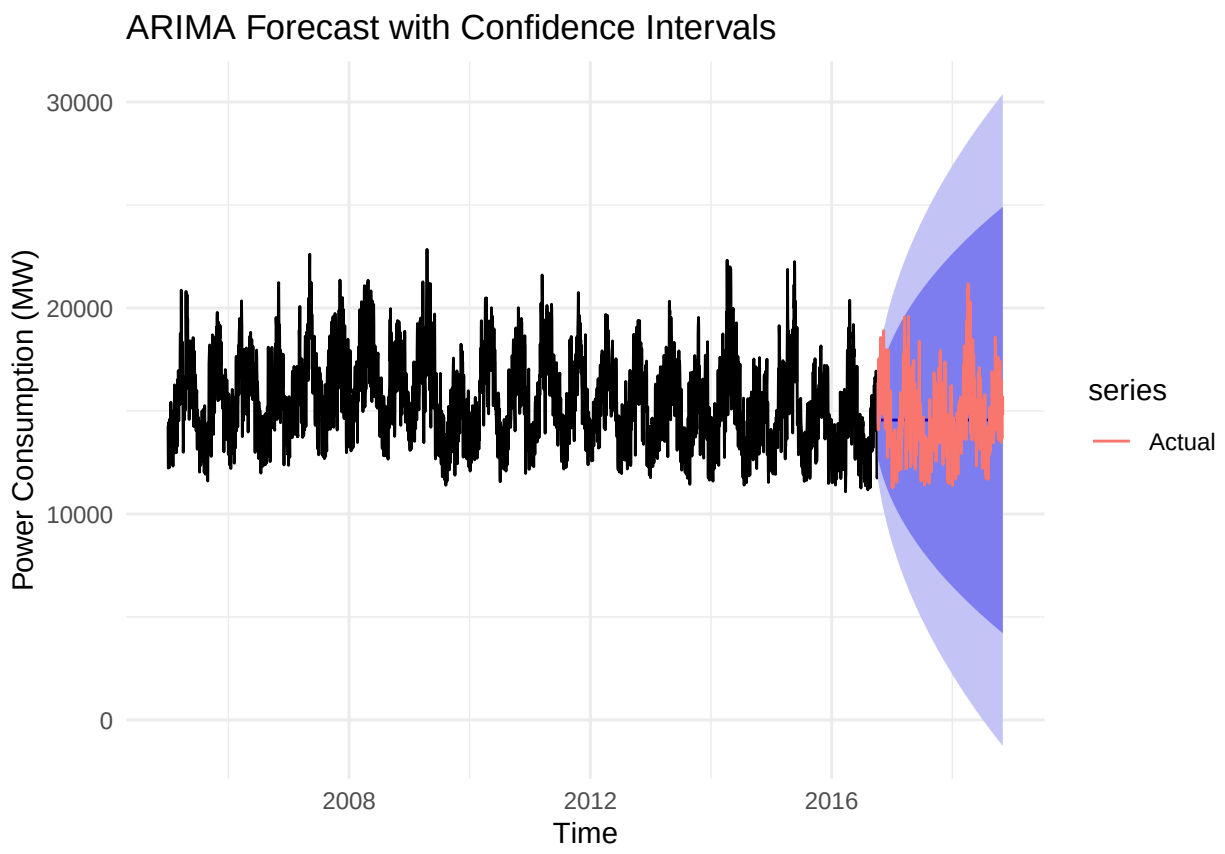

```r
# Convert to time series object
aep_ts <- ts(aep_data_daily$AEP_MW, start = c(2005, 1), frequency = 365.25)

# Fit ARIMA model using auto.arima()
# Split data into training (85%) and testing (15%) sets
# Note: Seasonal component is set to FALSE as this analysis does not focus on seasonal patterns
split_point <- floor(0.85 * length(aep_ts))
train_data <- window(aep_ts, end = c(2005 + (split_point / 365.25)))
test_data <- window(aep_ts, start = c(2005 + (split_point / 365.25) + 1 / 365.25))

# Forecast future values using ARIMA
arima_model <- auto.arima(train_data, seasonal = FALSE)


# Display ARMA model summary
summary(arima_model)
```

```
## Series: train_data
## ARIMA(2,1,4)
##
## Coefficients:
##           ar1      ar2     ma1      ma2      ma3      ma4
##       -0.9343  -0.4117  1.0558  -0.0076  -0.8025  -0.5102
## s.e.   0.0442   0.0299  0.0406   0.0270   0.0241   0.0149
##
## sigma^2 = 849506:  log likelihood = -35418.76
```

```
## AIC=70851.52   AICc=70851.55   BIC=70896.08
##
## Training set error measures:
##                     ME     RMSE      MAE        MPE     MAPE      MASE
## Training set 0.4519411 920.9354 726.4187 -0.2880247 4.667184 0.4924075
##                     ACF1
## Training set 0.002969507
```

```r
# Forecast future values
arima_forecast <- forecast(arima_model, h = length(test_data))

# Plot the ARIMA forecast with confidence intervals
autoplot(arima_forecast) +
  autolayer(test_data, series = "Actual", PI = TRUE) +
  labs(
    title = "ARIMA Forecast with Confidence Intervals",
    x = "Time",
    y = "Power Consumption (MW)"
  ) +
  theme_minimal()
```

```
## Warning in ggplot2::geom_line(ggplot2::aes(x = .data[["timeVal"]], y =
## .data[["seriesVal"]], : Ignoring unknown parameters: 'PI'
```




```r
# Print the first few rows of the forecast
print(head(arima_forecast))
```

```
## $method
## [1] "ARIMA(2,1,4)"
##
## $model
## Series: train_data
```

```
