

ENV 790.30 - Time Series Analysis for Energy Data | Spring 2024

Assignment 2 - Due date 02/25/24

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Submission Instructions

You should open the .rmd file corresponding to this assignment on RStudio. The file is available on our class repository on Github.

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_A02_Sp24.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

R packages needed for this assignment: “forecast”, “tseries”, and “dplyr”. 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
```

```
# installing packages  
# install.packages("forecast")  
# install.packages("tseries")  
# install.packages("dplyr")  
# install.packages("lubridate")  
# install.packages("ggplot2")
```

```
# loading packages
```

```
library("forecast")
```

```
## Registered S3 method overwritten by 'quantmod':
```

```
##   method      from
```

```
##   as.zoo.data.frame zoo
```

```
library("tseries")
```

```
library("dplyr")
```

```
##
```

```
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
```

```
##
```

```
##   filter, lag
```

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

```
library("lubridate")
```

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

```
library("ggplot2")
```

Data set information

Consider the data provided in the spreadsheet “Table_10.1_Renewable_Energy_Production_and_Consumption_by_Source.x” on our **Data** folder. The data comes from the US Energy Information and Administration and corresponds to the December 2023 Monthly Energy Review. The spreadsheet is ready to be used. You will also find a .csv version of the data “Table_10.1_Renewable_Energy_Production_and_Consumption_by_Source-Edit.csv”. You may use the function `read.table()` to import the .csv data in R. Or refer to the file “M2_ImportingData_CSV_XLSX.Rmd” in our Lessons folder for functions that are better suited for importing the .xlsx.

```
#Importing data set
```

```
# checking working directory
getwd()
```

```
## [1] "/home/guest/ENV797_APJ_S24_NEW/Assignments/RMD"
```

```
# loading data using read.csv
# NOTE - R not letting me change my working directory to be my project folder, so
# I moved the file to Assignments > RMD (current wd) as a workaround
```

```
renewable_energy_full <- read.csv(
  file="Table_10.1_Renewable_Energy_Production_and_Consumption_by_Source.csv",
  header = TRUE, dec = ".", sep=",", stringsAsFactors = TRUE)
```

```
# converting Month column to date object using lubridate
renewable_energy_full$Month <- ym(renewable_energy_full$Month)
```

```
# renaming Month column to "Date"
colnames(renewable_energy_full)[colnames(renewable_energy_full) == "Month"] <- "Date"
```

Question 1

You will work only with the following columns: Total Biomass Energy Production, Total Renewable Energy Production, Hydroelectric Power Consumption. Create a data frame structure with these three time series only. Use the command `head()` to verify your data.

```
# creating subset of data with Total Biomass Energy Production,
# Total Renewable Energy Production, Hydroelectric Power Consumption by date
renewable_energy_sub <- renewable_energy_full %>%
  select(
    Date,
```

```

    Total.Biomass.Energy.Production,
    Total.Renewable.Energy.Production,
    Hydroelectric.Power.Consumption)

# Verifying data
head(renewable_energy_sub)

##           Date Total.Biomass.Energy.Production Total.Renewable.Energy.Production
## 1 1973-01-01                      129.787                      219.839
## 2 1973-02-01                      117.338                      197.330
## 3 1973-03-01                      129.938                      218.686
## 4 1973-04-01                      125.636                      209.330
## 5 1973-05-01                      129.834                      215.982
## 6 1973-06-01                      125.611                      208.249
## Hydroelectric.Power.Consumption
## 1                      89.562
## 2                      79.544
## 3                      88.284
## 4                      83.152
## 5                      85.643
## 6                      82.060

```

Question 2

Transform your data frame in a time series object and specify the starting point and frequency of the time series using the function `ts()`.

```

# transforming data into ts object
# start date is Jan 1, 1973
# frequency is 12 (monthly data)
renewable_energy_ts <- ts(renewable_energy_sub, start=c(1973,1), frequency=12)

