ENV 797 - Time Series Analysis for Energy and Environment Applications | Spring 2025

Assignment 5 - Due date 02/18/25

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Directions

You should open the .rmd file corresponding to this assignment on RStudio. The file is available on our class repository on Github. And to do so you will need to fork our repository and link it to your RStudio.

Once you have the file open on your local machine the first thing you will do is rename the file such that it includes your first and last name (e.g., "LuanaLima_TSA_A05_Sp25.Rmd"). Then change "Student Name" on line 4 with your name.

Then you will start working through the assignment by **creating code and output** that answer each question. Be sure to use this assignment document. Your report should contain the answer to each question and any plots/tables you obtained (when applicable).

When you have completed the assignment, **Knit** the text and code into a single PDF file. Submit this pdf using Sakai.

R packages needed for this assignment: "readxl", "ggplot2", "forecast","tseries", and "Kendall". Install these packages, if you haven't done yet. Do not forget to load them before running your script, since they are NOT default packages.\

```
#Load/install required package here
library(forecast)
```

```
## Warning: package 'forecast' was built under R version 4.3.3
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
library(tseries)
```

```
## Warning: package 'tseries' was built under R version 4.3.3
```

```
library(ggplot2)
library(Kendall)
```

```
## Warning: package 'Kendall' was built under R version 4.3.3
```

```
library(lubridate)
```

```
##
## Attaching package: 'lubridate'

## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union
```

```
library(tidyverse)  #load this package so yon clean the data frame using pipes
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v stringr 1.5.1
## v forcats 1.0.0     v tibble  3.2.1
## v purrr   1.0.2     v tidyr   1.3.0
## v readr   2.1.5

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become error
```

```
library(zoo)
```

```
##
## Attaching package: 'zoo'
##
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
library(dplyr)
```

Decomposing Time Series

Consider the same data you used for A04 from the spreadsheet “Table_10.1_Renewable_Energy_Production_and_Consump
The data comes from the US Energy Information and Administration and corresponds to the December 2023 Monthly Energy Review.

```
#Importing data set - using xlsx package
library(openxlsx)
```

```
## Warning: package 'openxlsx' was built under R version 4.3.3
```

```
library(readxl)

getwd()
```

```
## [1] "/Users/ayoungkim/TSA_Sp25/Assignments"
```

```
setwd("/Users/ayoungkim/TSA_Sp25/Data")
getwd()
```

```
## [1] "/Users/ayoungkim/TSA_Sp25/Data"
```

```
renewable_data2 <- read.xlsx(xlsxFile="./Table_10.1_Renewable_Energy_Production_and_Consumption_by_Sourc
                             sheet = "Monthly Data",
                             startRow = 13,
                             colNames = FALSE)

read_col_names2  <- read.xlsx(xlsxFile="./Table_10.1_Renewable_Energy_Production_and_Consumption_by_Sou
                              sheet = "Monthly Data",
                              rows = 11,
                              colNames = FALSE)

colnames(renewable_data2) <- read_col_names2
head(renewable_data2)
```

```
##   Month Wood Energy Production Biofuels Production
## 1 26665                129.630       Not Available
## 2 26696                117.194       Not Available
## 3 26724                129.763       Not Available
## 4 26755                125.462       Not Available
## 5 26785                129.624       Not Available
## 6 26816                125.435       Not Available
##   Total Biomass Energy Production Total Renewable Energy Production
## 1                       129.787                           219.839
## 2                       117.338                           197.330
## 3                       129.938                           218.686
## 4                       125.636                           209.330
## 5                       129.834                           215.982
## 6                       125.611                           208.249
##   Hydroelectric Power Consumption Geothermal Energy Consumption
## 1                          89.562                         0.490
## 2                          79.544                         0.448
## 3                          88.284                         0.464
## 4                          83.152                         0.542
## 5                          85.643                         0.505
## 6                          82.060                         0.579
##   Solar Energy Consumption Wind Energy Consumption Wood Energy Consumption
## 1            Not Available           Not Available                 129.630
## 2            Not Available           Not Available                 117.194
## 3            Not Available           Not Available                 129.763
## 4            Not Available           Not Available                 125.462
## 5            Not Available           Not Available                 129.624
## 6            Not Available           Not Available                 125.435
##   Waste Energy Consumption Biofuels Consumption
## 1                    0.157        Not Available
## 2                    0.144        Not Available
## 3                    0.176        Not Available
## 4                    0.174        Not Available
## 5                    0.210        Not Available
## 6                    0.176        Not Available
##   Total Biomass Energy Consumption Total Renewable Energy Consumption
## 1                          129.787                            219.839
## 2                          117.338                            197.330
## 3                          129.938                            218.686
## 4                          125.636                            209.330
## 5                          129.834                            215.982
## 6                          125.611                            208.249
```

```
nobs=nrow(renewable_data2)
nvar=ncol(renewable_data2)
```

Q1

For this assignment you will work only with the following columns: Solar Energy Consumption and Wind Energy Consumption. Create a data frame structure with these two time series only and the Date column. Drop the rows with *Not Available* and convert the columns to numeric. You can use filtering to eliminate the initial rows or convert to numeric and then use the drop_na() function. If you are familiar with pipes for data wrangling, try using it!

```
#Using "select" function, selected only Solar Energy Consumption and Wind Energy Consumtpion
renewable_data2_filtered <- select(renewable_data2, 'Month', 'Solar Energy Consumption', 'Wind Energy C

start_date <- "1973-01-01"
renewable_data2_filtered$Month <- as.Date(seq(from = as.Date(start_date),
                                               by = "month",
                                               length.out = nobs))

head(renewable_data2_filtered$Month)
```

```
## [1] "1973-01-01" "1973-02-01" "1973-03-01" "1973-04-01" "1973-05-01"
## [6] "1973-06-01"
```

```
# Converted the format to Year-Month
renewable_data2_filtered$Month <- format(renewable_data2_filtered$Month, "%Y-%m")
head(renewable_data2_filtered)
```

```
##     Month Solar Energy Consumption Wind Energy Consumption
## 1 1973-01            Not Available           Not Available
## 2 1973-02            Not Available           Not Available
## 3 1973-03            Not Available           Not Available
## 4 1973-04            Not Available           Not Available
## 5 1973-05            Not Available           Not Available
## 6 1973-06            Not Available           Not Available
```

```
#Convert to numeric
renewable_data2_filtered$`Solar Energy Consumption` <- as.numeric(renewable_data2_filtered$`Solar Energ
```

```
## Warning: NAs introduced by coercion
```

```r
renewable_data2_filtered$`Wind Energy Consumption` <- as.numeric(renewable_data2_filtered$`Wind Energy
```

```
## Warning: NAs introduced by coercion
```

```r
#Dropped 'Not available'
renewable_data2_filtered <- drop_na(renewable_data2_filtered)
head(renewable_data2_filtered)
```

```
##     Month Solar Energy Consumption Wind Energy Consumption
## 1 1984-01                    0.000                   0.000
## 2 1984-02                    0.000                   0.001
## 3 1984-03                    0.001                   0.001
## 4 1984-04                    0.001                   0.002
## 5 1984-05                    0.002                   0.003
## 6 1984-06                    0.003                   0.002
```

```r
#1 ts1 - Solar energy consumption
ts1_renewable_data2_filtered<-ts(renewable_data2_filtered$'Solar Energy Consumption',
                                 start = c(1,1),
                                 frequency=12)
ts1_renewable_data2_filtered
```

```
##        Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep
## 1    0.000 0.000 0.001 0.001 0.002 0.003 0.001 0.003 0.003
## 2    0.002 0.000 0.000 0.004 0.005 0.005 0.004 0.007 0.005
## 3    0.002 0.002 0.003 0.005 0.006 0.005 0.006 0.006 0.005
## 4    0.000 0.002 0.003 0.004 0.004 0.006 0.006 0.004 0.003
## 5    0.002 0.003 0.004 0.002 0.004 0.005 0.004 0.004 0.003
## 6    2.821 3.041 4.220 4.660 5.109 5.175 5.476 5.389 4.941
## 7    3.015 3.256 4.489 4.946 5.515 5.534 5.832 5.781 5.228
## 8    3.125 3.369 4.561 5.026 5.739 5.803 6.133 6.035 5.487
## 9    3.196 3.451 4.752 5.284 5.883 5.931 6.274 6.205 5.628
## 10   3.288 3.570 4.954 5.515 6.053 6.058 6.445 6.401 5.818
## 11   3.432 3.680 5.137 5.640 6.216 6.292 6.584 6.471 5.949
## 12   3.415 3.692 5.105 5.735 6.370 6.471 6.750 6.674 6.047
## 13   3.472 3.760 5.293 5.865 6.487 6.562 6.804 6.602 5.956
## 14   3.422 3.762 5.176 5.748 6.292 6.433 6.721 6.612 5.958
## 15   3.375 3.629 5.138 5.664 6.173 6.327 6.679 6.584 5.956
## 16   3.294 3.570 4.984 5.536 6.121 6.184 6.482 6.377 5.775
## 17   3.155 3.440 4.733 5.239 5.832 5.895 6.261 6.144 5.608
## 18   3.008 3.261 4.542 5.020 5.672 5.755 6.029 5.947 5.380
## 19   2.923 3.189 4.435 4.877 5.408 5.585 5.812 5.719 5.162
## 20   2.848 3.083 4.334 4.795 5.298 5.421 5.579 5.522 5.034
## 21   2.809 3.019 4.289 4.722 5.278 5.343 5.575 5.488 4.986
## 22   2.742 2.968 4.158 4.638 5.178 5.247 5.438 5.396 4.894
## 23   2.881 3.124 4.327 4.821 5.368 5.410 5.640 5.657 5.085
## 24   3.016 3.269 4.579 5.051 5.658 5.707 5.981 5.886 5.367
## 25   3.206 3.518 4.933 5.478 6.029 6.181 6.408 6.326 5.758
## 26   3.247 3.578 5.053 5.614 6.200 6.229 6.582 6.501 5.892
## 27   3.485 3.833 5.386 6.033 6.760 6.895 7.158 7.072 6.433
## 28   3.924 4.374 6.043 6.760 7.496 7.667 7.903 7.958 7.178
## 29   4.607 5.077 7.148 8.096 9.316 9.605 9.934 9.685 8.960
## 30   5.869   6.663   9.260  10.151  11.264  11.745  12.038  12.336  11.551
## 31   8.157   8.799  12.624  13.934  15.758  16.428  16.395  16.624  15.631
## 32   9.815  11.480  15.989  18.058  19.510  19.804  20.660  20.720  18.026
## 33  11.728  15.428  19.297  21.401  24.459  24.955  27.056  26.741  24.199
## 34  15.555  17.857  27.472  30.175  34.567  36.083  34.635  33.492  30.881
## 35  20.417  23.213  30.918  36.049  40.277  42.476  40.715  39.785  35.355
## 36  22.249  23.942  35.490  40.146  43.146  46.198  47.572  45.914  40.157
## 37  26.741  32.049  38.731  46.045  54.208  54.219  58.159  52.712  44.933
## 38  32.034  35.565  51.477  59.068  66.559  65.882  66.269  64.229  59.026
## 39  41.781  47.414  62.793  71.077  79.465  82.616  82.569  77.172  70.117
## 40  43.772  51.049  67.465  80.376  91.383  92.683  97.656  92.824  81.556
## 41  53.206  65.064  83.696  98.077 111.667 118.688 119.326 117.388 100.303
##        Oct     Nov     Dec
## 1    0.002   0.001   0.000
## 2    0.003   0.001   0.001
## 3    0.004   0.003   0.001
## 4    0.002   0.001   0.001
## 5    0.000   0.000   0.000
## 6    4.501   3.697   3.465
## 7    4.782   3.884   3.700
## 8    4.935   4.034   3.792
## 9    5.115   4.187   3.914
## 10   5.243   4.297   4.039
## 11   5.458   4.415   4.136
## 12   5.471   4.473   4.192
## 13   5.494   4.495   4.262
## 14   5.437   4.424   4.187
## 15   5.395   4.389   4.147
## 16   5.311   4.307   4.068
## 17   5.056   4.103   3.882
## 18   4.773   3.905   3.675
## 19   4.647   3.821   3.551
## 20   4.535   3.669   3.452
## 21   4.470   3.625   3.418
## 22   4.399   3.547   3.335
## 23   4.577   3.718   3.487
## 24   4.848   3.922   3.662
## 25   5.166   4.167   3.926
## 26   5.307   4.300   4.023
## 27   5.693   4.721   4.384
## 28   6.507   5.259   5.056
## 29   8.214   6.715   6.439
## 30  10.946   9.028   8.800
## 31  14.507  11.805  10.387
## 32  15.938  13.628  12.547
## 33  21.438  17.985  16.202
## 34  28.042  20.501  19.362
## 35  30.386  23.468  20.576
## 36  35.724  26.634  22.573
## 37  40.674  33.068  29.778
## 38  49.778  42.082  34.895
## 39  63.195  46.708  39.656
## 40  74.296  56.874  50.393
## 41
```

```r
#2 ts2 - Wind Energy Consumption
ts2_renewable_data2_filtered<-ts(renewable_data2_filtered$'Wind Energy Consumption',
                                  start = c(1,1),
                                  frequency=12)
ts2_renewable_data2_filtered
```

```
##        Jan     Feb     Mar     Apr     May     Jun     Jul     Aug     Sep
## 1    0.000   0.001   0.001   0.002   0.003   0.002   0.002   0.001   0.002
## 2    0.002   0.004   0.002   0.002   0.001   0.001   0.000   0.001   0.003
## 3    0.001   0.001   0.002   0.002   0.003   0.002   0.002   0.002   0.000
## 4    0.000   0.000   0.000   0.000   0.001   0.003   0.004   0.001   0.001
## 5    0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
## 6    0.497   0.763   0.873   0.812   0.697   0.534   0.485   0.352   0.956
## 7    1.028   0.789   0.837   1.434   1.195   1.387   0.406   0.239   0.311
## 8    0.212   0.989   0.707   0.813   1.237   0.530   0.530   0.777   0.707
## 9    0.512   1.759   1.120   1.088   0.320   0.256   0.256   0.480   1.088
## 10   0.844   0.169   1.773   1.266   1.266   0.295   0.464   0.253   0.464
## 11   0.000   0.343   1.865   1.408   1.256   1.256   0.647   0.457   1.066
## 12   0.019   0.080   0.016   0.023   1.394   1.701   2.115   1.862   1.955
## 13   0.503   0.382   0.640   0.834   1.336   1.282   1.826   1.416   1.199
## 14   0.411   0.372   0.507   1.106   1.196   1.764   1.738   1.809   0.888
## 15   0.059   0.028   0.021   0.293   0.489   1.348   1.868   1.438   1.623
## 16   1.150   1.054   1.524   1.274   0.940   0.866   1.556   1.304   1.288
## 17   2.202   2.409   1.194   1.126   1.392   1.525   1.296   1.284   1.134
## 18   1.328   1.471   1.816   2.336   2.167   2.285   2.167   1.969   1.673
## 19   2.769   2.436   2.907   3.495   3.677   3.843   3.038   3.332   2.511
## 20   2.158   2.543   3.535   3.729   3.434   3.573   3.253   2.782   3.054
## 21   3.410   3.486   4.406   4.418   5.806   4.767   3.973   3.585   3.718
## 22   3.861   3.298   5.325   5.792   5.959   6.131   4.848   3.883   5.010
## 23   8.130   6.558   8.048   8.434   8.389   7.001   6.671   5.647   6.412
## 24   8.367   8.598  10.397  10.822  10.073   8.941   7.364   9.210   9.781
## 25  14.580  13.142  16.316  17.829  18.221  17.539  13.677  11.138  10.616
## 26  20.304  19.968  24.222  25.446  21.366  19.105  16.906  18.645  15.868
## 27  23.387  18.533  29.306  33.316  29.676  27.463  22.942  22.812  24.244
## 28  29.174  35.661  35.978  42.383  40.167  37.481  25.551  25.500  23.437
## 29  46.508  37.708  47.861  43.363  42.788  40.849  30.104  28.898  29.991
## 30  50.288  48.026  53.758  59.629  55.406  46.909  37.851  32.871  39.832
## 31  61.113  47.798  60.515  63.584  53.232  53.906  41.583  34.702  39.305
## 32  51.733  50.912  52.231  60.963  58.520  45.793  46.661  44.629  47.671
## 33  63.007  68.712  74.857  70.967  64.309  55.627  60.114  46.367  55.969
## 34  70.965  75.375  87.793  86.590  78.707  68.724  55.001  47.355  61.115
## 35  87.343  79.123  90.294  90.182  81.728  84.286  56.116  67.716  63.189
## 36  82.917  77.189  87.936  98.659  87.959  76.586  75.408  68.165  83.640
## 37  95.950  99.325 100.039 101.515  96.824 103.085  78.019  78.576  79.111
## 38 102.566  91.153 133.768 123.370 115.280  91.003  74.093  92.367  98.941
## 39 127.664 128.443 146.820 157.522 143.726 115.215 100.569  84.339  93.254
## 40 130.877 141.340 148.708 145.848 109.959  93.990  95.552  96.881  96.742
## 41 118.833 141.413 155.252 161.170 131.666 129.865  95.229  97.908  98.641
##        Oct     Nov     Dec
## 1    0.003   0.003   0.004
## 2    0.002   0.001   0.000
## 3    0.001   0.000   0.000
## 4    0.000   0.000   0.001
## 5    0.000   0.000   0.000
## 6    0.599   0.419   0.219
## 7    0.693   0.789   0.406
## 8    1.448   1.448   0.671
## 9    0.832   0.960   1.184
## 10   0.971   1.562   0.929
## 11   1.218   1.675   0.571
## 12   0.876   0.427   0.329
## 13   0.863   0.337   0.417
## 14   0.937   0.248   0.244
## 15   1.019   0.618   1.519
## 16   1.428   1.209   1.720
## 17   1.404   2.808   1.309
## 18   2.071   1.605   2.101
## 19   2.506   2.238   2.577
## 20   3.061   3.280   3.770
## 21   3.511   3.181   3.999
## 22   4.934   5.492   6.237
## 23   8.333   8.668   8.433
## 24  11.521  10.560  11.909
## 25  16.229  17.038  22.573
## 26  23.248  23.458  23.563
## 27  27.104  33.259  30.910
## 28  35.913  42.440  36.358
## 29  43.114  39.745  49.554
## 30  46.523  53.921  47.656
## 31  49.501  64.374  50.195
## 32  55.889  67.154  68.576
## 33  69.384  66.212  78.973
## 34  83.146  77.162  75.749
## 35  72.314  75.118  82.933
## 36  94.255  85.929  90.909
## 37  98.343 113.038 109.220
## 38 109.918 121.983 135.965
## 39 111.725 140.570 131.975
## 40 122.900 124.352 129.787
## 41
```