## ARIMA(2,1,4)
##
## Coefficients:
##           ar1      ar2     ma1      ma2      ma3      ma4
##       -0.9343  -0.4117  1.0558  -0.0076  -0.8025  -0.5102
## s.e.   0.0442   0.0299  0.0406   0.0270   0.0241   0.0149
##
## sigma^2 = 849506:  log likelihood = -35418.76
## AIC=70851.52   AICc=70851.55   BIC=70896.08
##
## $level
## [1] 80 95
##
## $mean
## Time Series:
## Start = 2016.76454483231
## End = 2018.83709787817
## Frequency = 365.25
##   [1] 15145.68 14418.65 14431.42 14739.35 14446.40 14593.33 14576.65 14531.75
##   [9] 14580.57 14553.44 14558.69 14564.95 14556.94 14561.85 14560.56 14559.74
##  [17] 14561.04 14560.16 14560.45 14560.54 14560.34 14560.49 14560.43 14560.42
##  [25] 14560.45 14560.43 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [33] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [41] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [49] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [57] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [65] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [73] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [81] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [89] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##  [97] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [105] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [113] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [121] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [129] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [137] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [145] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [153] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [161] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [169] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [177] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [185] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [193] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [201] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [209] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [217] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [225] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [233] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [241] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [249] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [257] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [265] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [273] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [281] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
```

