A PROJECT REPORT

ON

STATISTICAL ANALYSIS OF ELECTRICITY PRODUCTION: A CASE STUDY OF TOP SEVEN (7) ELECTRICITY PRODUCER COUNTRIES

SUBMITTED TO

MAHARSHI DAYANAND UNIVERSITY ROHTAK

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE

AWARD OF THE DEGREE

OF

MASTER OF SCIENCE IN STATISTICS

SUPERVISOR:

Prof. S.C. MALIK

DEPARTMENT OF STATISTICS

M.D. University, Rohtak

INVESTIGATOR:

Preeti

Roll No-212234

M.Sc. Statistics

MAHARSHI DAYANAND UNIVERSITY ROHTAK

(HARYANA)

Session: 2021-2023

DECLARATION

I hereby certify that the project "**Statistical analysis of electricity production: a case study of top seven (7) Electricity producer Countrie**s" submitted for the partial fulfilment of the degree of Master of Science in Department of Statistics, Maharshi Dayanand University, Rohtak, is based on the theoretical work completed by me under the direction of Prof. S.C. MALIK, Department of Statistics, Maharshi Dayanand University, Rohtak. The result embodied in the report have not been submitted by any university or institution for the award of any degree and diploma.

Place: Rohtak

DATE:

Preeti

M.Sc. Statistics

Roll No- 212234

CERTIFICATE

This is to confirm that Preeti, an M.Sc. Statistics student at Maharshi Dayanand University, Rohtak, completed the project work named "**Statistical analysis of electricity production: a case study of top seven (7) Electricity producer Countries**" during the academic year 2021-2023.

To the best of my knowledge, no other institution or university has submitted the project work's contents for the award of a degree or diploma.

Prof. S.C. MALIK

Dept. of Statistics

M.D. University Rohtak

DATE-

ACKNOWLEDGEMENT

Without the generous support and assistance of several people, the completion of this project would not have been possible. I am grateful to each and every one of them.

First and foremost, I owe a huge debt of gratitude to **Prof. S.C. Malik** for his direction, ongoing monitoring, for providing the project with the knowledge that was needed in the first place, and for helping me finish the research. His advice gives me encouragement and aids in the diversification of my thinking.

Finally, I'd want to express my gratitude for the success of this initiative to the research scholar **Rahul Thakur,** my beloved parents and my friends.

Preeti

Roll no.-212234

CONTENTS

CHAPTER-1

INTRODUCTION

What is electricity?

Electricity is a form of energy. Electricity is the flow of electrons. All matter is made up of atoms, and an atom has a center, called a nucleus. The nucleus contains positively charged particles called protons and uncharged particles called neutrons. The nucleus of an atom is surrounded by negatively charged particles called electrons. The negative charge of an electron is equal to the positive charge of a proton, and the number of electrons in an atom is usually equal to the number of protons. When the balancing force between protons and electrons is upset by an outside force, an atom may gain or lose an electron. When electrons are "lost" from an atom, the free movement of these electrons constitutes an electric current. Electricity is a basic part of nature and it is one of our most widely used forms of energy.

We get electricity, which is a secondary energy source, from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources, which are called primary sources. Many cities and towns were built alongside waterfalls (a primary source of mechanical energy) that turned water wheels to perform work. Before electricity generation began slightly over 100 years ago, houses were lit with kerosene lamps, food was cooled in iceboxes, and rooms were warmed by wood-burning or coal-burning stoves. Beginning with Benjamin Franklin's experiment with a kite one stormy night in Philadelphia, the principles of electricity gradually became understood. In the mid-1800s, everyone's life changed with the invention of the electric light bulb. Prior to 1879, electricity had been used in arc lights for outdoor lighting. The lightbulb's invention used electricity to bring indoor lighting to our homes.

How electricity is generated?

Electricity and Coal

Coal plays a vital role in electricity generation worldwide. Coal-fired power plants currently fuel 37% of global electricity and figures from the IEA show that coal will still generate 22% of the world's electricity in 2040, retaining coal's position as the single largest source of electricity worldwide.

How is coal converted to electricity?