renewable_energy_ts

```

```

##           Date Total.Biomass.Energy.Production
## Jan 1973    1096                      129.787
## Feb 1973    1127                      117.338
## Mar 1973    1155                      129.938
## Apr 1973    1186                      125.636
## May 1973    1216                      129.834
## Jun 1973    1247                      125.611
## Jul 1973    1277                      129.787
## Aug 1973    1308                      129.918
## Sep 1973    1339                      125.782
## Oct 1973    1369                      129.970
## Nov 1973    1400                      125.643
## Dec 1973    1430                      129.824
## Jan 1974    1461                      130.807
## Feb 1974    1492                      118.091
## Mar 1974    1520                      130.727
## Apr 1974    1551                      126.583
## May 1974    1581                      130.789
## Jun 1974    1612                      126.611
## Jul 1974    1642                      130.756
## Aug 1974    1673                      130.763

```

## Sep 1974	1704	126.637
## Oct 1974	1734	130.718
## Nov 1974	1765	126.506
## Dec 1974	1795	130.674
## Jan 1975	1826	127.269
## Feb 1975	1857	114.942
## Mar 1975	1885	127.251
## Apr 1975	1916	123.139
## May 1975	1946	127.303
## Jun 1975	1977	123.241
## Jul 1975	2007	127.288
## Aug 1975	2038	127.321
## Sep 1975	2069	123.210
## Oct 1975	2099	127.312
## Nov 1975	2130	123.180
## Dec 1975	2160	127.277
## Jan 1976	2191	145.049
## Feb 1976	2222	135.695
## Mar 1976	2251	145.051
## Apr 1976	2282	140.363
## May 1976	2312	145.047
## Jun 1976	2343	140.405
## Jul 1976	2373	145.088
## Aug 1976	2404	145.110
## Sep 1976	2435	140.436
## Oct 1976	2465	145.114
## Nov 1976	2496	140.651
## Dec 1976	2526	145.364
## Jan 1977	2557	156.220
## Feb 1977	2588	141.176
## Mar 1977	2616	156.217
## Apr 1977	2647	151.161
## May 1977	2677	156.186
## Jun 1977	2708	151.153
## Jul 1977	2738	155.920
## Aug 1977	2769	156.081
## Sep 1977	2800	151.110
## Oct 1977	2830	156.172
## Nov 1977	2861	151.000
## Dec 1977	2891	155.935
## Jan 1978	2922	173.128
## Feb 1978	2953	156.387
## Mar 1978	2981	173.136
## Apr 1978	3012	167.349
## May 1978	3042	172.923
## Jun 1978	3073	167.340
## Jul 1978	3103	172.912
## Aug 1978	3134	173.189
## Sep 1978	3165	167.455
## Oct 1978	3195	173.169
## Nov 1978	3226	167.557
## Dec 1978	3256	173.060
## Jan 1979	3287	182.600
## Feb 1979	3318	165.096

## Mar 1979	3346	182.881
## Apr 1979	3377	176.844
## May 1979	3407	182.782
## Jun 1979	3438	176.833
## Jul 1979	3468	182.700
## Aug 1979	3499	182.808
## Sep 1979	3530	176.891
## Oct 1979	3560	182.752
## Nov 1979	3591	176.949
## Dec 1979	3621	182.770
## Jan 1980	3652	209.829
## Feb 1980	3683	196.310
## Mar 1980	3712	209.727
## Apr 1980	3743	202.894
## May 1980	3773	209.548
## Jun 1980	3804	202.723
## Jul 1980	3834	209.554
## Aug 1980	3865	209.675
## Sep 1980	3896	202.905
## Oct 1980	3926	209.717
## Nov 1980	3957	202.945
## Dec 1980	3987	209.671
## Jan 1981	4018	220.544
## Feb 1981	4049	199.248
## Mar 1981	4077	220.595
## Apr 1981	4108	213.467
## May 1981	4138	220.433
## Jun 1981	4169	213.237
## Jul 1981	4199	220.392
## Aug 1981	4230	220.428
## Sep 1981	4261	213.480
## Oct 1981	4291	220.581
## Nov 1981	4322	213.437
## Dec 1981	4352	220.440
## Jan 1982	4383	226.251
## Feb 1982	4414	204.375
## Mar 1982	4442	226.157
## Apr 1982	4473	218.821
## May 1982	4503	226.135
## Jun 1982	4534	218.866
## Jul 1982	4564	226.202
## Aug 1982	4595	226.168
## Sep 1982	4626	218.947
## Oct 1982	4656	226.373
## Nov 1982	4687	218.948
## Dec 1982	4717	226.210
## Jan 1983	4748	246.575
## Feb 1983	4779	222.738
## Mar 1983	4807	246.610
## Apr 1983	4838	238.625
## May 1983	4868	246.647
## Jun 1983	4899	238.736
## Jul 1983	4929	246.651
## Aug 1983	4960	246.695

## Sep 1983	4991	238.755
## Oct 1983	5021	246.732
## Nov 1983	5052	238.780
## Dec 1983	5082	246.871
## Jan 1984	5113	251.483
## Feb 1984	5144	235.169
## Mar 1984	5173	251.529
## Apr 1984	5204	243.277
## May 1984	5234	251.408
## Jun 1984	5265	243.303
## Jul 1984	5295	251.632
## Aug 1984	5326	251.638
## Sep 1984	5357	243.596
## Oct 1984	5387	251.974
## Nov 1984	5418	244.068
## Dec 1984	5448	252.042
## Jan 1985	5479	256.315
## Feb 1985	5510	231.512
## Mar 1985	5538	256.336
## Apr 1985	5569	247.599
## May 1985	5599	255.881
## Jun 1985	5630	247.643
## Jul 1985	5660	256.159
## Aug 1985	5691	256.301
## Sep 1985	5722	247.997
## Oct 1985	5752	256.175
## Nov 1985	5783	248.070
## Dec 1985	5813	256.246
## Jan 1986	5844	249.178
## Feb 1986	5875	224.922
## Mar 1986	5903	248.837
## Apr 1986	5934	240.788
## May 1986	5964	248.822
## Jun 1986	5995	240.837
## Jul 1986	6025	249.011
## Aug 1986	6056	249.176
## Sep 1986	6087	241.074
## Oct 1986	6117	248.974
## Nov 1986	6148	241.122
## Dec 1986	6178	249.352
## Jan 1987	6209	244.137
## Feb 1987	6240	220.511
## Mar 1987	6268	244.157
## Apr 1987	6299	236.139
## May 1987	6329	244.007
## Jun 1987	6360	236.522
## Jul 1987	6390	244.359
## Aug 1987	6421	244.396
## Sep 1987	6452	236.298
## Oct 1987	6482	244.059
## Nov 1987	6513	236.197
## Dec 1987	6543	244.104
## Jan 1988	6574	255.331
## Feb 1988	6605	238.853

## Mar 1988	6634	255.385
## Apr 1988	6665	247.241
## May 1988	6695	255.188
## Jun 1988	6726	247.340
## Jul 1988	6756	255.582
## Aug 1988	6787	255.815
## Sep 1988	6818	247.357
## Oct 1988	6848	255.517
## Nov 1988	6879	247.096
## Dec 1988	6909	255.345
## Jan 1989	6940	266.572
## Feb 1989	6971	243.927
## Mar 1989	6999	268.315
## Apr 1989	7030	251.946
## May 1989	7060	241.235
## Jun 1989	7091	248.447
## Jul 1989	7121	261.318
## Aug 1989	7152	276.985
## Sep 1989	7183	264.811
## Oct 1989	7213	276.462
## Nov 1989	7244	276.819
## Dec 1989	7274	282.520
## Jan 1990	7305	236.692
## Feb 1990	7336	226.266
## Mar 1990	7364	244.248
## Apr 1990	7395	232.640
## May 1990	7425	210.108
## Jun 1990	7456	178.544
## Jul 1990	7486	219.713
## Aug 1990	7517	245.632
## Sep 1990	7548	239.932
## Oct 1990	7578	235.437
## Nov 1990	7609	220.256
## Dec 1990	7639	245.644
## Jan 1991	7670	269.531
## Feb 1991	7701	204.535
## Mar 1991	7729	214.374
## Apr 1991	7760	190.452
## May 1991	7790	206.579
## Jun 1991	7821	209.721
## Jul 1991	7851	210.055
## Aug 1991	7882	250.834
## Sep 1991	7913	267.735
## Oct 1991	7943	249.408
## Nov 1991	7974	241.541
## Dec 1991	8004	267.033
## Jan 1992	8035	279.197
## Feb 1992	8066	230.468
## Mar 1992	8095	221.177
## Apr 1992	8126	210.172
## May 1992	8156	190.537
## Jun 1992	8187	230.985
## Jul 1992	8217	250.150
## Aug 1992	8248	269.662

## Sep 1992	8279	251.511
## Oct 1992	8309	269.545
## Nov 1992	8340	264.383
## Dec 1992	8370	263.891
## Jan 1993	8401	274.257
## Feb 1993	8432	240.964
## Mar 1993	8460	263.204
## Apr 1993	8491	226.859
## May 1993	8521	196.012
## Jun 1993	8552	197.445
## Jul 1993	8582	212.707
## Aug 1993	8613	262.322
## Sep 1993	8644	250.551
## Oct 1993	8674	257.383
## Nov 1993	8705	262.183
## Dec 1993	8735	264.559
## Jan 1994	8766	306.708
## Feb 1994	8797	244.594
## Mar 1994	8825	261.461
## Apr 1994	8856	236.035
## May 1994	8886	202.480
## Jun 1994	8917	215.744
## Jul 1994	8947	274.451
## Aug 1994	8978	251.577
## Sep 1994	9009	238.967
## Oct 1994	9039	271.599
## Nov 1994	9070	261.436
## Dec 1994	9100	262.482
## Jan 1995	9131	243.462
## Feb 1995	9162	206.657
## Mar 1995	9190	239.820
## Apr 1995	9221	267.571
## May 1995	9251	227.439
## Jun 1995	9282	226.934
## Jul 1995	9312	294.251
## Aug 1995	9343	301.628
## Sep 1995	9374	268.791
## Oct 1995	9404	292.175
## Nov 1995	9435	267.659
## Dec 1995	9465	262.694
## Jan 1996	9496	272.584
## Feb 1996	9527	226.038
## Mar 1996	9556	259.039
## Apr 1996	9587	205.729
## May 1996	9617	231.211
## Jun 1996	9648	254.182
## Jul 1996	9678	281.656
## Aug 1996	9709	294.581
## Sep 1996	9740	259.345
## Oct 1996	9770	310.461
## Nov 1996	9801	295.562
## Dec 1996	9831	264.912
## Jan 1997	9862	275.641
## Feb 1997	9893	226.521

## Mar 1997	9921	251.136
## Apr 1997	9952	252.010
## May 1997	9982	268.515
## Jun 1997	10013	231.690
## Jul 1997	10043	259.985
## Aug 1997	10074	264.422
## Sep 1997	10105	250.744
## Oct 1997	10135	305.656
## Nov 1997	10166	264.591
## Dec 1997	10196	256.998
## Jan 1998	10227	278.211
## Feb 1998	10258	212.209
## Mar 1998	10286	240.963
## Apr 1998	10317	240.612
## May 1998	10347	250.239