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## [289] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [297] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [305] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [313] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [321] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [329] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [337] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [345] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [353] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [361] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [369] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [377] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [385] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [393] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [401] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [409] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [417] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [425] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [433] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [441] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [449] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [457] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [465] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [473] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [481] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [489] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [497] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [505] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [513] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [521] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [529] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [537] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [545] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [553] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [561] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [569] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [577] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [585] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [593] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [601] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [609] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [617] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [625] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [633] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [641] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [649] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [657] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [665] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [673] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [681] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [689] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [697] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [705] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [713] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
```

```
## [721] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [729] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [737] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [745] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
## [753] 14560.44 14560.44 14560.44 14560.44 14560.44 14560.44
##
## $lower
## Time Series:
## Start = 2016.76454483231
## End = 2018.83709787817
## Frequency = 365.25
##                80%           95%
## 2016.765 13964.493 13339.2095305
## 2016.767 12643.838 11704.3075548
## 2016.770 12525.271 11516.2148198
## 2016.773 12813.264 11793.6567806
## 2016.775 12493.220 11459.2701723
## 2016.778 12588.540 11527.2670353
## 2016.781 12547.591 11473.4701146
## 2016.784 12465.496 11371.6902350
## 2016.786 12480.524 11368.8275672
## 2016.789 12423.199 11295.5161438
## 2016.792 12394.773 11249.2669615
## 2016.795 12370.265 11208.4663446
## 2016.797 12331.291 11153.1047085
## 2016.800 12305.283 11110.7305375
## 2016.803 12274.096 11063.7146326
## 2016.806 12243.365 11017.1487946
## 2016.808 12215.256 10973.4746693
## 2016.811 12185.386 10928.2547623
## 2016.814 12156.931 10884.5865773
## 2016.817 12128.695 10841.3525076
## 2016.819 12100.459 10798.2783006
## 2016.822 12072.893 10756.0396147
## 2016.825 12045.436 10714.0779858
## 2016.828 12018.313 10672.6006338
## 2016.830 11991.520 10631.6087272
## 2016.833 11964.947 10590.9826269
## 2016.836 11938.679 10550.8023234
## 2016.838 11912.662 10511.0123859
## 2016.841 11886.892 10471.6033180
## 2016.844 11861.377 10432.5798134
## 2016.847 11836.095 10393.9156532
## 2016.849 11811.048 10355.6088914
## 2016.852 11786.227 10317.6487341
## 2016.855 11761.625 10280.0237179
## 2016.858 11737.239 10242.7276382
## 2016.860 11713.061 10205.7505750
## 2016.863 11689.086 10169.0847898
## 2016.866 11665.311 10132.7228550
## 2016.869 11641.728 10096.6569273
## 2016.871 11618.335 10060.8801538
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## 2018.098  6189.169  1757.6875198
## 2018.101  6180.985  1745.1697890
## 2018.103  6172.808  1732.6642733
## 2018.106  6164.639  1720.1709371
## 2018.109  6156.478  1707.6897449
## 2018.112  6148.325  1695.2206614
## 2018.114  6140.179  1682.7636512
## 2018.117  6132.042  1670.3186795
## 2018.120  6123.913  1657.8857115
## 2018.123  6115.791  1645.4647123
## 2018.125  6107.677  1633.0556476
## 2018.128  6099.571  1620.6584831
## 2018.131  6091.473  1608.2731845
## 2018.133  6083.382  1595.8997178
## 2018.136  6075.299  1583.5380491
## 2018.139  6067.224  1571.1881449
## 2018.142  6059.157  1558.8499716
## 2018.144  6051.097  1546.5234958
## 2018.147  6043.044  1534.2086843
## 2018.150  6035.000  1521.9055041
## 2018.153  6026.963  1509.6139222
## 2018.155  6018.933  1497.3339059
## 2018.158  6010.911  1485.0654227
## 2018.161  6002.897  1472.8084401
## 2018.164  5994.890  1460.5629258
## 2018.166  5986.891  1448.3288476
## 2018.169  5978.899  1436.1061737
## 2018.172  5970.914  1423.8948722
## 2018.175  5962.937  1411.6949113
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## 2018.180  5947.005  1387.3288857
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## 2018.194  5907.303  1326.6100938
## 2018.196  5899.385  1314.4997353
## 2018.199  5891.473  1302.4004388
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## 2018.207  5867.782  1266.1686194
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## 2018.238  5781.463  1134.1551022
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## 2018.287  5642.016   920.8887853
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## 2018.355  5451.880   630.1009851
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## 2018.552  4925.229  -175.3419476
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## 2018.596  4812.059  -348.4211806
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## 2018.604  4790.985  -380.6503290
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## 2018.634  4714.102  -498.2337391
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## 2018.651  4672.417  -561.9847994
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## 2018.670  4624.006  -636.0230210
## 2018.673  4617.110  -646.5704838
## 2018.676  4610.218  -657.1106360
## 2018.678  4603.331  -667.6434928
## 2018.681  4596.448  -678.1690693
## 2018.684  4589.571  -688.6873807
## 2018.687  4582.698  -699.1984419
## 2018.689  4575.830  -709.7022679
## 2018.692  4568.967  -720.1988736
## 2018.695  4562.108  -730.6882740
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## 2018.769  4378.671 -1011.2314102
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## 2018.788  4331.650 -1083.1435740
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## 2018.796  4311.564 -1113.8620753
## 2018.799  4304.878 -1124.0882062
```

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## 2018.829  4231.612 -1236.1387305
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##
## $upper
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## End = 2018.83709787817
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## 2016.775 16399.58 17433.53
## 2016.778 16598.12 17659.40
## 2016.781 16605.72 17679.84
## 2016.784 16597.99 17691.80
## 2016.786 16680.61 17792.31
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## 2016.792 16722.60 17868.11
## 2016.795 16759.64 17921.44
## 2016.797 16782.59 17960.77
## 2016.800 16818.41 18012.96
## 2016.803 16847.03 18057.41
## 2016.806 16876.12 18102.34
## 2016.808 16906.82 18148.60
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## 2016.838 17208.22 18609.87
## 2016.841 17233.98 18649.27
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## 2016.852 17334.65 18803.23
```