Steam coal, also known as thermal coal, is used in power stations to generate electricity. First coal is milled to a fine powder, which increases the surface area and allows it to burn more quickly.

1. In pulverized coal combustion (PCC) systems, the powdered coal is blown into the combustion chamber of a boiler where it is burnt at high temperature.
2. The hot gases and heat energy produced converts water – in tubes lining the boiler – into steam.
3. The high-pressure steam is passed into a turbine containing thousands of propeller-like blades.
4. The steam pushes these blades causing the turbine shaft to rotate at high speed.
5. A generator is mounted at one end of the turbine shaft and consists of carefully wound wire coils.
6. Electricity is generated when these are rapidly rotated in a strong magnetic field.
7. After passing through the turbine, the steam is condensed and returned to the boiler to be heated once again.
8. The electricity generated is transformed into the higher voltages – up to 400,000 volts – used for economic, efficient transmission via power line grids.
9. When it nears the point of consumption, such as our homes, the electricity is transformed down to the safer 100-250 voltage system used in the domestic market.

Electricity generated using gas

Gas is a fossil fuel which can be used to generate electricity. By burning gas, we create heat which powers a turbine. The rotation of this turbine spins a generator which creates electricity.

How do gas power station works?

There are three types of gas power stations:

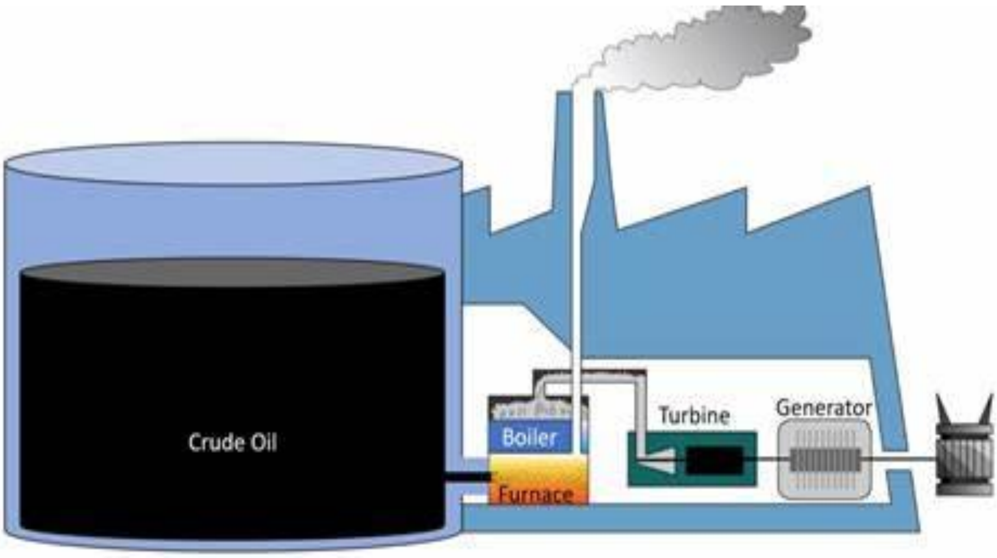
1. OCGT - Open cycle fast turbines, these are generally smaller and use gas, which when burnt produces hot air that drives the turbine and produces electricity. There are hundreds of these across the country. OCGTs are cheap to build and good for short runs in producing energy.
2. CCGT - combined cycle gas turbines, these are primarily the same as OCGTs at the beginning, except the hot air that exits the engine is then used to heat water, this creates steam which drives another turbine producing more energy, making them much more efficient but are more costly to build.
3. CHP - combined heat and power, these again are like OCGTs at the beginning. However, the heat from the engine is then used for other purposes, such as local district heating or larger stations using the steam to power chemical services such as oil refineries. CHPs are efficient but only when the heat can be used effectively.

Oil and Electricity Generation

Like its fellow fossil fuels coal and natural gas, crude oil is combustible, which means it can be burned. When burned in an oil-fired power plant, it can heat water past its boiling point to produce steam, which can be used to spin turbines in order to generate electricity.