## Jun 1998	10378	186.089
## Jul 1998	10408	246.326
## Aug 1998	10439	254.237
## Sep 1998	10470	248.270
## Oct 1998	10500	267.922
## Nov 1998	10531	230.488
## Dec 1998	10561	273.362
## Jan 1999	10592	272.260
## Feb 1999	10623	220.539
## Mar 1999	10651	212.177
## Apr 1999	10682	249.920
## May 1999	10712	289.264
## Jun 1999	10743	236.090
## Jul 1999	10773	264.292
## Aug 1999	10804	258.854
## Sep 1999	10835	244.140
## Oct 1999	10865	228.256
## Nov 1999	10896	254.125
## Dec 1999	10926	235.215
## Jan 2000	10957	222.067
## Feb 2000	10988	246.169
## Mar 2000	11017	263.209
## Apr 2000	11048	254.609
## May 2000	11078	254.678
## Jun 2000	11109	227.712
## Jul 2000	11139	255.348
## Aug 2000	11170	254.942
## Sep 2000	11201	240.331
## Oct 2000	11231	270.472
## Nov 2000	11262	261.335
## Dec 2000	11292	254.788
## Jan 2001	11323	228.434
## Feb 2001	11354	202.849
## Mar 2001	11382	219.649
## Apr 2001	11413	213.628
## May 2001	11443	211.506
## Jun 2001	11474	213.950
## Jul 2001	11504	221.842
## Aug 2001	11535	225.897

## Sep 2001	11566	214.229
## Oct 2001	11596	227.319
## Nov 2001	11627	219.773
## Dec 2001	11657	225.088
## Jan 2002	11688	228.396
## Feb 2002	11719	198.932
## Mar 2002	11747	217.568
## Apr 2002	11778	212.852
## May 2002	11808	225.155
## Jun 2002	11839	215.107
## Jul 2002	11869	235.713
## Aug 2002	11900	224.400
## Sep 2002	11931	230.855
## Oct 2002	11961	243.767
## Nov 2002	11992	230.328
## Dec 2002	12022	242.334
## Jan 2003	12053	237.044
## Feb 2003	12084	212.693
## Mar 2003	12112	233.288
## Apr 2003	12143	228.516
## May 2003	12173	229.756
## Jun 2003	12204	228.254
## Jul 2003	12234	242.533
## Aug 2003	12265	239.928
## Sep 2003	12296	230.968
## Oct 2003	12326	236.938
## Nov 2003	12357	233.698
## Dec 2003	12387	251.160
## Jan 2004	12418	255.574
## Feb 2004	12449	236.689
## Mar 2004	12478	248.532
## Apr 2004	12509	247.253
## May 2004	12539	244.383
## Jun 2004	12570	244.075
## Jul 2004	12600	257.042
## Aug 2004	12631	254.446
## Sep 2004	12662	243.019
## Oct 2004	12692	253.520
## Nov 2004	12723	247.286
## Dec 2004	12753	264.199
## Jan 2005	12784	264.707
## Feb 2005	12815	247.271
## Mar 2005	12843	260.043
## Apr 2005	12874	246.929
## May 2005	12904	255.790
## Jun 2005	12935	252.466
## Jul 2005	12965	266.332
## Aug 2005	12996	266.097
## Sep 2005	13027	255.348
## Oct 2005	13057	261.121
## Nov 2005	13088	256.532
## Dec 2005	13118	268.550
## Jan 2006	13149	276.647
## Feb 2006	13180	247.274

## Mar 2006	13208	265.069
## Apr 2006	13239	250.384
## May 2006	13269	261.125
## Jun 2006	13300	261.960
## Jul 2006	13330	274.809
## Aug 2006	13361	277.063
## Sep 2006	13392	267.952
## Oct 2006	13422	275.120
## Nov 2006	13453	270.475
## Dec 2006	13483	283.636
## Jan 2007	13514	290.845
## Feb 2007	13545	261.666
## Mar 2007	13573	285.146
## Apr 2007	13604	278.386
## May 2007	13634	286.010
## Jun 2007	13665	281.995
## Jul 2007	13695	295.653
## Aug 2007	13726	295.523
## Sep 2007	13757	287.603
## Oct 2007	13787	299.416
## Nov 2007	13818	297.828
## Dec 2007	13848	312.007
## Jan 2008	13879	331.138
## Feb 2008	13910	300.535
## Mar 2008	13939	321.487
## Apr 2008	13970	314.073
## May 2008	14000	324.185
## Jun 2008	14031	313.335
## Jul 2008	14061	330.507
## Aug 2008	14092	333.607
## Sep 2008	14123	318.840
## Oct 2008	14153	330.125
## Nov 2008	14184	327.317
## Dec 2008	14214	323.102
## Jan 2009	14245	318.353
## Feb 2009	14276	294.389
## Mar 2009	14304	319.356
## Apr 2009	14335	303.489
## May 2009	14365	319.032
## Jun 2009	14396	321.739
## Jul 2009	14426	343.841
## Aug 2009	14457	348.551
## Sep 2009	14488	332.374
## Oct 2009	14518	346.472
## Nov 2009	14549	348.333
## Dec 2009	14579	360.689
## Jan 2010	14610	377.071
## Feb 2010	14641	347.952
## Mar 2010	14669	384.094
## Apr 2010	14700	368.922
## May 2010	14730	376.012
## Jun 2010	14761	372.328
## Jul 2010	14791	385.443
## Aug 2010	14822	389.064

## Sep 2010	14853	377.355
## Oct 2010	14883	386.771
## Nov 2010	14914	386.602
## Dec 2010	14944	400.917
## Jan 2011	14975	400.710
## Feb 2011	15006	359.327
## Mar 2011	15034	394.959
## Apr 2011	15065	373.481
## May 2011	15095	385.273
## Jun 2011	15126	389.673
## Jul 2011	15156	399.454
## Aug 2011	15187	402.931
## Sep 2011	15218	387.218
## Oct 2011	15248	397.994
## Nov 2011	15279	400.892
## Dec 2011	15309	420.525
## Jan 2012	15340	399.385
## Feb 2012	15371	373.028
## Mar 2012	15400	388.074
## Apr 2012	15431	368.981
## May 2012	15461	387.318
## Jun 2012	15492	377.792
## Jul 2012	15522	379.862
## Aug 2012	15553	386.269
## Sep 2012	15584	366.955
## Oct 2012	15614	373.976
## Nov 2012	15645	368.902
## Dec 2012	15675	383.017
## Jan 2013	15706	391.713
## Feb 2013	15737	354.251
## Mar 2013	15765	397.835
## Apr 2013	15796	386.469
## May 2013	15826	404.782
## Jun 2013	15857	401.893
## Jul 2013	15887	419.452
## Aug 2013	15918	413.684
## Sep 2013	15949	395.313
## Oct 2013	15979	417.493
## Nov 2013	16010	415.796
## Dec 2013	16040	436.115
## Jan 2014	16071	421.219
## Feb 2014	16102	382.387
## Mar 2014	16130	423.831
## Apr 2014	16161	409.123
## May 2014	16191	420.280
## Jun 2014	16222	422.985
## Jul 2014	16252	437.716
## Aug 2014	16283	431.265
## Sep 2014	16314	411.320
## Oct 2014	16344	424.919
## Nov 2014	16375	420.082
## Dec 2014	16405	446.975
## Jan 2015	16436	427.054
## Feb 2015	16467	385.885

## Mar 2015	16495	418.601
## Apr 2015	16526	404.645
## May 2015	16556	422.303
## Jun 2015	16587	419.763
## Jul 2015	16617	435.439
## Aug 2015	16648	432.205
## Sep 2015	16679	410.191
## Oct 2015	16709	418.690
## Nov 2015	16740	419.255
## Dec 2015	16770	437.317
## Jan 2016	16801	427.949
## Feb 2016	16832	406.692
## Mar 2016	16861	429.456
## Apr 2016	16892	400.491
## May 2016	16922	424.186
## Jun 2016	16953	425.120
## Jul 2016	16983	434.897
## Aug 2016	17014	442.383
## Sep 2016	17045	417.250
## Oct 2016	17075	425.218
## Nov 2016	17106	428.755
## Dec 2016	17136	469.360
## Jan 2017	17167	440.361
## Feb 2017	17198	397.221
## Mar 2017	17226	438.279
## Apr 2017	17257	408.991
## May 2017	17287	427.713
## Jun 2017	17318	424.376
## Jul 2017	17348	435.876
## Aug 2017	17379	446.874
## Sep 2017	17410	417.527
## Oct 2017	17440	434.336
## Nov 2017	17471	439.367
## Dec 2017	17501	454.794
## Jan 2018	17532	449.901
## Feb 2018	17563	413.516
## Mar 2018	17591	449.807
## Apr 2018	17622	425.820
## May 2018	17652	445.435
## Jun 2018	17683	438.894
## Jul 2018	17713	456.125
## Aug 2018	17744	459.996
## Sep 2018	17775	427.721
## Oct 2018	17805	449.554
## Nov 2018	17836	440.785
## Dec 2018	17866	456.593
## Jan 2019	17897	445.618
## Feb 2019	17928	405.314
## Mar 2019	17956	434.186
## Apr 2019	17987	423.416
## May 2019	18017	440.470
## Jun 2019	18048	433.492
## Jul 2019	18078	449.754
## Aug 2019	18109	447.086

##	Sep	2019	18140	416.911	
##	Oct	2019	18170	432.540	
##	Nov	2019	18201	431.235	
##	Dec	2019	18231	454.980	
##	Jan	2020	18262	433.538	
##	Feb	2020	18293	404.020	
##	Mar	2020	18322	411.929	
##	Apr	2020	18353	324.772	
##	May	2020	18383	355.693	
##	Jun	2020	18414	375.486	
##	Jul	2020	18444	396.389	
##	Aug	2020	18475	398.732	
##	Sep	2020	18506	386.923	
##	Oct	2020	18536	399.780	
##	Nov	2020	18567	403.366	
##	Dec	2020	18597	419.147	
##	Jan	2021	18628	409.000	
##	Feb	2021	18659	348.243	
##	Mar	2021	18687	410.780	
##	Apr	2021	18718	393.027	
##	May	2021	18748	418.210	
##	Jun	2021	18779	410.360	
##	Jul	2021	18809	425.507	
##	Aug	2021	18840	412.988	
##	Sep	2021	18871	394.918	
##	Oct	2021	18901	422.097	
##	Nov	2021	18932	423.575	
##	Dec	2021	18962	444.912	
##	Jan	2022	18993	435.124	
##	Feb	2022	19024	394.151	
##	Mar	2022	19052	430.403	
##	Apr	2022	19083	405.815	
##	May	2022	19113	429.947	
##	Jun	2022	19144	429.508	
##	Jul	2022	19174	436.315	
##	Aug	2022	19205	428.868	
##	Sep	2022	19236	401.522	
##	Oct	2022	19266	425.435	
##	Nov	2022	19297	427.493	
##	Dec	2022	19327	428.630	
##	Jan	2023	19358	436.916	
##	Feb	2023	19389	392.661	
##	Mar	2023	19417	436.299	
##	Apr	2023	19448	404.131	
##	May	2023	19478	437.506	
##	Jun	2023	19509	429.839	
##	Jul	2023	19539	437.109	
##	Aug	2023	19570	439.521	
##	Sep	2023	19601	422.351	
##	Total.Renewable.Energy.Production Hydroelectric.Power.Consumption				
##	Jan	1973	219.839	89.562	
##	Feb	1973	197.330	79.544	
##	Mar	1973	218.686	88.284	
##	Apr	1973	209.330	83.152	

## May 1973	215.982	85.643
## Jun 1973	208.249	82.060
## Jul 