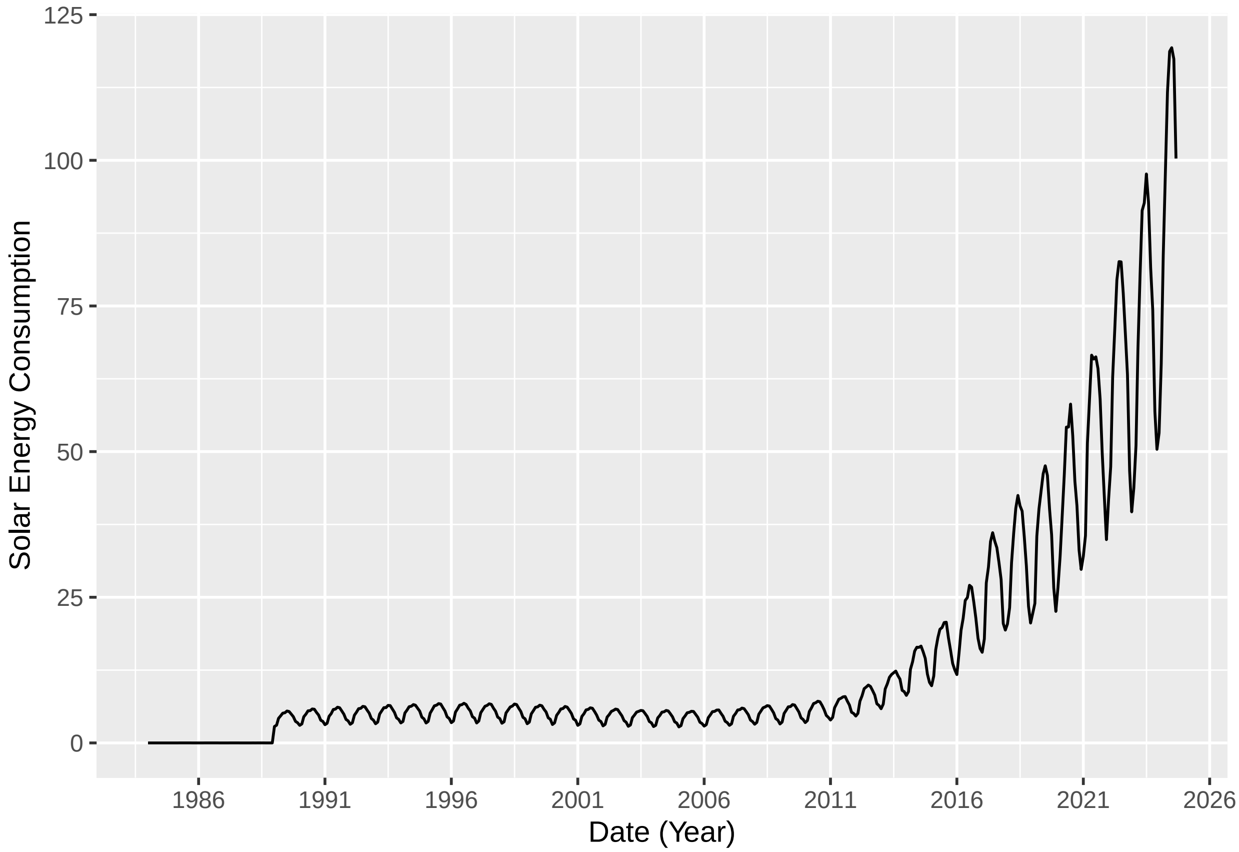
```r
#Converting time series to numeric
solar_energy_numeric <- as.numeric(ts1_renewable_data2_filtered)
wind_energy_numeric <- as.numeric(ts2_renewable_data2_filtered)

#Make two ts and month as a dataframe
df_ts_renewable_data2_filtered <- data.frame(
   Month = renewable_data2_filtered$Month,
   Solar_Energy_Consumption = solar_energy_numeric,
   Wind_Energy_Consumption = wind_energy_numeric)

df_ts_renewable_data2_filtered
```

```
##       Month Solar_Energy_Consumption Wind_Energy_Consumption
## 1   1984-01                    0.000                   0.000
## 2   1984-02                    0.000                   0.001
## 3   1984-03                    0.001                   0.001
## 4   1984-04                    0.001                   0.002
## 5   1984-05                    0.002                   0.003
## 6   1984-06                    0.003                   0.002
## 7   1984-07                    0.001                   0.002
## 8   1984-08                    0.003                   0.001
## 9   1984-09                    0.003                   0.002
## 10  1984-10                    0.002                   0.003
## 11  1984-11                    0.001                   0.003
## 12  1984-12                    0.000                   0.004
## 13  1985-01                    0.002                   0.002
## 14  1985-02                    0.000                   0.004
## 15  1985-03                    0.000                   0.002
## 16  1985-04                    0.004                   0.002
## 17  1985-05                    0.005                   0.001
## 18  1985-06                    0.005                   0.001
## 19  1985-07                    0.004                   0.000
## 20  1985-08                    0.007                   0.001
## 21  1985-09                    0.005                   0.003
## 22  1985-10                    0.003                   0.002
## 23  1985-11                    0.001                   0.001
## 24  1985-12                    0.001                   0.000
## 25  1986-01                    0.002                   0.001
## 26  1986-02                    0.002                   0.001
## 27  1986-03                    0.003                   0.002
## 28  1986-04                    0.005                   0.002
## 29  1986-05                    0.006                   0.003
## 30  1986-06                    0.005                   0.002
## 31  1986-07                    0.006                   0.002
## 32  1986-08                    0.006                   0.002
## 33  1986-09                    0.005                   0.000
## 34  1986-10                    0.004                   0.001
## 35  1986-11                    0.003                   0.000
## 36  1986-12                    0.001                   0.000
## 37  1987-01                    0.000                   0.000
## 38  1987-02                    0.002                   0.000
## 39  1987-03                    0.003                   0.000
## 40  1987-04                    0.004                   0.000
## 41  1987-05                    0.004                   0.001
## 42  1987-06                    0.006                   0.003
## 43  1987-07                    0.006                   0.004
## 44  1987-08                    0.004                   0.001
## 45  1987-09                    0.003                   0.001
## 46  1987-10                    0.002                   0.000
## 47  1987-11                    0.001                   0.000
## 48  1987-12                    0.001                   0.001
## 49  1988-01                    0.002                   0.002
## 50  1988-02                    0.003                   0.000
## 51  1988-03                    0.004                   0.000
## 52  1988-04                    0.002                   0.000
## 53  1988-05                    0.004                   0.000
## 54  1988-06                    0.005                   0.000
## 55  1988-07                    0.004                   0.000
## 56  1988-08                    0.004                   0.000
## 57  1988-09                    0.003                   0.000
## 58  1988-10                    0.000                   0.000
## 59  1988-11                    0.000                   0.000
## 60  1988-12                    0.000                   0.000
## 61  1989-01                    2.821                   0.497
## 62  1989-02                    3.041                   0.763
## 63  1989-03                    4.220                   0.873
## 64  1989-04                    4.660                   0.812
## 65  1989-05                    5.109                   0.697
## 66  1989-06                    5.175                   0.534
## 67  1989-07                    5.476                   0.485
## 68  1989-08                    5.389                   0.352
## 69  1989-09                    4.941                   0.956
## 70  1989-10                    4.501                   0.599
## 71  1989-11                    3.697                   0.419
## 72  1989-12                    3.465                   0.219
## 73  1990-01                    3.015                   1.028
## 74  1990-02                    3.256                   0.789
## 75  1990-03                    4.489                   0.837
## 76  1990-04                    4.946                   1.434
## 77  1990-05                    5.515                   1.195
## 78  1990-06                    5.534                   1.387
## 79  1990-07                    5.832                   0.406
## 80  1990-08                    5.781                   0.239
## 81  1990-09                    5.228                   0.311
## 82  1990-10                    4.782                   0.693
## 83  1990-11                    3.884                   0.789
## 84  1990-12                    3.700                   0.406
## 85  1991-01                    3.125                   0.212
## 86  1991-02                    3.369                   0.989
## 87  1991-03                    4.561                   0.707
## 88  1991-04                    5.026                   0.813
## 89  1991-05                    5.739                   1.237
## 90  1991-06                    5.803                   0.530
## 91  1991-07                    6.133                   0.530
## 92  1991-08                    6.035                   0.777
## 93  1991-09                    5.487                   0.707
## 94  1991-10                    4.935                   1.448
## 95  1991-11                    4.034                   1.448
## 96  1991-12                    3.792                   0.671
## 97  1992-01                    3.196                   0.512
## 98  1992-02                    3.451                   1.759
## 99  1992-03                    4.752                   1.120
## 100 1992-04                    5.284                   1.088
## 101 1992-05                    5.883                   0.320
## 102 1992-06                    5.931                   0.256
## 103 1992-07                    6.274                   0.256
## 104 1992-08                    6.205                   0.480
## 105 1992-09                    5.628                   1.088
## 106 1992-10                    5.115                   0.832
## 107 1992-11                    4.187                   0.960
## 108 1992-12                    3.914                   1.184
## 109 1993-01                    3.288                   0.844
## 110 1993-02                    3.570                   0.169
## 111 1993-03                    4.954                   1.773
## 112 1993-04                    5.515                   1.266
## 113 1993-05                    6.053                   1.266
## 114 1993-06                    6.058                   0.295
## 115 1993-07                    6.445                   0.464
## 116 1993-08                    6.401                   0.253
## 117 1993-09                    5.818                   0.464
## 118 1993-10                    5.243                   0.971
## 119 1993-11                    4.297                   1.562
## 120 1993-12                    4.039                   0.929
## 121 1994-01                    3.432                   0.000
## 122 1994-02                    3.680                   0.343
## 123 1994-03                    5.137                   1.865
## 124 1994-04                    5.640                   1.408
## 125 1994-05                    6.216                   1.256
## 126 1994-06                    6.292                   1.256
## 127 1994-07                    6.584                   0.647
## 128 1994-08                    6.471                   0.457
## 129 1994-09                    5.949                   1.066
## 130 1994-10                    5.458                   1.218
## 131 1994-11                    4.415                   1.675
## 132 1994-12                    4.136                   0.571
## 133 1995-01                    3.415                   0.019
## 134 1995-02                    3.692                   0.080
## 135 1995-03                    5.105                   0.016
## 136 1995-04                    5.735                   0.023
## 137 1995-05                    6.370                   1.394
## 138 1995-06                    6.471                   1.701
## 139 1995-07                    6.750                   2.115
## 140 1995-08                    6.674                   1.862
## 141 1995-09                    6.047                   1.955
## 142 1995-10                    5.471                   0.876
## 143 1995-11                    4.473                   0.427
## 144 1995-12                    4.192                   0.329
## 145 1996-01                    3.472                   0.503
## 146 1996-02                    3.760                   0.382
## 147 1996-03                    5.293                   0.640
## 148 1996-04                    5.865                   0.834
## 149 1996-05                    6.487                   1.336
## 150 1996-06                    6.562                   1.282
## 151 1996-07                    6.804                   1.826
## 152 1996-08                    6.602                   1.416
## 153 1996-09                    5.956                   1.199
## 154 1996-10                    5.494                   0.863
## 155 1996-11                    4.495                   0.337
## 156 1996-12                    4.262                   0.417
## 157 1997-01                    3.422                   0.411
## 158 1997-02                    3.762                   0.372
## 159 1997-03                    5.176                   0.507
## 160 1997-04                    5.748                   1.106
## 161 1997-05                    6.292                   1.196
## 162 1997-06                    6.433                   1.764
## 163 1997-07                    6.721                   1.738
## 164 1997-08                    6.612                   1.809
## 165 1997-09                    5.958                   0.888
## 166 1997-10                    5.437                   0.937
## 167 1997-11                    4.424                   0.248
## 168 1997-12                    4.187                   0.244
## 169 1998-01                    3.375                   0.059
## 170 1998-02                    3.629                   0.028
## 171 1998-03                    5.138                   0.021
## 172 1998-04                    5.664                   0.293
## 173 1998-05                    6.173                   0.489
## 174 1998-06                    6.327                   1.348
## 175 1998-07                    6.679                   1.868
## 176 1998-08                    6.584                   1.438
## 177 1998-09                    5.956                   1.623
## 178 1998-10                    5.395                   1.019
## 179 1998-11                    4.389                   0.618
## 180 1998-12                    4.147                   1.519
## 181 1999-01                    3.294                   1.150
## 182 1999-02                    3.570                   1.054
## 183 1999-03                    4.984                   1.524
## 184 1999-04                    5.536                   1.274
## 185 1999-05                    6.121                   0.940
## 186 1999-06                    6.184                   0.866
## 187 1999-07                    6.482                   1.556
## 188 1999-08                    6.377                   1.304
## 189 1999-09                    5.775                   1.288
## 190 1999-10                    5.311                   1.428
## 191 1999-11                    4.307                   1.209
## 192 1999-12                    4.068                   1.720
## 193 2000-01                    3.155                   2.202
## 194 2000-02                    3.440                   2.409
## 195 2000-03                    4.733                   1.194
## 196 2000-04                    5.239                   1.126
## 197 2000-05                    5.832                   1.392
## 198 2000-06                    5.895                   1.525
## 199 2000-07                    6.261                   1.296
## 200 2000-08                    6.144                   1.284
## 201 2000-09                    5.608                   1.134
## 202 2000-10                    5.056                   1.404
## 203 2000-11                    4.103                   2.808
## 204 2000-12                    3.882                   1.309
## 205 2001-01                    3.008                   1.328
## 206 2001-02                    3.261                   1.471
## 207 2001-03                    4.542                   1.816
## 208 2001-04                    5.020                   2.336
## 209 2001-05                    5.672                   2.167
## 210 2001-06                    5.755                   2.285
## 211 2001-07                    6.029                   2.167
## 212 2001-08                    5.947                   1.969
## 213 2001-09                    5.380                   1.673
## 214 2001-10                    4.773                   2.071
## 215 2001-11                    3.905                   1.605
## 216 2001-12                    3.675                   2.101
## 217 2002-01                    2.923                   2.769
## 218 2002-02                    3.189                   2.436
## 219 2002-03                    4.435                   2.907
## 220 2002-04                    4.877                   3.495
## 221 2002-05                    5.408                   3.677
## 222 2002-06                    5.585                   3.843
## 223 2002-07                    5.812                   3.038
## 224 2002-08                    5.719                   3.332
## 225 2002-09                    5.162                   2.511
## 226 2002-10                    4.647                   2.506
## 227 2002-11                    3.821                   2.238
## 228 2002-12                    3.551                   2.577
## 229 2003-01                    2.848                   2.158
## 230 2003-02                    3.083                   2.543
## 231 2003-03                    4.334                   3.535
## 232 2003-04                    4.795                   3.729
## 233 2003-05                    5.298                   3.434
## 234 2003-06                    5.421                   3.573
## 235 2003-07                    5.579                   3.253
## 236 2003-08                    5.522                   2.782
## 237 2003-09                    5.034                   3.054
## 238 2003-10                    4.535                   3.061
## 239 2003-11                    3.669                   3.280
## 240 2003-12                    3.452                   3.770
## 241 