Oil isn't used often for electricity generation though. There are a number of reasons why. Oil is a relatively expensive fuel source for electricity generation, so it's rarely used if there are alternative energy sources. Moreover, the energy efficiency of oil as a feedstock for power generation is relatively low.

Additionally, burning oil produces a lot of air pollution, which can be dangerous to surrounding communities. It also emits large amounts of greenhouse gasses like carbon dioxide and methane, which contribute to climate change.



Nuclear power and electricity

Nuclear power is the use of nuclear reactions to produce electricity. Nuclear power can be obtained from nuclear fission, nuclear decay and nuclear fusion reactions. Presently, the vast majority of electricity from nuclear power is produced by nuclear *fission* of uranium and plutonium in nuclear power plants. Nuclear *decay* processes are used in niche applications such as radioisotope thermoelectric generators in some space probes such as *Voyager 2*. Generating electricity from *fusion* power remains the focus of international research. Nuclear power generation causes one of the lowest levels of fatalities per unit of energy generated compared to other energy sources. Coal, petroleum, natural gas and hydroelectricity each have caused more fatalities per unit of energy due to air pollution and accidents. Nuclear power plants emit no greenhouse gases. One of the dangers of nuclear power is the potential for accidents like the Fukushima nuclear disaster in Japan in 2011.

There is a debate about nuclear power. Proponents contend that nuclear power is a safe, sustainable energy source that reduces carbon emissions. The anti-nuclear movement contends that nuclear power poses many threats to people and the environment and is too expensive and slow to deploy when compared to alternative sustainable energy sources.

Hydroelectric power and electricity

Hydroelectric power, also called hydropower, electricity produced from generators driven by turbines that convert the potential energy of falling or fast-flowing water into mechanical energy. In the early 21st century, hydroelectric power was the most widely utilized form of renewable energy; in 2019 it accounted for more than 18 percent of the world’s total power generation capacity.

In the generation of hydroelectric power, water is collected or stored at a higher elevation and led downward through large pipes or tunnels (penstocks) to a lower elevation; the difference in these two elevations is known as the head. At the end of its passage down the pipes, the falling water causes turbines to rotate. The turbines in turn drive generators, which convert the turbines' mechanical energy into electricity. Transformers are then used to convert the alternating voltage suitable for the generators to a higher voltage suitable for long-distance transmission. The structure that houses the turbines and generators, and into which the pipes or penstocks feed, is called the powerhouse.

Solar electricity

The amount of sunlight that strikes the earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year. Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation. This energy can be used to generate electricity or be stored in batteries or thermal storage.

Below, you can find resources and information on the basics of solar radiation, photovoltaic and concentrating solar-thermal power technologies, electrical grid systems integration, and the non-hardware aspects (soft costs) of solar energy. You can also learn more about how to go solar and the solar energy industry. In addition, you can dive deeper into solar energy and learn about how the U.S. Department of Energy Solar Energy Technologies Office is driving innovative research and development in these areas.

Solar energy 101

You're likely most familiar with PV, which is utilized in solar panels. When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow.

Concentrating solar- thermal power station

Concentrating solar-thermal power (CSP) systems use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat, which can then be used to produce electricity or stored for later use. It is used primarily in very large power plants.

System integration basics

Solar energy technology doesn't end with electricity generation by PV or CSP systems. These solar energy systems must be integrated into homes, businesses, and existing electrical grids with varying mixtures of traditional and other renewable energy sources.

Soft costs basics

A number of non-hardware costs, known as soft costs, also impact the cost of solar energy. These costs include permitting, financing, and installing solar, as well as the expenses solar companies incur to acquire new customers, pay suppliers, and cover their bottom line. For rooftop solar energy systems, soft costs represent the largest share of total costs.

Uses of electricity in our daily life

Uses of electricity in entertainment

- Listening to music on MP3 players.
- Watching Television.
- Playing movies on DVDs, VCDs or VCRs runs on electricity.

Uses of electricity in hospitals

- Surgical operations
- Doctors need a powerful light during an operation on a patient
    - Without electricity, the operation can prove fatal

Uses of electricity in engineering

Constructions of buildings and structures for the convenience of people require electricity at every step. Building houses, installing gates and windows, and welding materials require current electricity to operate the machines.