1973	207.800	77.400
## Aug 1973	203.432	72.936
## Sep 1973	185.300	59.029
## Oct 1973	193.514	62.967
## Nov 1973	195.326	69.063
## Dec 1973	220.755	90.131
## Jan 1974	231.010	99.500
## Feb 1974	210.188	91.476
## Mar 1974	226.384	94.950
## Apr 1974	223.218	95.969
## May 1974	227.793	96.337
## Jun 1974	218.976	91.719
## Jul 1974	221.909	90.437
## Aug 1974	214.197	82.727
## Sep 1974	200.900	73.610
## Oct 1974	200.312	68.931
## Nov 1974	200.068	72.773
## Dec 1974	211.046	79.542
## Jan 1975	214.319	86.356
## Feb 1975	198.008	82.404
## Mar 1975	224.384	96.386
## Apr 1975	215.679	91.791
## May 1975	223.695	95.581
## Jun 1975	217.798	93.550
## Jul 1975	216.202	87.900
## Aug 1975	206.312	77.892
## Sep 1975	194.934	70.756
## Oct 1975	206.489	78.060
## Nov 1975	208.436	84.171
## Dec 1975	217.911	89.510
## Jan 1976	236.073	89.904
## Feb 1976	221.374	84.626
## Mar 1976	237.807	91.629
## Apr 1976	224.756	83.378
## May 1976	234.082	88.065
## Jun 1976	229.595	88.182
## Jul 1976	235.984	89.807
## Aug 1976	228.336	82.153
## Sep 1976	211.665	70.186
## Oct 1976	218.818	72.690
## Nov 1976	209.968	68.463
## Dec 1976	216.239	69.900
## Jan 1977	228.907	71.630
## Feb 1977	194.523	52.424
## Mar 1977	225.781	68.518
## Apr 1977	216.602	64.508
## May 1977	221.823	64.629
## Jun 1977	211.752	59.609
## Jul 1977	215.097	58.130
## Aug 1977	214.871	57.830
## Sep 1977	208.974	56.835
## Oct 1977	216.727	59.480

## Nov 1977	222.663	70.583
## Dec 1977	235.754	78.744
## Jan 1978	260.677	86.454
## Feb 1978	233.933	76.606
## Mar 1978	258.863	84.951
## Apr 1978	255.285	87.281
## May 1978	272.691	99.185
## Jun 1978	254.703	86.645
## Jul 1978	258.056	84.339
## Aug 1978	250.652	76.518
## Sep 1978	241.494	73.042
## Oct 1978	241.095	67.184
## Nov 1978	237.214	68.818
## Dec 1978	250.285	76.162
## Jan 1979	270.000	86.378
## Feb 1979	239.377	73.446
## Mar 1979	273.485	89.483
## Apr 1979	265.526	87.645
## May 1979	283.727	99.903
## Jun 1979	264.118	86.230
## Jul 1979	262.394	78.573
## Aug 1979	257.423	73.393
## Sep 1979	243.468	65.516
## Oct 1979	253.559	69.619
## Nov 1979	255.317	77.213
## Dec 1979	262.637	78.457
## Jan 1980	298.221	87.244
## Feb 1980	271.194	73.781
## Mar 1980	294.931	83.978
## Apr 1980	293.043	88.865
## May 1980	310.682	99.622
## Jun 1980	299.633	95.451
## Jul 1980	295.537	84.448
## Aug 1980	281.831	70.517
## Sep 1980	268.204	63.819
## Oct 1980	273.058	61.661
## Nov 1980	270.913	66.325
## Dec 1980	288.131	76.858
## Jan 1981	299.483	77.214
## Feb 1981	273.604	72.830
## Mar 1981	293.454	71.150
## Apr 1981	286.764	71.718
## May 1981	305.297	83.301
## Jun 1981	305.860	91.061
## Jul 1981	308.821	86.714
## Aug 1981	296.678	74.556
## Sep 1981	276.720	61.534
## Oct 1981	284.684	62.420
## Nov 1981	280.364	65.459
## Dec 1981	304.193	82.279
## Jan 1982	320.311	92.763
## Feb 1982	297.475	91.907
## Mar 1982	330.131	102.924
## Apr 1982	316.183	96.303

## May 1982	323.939	96.572
## Jun 1982	316.816	96.463
## Jul 1982	321.854	94.087
## Aug 1982	310.059	82.333
## Sep 1982	289.054	68.612
## Oct 1982	296.056	68.091
## Nov 1982	300.864	80.245
## Dec 1982	323.054	95.522
## Jan 1983	348.969	100.743
## Feb 1983	320.213	96.206
## Mar 1983	352.422	104.348
## Apr 1983	343.331	103.334
## May 1983	355.330	107.568
## Jun 1983	346.012	105.810
## Jul 1983	345.359	96.883
## Aug 1983	338.025	88.929
## Sep 1983	315.758	74.808
## Oct 1983	320.524	71.491
## Nov 1983	325.785	84.956
## Dec 1983	357.437	108.936
## Jan 1984	355.607	102.459
## Feb 1984	333.238	96.034
## Mar 1984	358.566	104.801
## Apr 1984	348.756	103.270
## May 1984	363.212	109.683
## Jun 1984	344.623	99.261
## Jul 1984	348.366	94.772
## Aug 1984	340.669	86.573
## Sep 1984	317.887	72.076
## Oct 1984	326.373	71.968
## Nov 1984	323.172	76.704
## Dec 1984	343.652	88.949
## Jan 1985	353.933	94.973
## Feb 1985	323.067	89.219
## Mar 1985	344.083	85.029
## Apr 1985	334.259	84.276
## May 1985	349.644	91.284
## Jun 1985	332.457	82.425
## Jul 1985	332.393	73.612
## Aug 1985	328.026	68.980
## Sep 1985	315.367	64.761
## Oct 1985	327.776	69.105
## Nov 1985	330.222	79.075
## Dec 1985	346.947	87.328
## Jan 1986	326.552	73.934
## Feb 1986	307.952	80.075
## Mar 1986	349.995	98.081
## Apr 1986	338.487	94.922
## May 1986	345.587	93.958
## Jun 1986	334.442	90.562
## Jul 1986	335.334	83.094
## Aug 1986	325.501	73.104
## Sep 1986	316.539	72.767
## Oct 1986	325.125	73.498

## Nov 1986	323.172	79.755
## Dec 1986	341.787	89.397
## Jan 1987	334.890	87.702
## Feb 1987	296.606	73.264
## Mar 1987	327.541	80.279
## Apr 1987	315.231	76.163
## May 1987	330.797	83.712
## Jun 1987	311.957	72.271
## Jul 1987	317.495	69.864
## Aug 1987	311.395	63.744
## Sep 1987	302.090	62.756
## Oct 1987	309.095	61.964
## Nov 1987	297.439	58.272
## Dec 1987	319.908	72.753
## Jan 1988	334.583	76.171
## Feb 1988	307.533	66.029
## Mar 1988	326.015	67.539
## Apr 1988	316.232	66.195
## May 1988	331.539	73.601
## Jun 1988	315.603	65.346
## Jul 1988	317.391	58.636
## Aug 1988	315.766	56.923
## Sep 1988	306.500	56.241
## Oct 1988	310.737	52.265
## Nov 1988	313.792	63.762
## Dec 1988	326.992	68.748
## Jan 1989	348.321	73.277
## Feb 1989	317.572	65.188
## Mar 1989	358.115	79.268
## Apr 1989	346.511	84.295
## May 1989	350.304	98.200
## Jun 1989	349.753	90.614
## Jul 1989	351.720	79.373
## Aug 1989	358.320	70.675
## Sep 1989	341.553	66.237
## Oct 1989	356.682	70.285
## Nov 1989	359.731	74.172
## Dec 1989	367.555	76.402
## Jan 1990	329.327	83.078
## Feb 1990	321.465	86.122
## Mar 1990	353.956	98.841
## Apr 1990	334.136	90.589
## May 1990	317.791	95.753
## Jun 1990	289.276	98.444
## Jul 1990	315.872	84.490
## Aug 1990	332.580	75.559
## Sep 1990	311.965	61.422
## Oct 1990	312.873	66.657
## Nov 1990	301.883	71.863
## Dec 1990	341.584	86.440
## Jan 1991	370.278	91.732
## Feb 1991	292.511	78.638
## Mar 1991	317.683	92.384
## Apr 1991	293.309	91.874

## May 1991	320.120	101.296
## Jun 1991	313.437	91.854
## Jul 1991	309.257	86.984
## Aug 1991	340.813	77.658
## Sep 1991	345.122	65.997
## Oct 1991	324.454	63.197
## Nov 1991	318.757	66.085
## Dec 1991	355.690	78.349
## Jan 1992	366.577	77.844
## Feb 1992	305.537	64.670
## Mar 1992	311.299	78.408
## Apr 1992	292.073	70.180
## May 1992	282.361	79.980
## Jun 1992	323.546	80.819
## Jul 1992	333.005	70.671
## Aug 1992	347.510	65.474
## Sep 1992	324.027	60.474
## Oct 1992	340.565	59.474
## Nov 1992	345.048	69.964
## Dec 1992	360.200	85.579
## Jan 1993	373.255	88.873
## Feb 1993	322.185	71.730
## Mar 1993	359.855	83.868
## Apr 1993	330.605	90.980
## May 1993	313.546	104.743
## Jun 1993	304.450	95.182
## Jul 1993	309.916	84.360
## Aug 1993	346.577	71.587
## Sep 1993	324.882	62.245
## Oct 1993	331.480	62.087
## Nov 1993	338.485	64.729
## Dec 1993	352.074	76.662
## Jan 1994	388.854	72.773
## Feb 1994	323.751	69.738
## Mar 1994	354.509	80.508
## Apr 1994	332.955	84.264
## May 1994	303.865	88.353
## Jun 1994	313.708	85.343
## Jul 1994	366.741	79.712
## Aug 1994	333.540	69.257
## Sep 1994	307.933	56.561
## Oct 1994	343.569	59.757
## Nov 1994	338.304	65.325
## Dec 1994	348.732	75.959
## Jan 1995	336.872	84.852
## Feb 1995	299.810	85.447
## Mar 1995	346.752	97.479
## Apr 1995	361.046	83.847
## May 1995	333.643	94.791
## Jun 1995	342.092	103.128
## Jul 1995	400.977	93.729
## Aug 1995	399.583	83.175
## Sep 1995	349.815	68.333
## Oct 1995	384.663	78.993

## Nov 1995	366.200	87.148
## Dec 1995	373.129	99.640
## Jan 1996	385.971	104.821
## Feb 1996	343.243	108.488
## Mar 1996	385.026	115.603
## Apr 1996	325.915	108.647
## May 1996	356.221	113.485
## Jun 1996	375.816	108.928
## Jul 1996	395.278	98.519
## Aug 1996	398.870	89.620
## Sep 1996	347.920	75.536
## Oct 1996	400.155	77.094
## Nov 1996	387.043	80.374
## Dec 1996	378.537	103.400
## Jan 1997	397.124	112.458
## Feb 1997	342.279	107.528
## Mar 1997	381.623	119.397
## Apr 1997	374.093	109.441
## May 1997	398.347	116.635
## Jun 1997	362.325	117.564
## Jul 1997	382.540	108.011
## Aug 1997	370.673	91.802
## Sep 1997	343.197	79.836
## Oct 1997	402.188	84.394
## Nov 1997	355.868	80.900
## Dec 1997	355.807	88.252
## Jan 1998	386.269	98.328
## Feb 1998	323.378	102.347
## Mar 1998	360.492	108.119
## Apr 1998	348.763	97.610
## May 1998	374.487	113.264
## Jun 1998	309.019	110.348
## Jul 1998	358.537	97.785
## Aug 1998	354.150	85.678
## Sep 1998	332.989	