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## 2018.834 24902.53 30377.30
## 2018.837 24909.16 30387.44
```

```
# Calculate RMSE and MAE for ARIMA
# RMSE: Root Mean Squared Error (sensitive to large errors)
arima_rmse <- sqrt(mean((test_data - arima_forecast$mean)^2, na.rm = TRUE))

# MAE: Mean Absolute Error (average magnitude of errors)
arima_mae <- mean(abs(test_data - arima_forecast$mean), na.rm = TRUE)

# MAPE: Mean Absolute Percentage Error (relative error in %)
arima_mape <- mean(abs((test_data - arima_forecast$mean) / test_data), na.rm = TRUE) * 100

# SMAPE: Symmetric Mean Absolute Percentage Error (scale-independent relative error)
arima_smape <- mean(2 * abs(test_data - arima_forecast$mean) /
                      (abs(test_data) + abs(arima_forecast$mean)), na.rm = TRUE) * 100

# Print results
cat("ARIMA - MAPE:", arima_mape, "%\n")
```

```
## ARIMA - MAPE: 9.654934 %
```

```
cat("ARIMA - SMAPE:", arima_smape, "%\n")
```

```
## ARIMA - SMAPE: 9.752109 %
```

```
cat("ARIMA - RMSE:", arima_rmse, "\n")
```

```
## ARIMA - RMSE: 1828.204
```

```r
cat("ARIMA - MAE:", arima_mae, "\n")
```

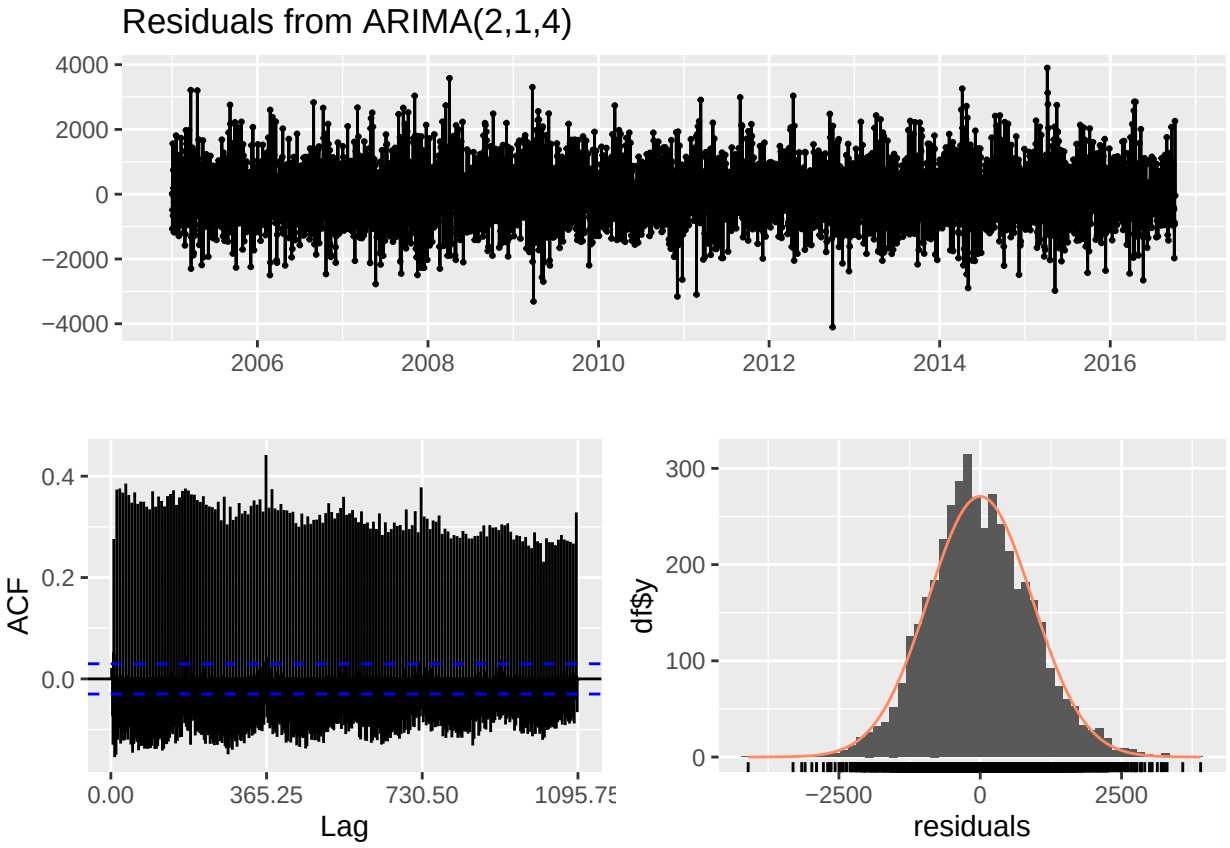
```
## ARIMA - MAE: 1453.795
```

Evaluation Metrics Interpretation

- **Root Mean Squared Error (RMSE)**: Measures the square root of the average squared errors. It penalizes large errors more heavily and is sensitive to outliers.
- **Mean Absolute Error (MAE)**: Calculates the average magnitude of forecast errors. It provides a straightforward view of how far predictions are from actual values.
- **Mean Absolute Percentage Error (MAPE)**: Indicates the average percentage error relative to actual values. Useful for understanding error magnitude in relative terms.
- **Symmetric Mean Absolute Percentage Error (SMAPE)**: Similar to MAPE but accounts for scale differences between the actual and predicted values, providing a more balanced perspective.

Lower values for these metrics indicate better forecasting performance. In this case, the ARIMA model's RMSE, MAE, MAPE, and SMAPE values provide insights into the model's accuracy and error characteristics. The results can guide further model refinement and help assess the model's suitability for forecasting power consumption trends.