2004-01                    2.809                   3.410
## 242 2004-02                    3.019                   3.486
## 243 2004-03                    4.289                   4.406
## 244 2004-04                    4.722                   4.418
## 245 2004-05                    5.278                   5.806
## 246 2004-06                    5.343                   4.767
## 247 2004-07                    5.575                   3.973
## 248 2004-08                    5.488                   3.585
## 249 2004-09                    4.986                   3.718
## 250 2004-10                    4.470                   3.511
## 251 2004-11                    3.625                   3.181
## 252 2004-12                    3.418                   3.999
## 253 2005-01                    2.742                   3.861
## 254 2005-02                    2.968                   3.298
## 255 2005-03                    4.158                   5.325
## 256 2005-04                    4.638                   5.792
## 257 2005-05                    5.178                   5.959
## 258 2005-06                    5.247                   6.131
## 259 2005-07                    5.438                   4.848
## 260 2005-08                    5.396                   3.883
## 261 2005-09                    4.894                   5.010
## 262 2005-10                    4.399                   4.934
## 263 2005-11                    3.547                   5.492
## 264 2005-12                    3.335                   6.237
## 265 2006-01                    2.881                   8.130
## 266 2006-02                    3.124                   6.558
## 267 2006-03                    4.327                   8.048
## 268 2006-04                    4.821                   8.434
## 269 2006-05                    5.368                   8.389
## 270 2006-06                    5.410                   7.001
## 271 2006-07                    5.640                   6.671
## 272 2006-08                    5.657                   5.647
## 273 2006-09                    5.085                   6.412
## 274 2006-10                    4.577                   8.333
## 275 2006-11                    3.718                   8.668
## 276 2006-12                    3.487                   8.433
## 277 2007-01                    3.016                   8.367
## 278 2007-02                    3.269                   8.598
## 279 2007-03                    4.579                  10.397
## 280 2007-04                    5.051                  10.822
## 281 2007-05                    5.658                  10.073
## 282 2007-06                    5.707                   8.941
## 283 2007-07                    5.981                   7.364
## 284 2007-08                    5.886                   9.210
## 285 2007-09                    5.367                   9.781
## 286 2007-10                    4.848                  11.521
## 287 2007-11                    3.922                  10.560
## 288 2007-12                    3.662                  11.909
## 289 2008-01                    3.206                  14.580
## 290 2008-02                    3.518                  13.142
## 291 2008-03                    4.933                  16.316
## 292 2008-04                    5.478                  17.829
## 293 2008-05                    6.029                  18.221
## 294 2008-06                    6.181                  17.539
## 295 2008-07                    6.408                  13.677
## 296 2008-08                    6.326                  11.138
## 297 2008-09                    5.758                  10.616
## 298 2008-10                    5.166                  16.229
## 299 2008-11                    4.167                  17.038
## 300 2008-12                    3.926                  22.573
## 301 2009-01                    3.247                  20.304
## 302 2009-02                    3.578                  19.968
## 303 2009-03                    5.053                  24.222
## 304 2009-04                    5.614                  25.446
## 305 2009-05                    6.200                  21.366
## 306 2009-06                    6.229                  19.105
## 307 2009-07                    6.582                  16.906
## 308 2009-08                    6.501                  18.645
## 309 2009-09                    5.892                  15.868
## 310 2009-10                    5.307                  23.248
## 311 2009-11                    4.300                  23.458
## 312 2009-12                    4.023                  23.563
## 313 2010-01                    3.485                  23.387
## 314 2010-02                    3.833                  18.533
## 315 2010-03                    5.386                  29.306
## 316 2010-04                    6.033                  33.316
## 317 2010-05                    6.760                  29.676
## 318 2010-06                    6.895                  27.463
## 319 2010-07                    7.158                  22.942
## 320 2010-08                    7.072                  22.812
## 321 2010-09                    6.433                  24.244
## 322 2010-10                    5.693                  27.104
## 323 2010-11                    4.721                  33.259
## 324 2010-12                    4.384                  30.910
## 325 2011-01                    3.924                  29.174
## 326 2011-02                    4.374                  35.661
## 327 2011-03                    6.043                  35.978
## 328 2011-04                     6.760                 42.383
## 329 2011-05                     7.496                 40.167
## 330 2011-06                     7.667                 37.481
## 331 2011-07                     7.903                 25.551
## 332 2011-08                     7.958                 25.500
## 333 2011-09                     7.178                 23.437
## 334 2011-10                     6.507                 35.913
## 335 2011-11                     5.259                 42.440
## 336 2011-12                     5.056                 36.358
## 337 2012-01                     4.607                 46.508
## 338 2012-02                     5.077                 37.708
## 339 2012-03                     7.148                 47.861
## 340 2012-04                     8.096                 43.363
## 341 2012-05                     9.316                 42.788
## 342 2012-06                     9.605                 40.849
## 343 2012-07                     9.934                 30.104
## 344 2012-08                     9.685                 28.898
## 345 2012-09                     8.960                 29.991
## 346 2012-10                     8.214                 43.114
## 347 2012-11                     6.715                 39.745
## 348 2012-12                     6.439                 49.554
## 349 2013-01                     5.869                 50.288
## 350 2013-02                     6.663                 48.026
## 351 2013-03                     9.260                 53.758
## 352 2013-04                    10.151                 59.629
## 353 2013-05                    11.264                 55.406
## 354 2013-06                    11.745                 46.909
## 355 2013-07                    12.038                 37.851
## 356 2013-08                    12.336                 32.871
## 357 2013-09                    11.551                 39.832
## 358 2013-10                    10.946                 46.523
## 359 2013-11                     9.028                 53.921
## 360 2013-12                     8.800                 47.656
## 361 2014-01                     8.157                 61.113
## 362 2014-02                     8.799                 47.798
## 363 2014-03                    12.624                 60.515
## 364 2014-04                    13.934                 63.584
## 365 2014-05                    15.758                 53.232
## 366 2014-06                    16.428                 53.906
## 367 2014-07                    16.395                 41.583
## 368 2014-08                    16.624                 34.702
## 369 2014-09                    15.631                 39.305
## 370 2014-10                    14.507                 49.501
## 371 2014-11                    11.805                 64.374
## 372 2014-12                    10.387                 50.195
## 373 2015-01                     9.815                 51.733
## 374 2015-02                    11.480                 50.912
## 375 2015-03                    15.989                 52.231
## 376 2015-04                    18.058                 60.963
## 377 2015-05                    19.510                 58.520
## 378 2015-06                    19.804                 45.793
## 379 2015-07                    20.660                 46.661
## 380 2015-08                    20.720                 44.629
## 381 2015-09                    18.026                 47.671
## 382 2015-10                   15.938                  55.889
## 383 2015-11                   13.628                  67.154
## 384 2015-12                   12.547                  68.576
## 385 2016-01                   11.728                  63.007
## 386 2016-02                   15.428                  68.712
## 387 2016-03                   19.297                  74.857
## 388 2016-04                   21.401                  70.967
## 389 2016-05                   24.459                  64.309
## 390 2016-06                   24.955                  55.627
## 391 2016-07                   27.056                  60.114
## 392 2016-08                   26.741                  46.367
## 393 2016-09                   24.199                  55.969
## 394 2016-10                   21.438                  69.384
## 395 2016-11                   17.985                  66.212
## 396 2016-12                   16.202                  78.973
## 397 2017-01                   15.555                  70.965
## 398 2017-02                   17.857                  75.375
## 399 2017-03                   27.472                  87.793
## 400 2017-04                   30.175                  86.590
## 401 2017-05                   34.567                  78.707
## 402 2017-06                   36.083                  68.724
## 403 2017-07                   34.635                  55.001
## 404 2017-08                   33.492                  47.355
## 405 2017-09                   30.881                  61.115
## 406 2017-10                   28.042                  83.146
## 407 2017-11                   20.501                  77.162
## 408 2017-12                   19.362                  75.749
## 409 2018-01                   20.417                  87.343
## 410 2018-02                   23.213                  79.123
## 411 2018-03                   30.918                  90.294
## 412 2018-04                   36.049                  90.182
## 413 2018-05                   40.277                  81.728
## 414 2018-06                   42.476                  84.286
## 415 2018-07                   40.715                  56.116
## 416 2018-08                   39.785                  67.716
## 417 2018-09                   35.355                  63.189
## 418 2018-10                   30.386                  72.314
## 419 2018-11                   23.468                  75.118
## 420 2018-12                   20.576                  82.933
## 421 2019-01                   22.249                  82.917
## 422 2019-02                   23.942                  77.189
## 423 2019-03                   35.490                  87.936
## 424 2019-04                   40.146                  98.659
## 425 2019-05                   43.146                  87.959
## 426 2019-06                   46.198                  76.586
## 427 2019-07                   47.572                  75.408
## 428 2019-08                   45.914                  68.165
## 429 2019-09                   40.157                  83.640
## 430 2019-10                   35.724                  94.255
## 431 2019-11                   26.634                  85.929
## 432 2019-12                   22.573                  90.909
## 433 2020-01                   26.741                  95.950
## 434 2020-02                   32.049                  99.325
## 435 2020-03                   38.731                 100.039
## 436 2020-04                   46.045                 101.515
## 437 2020-05                   54.208                  96.824
## 438 2020-06                   54.219                 103.085
## 439 2020-07                   58.159                  78.019
## 440 2020-08                   52.712                  78.576
## 441 2020-09                   44.933                  79.111
## 442 2020-10                   40.674                  98.343
## 443 2020-11                   33.068                 113.038
## 444 2020-12                   29.778                 109.220
## 445 2021-01                   32.034                 102.566
## 446 2021-02                   35.565                  91.153
## 447 2021-03                   51.477                 133.768
## 448 2021-04                   59.068                 123.370
## 449 2021-05                   66.559                 115.280
## 450 2021-06                   65.882                  91.003
## 451 2021-07                   66.269                  74.093
## 452 2021-08                   64.229                  92.367
## 453 2021-09                   59.026                  98.941
## 454 2021-10                   49.778                 109.918
## 455 2021-11                   42.082                 121.983
## 456 2021-12                   34.895                 135.965
## 457 2022-01                   41.781                 127.664
## 458 2022-02                   47.414                 128.443
## 459 2022-03                   62.793                 146.820
## 460 2022-04                   71.077                 157.522
## 461 2022-05                   79.465                 143.726
## 462 2022-06                   82.616                 115.215
## 463 2022-07                   82.569                 100.569
## 464 2022-08                   77.172                  84.339
## 465 2022-09                   70.117                  93.254
## 466 2022-10                   63.195                 111.725
## 467 2022-11                   46.708                 140.570
## 468 2022-12                   39.656                 131.975
## 469 2023-01                   43.772                 130.877
## 470 2023-02                   51.049                 141.340
## 471 2023-03                   67.465                 148.708
## 472 2023-04                   80.376                 145.848
## 473 2023-05                   91.383                 109.959
## 474 2023-06                   92.683                  93.990
## 475 2023-07                   97.656                  95.552
## 476 2023-08                   92.824                  96.881
## 477 2023-09                   81.556                  96.742
## 478 2023-10                   74.296                 122.900
## 479 2023-11                   56.874                 124.352
## 480 2023-12                   50.393                 129.787
## 481 2024-01                   53.206                 118.833
## 482 2024-02                   65.064                 141.413
## 483 2024-03                   83.696                 155.252
## 484 2024-04                   98.077                 161.170
## 485 2024-05                  111.667                 131.666
## 486 2024-06                  118.688                 129.865
## 487 2024-07                  119.326                  95.229
## 488 2024-08                  117.388                  97.908
## 489 2024-09                  100.303                  98.641
```