71.060
## Oct 1998	345.379	64.434
## Nov 1998	309.809	68.310
## Dec 1998	370.867	85.937
## Jan 1999	383.582	100.724
## Feb 1999	328.183	97.902
## Mar 1999	334.062	109.456
## Apr 1999	355.198	93.280
## May 1999	401.370	98.936
## Jun 1999	353.158	104.294
## Jul 1999	379.433	101.288
## Aug 1999	360.215	87.778
## Sep 1999	328.356	71.283
## Oct 1999	308.985	67.908
## Nov 1999	337.650	72.210
## Dec 1999	332.407	85.198
## Jan 2000	319.978	86.468
## Feb 2000	334.369	76.714
## Mar 2000	366.040	91.110
## Apr 2000	364.110	97.207

## May 2000	361.267	93.560
## Jun 2000	326.724	85.931
## Jul 2000	351.077	82.333
## Aug 2000	343.214	74.999
## Sep 2000	312.937	60.736
## Oct 2000	341.025	58.639
## Nov 2000	339.223	65.377
## Dec 2000	333.069	67.181
## Jan 2001	303.197	64.323
## Feb 2001	272.585	59.617
## Mar 2001	301.844	69.868
## Apr 2001	288.028	61.460
## May 2001	290.338	65.427
## Jun 2001	298.272	70.723
## Jul 2001	297.654	61.686
## Aug 2001	304.239	64.534
## Sep 2001	279.069	52.054
## Oct 2001	292.015	51.980
## Nov 2001	283.668	52.589
## Dec 2001	302.843	66.010
## Jan 2002	314.861	74.364
## Feb 2002	279.136	68.894
## Mar 2002	302.856	71.682
## Apr 2002	309.709	82.729
## May 2002	331.378	90.973
## Jun 2002	326.674	96.262
## Jul 2002	337.792	86.906
## Aug 2002	311.593	71.938
## Sep 2002	302.858	58.300
## Oct 2002	315.739	58.589
## Nov 2002	309.716	67.319
## Dec 2002	328.629	73.933
## Jan 2003	318.956	70.287
## Feb 2003	291.767	67.489
## Mar 2003	330.201	82.578
## Apr 2003	327.749	84.478
## May 2003	345.099	100.297
## Jun 2003	341.209	97.536
## Jul 2003	342.647	84.765
## Aug 2003	333.101	78.381
## Sep 2003	308.470	63.055
## Oct 2003	313.818	62.878
## Nov 2003	314.096	67.268
## Dec 2003	347.074	82.039
## Jan 2004	347.154	78.419
## Feb 2004	321.055	71.357
## Mar 2004	342.168	78.184
## Apr 2004	334.068	71.270
## May 2004	344.066	81.955
## Jun 2004	346.968	86.161
## Jul 2004	353.034	79.562
## Aug 2004	344.004	73.672
## Sep 2004	328.252	70.032
## Oct 2004	332.739	64.360

## Nov 2004	332.106	71.437
## Dec 2004	367.856	89.431
## Jan 2005	361.269	82.817
## Feb 2005	333.479	73.722
## Mar 2005	354.763	78.258
## Apr 2005	342.863	78.675
## May 2005	367.186	93.074
## Jun 2005	362.264	91.384
## Jul 2005	372.396	88.565
## Aug 2005	356.107	73.582
## Sep 2005	331.447	59.245
## Oct 2005	339.018	61.438
## Nov 2005	338.541	66.031
## Dec 2005	360.826	75.546
## Jan 2006	388.583	93.614
## Feb 2006	348.049	84.487
## Mar 2006	368.883	84.019
## Apr 2006	367.940	97.432
## May 2006	386.890	105.153
## Jun 2006	383.011	101.532
## Jul 2006	381.340	86.799
## Aug 2006	370.019	74.137
## Sep 2006	345.317	58.691
## Oct 2006	353.690	58.192
## Nov 2006	359.164	69.167
## Dec 2006	376.761	73.685
## Jan 2007	399.004	88.865
## Feb 2007	343.865	63.349
## Mar 2007	390.167	82.446
## Apr 2007	383.102	81.515
## May 2007	398.044	88.872
## Jun 2007	382.096	77.850
## Jul 2007	393.450	76.694
## Aug 2007	386.428	68.037
## Sep 2007	360.587	50.302
## Oct 2007	374.075	50.485
## Nov 2007	373.327	53.507
## Dec 2007	397.970	62.582
## Jan 2008	427.860	70.898
## Feb 2008	388.671	64.108
## Mar 2008	424.851	73.934
## Apr 2008	421.184	75.862
## May 2008	449.522	92.879
## Jun 2008	444.695	99.553
## Jul 2008	446.062	87.194
## Aug 2008	431.761	72.434
## Sep 2008	398.411	55.200
## Oct 2008	412.573	52.783
## Nov 2008	409.976	53.459
## Dec 2008	428.996	71.179
## Jan 2009	431.011	80.149
## Feb 2009	386.812	60.775
## Mar 2009	432.104	74.475
## Apr 2009	431.059	87.927

## May 2009	456.231	100.858
## Jun 2009	455.356	99.744
## Jul 2009	455.962	79.789
## Aug 2009	449.335	66.808
## Sep 2009	421.927	59.228
## Oct 2009	450.940	67.186
## Nov 2009	456.527	71.678
## Dec 2009	481.882	84.378
## Jan 2010	489.844	76.371
## Feb 2010	449.090	70.252
## Mar 2010	499.560	71.262
## Apr 2010	482.552	65.158
## May 2010	507.544	85.570
## Jun 2010	517.750	101.861
## Jul 2010	508.593	83.651
## Aug 2010	497.073	68.647
## Sep 2010	476.105	58.909
## Oct 2010	489.125	60.334
## Nov 2010	500.488	66.744
## Dec 2010	524.855	79.053
## Jan 2011	530.909	87.112
## Feb 2011	490.715	82.336
## Mar 2011	553.169	106.231
## Apr 2011	538.506	106.435
## May 2011	554.011	111.187
## Jun 2011	553.885	109.700
## Jul 2011	549.374	106.743
## Aug 2011	534.036	87.905
## Sep 2011	500.175	72.940
## Oct 2011	517.691	67.515
## Nov 2011	528.710	70.562
## Dec 2011	552.823	80.973
## Jan 2012	539.035	78.842
## Feb 2012	494.125	69.207
## Mar 2012	541.244	88.400
## Apr 2012	519.621	89.716
## May 2012	546.977	97.728
## Jun 2012	528.771	90.960
## Jul 2012	520.168	90.388
## Aug 2012	513.269	78.592
## Sep 2012	475.610	60.064
## Oct 2012	491.516	56.300
## Nov 2012	489.078	63.915
## Dec 2012	527.556	78.420
## Jan 2013	542.692	84.715
## Feb 2013	487.697	69.668
## Mar 2013	541.012	70.063
## Apr 2013	551.448	85.631
## May 2013	578.378	97.072
## Jun 2013	563.561	93.434
## Jul 2013	572.289	92.993
## Aug 2013	542.610	73.813
## Sep 2013	514.219	57.871
## Oct 2013	543.689	58.682

## Nov 2013	548.475	60.313
## Dec 2013	574.712	72.090
## Jan 2014	574.319	73.815
## Feb 2014	507.326	59.356
## Mar 2014	589.693	82.765
## Apr 2014	583.144	86.801
## May 2014	589.777	90.568
## Jun 2014	590.788	87.838
## Jul 2014	588.697	83.107
## Aug 2014	560.101	67.582
## Sep 2014	530.782	54.846
## Oct 2014	557.457	58.547
## Nov 2014	569.677	63.548
## Dec 2014	593.827	76.186
## Jan 2015	581.002	82.360
## Feb 2015	533.488	76.040
## Mar 2015	579.817	82.846
## Apr 2015	569.898	76.671
## May 2015	579.138	68.668
## Jun 2015	564.673	69.653
## Jul 2015	584.483	71.701
## Aug 2015	572.778	65.245
## Sep 2015	540.124	54.913
## Oct 2015	557.167	56.743
## Nov 2015	575.787	65.981
## Dec 2015	607.572	79.041
## Jan 2016	600.004	87.397
## Feb 2016	582.468	82.362
## Mar 2016	626.931	93.454
## Apr 2016	590.484	88.296
## May 2016	609.870	86.960
## Jun 2016	594.461	79.284
## Jul 2016	605.124	73.206
## Aug 2016	592.159	66.771
## Sep 2016	562.996	55.847
## Oct 2016	585.197	59.160
## Nov 2016	586.984	64.174
## Dec 2016	651.738	76.865
## Jan 2017	627.929	90.854
## Feb 2017	581.036	81.485
## Mar 2017	664.711	101.040
## Apr 2017	635.896	100.345
## May 2017	662.077	111.255
## Jun 2017	643.105	104.323
## Jul 2017	626.343	90.753
## Aug 2017	612.943	75.180
## Sep 2017	584.631	65.346
## Oct 2017	615.446	60.386
## Nov 2017	614.560	67.859
## Dec 2017	635.919	75.910
## Jan 2018	653.150	85.519
## Feb 2018	610.036	84.967
## Mar 2018	669.313	88.236
## Apr 2018	657.253	95.929

## May 2018	681.427	103.876
## Jun 2018	669.472	94.163
## Jul 2018	648.661	85.640
## Aug 2018	652.676	75.122
## Sep 2018	601.408	65.393
## Oct 2018	628.690	66.698
## Nov 2018	623.898	74.766
## Dec 2018	648.213	77.784
## Jan 2019	645.530	84.610
## Feb 2019	593.795	78.068
## Mar 2019	657.711	89.852
## Apr 2019	666.642	94.922
## May 2019	690.669	109.123
## Jun 2019	661.828	95.801
## Jul 2019	667.695	84.875
## Aug 2019	648.350	77.038
## Sep 2019	613.803	63.210
## Oct 2019	634.265	62.459
## Nov 2019	621.355	68.982
## Dec 2019	651.174	73.284
## Jan 2020	649.110	83.587
## Feb 2020	632.884	88.262
## Mar 2020	642.361	81.284
## Apr 2020	561.380	79.139
## May 2020	619.030	102.279
## Jun 2020	637.875	95.534
## Jul 2020	633.731	91.243
## Aug 2020	619.356	79.443
## Sep 2020	584.297	63.732
## Oct 2020	612.749	64.181
## Nov 2020	630.734	71.286
## Dec 2020	641.695	73.385
## Jan 2021	637.388	83.799
## Feb 2021	552.930	68.706
## Mar 2021	678.059	72.404
## Apr 2021	651.233	66.155
## May 2021	689.525	79.530
## Jun 2021	656.848	80.025
## Jul 2021	651.269	75.397
## Aug 2021	648.898	69.360
## Sep 2021	620.767	58.080
## Oct 2021	650.143	58.458
## Nov 2021	663.620	66.102
## Dec 2021	706.622	80.393
## Jan 2022	697.568	82.562
## Feb 2022	651.899	72.746
## Mar 2022	733.189	83.377
## Apr 2022	712.467	68.465
## May 2022	742.753	79.700
## Jun 2022	725.578	88.670
## Jul 2022	713.262	83.824
## Aug 2022	672.494	72.106
## Sep 2022	632.729	58.093
## Oct 2022	659.196	49.022

## Nov 2022	685.824	61.068
## Dec 2022	680.383	69.706
## Jan 2023	701.741	76.048
## Feb 2023	659.745	63.745
## Mar 2023	734.657	69.017
## Apr 2023	699.747	59.646
## May 2023	740.660	93.759
## Jun 2023	691.709	66.434
## Jul 2023	711.895	72.463
## Aug 2023	711.962	72.150
## Sep 2023	666.253	56.284

Question 3

Compute mean and standard deviation for these three series.