Uses of electricity in transport and communication

Reaching places or communicating from a different corner of the world is only possible because of electricity. A power cut during airline travel can be dangerous.

Uses of electricity in outdoors

The street lights on the road use electricity to function, even the pool requires electricity to heat the water in colder regions. The lawnmower, which is used to cut grass, uses electricity to operate. The water sprinkler for the grass on the lawn uses electricity as well.

Uses of electricity in household

Starting from toasters to refrigerators, microwaves, washing machines, dishwashers, electrical chimneys, and many more appliances which are simple to use and made for the convenience of day-to-day activities use electricity to function.

Uses of electricity in commercial places

For the production of various materials, the factory uses heavy machinery which always runs on electricity. Even the magnets, which are giant-like structures, require electricity to keep them charged for lifting heavy metals.

Uses of electricity in offices

We go to work in offices in which most things run on electricity. The lights, lifts, AC, coffee machine, ID card reader, biometric scanners and everything else require electricity.

Uses of electricity as fuel

Electrical energy comes under renewable energy, and we can produce it using most of the natural resources available to us. Today, things which were running on fossil fuels, such as cars and bikes, are now made in such a way that it runs on electricity (like solar-powered), which will be more convenient in the future.

Uses of electricity in space

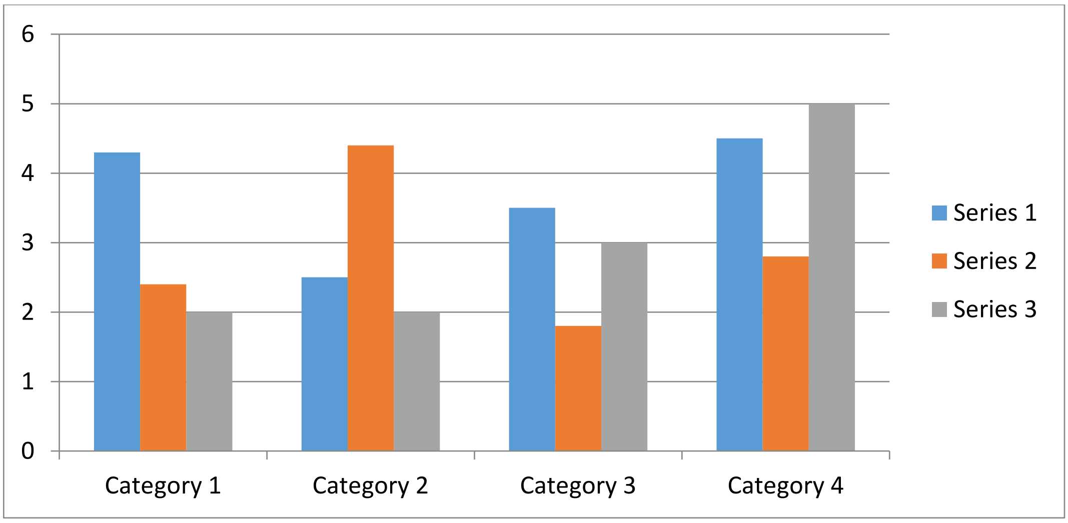
The satellites and probes which are sent from the earth for space expeditions run on electricity. The electricity is generated with the help of a generator or is battery-powered.