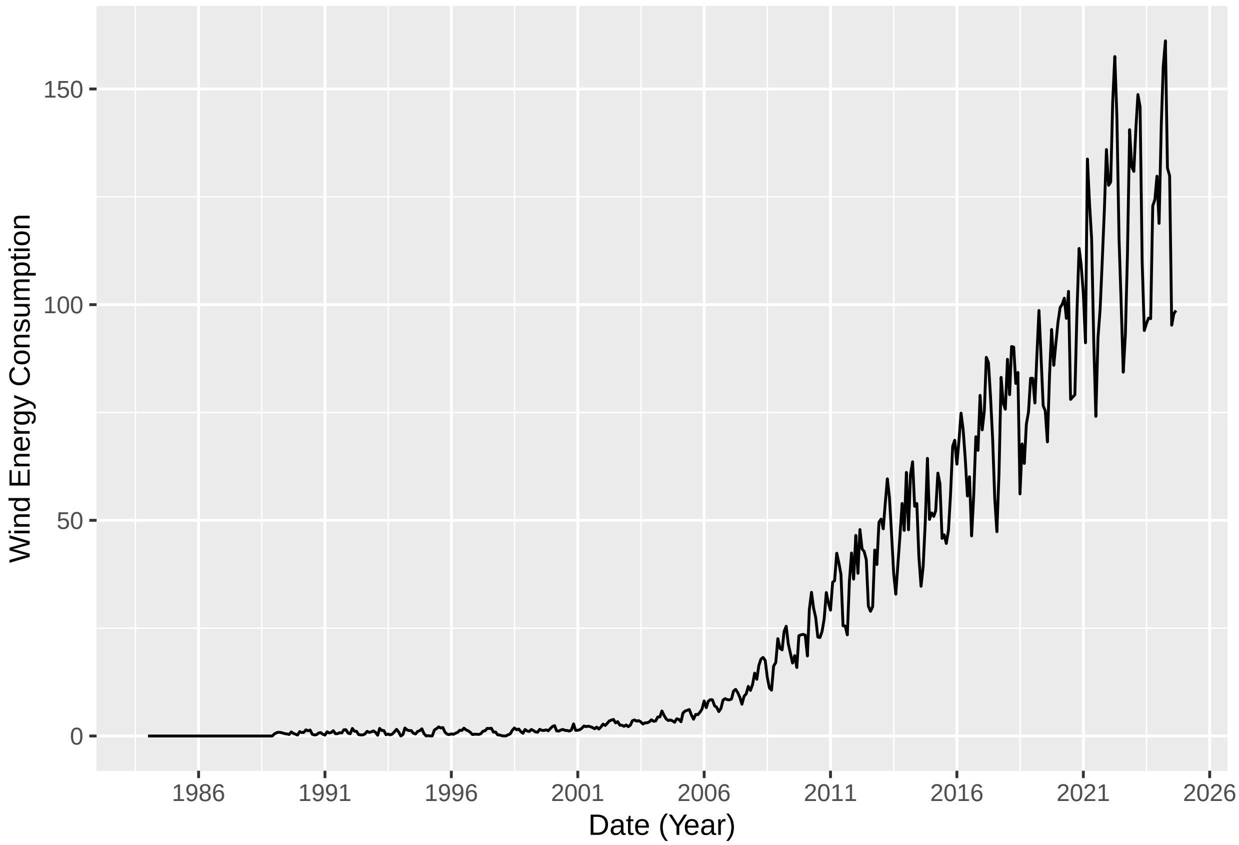
Q2

Plot the Solar and Wind energy consumption over time using ggplot. Plot each series on a separate graph. No need to add legend. Add informative names to the y axis using `ylab()`. Explore the function `scale_x_date()` on ggplot and see if you can change the x axis to improve your plot. Hint: use `scale_x_date(date_breaks = "5 years", date_labels = "%Y")`

```
# Convert the 'Month' column to Date format (Confirmed my code with gpt)
df_ts_renewable_data2_filtered$Month <- as.Date(paste0(df_ts_renewable_data2_filtered$Month, "-01"), fo

#1 Plot - Solar Energy Consumption + ylab, scale_x_date
plot_ts1 <- ggplot(df_ts_renewable_data2_filtered, aes(x = Month, y = Solar_Energy_Consumption)) +
  geom_line() +
  ylab("Solar Energy Consumption") +
   xlab("Date (Year)")+
  scale_x_date(date_breaks = "5 years", date_labels = "%Y")

print(plot_ts1)
```



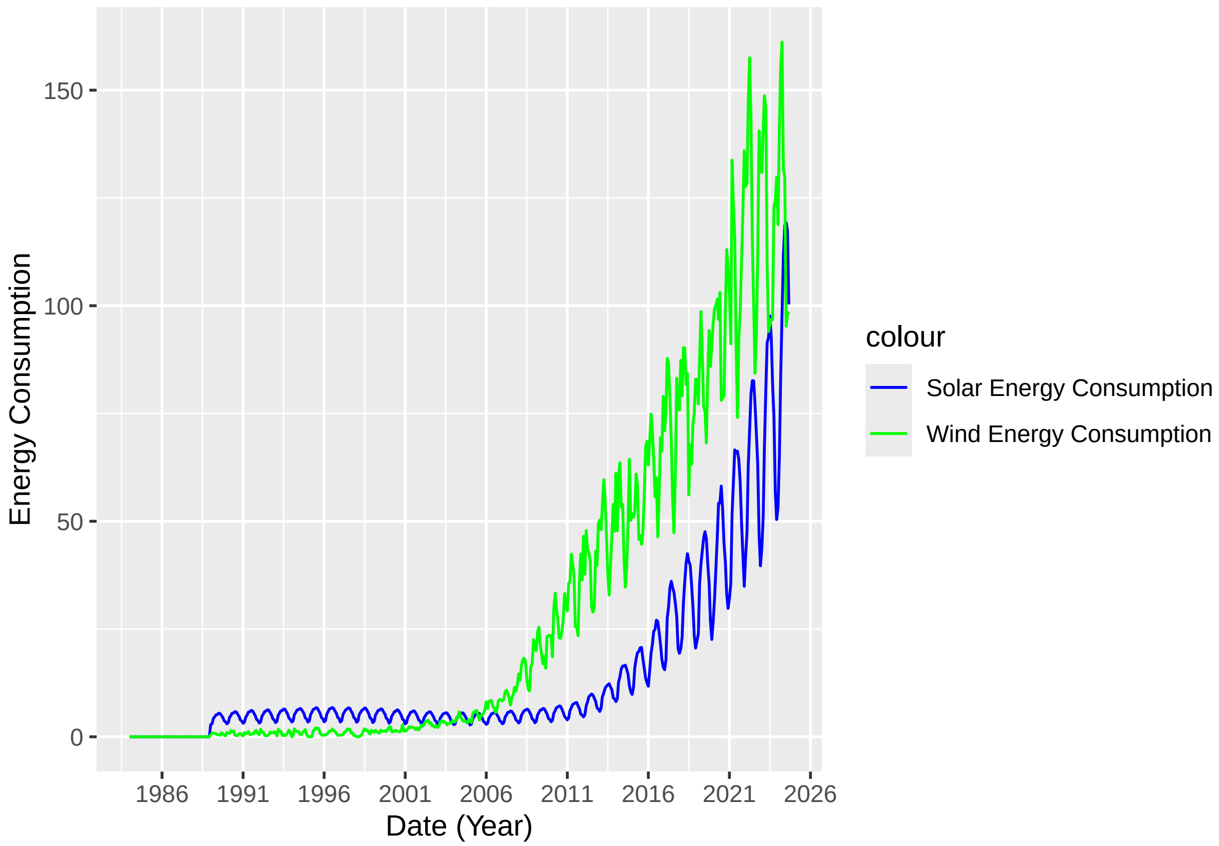
```
#2 Plot - Wind Energy Consumption
plot_ts2 <- ggplot(df_ts_renewable_data2_filtered,
                   aes(x = Month,
                       y = Wind_Energy_Consumption)) +
  ylab("Wind Energy Consumption") +
   xlab("Date (Year)")+
  geom_line()+
  scale_x_date(date_breaks = "5 years", date_labels = "%Y")

print(plot_ts2)
```