```
# calculating mean and standard deviation for each time series
```

```
# mean and sd for biomass
```

```
bioMass_mean_ts <- print(mean(renewable_energy_ts[,2]))
```

```
## [1] 279.8046
```

```
bioMass_stDev_ts <- print(sd(renewable_energy_ts[,2]))
```

```
## [1] 92.66504
```

```
# mean and sd for renewable energy
```

```
renewEnergy_mean_ts <- print(mean(renewable_energy_ts[,3]))
```

```
## [1] 395.7213
```

```
renewEnergy_stDev_ts <- print(sd(renewable_energy_ts[,3]))
```

```
## [1] 137.7952
```

```
# mean and sd for hydroelectric
```

```
Hydro_mean_ts <- print(mean(renewable_energy_ts[,4]))
```

```
## [1] 79.73071
```

```
Hydro_stDev_ts <- print(sd(renewable_energy_ts[,4]))
```

```
## [1] 14.14734
```

Question 4

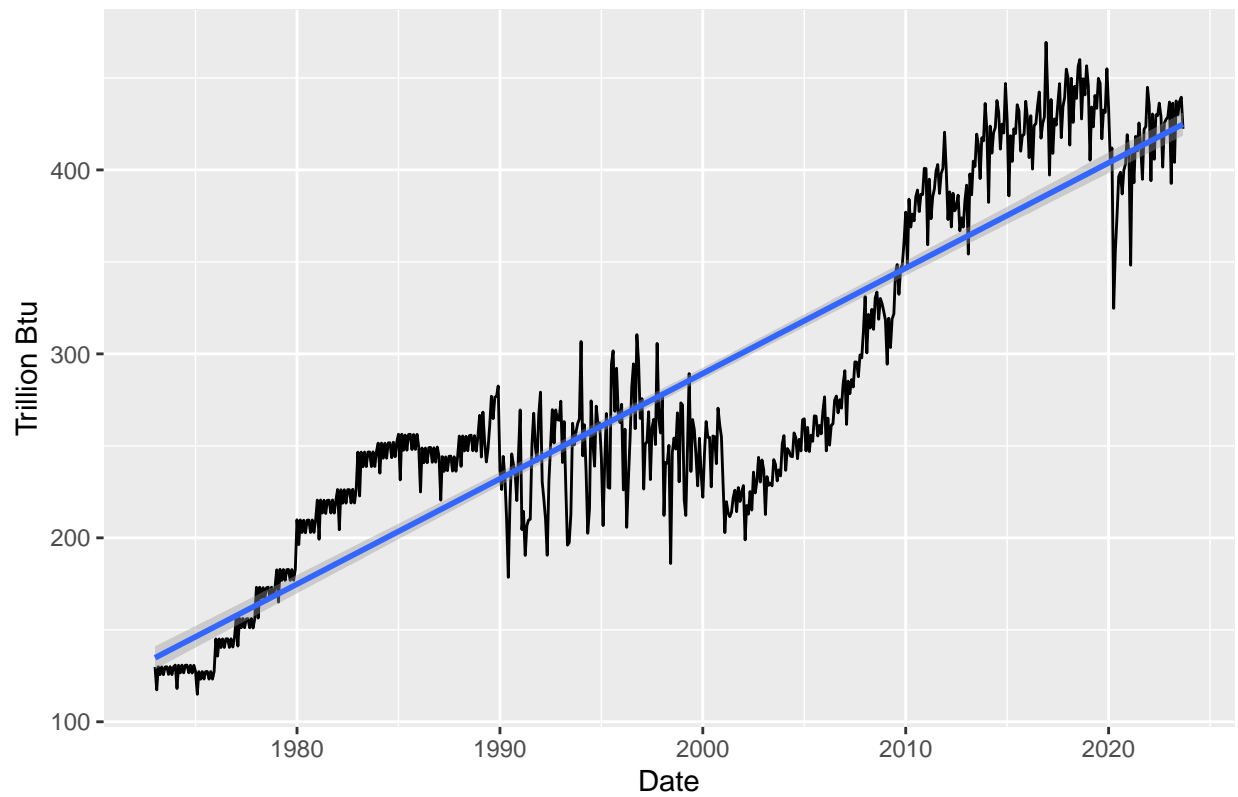
Display and interpret the time series plot for each of these variables. Try to make your plot as informative as possible by writing titles, labels, etc. For each plot add a horizontal line at the mean of each series in a different color.

```
# plotting Total Biomass Production
```

```
ggplot(renewable_energy_sub,aes(x=Date,y=Total.Biomass.Energy.Production))+
  geom_line(color="black")+
  geom_smooth(method="lm")+
  labs(x="Date",y="Trillion Btu",title="Total Biomass Production")
```

```
## `geom_smooth()` using formula = 'y ~ x'
```

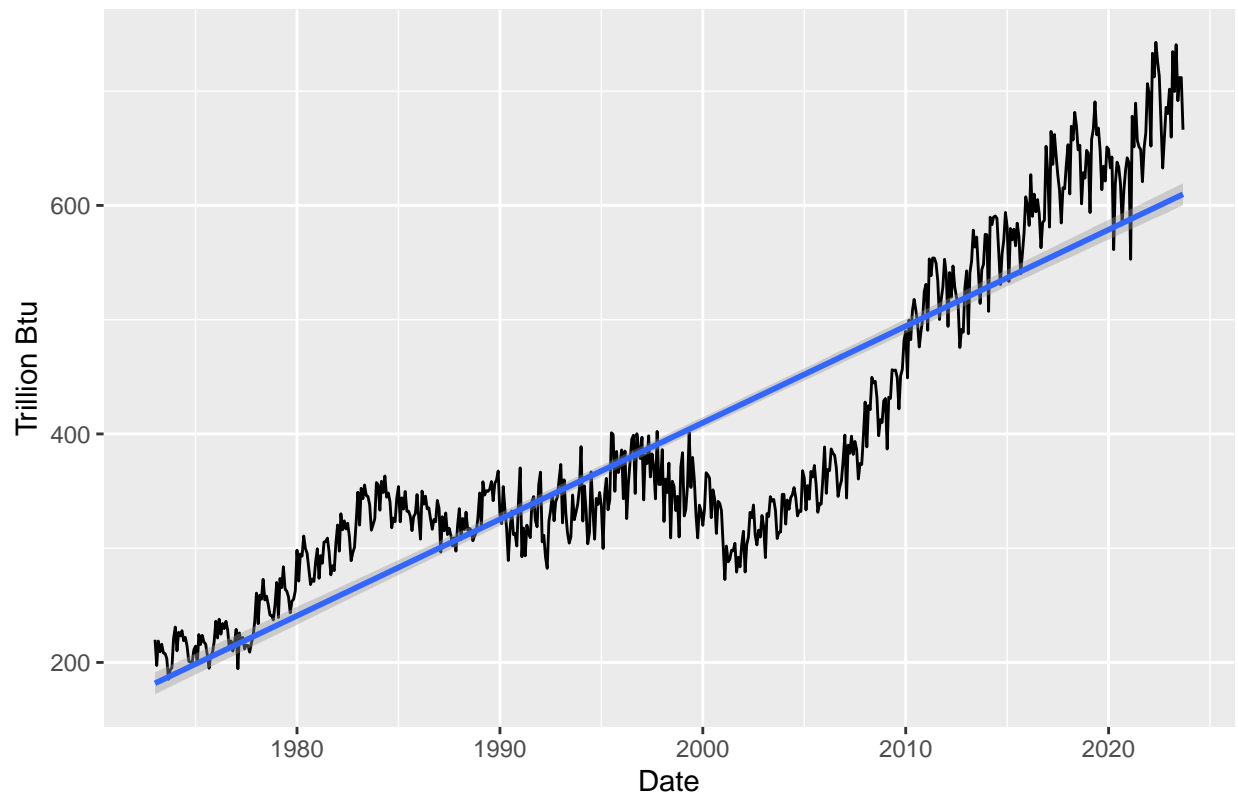
Total Biomass Production



```
# plotting Total Renewable Energy Production
ggplot(renewable_energy_sub, aes(x=Date, y=Total.Renewable.Energy.Production)) +
  geom_line(color="black") +
  geom_smooth(method="lm") +
  labs(x="Date", y="Trillion Btu", title="Total Renewable Energy Production")
```

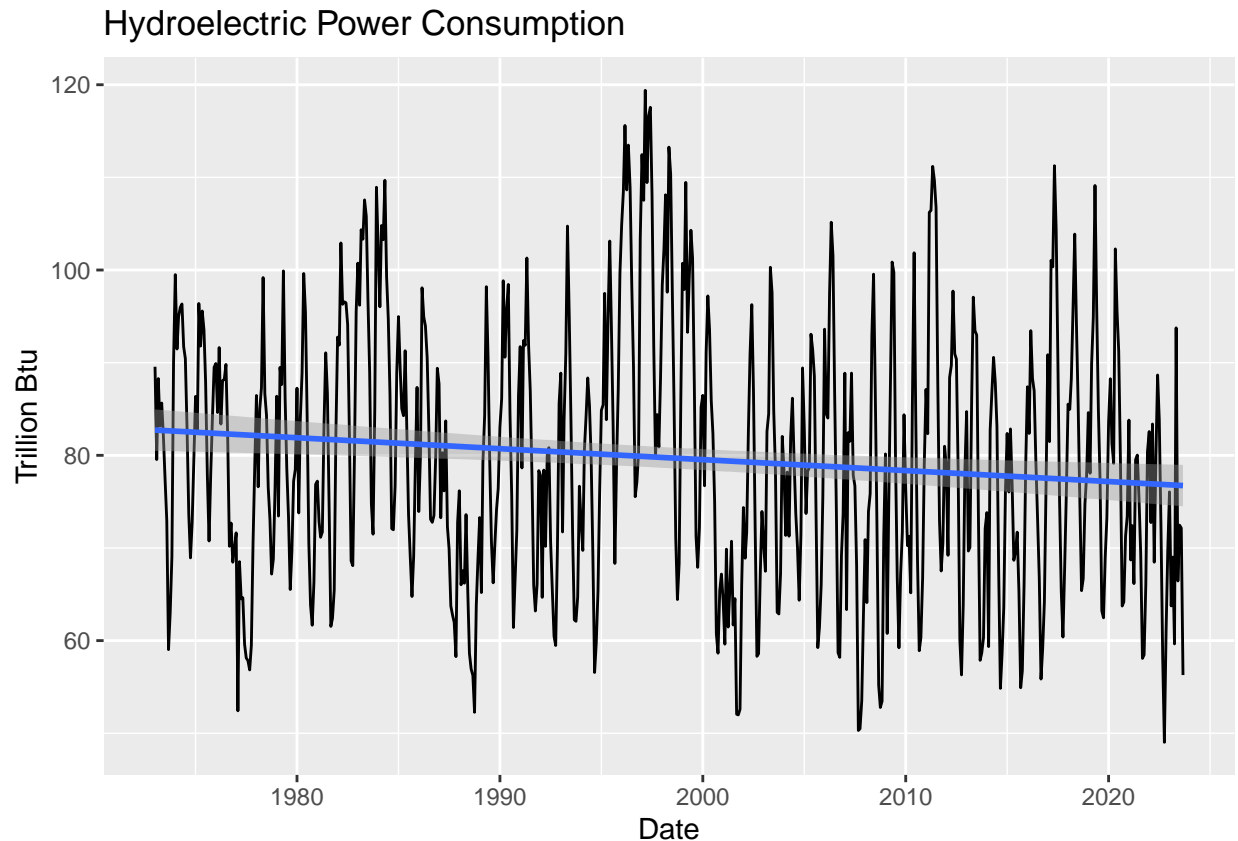
```
## `geom_smooth()` using formula = 'y ~ x'
```

Total Renewable Energy Production