STATISTICAL TOOLS

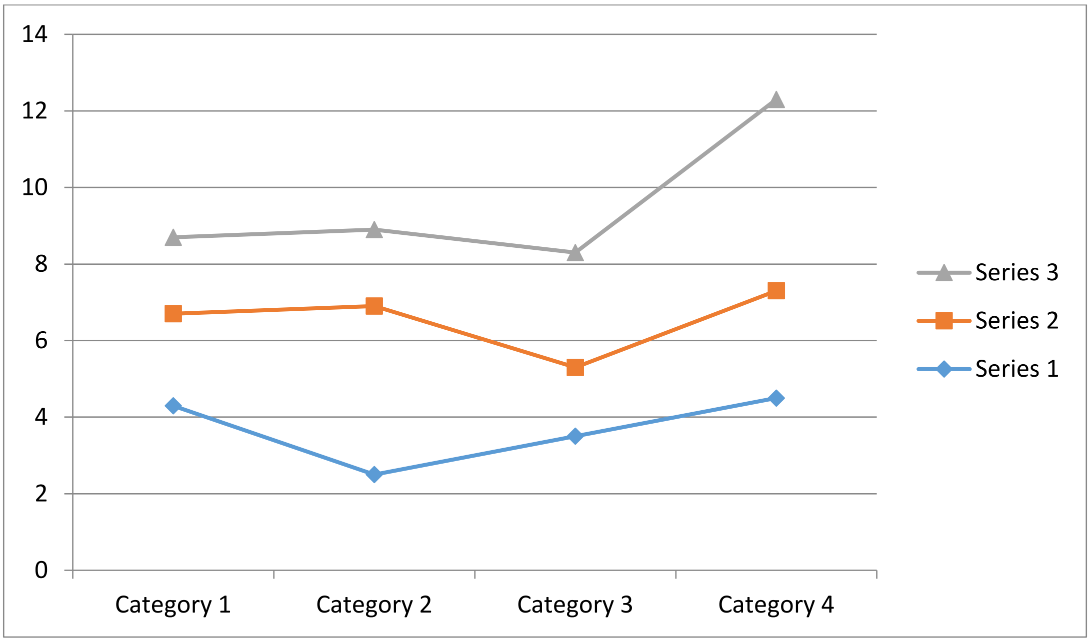
BAR GRAPHS -A graph, in layman terms, is a pictorial representation of organized data that helps the readers of the same to understand complex information more easily. They provide information in easy-to-understand images. It presents categorical data with rectangular bars with heights or lengths proportional to the values that they represent. The bars can be plotted vertically or horizontally.

A bar graph shows comparisons among discrete categories. One axis of the chart shows the specific categories being compared, and the other axis represents a measured value. Some bar graph represents bars clustered in groups of more than one, showing the values of more than one measured variable.

GROUPED BAR CHART- Bar graphs can also be used for more complex comparisons of data with grouped bar charts and stacked bar charts. In a grouped bar chart, for each categorical group there are two or more bars. These bars are color-coded to represent a particular grouping. For example, a business owner with two stores might make a grouped bar chart with different colored bars to represent each store: the horizontal axis would show the months of the year and the vertical axis would show the revenue.



LINE GRAPH – A line chart or graph is a type of chart which displays information as a series of data points called ‘markers’ connected by straight line segments. It is a basic type of chart common in many fields. It is similar to scatter plot except that the measurement points are ordered (typically by their x-axis value) and joined with straight line segments. A line chart is often used to visualize a trend in data over intervals of time, thus the line is often drawn chronologically.



STATISTICAL SUMMARY

Mean

The mean of a data set is the sum of all of the data divided by the size. The mean is also known as the average.

For a Population

$$\mu = \frac{\sum_i^n x_i}{n}$$

For a Sample

$$X = \frac{\sum_i^n x_i}{n}$$

Variance

Variance measures dispersion of data from the mean. The formula for variance is the sum of squared differences from the mean divided by the size of the data set.

For a Population

$$\sigma^2 = \frac{\sum_i^n (x_i - \mu)^2}{n}$$

For a Sample

$$s^2 = \frac{\sum_i^n (x_i - x)^2}{n - 1}$$

Standard deviation

Standard deviation is a measure of dispersion of data values from the mean. The formula for standard deviation is the square root of the sum of squared differences from the mean divided by the size of the data set.

For a Population

$$\sigma = \sqrt{\frac{\sum_i^n (x_i - \mu)^2}{n}}$$

For a Sample

$$s = \sqrt{\frac{\sum_i^n (x_i - x)^2}{n-1}}$$

Sum of squares

The sum of squares is the sum of the squared differences between data values and the mean.