Q3

Now plot both series in the same graph, also using ggplot(). Use function `scale_color_manual()` to manually add a legend to ggplot. Make the solar energy consumption red and wind energy consumption blue. Add informative name to the y axis using `ylab("Energy Consumption)`. And use function `scale_x_date()` to set x axis breaks every 5 years.

```
plot_ts_combined <- ggplot() +
  geom_line(data = df_ts_renewable_data2_filtered,
            aes(x = Month,
                y = Solar_Energy_Consumption,
                color = "Solar Energy Consumption")) +
  geom_line(data = df_ts_renewable_data2_filtered,
            aes(x = Month,
                y = Wind_Energy_Consumption,
                color = "Wind Energy Consumption")) +
  scale_color_manual(values = c("Solar Energy Consumption" = "blue", "Wind Energy Consumption" = "green
  xlab("Date (Year)")+
  ylab("Energy Consumption") +
  scale_x_date(date_breaks = "5 years", date_labels = "%Y")

print(plot_ts_combined)
```



Decomposing the time series

The stats package has a function called decompose(). This function only take time series object. As the name says the decompose function will decompose your time series into three components: trend, seasonal and random. This is similar to what we did in the previous script, but in a more automated way. The random component is the time series without seasonal and trend component.

Additional info on `decompose()`.

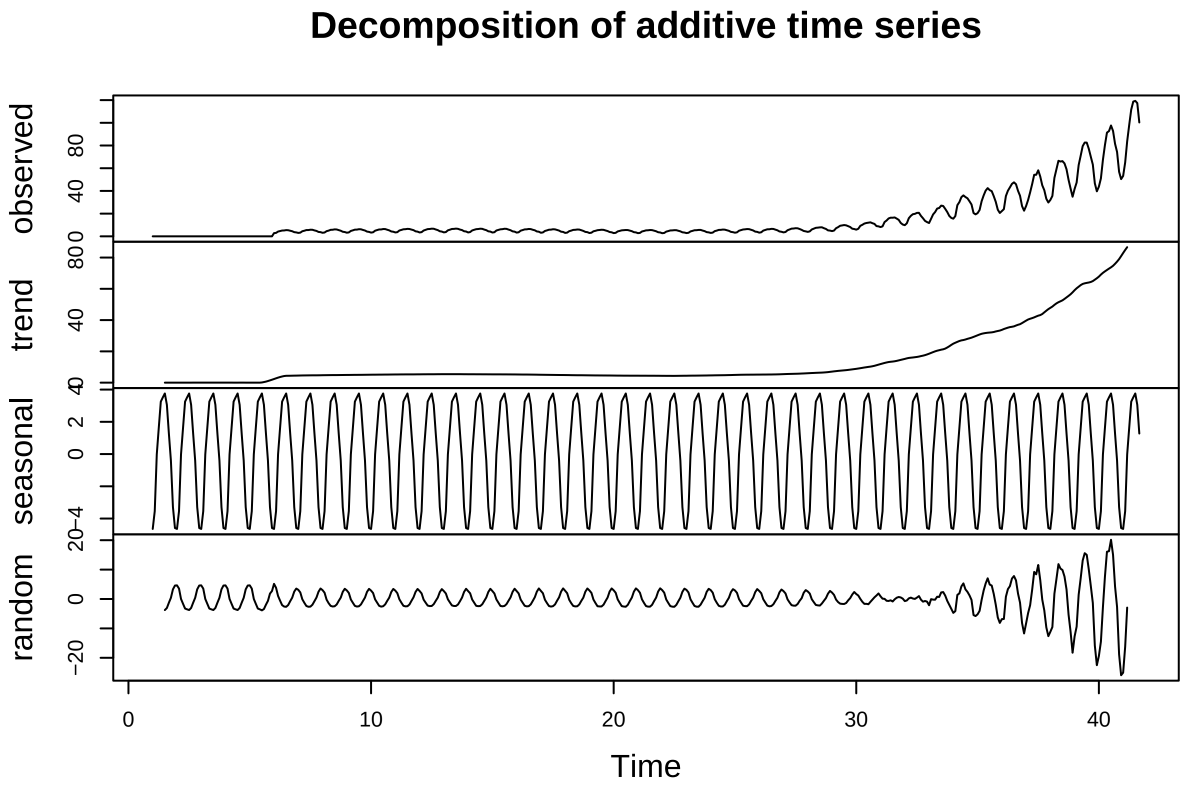
1) You have two options: alternative and multiplicative. Multiplicative models exhibit a change in frequency over time.
2) The trend is not a straight line because it uses a moving average method to detect trend.
3) The seasonal component of the time series is found by subtracting the trend component from the original data then grouping the results by month and averaging them.
4) The random component, also referred to as the noise component, is composed of all the leftover signal which is not explained by the combination of the trend and seasonal component.

Q4

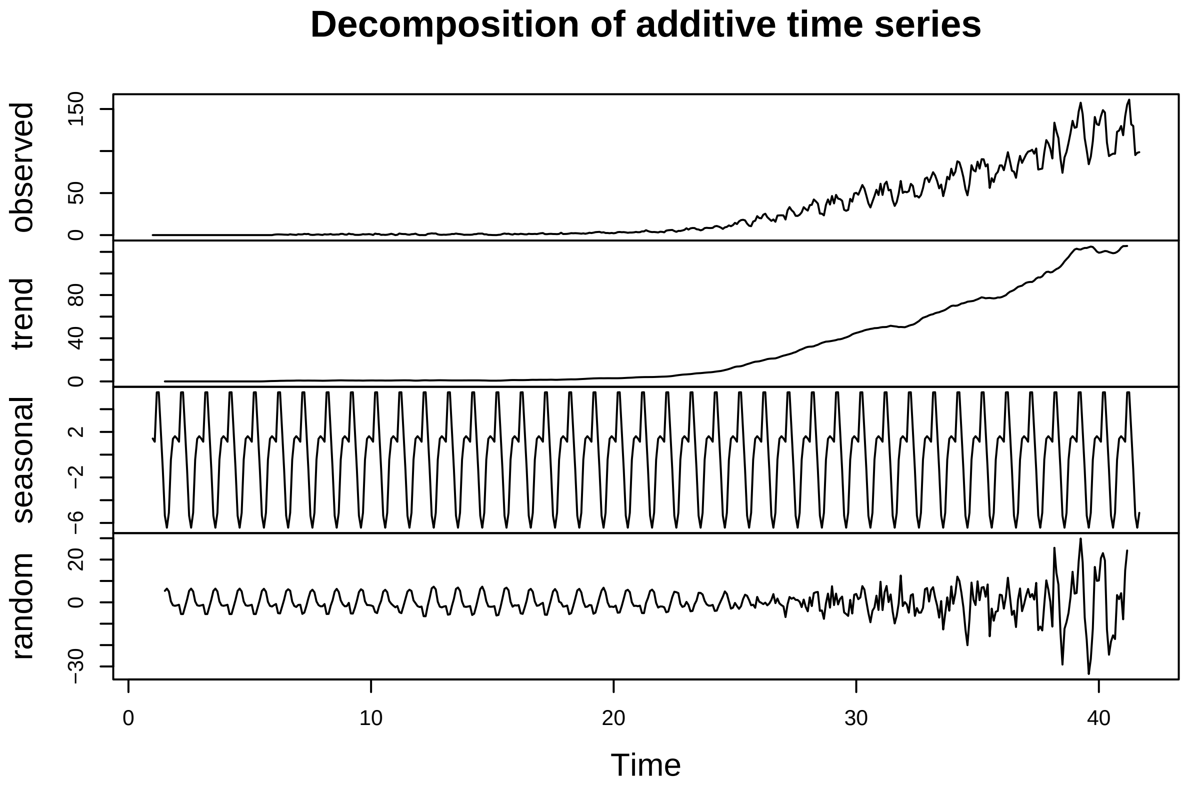
Transform wind and solar series into a time series object and apply the decompose function on them using the additive option, i.e., `decompose(ts_data, type = "additive")`. What can you say about the trend component? What about the random component? Does the random component look random? Or does it appear to still have some seasonality on it?

> Answer: First of all, the trend of solar (ts1) is upwarding. It seems like it still have some seasonality from 0 to 25 lag, while it looks random after that. The trend of wind (ts2) is also upwarding overall, while there is a slight drop at the end. Similar to the former one, it seems like it still have some seasonality from 0 to 27 lag, while it looks random after that.

```r
#Wind and Solar series - Already transformed into a time series object in Q1
#Decomposition of Solar  - Type: Additive
ts1_renewable_data2_filtered_decompose<-decompose(ts1_renewable_data2_filtered,type="additive")
plot(ts1_renewable_data2_filtered_decompose)
```



```r
#Decomposition of Wind - Type: Additive
ts2_renewable_data2_filtered_decompose<-decompose(ts2_renewable_data2_filtered,type="additive")
plot(ts2_renewable_data2_filtered_decompose)
```