```
# plotting Hydroelectric Power Consumption
ggplot(renewable_energy_sub, aes(x=Date, y=Hydroelectric.Power.Consumption)) +
  geom_line(color="black") +
  geom_smooth(method="lm") +
  labs(x="Date", y="Trillion Btu", title="Hydroelectric Power Consumption")
```

```
## `geom_smooth()` using formula = 'y ~ x'
```



Interpretation of Time Series Plots > Total Biomass Production: The plot shows an upward trend in production over time. We can see this from the highly positive slope of the trend line in blue. There also seems to be some seasonality in the plot as similar cyclical patterns seem to repeat.

Total Renewable Energy Production: Similarly to biomass production, there appears to be a positive trend in renewable energy production over time. The plot is very similar to that of the Biomass plot, which is unsurprising given the increasing demand alternatives to fossil energy. Like above, there seems to be some seasonality.

Hydroelectric Power Consumption: There is a slight downward trend in hydroelectric power consumption over time. This is interesting and stands in contrast to Biomass and Renewables production. This downward trend could be because consumers are switching to alternative forms of renewable energy as production / availability increases.

Question 5

Compute the correlation between these three series. Are they significantly correlated? Explain your answer.

*# NOTE: Used chatGPT to determine which function to use
to calculate correlation between all three time series*

```
cor_matrix <-  
  cor(renewable_energy_sub[,c("Total.Biomass.Energy.Production",  
                              "Total.Renewable.Energy.Production",  
                              "Hydroelectric.Power.Consumption")])  
  
print(cor_matrix)
```

```
##                                Total.Biomass.Energy.Production
```

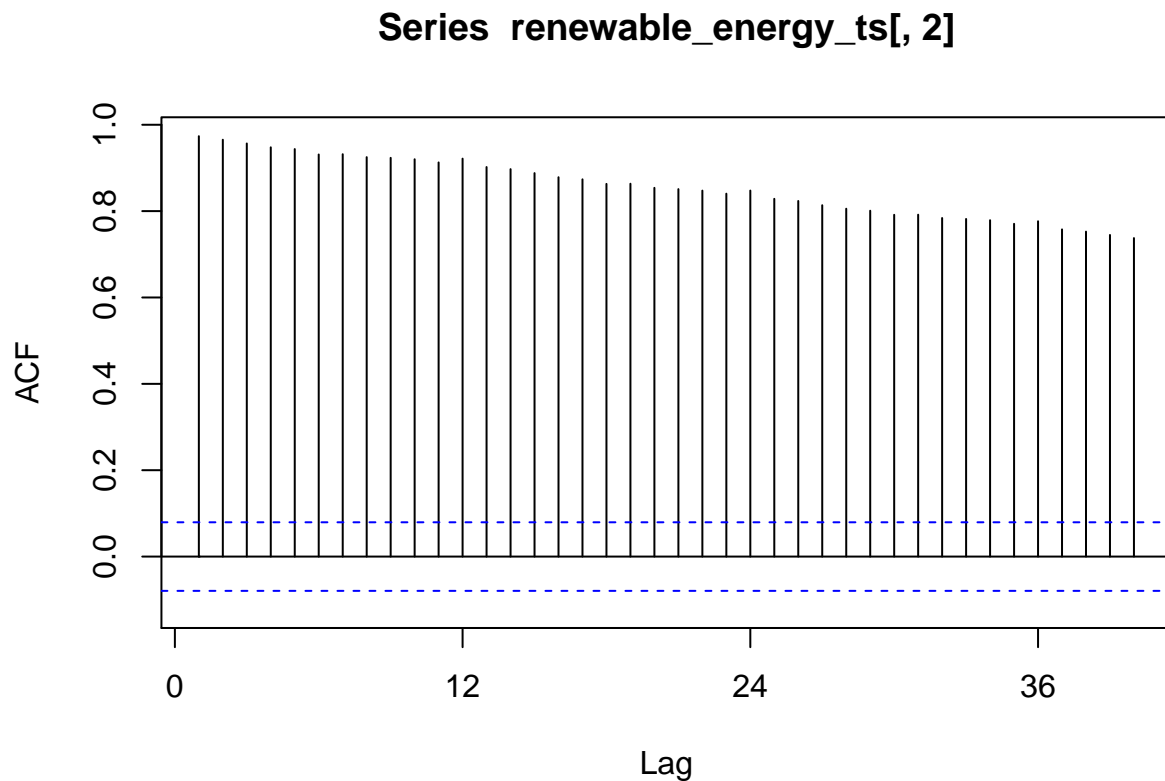
```
## Total.Biomass.Energy.Production      1.00000000
## Total.Renewable.Energy.Production    0.97074621
## Hydroelectric.Power.Consumption      -0.09656318
##                                     Total.Renewable.Energy.Production
## Total.Biomass.Energy.Production      0.970746212
## Total.Renewable.Energy.Production    1.000000000
## Hydroelectric.Power.Consumption      -0.001768629
##                                     Hydroelectric.Power.Consumption
## Total.Biomass.Energy.Production      -0.096563177
## Total.Renewable.Energy.Production    -0.001768629
## Hydroelectric.Power.Consumption      1.000000000
```

Answer: > It appears that biomass production and renewable energy production are highly correlated with a correlation coefficient of 0.97. This does not seem that surprising since both variables relate to the production of alternative forms of energy (non-fossil). Meanwhile, hydroelectric power consumption does not appear to be correlated with either biomass or renewable energy production based on the fact the correlation coefficients are > 0.1.

Question 6

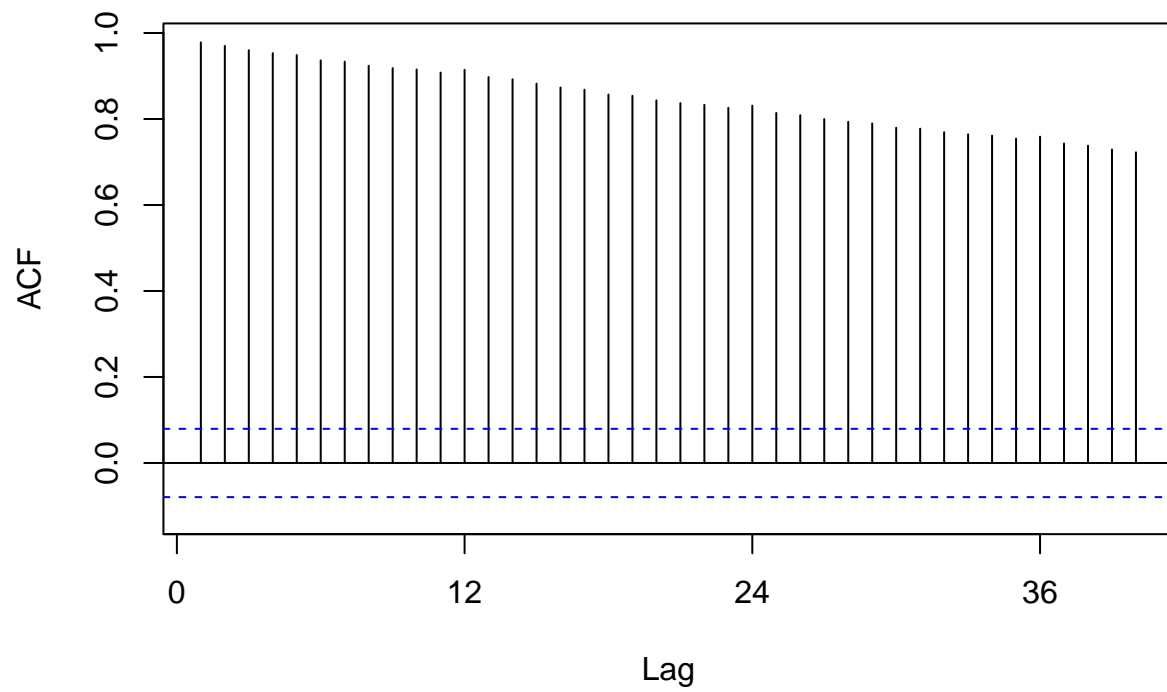
Compute the autocorrelation function from lag 1 up to lag 40 for these three variables. What can you say about these plots? Do the three of them have the same behavior?

```
BiomassProd_acf <- Acf(renewable_energy_ts[,2],lag.max=40)
```

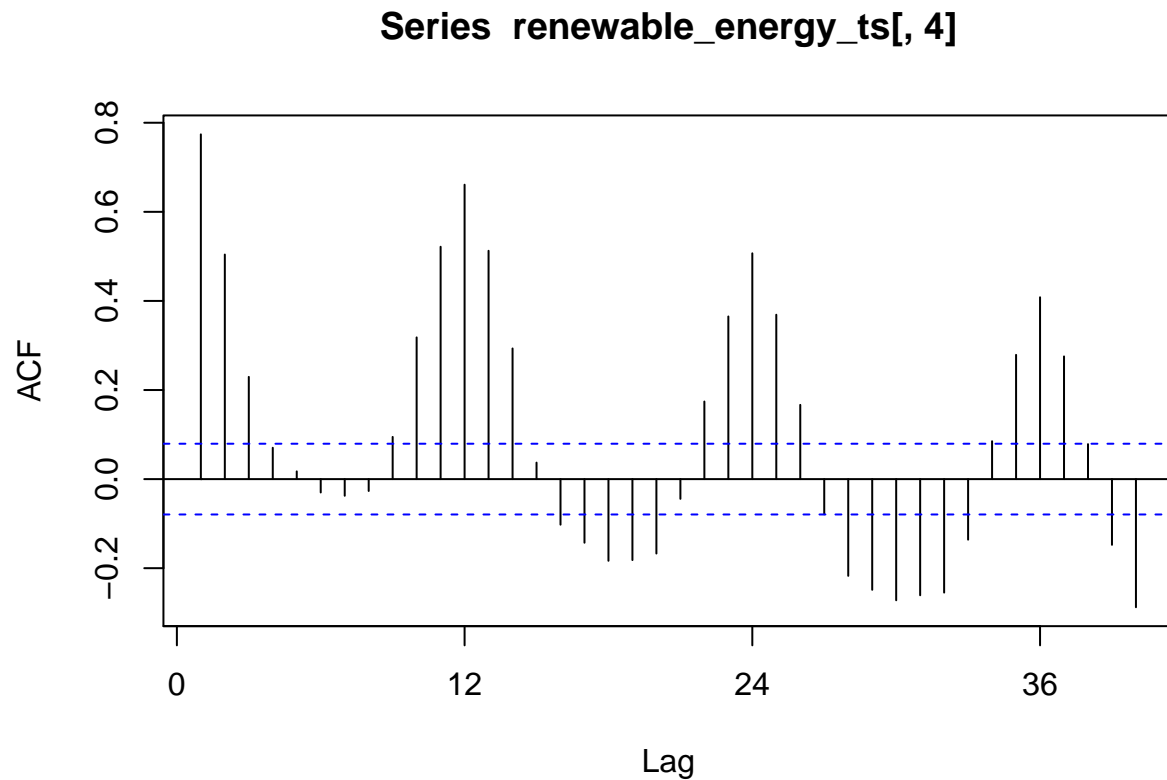