```r
# Check residuals
checkresiduals(arima_model)
```



```
##
##  Ljung-Box test
##
## data:  Residuals from ARIMA(2,1,4)
## Q* = 70508, df = 724.5, p-value < 2.2e-16
##
## Model df: 6.   Total lags used: 730.5
```

Residual Diagnostics

Residual diagnostics help assess whether the ARIMA model sufficiently captures the structure of the data. Key observations include:

- **ACF and PACF Plots**: Residual autocorrelation should be minimal.
- **Ljung-Box Test**: Tests whether residuals are white noise. A p-value > 0.05 indicates that residuals are independent and random.

If residuals exhibit patterns, the model may need adjustment, such as adding differencing or changing AR/MA terms.

```
# Random Walk Model
rw_forecast <- rwf(train_data, h = length(test_data), drift = FALSE)

# Calculate Random Walk metrics
rw_rmse <- sqrt(mean((test_data - rw_forecast$mean)^2, na.rm = TRUE))
rw_mae <- mean(abs(test_data - rw_forecast$mean), na.rm = TRUE)
rw_mape <- NA  # Random Walk may not have MAPE
rw_smape <- NA # Random Walk may not have SMAPE

# Print results
cat("Random Walk - RMSE:", rw_rmse, "\n")
```

```
## Random Walk - RMSE: 2291.718
```

```
cat("Random Walk - MAE:", rw_mae, "\n")
```

```
## Random Walk - MAE: 1947.201
```

```
model_comparison <- data.frame(
  Model = c("ARIMA", "Random Walk"),
  RMSE = c(arima_rmse, rw_rmse),
  MAE = c(arima_mae, rw_mae),
  MAPE = c(arima_mape, NA),  # Random Walk may not have MAPE
  SMAPE = c(arima_smape, NA) # Random Walk may not have SMAPE
)
print(model_comparison)
```

```
##         Model     RMSE      MAE     MAPE    SMAPE
## 1       ARIMA 1828.204 1453.795 9.654934 9.752109
## 2 Random Walk 2291.718 1947.201       NA       NA
```


Model Performance Metrics Comparison
Metric Value
2000
1500
1000
500
0
ARIMA
Random Walk
Model
Metric
RMSE
MAE
MAPE
SMAPE