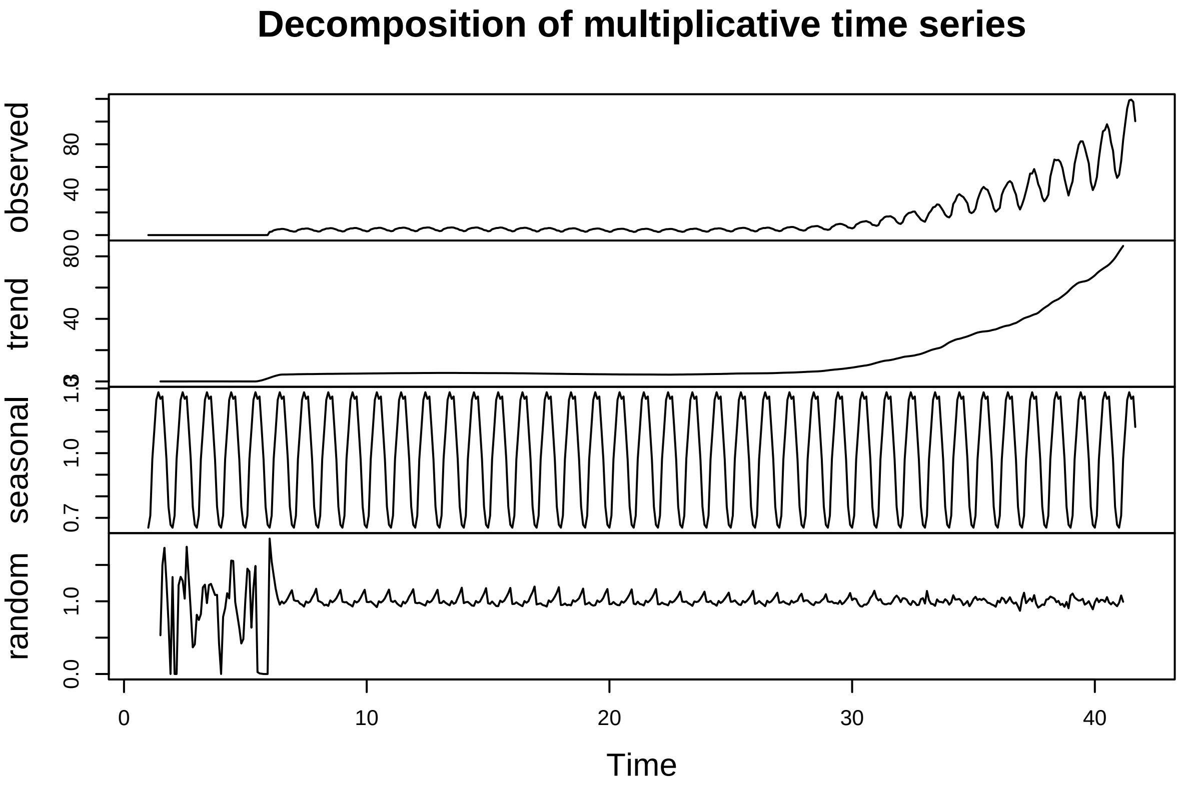


Q5

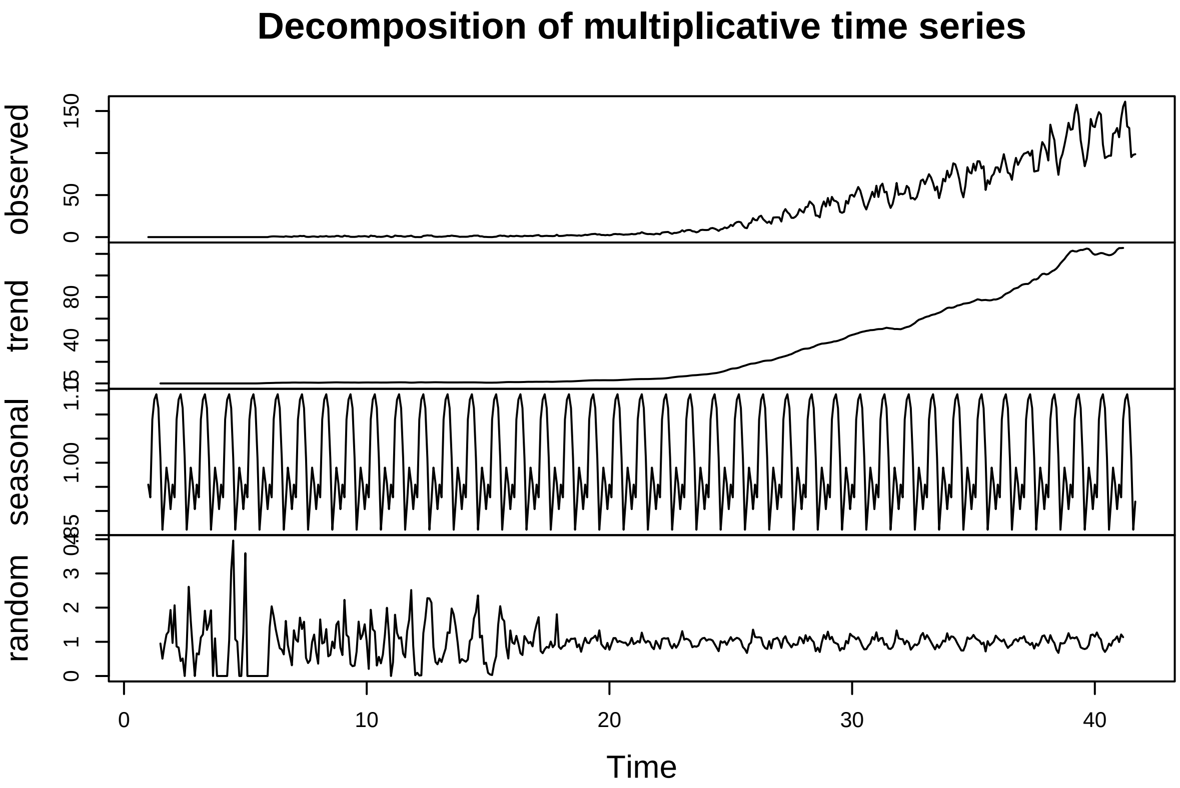
Use the decompose function again but now change the type of the seasonal component from additive to multiplicative. What happened to the random component this time?

Answer: The random component of solar energy consumption looks random at first, but it seems to have some seasonality after that. The wind energy one shows more random pattern through 15 or 16 unit of time. After that, it also seems to have some seasonality.

```
#Decomposition of Solar - Multiplicative
ts1_renewable_data2_filtered_decompose_M<-decompose(ts1_renewable_data2_filtered,type="multiplicative")
plot(ts1_renewable_data2_filtered_decompose_M)
```



```
#Decomposition of Wind - Multiplicative
ts2_renewable_data2_filtered_decompose_M<-decompose(ts2_renewable_data2_filtered,type="multiplicative")
plot(ts2_renewable_data2_filtered_decompose_M)
```



Q6

When fitting a model to this data, do you think you need all the historical data? Think about the data from 90s and early 20s. Are there any information from those years we might need to forecast the next six months of Solar and/or Wind consumption. Explain your response.

> Answer: I don't think we need all the historical data, seeing that the trend has significantly changed in more recent years for both Solar and Wind energy consumption.

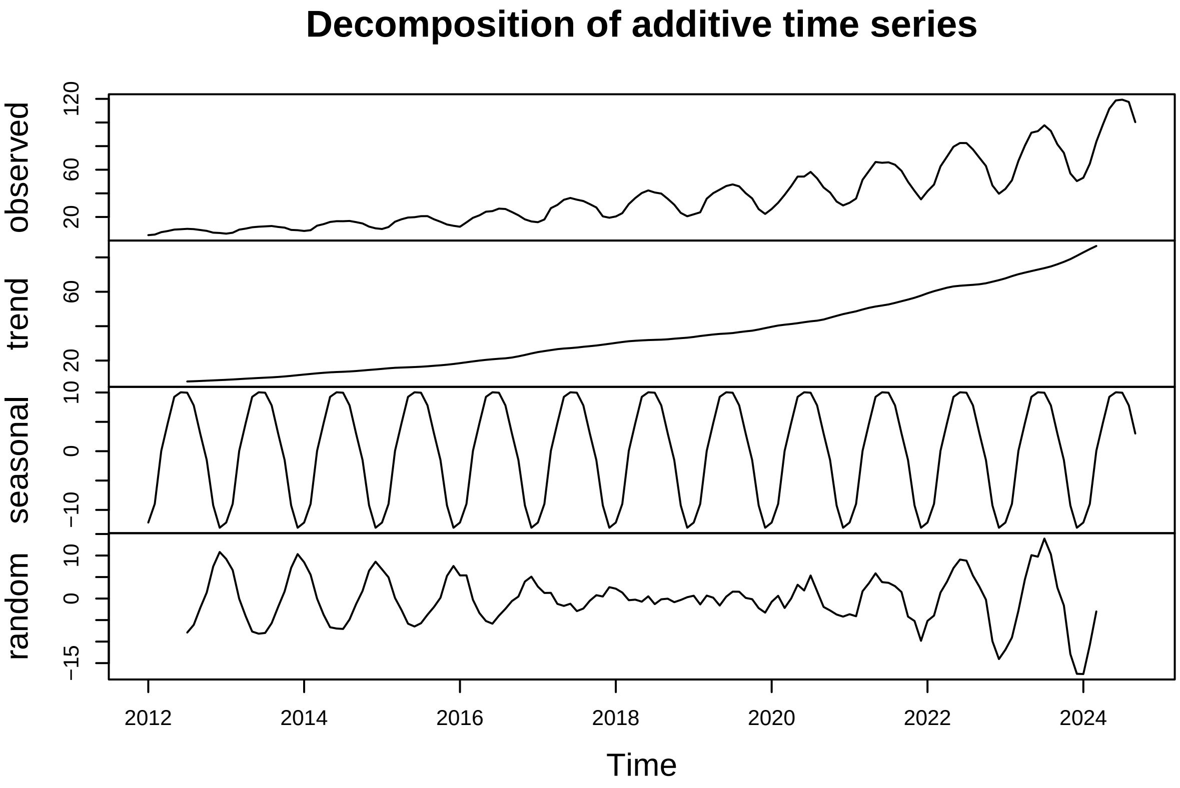
Q7

Create a new time series object where historical data starts on January 2012. Hint: use `filter()` function so that you don't need to point to row numbers, .i.e, `filter(xxxx, year(Date) >= 2012 )`. Apply the decompose function `type=additive` to this new time series. Comment the results. Does the random component look random? Think about our discussion in class about seasonal components that depends on the level of the series.

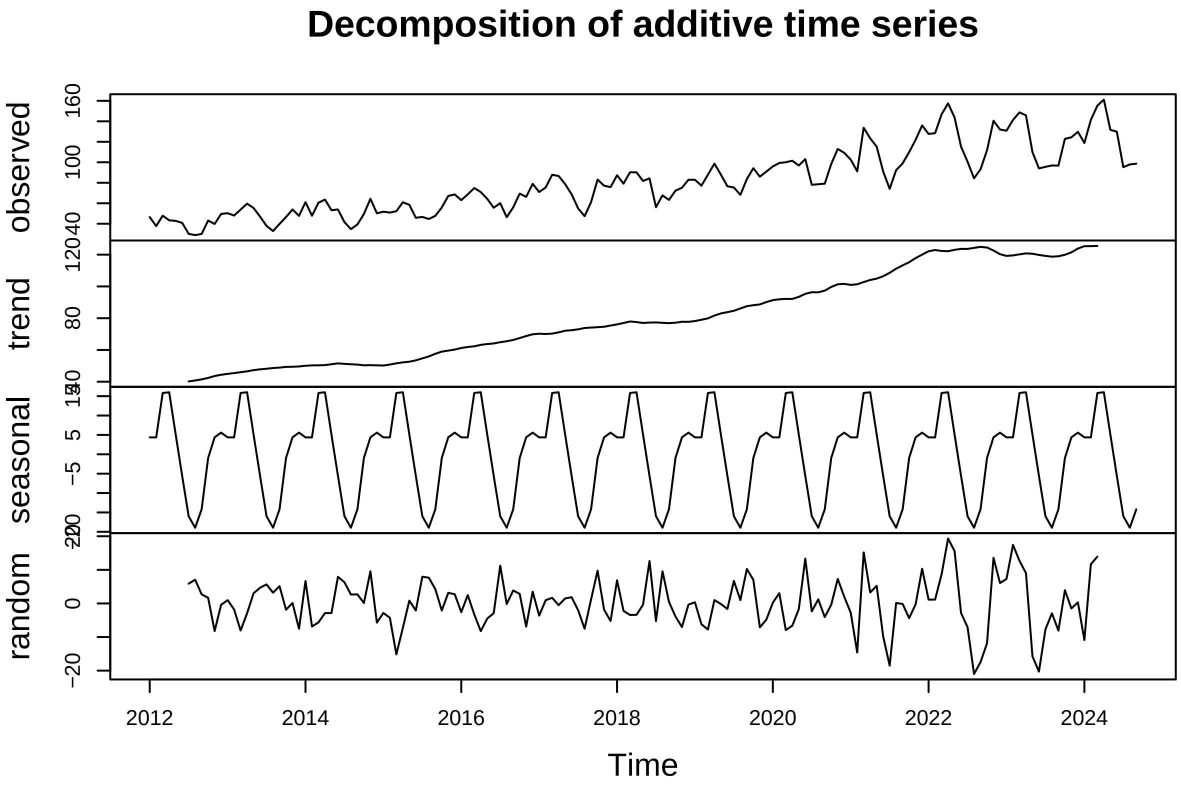
```
#Converted to Date (Checked my code with AI)
renewable_data2_filtered$Month <- as.Date(paste0(renewable_data2_filtered$Month, "-01"), format = "%Y-%
head(renewable_data2_filtered)
```

```
##        Month Solar Energy Consumption Wind Energy Consumption
## 1 1984-01-01                    0.000                   0.000
## 2 1984-02-01                    0.000                   0.001
## 3 1984-03-01                    0.001                   0.001
## 4 1984-04-01                    0.001                   0.002
## 5 1984-05-01                    0.002                   0.003
## 6 1984-06-01                    0.003                   0.002
```

```
#Filtered out the historical data starts on Jan 2012
renewable_data2_filtered_recent <- renewable_data2_filtered %>%
  filter(Month >= as.Date("2012-01-01"))

#1 Time Series object starts on Jan 2012 - Solar
ts1_renewable_data2_filtered_recent <- ts(renewable_data2_filtered_recent$`Solar Energy Consumption`,
                                          start = c(2012, 1),
                                          frequency = 12)

#2 Time Series object starts on Jan 2012 - Wind
ts2_renewable_data2_filtered_recent <- ts(renewable_data2_filtered_recent$`Wind Energy Consumption`,
                                          start = c(2012, 1),
                                          frequency = 12)

#1 Decomposition - Solar
ts1_renewable_data2_filtered_recent_decompose<-decompose(ts1_renewable_data2_filtered_recent,type="addi
plot(ts1_renewable_data2_filtered_recent_decompose)
```



```
#2 Decomposition - Wind
ts2_renewable_data2_filtered_recent_decompose<-decompose(ts2_renewable_data2_filtered_recent,type="addi
plot(ts2_renewable_data2_filtered_recent_decompose)
```



Answer: According to the decomposed time series of Solar and Wind, the random component in more recent data appears to be more unpredictable compared to the results in Q4 and Q5. The overall trends continue to rise, which contrasts with the previous trend component that remained stable in the past before shifting upward after a certain period.