```
RenewablesProd_acf <- Acf(renewable_energy_ts[,3],lag.max=40)
```

Series renewable_energy_ts[, 3]



```
HydroConsump_acf <- Acf(renewable_energy_ts[,4],lag.max=40)
```



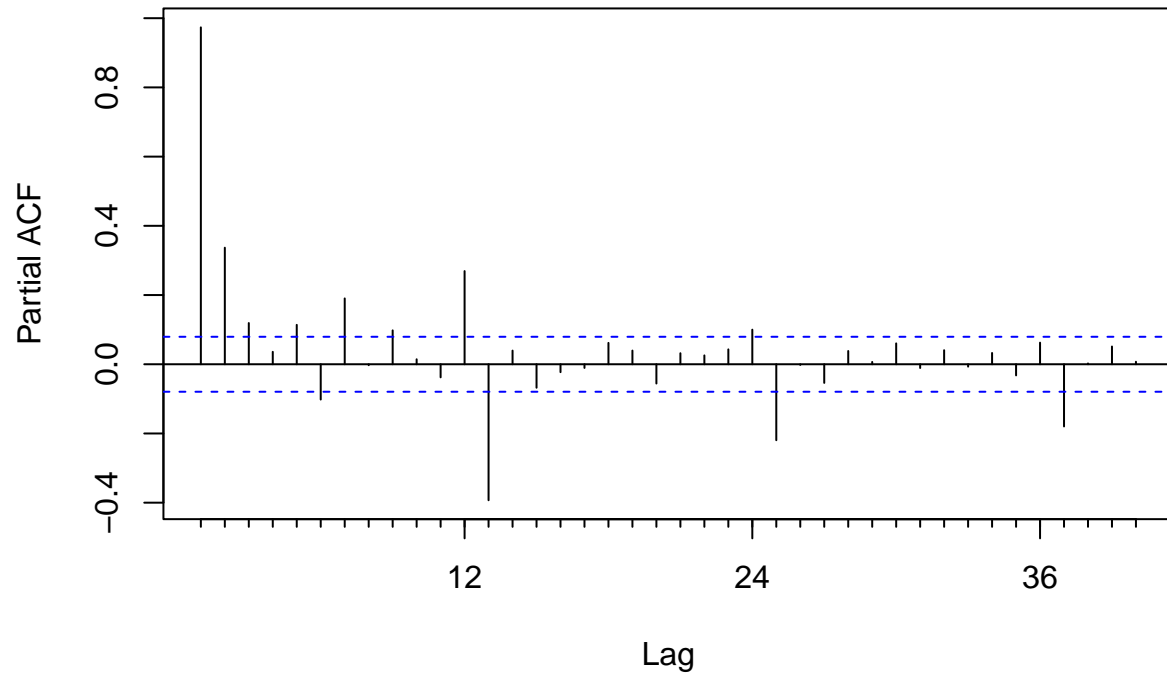
Answer: > The biomass and renewable energy ACF plots behave similarly, but the hydro power plot of ACF looks very different. The biomass and renewable energy plots show significant correlation within each dataset. ACF appears positive for all lags for these two time series. For hydro power, some autocorrelation is present, but the amplitudes don't appear as big compared to the first two time series, suggesting potentially less correlation between variables.

Question 7

Compute the partial autocorrelation function from lag 1 to lag 40 for these three variables. How these plots differ from the ones in Q6?

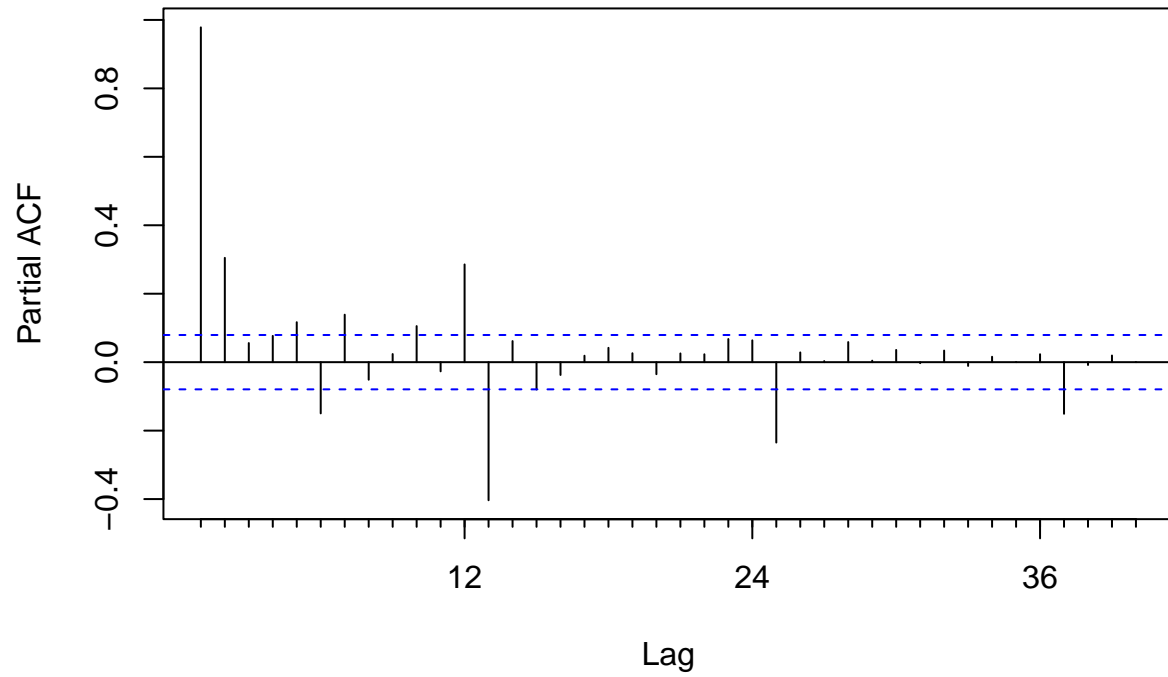
```
BiomassProd_pacf=Pacf(renewable_energy_ts[,2],lag.max=40)
```


Series renewable_energy_ts[, 2]



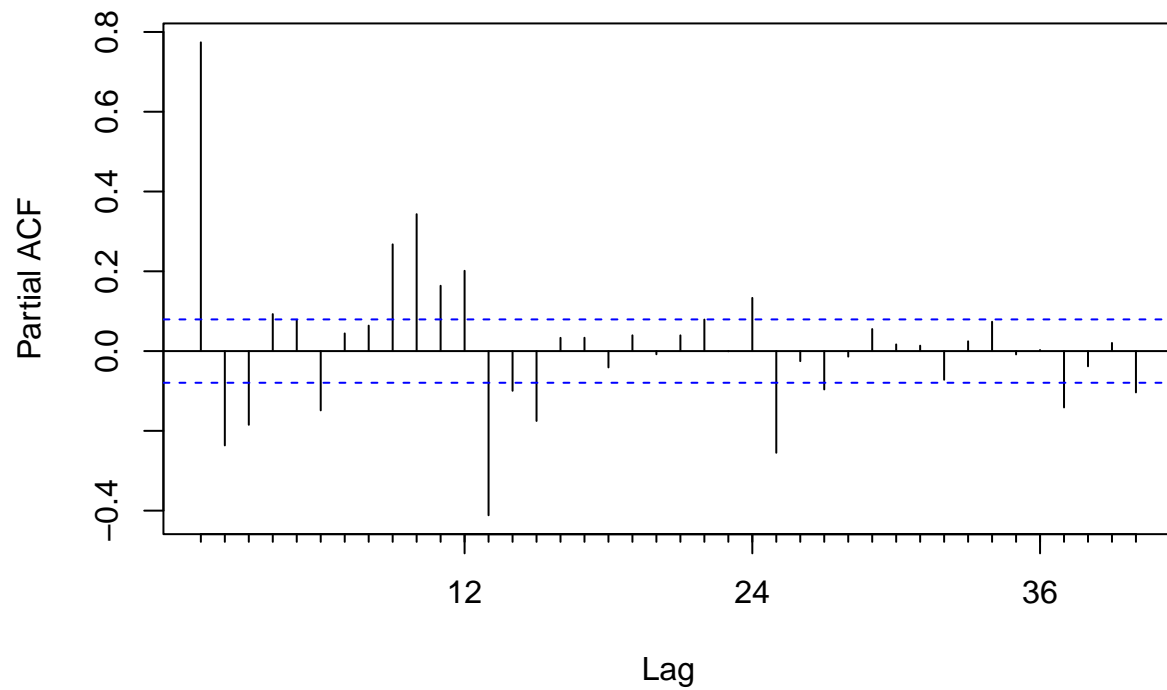
```
RenewablesProd_pacf=Pacf(renewable_energy_ts[,3],lag.max=40)
```

Series renewable_energy_ts[, 3]



```
HydroConsump_pacf=Pacf(renewable_energy_ts[,4],lag.max=40)
```

Series renewable_energy_ts[, 4]



Answer: > The PACF plots show us which lags are most significant within each time series. In other words, which instances within a specific variable are most correlated with each other. From these plots we should consider adding lags that breach the blue dotted line to our model as they may help us better explain trends / construct more accurate forecasts.