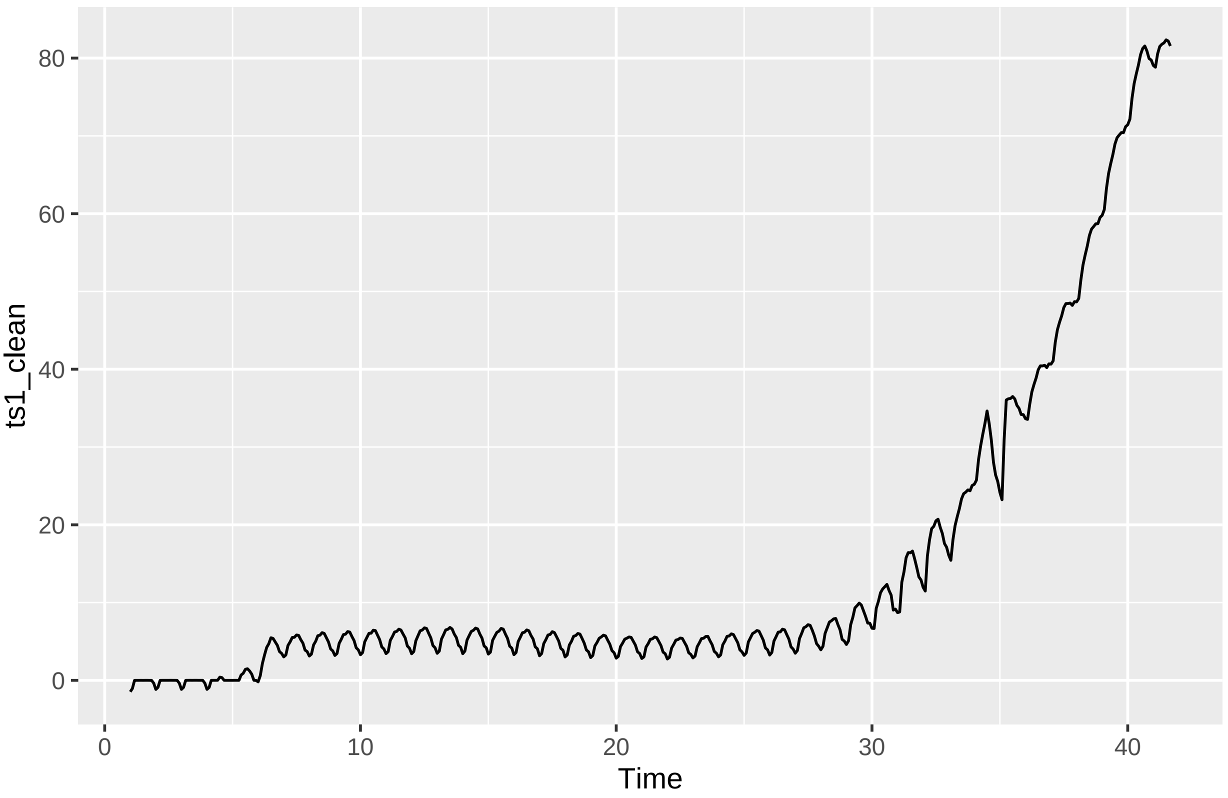
Identify and Remove outliers

Q8

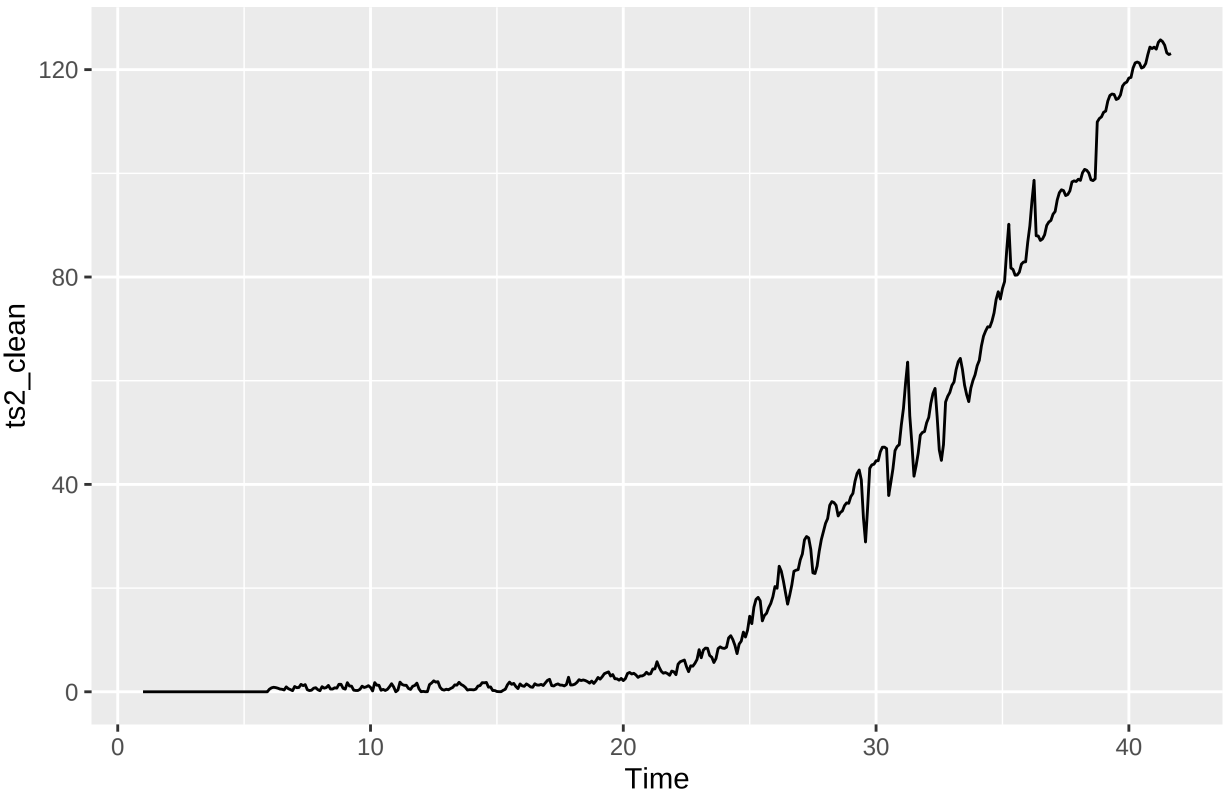
Apply the `tsclean()` to both series from Q7. Did the function removed any outliers from the series? Hint: Use `autoplot()` to check if there is difference between cleaned series and original series.

Answer: Yes, it seems like the outliers are removed from the series. Compared to the original plots, the cleaned ones are less fluctuating with fewer outliers.

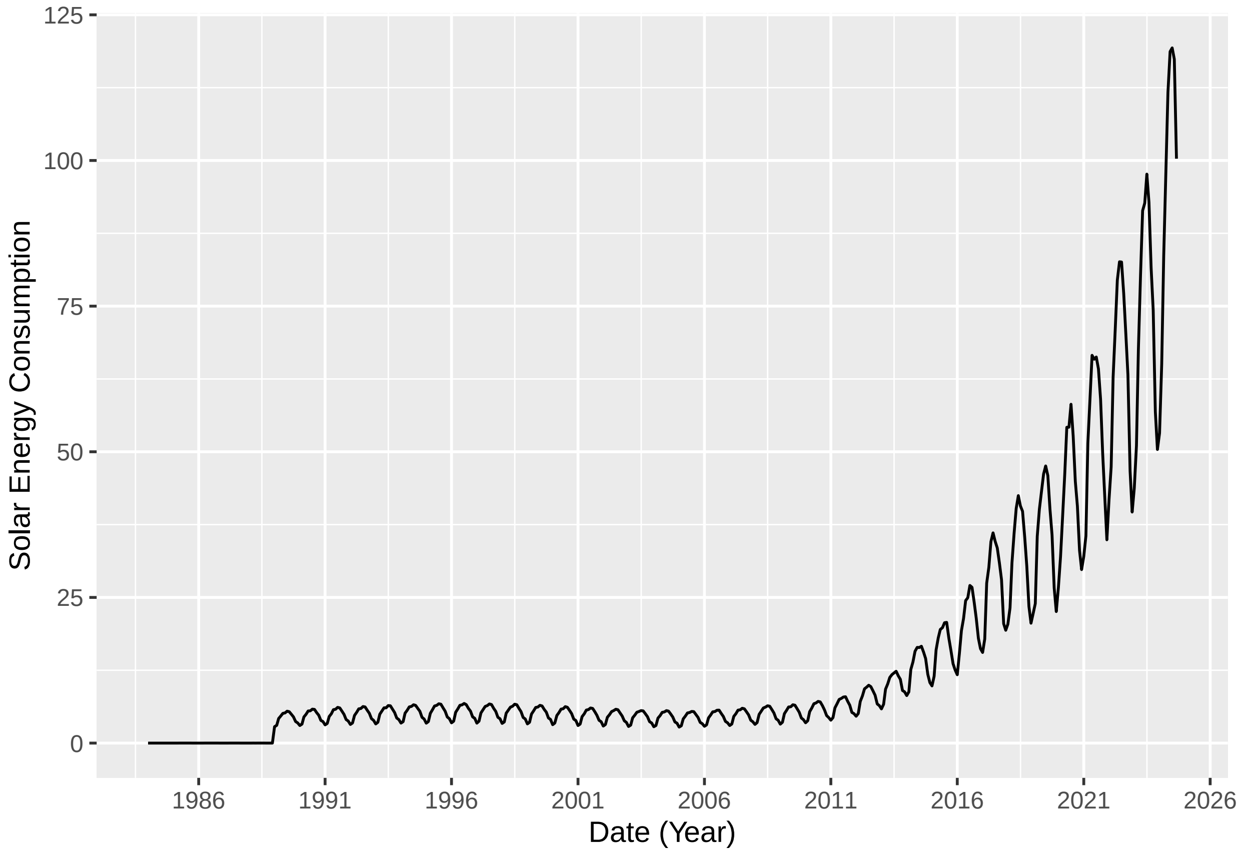
```
#1 Clean - Solar
ts1_clean<-tsclean(ts1_renewable_data2_filtered)

#2 Clean - Wind
ts2_clean <-tsclean(ts2_renewable_data2_filtered)

#Cleaned ver. autoplots
autoplot(ts1_clean)
```



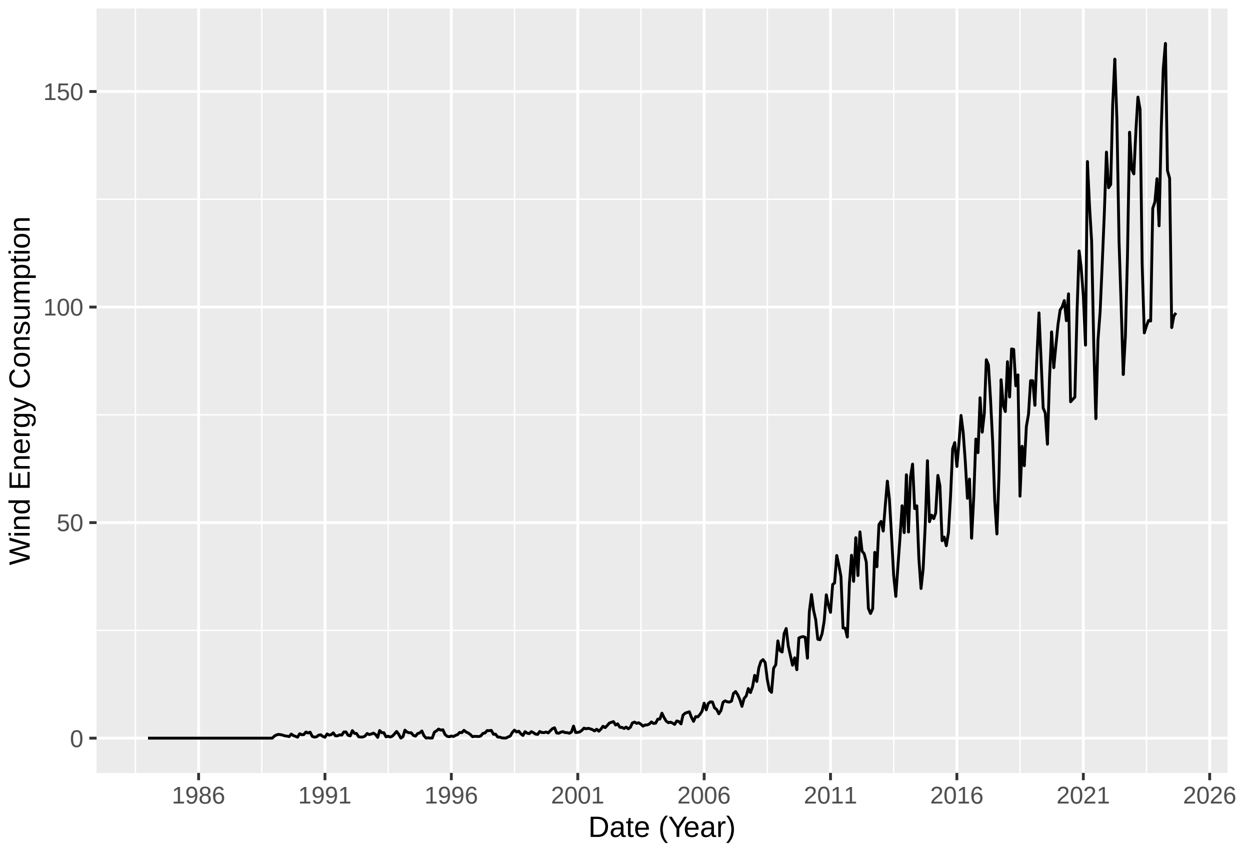
```r
autoplot(ts2_clean)
```



```
#Original plot
print(plot_ts1)
```



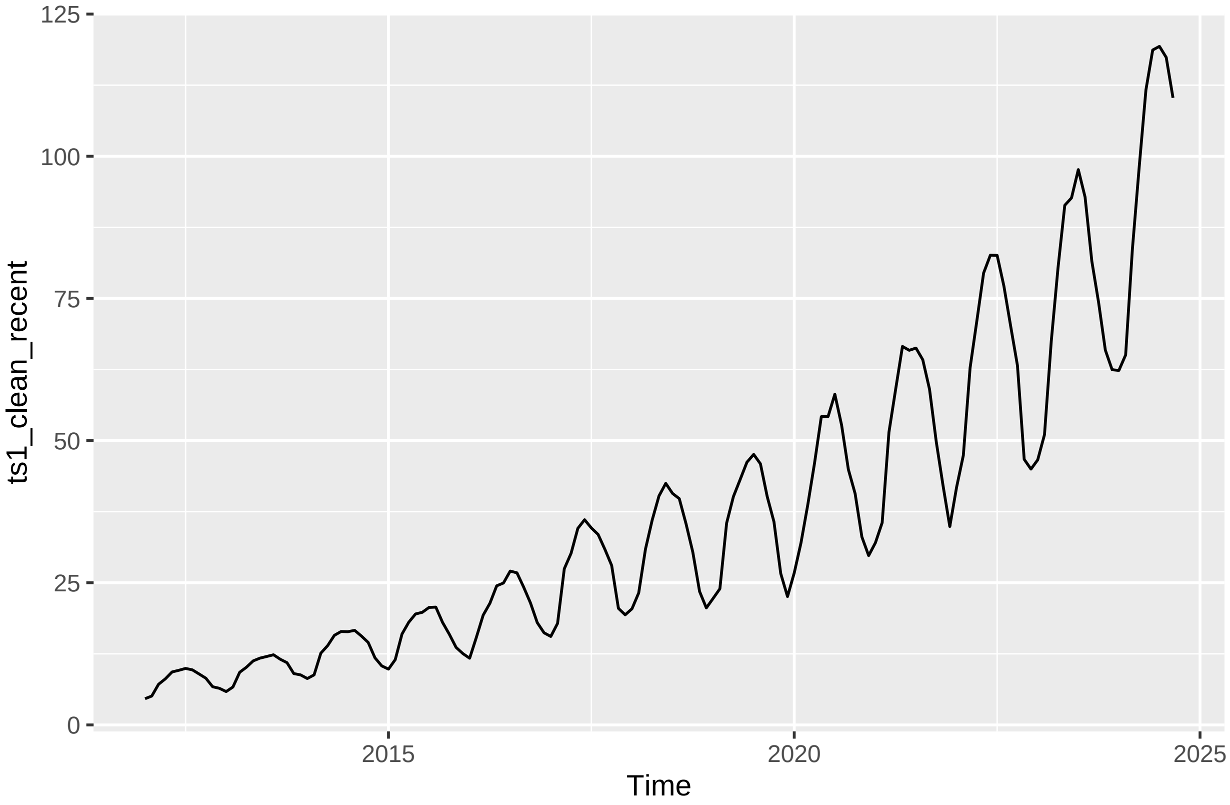
```r
print(plot_ts2)
```



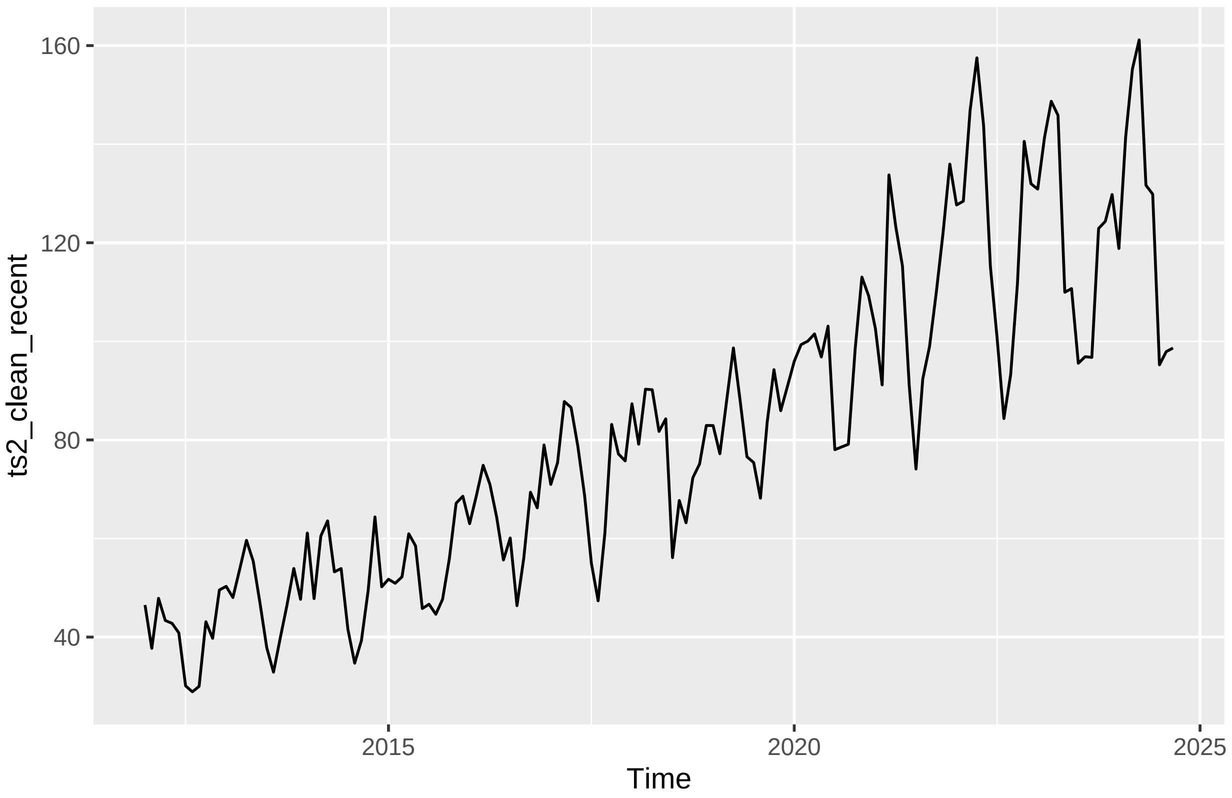
Q9

Redo number Q8 but now with the time series you created on Q7, i.e., the series starting in 2014. Using what `autoplot()` again what happened now?Did the function removed any outliers from the series?

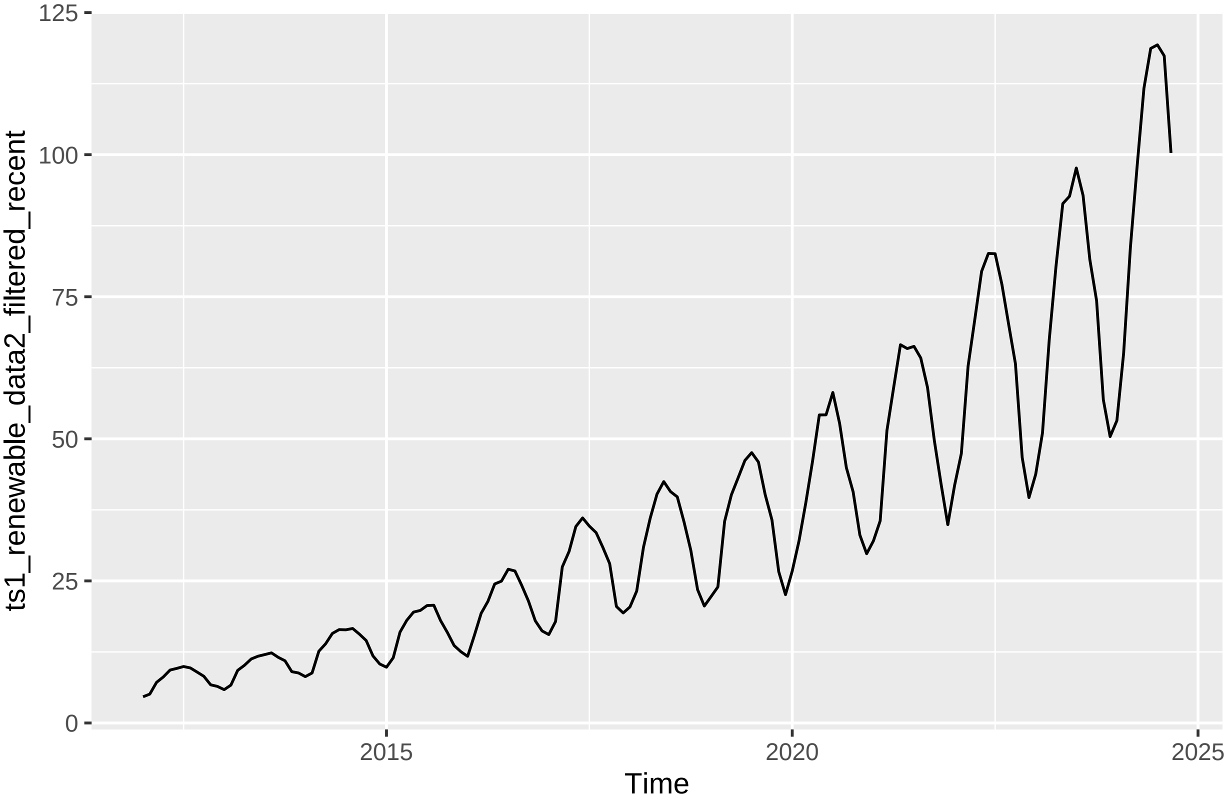
```
#1 Clean - Solar
ts1_clean_recent<-tsclean(ts1_renewable_data2_filtered_recent)

#2 Clean - Wind
ts2_clean_recent <-tsclean(ts2_renewable_data2_filtered_recent)

#Cleaned ver. autoplots
autoplot(ts1_clean_recent)
```



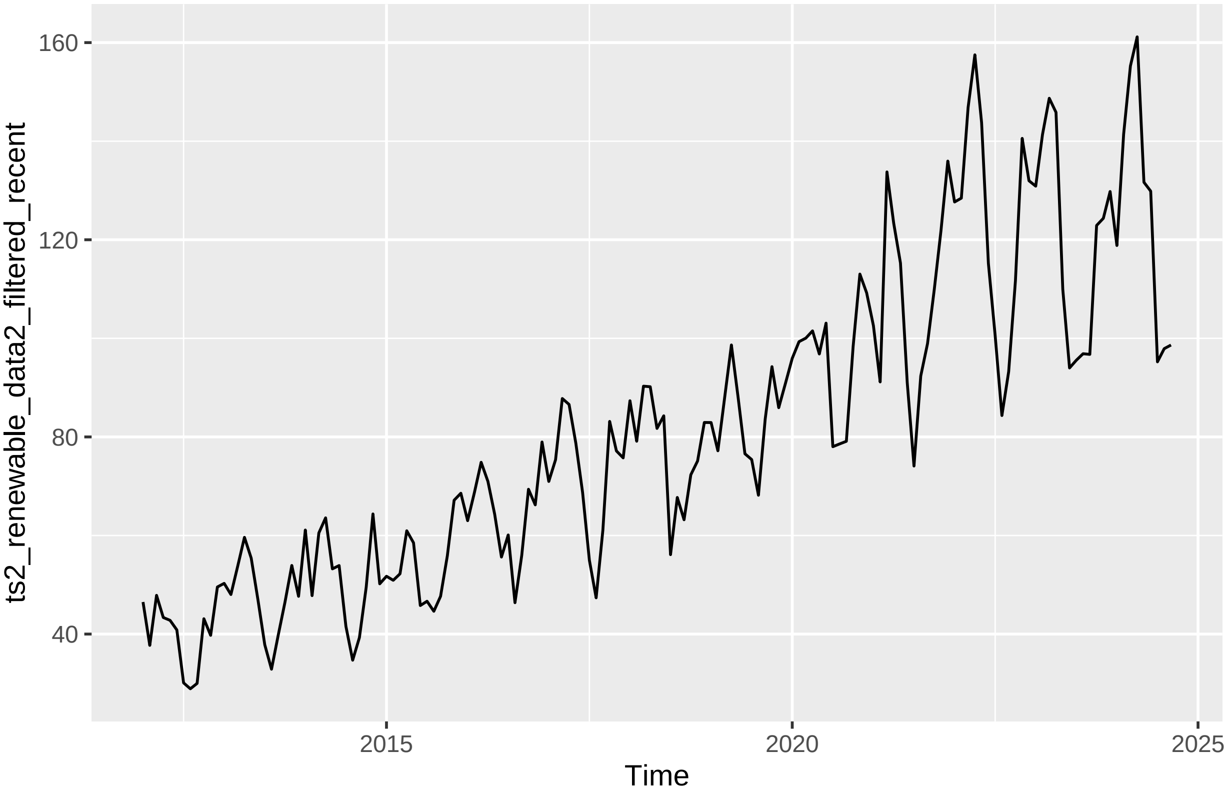
```r
autoplot(ts2_clean_recent)
```



```r
#Original autoplots
autoplot(ts1_renewable_data2_filtered_recent)
```



```
autoplot(ts2_renewable_data2_filtered_recent)
```



Answer: Answer: Similar to Q8, the plots with tsclean() function tend to have fewer outliers than the original plots. Compared to the original plots, the cleaned plots are less fluctuating with fewer outliers.