For a Population

$$SS = \sum_{i=1}^{n} (x_i - \mu)^2$$

For a Sample

$$SS = \sum_{i=1}^{n} (x_i - \bar{x})^2$$

ANOVA

The analysis of variance is a powerful statistical tool for tests of significance. The test of significance based on t-distribution is an adequate procedure only for testing the significance of the difference between two sample means. In a situation when we have three or more samples to consider at a time an alternative procedure is needed for testing the hypothesis that all samples are drawn from same population i.e., they have the same mean. For example, five fertilizers are applied to four plots each of wheat and yield of wheat on each of the plot is given. We may be interested in finding out whether the effect of these fertilizers on the yields is significantly different or in other words, whether the samples have come from the same normal population. The answer to this problem is provided by the technique of analysis of variance. The basic purpose of the analysis of variance is to test the homogeneity of several means.

The term “Analysis of Variance” was introduced by **Prof. R.A. Fisher** in 1920’s to deal with problem in the analysis of agronomical data. Variation is inherent in nature. The total variation in any set of data is due to a number of causes which may be classified as:

1) Assignable causes, and

2) Chance causes.

The variation due to assignable causes can be detected and measured whereas the variation due to chance causes is beyond the control of human hand and cannot be traced separately.

Definition. According to **Prof. R.A. Fisher**, Analysis of Variance (ANOVA) is the "Separation of variance ascribable to one group of causes from the variance ascribable to other groups". By this technique the total variation in the sample data is expressed as the sum of its non-negative components where each of these components is a measure of the variation due to some specific independent source or factor or cause. The ANOVA consists in the estimation of the amount of variation due to each of independent factors (causes)separately and then comparing these estimates due to assignable factor (causes) with the estimate due to chance factor (causes), the latter being known as the experimental error or simply error. Assumptions for ANOVA Test. ANOVA test is based on the test statistics F (or Variance Ratio). For the validity in f-test in ANOVA, the following assumptions are made:

1. The observations are independent.

2. Parent population from which observation are taken is normal, and

3. Various treatment and environmental effects are additive in nature.

In the following sequence we will discuss the analysis of variance for:

One-way classification, and Two-way classification

The one-way ANOVA model and assumptions

The mathematical model that describes the relationship between the response and treatment for one-way ANOVA is given by

$$y_{ij} = \mu + \alpha_i + \epsilon_{ij},$$

Where y_{ij} represents the jth observation (j=1, 2, 3, …, n) on the ith treatment (i=1, 2, 3, …, k levels). So, y_{23} represents the 3rd observation using level 2 of the factor. μ is the common effect for the whole experiment, x_i represents the ith treatment effect, and ϵ_{ij} represents the random error present in the jth observation on the ith treatment.

Fixed effect model

The error ε_{ij} are assumed to the normally and independently (NID) distributed, with mean zero and variance σ_ϵ^2. μ is always a fixed parameter, and α_1, α_2, …,α_k are considered to be fixed parameters if the levels the treatment are fixed and not a random sample from a population of possible levels. It is assumed that μ is chosen so that

$\sum \alpha_i$= 0, i = 1,2, … k holds.

This is the fixed effect model.

Random effect model

If the k levels of treatment are chosen at random, the model equation remains the same. However, now the α_i values are random variables assumed to be NID (0, ${\sigma^2}_\epsilon$). This is the random effect model.

The ANOVA table and test of hypothesis about means

The sum of squares SST and SSE previously computed for the one-way ANOVA are use two mean squares, one for treatment and second for error. These mean squares are represented by MST and MSE, respectively. These are typically displayed in a tabular form, known as Table. The ANOVA table also shows the statistics used to test the population.

When the null hypothesis of equal mean is true, the two means squares estimates the same (error variance), and should be of approximately equal magnitude. In order words, their ratio close to 1. If the null hypothesis is false, MST should be larger than MSE.

The mean squares are formed by dividing the sum of squares by the associated degrees of freedom.

Let N=$\sum y_i$.

Then, the degrees of freedom for treatment are

DFT=k-1,

and the degrees of freedom for errors are

DFE=N-k

The corresponding mean squares are:

MST=SST/DFT MSE=SSE/DFT

The F-test

The test statistics, used in testing the equality of treatment means is:

F = MST/MSE.

The critical value is the tabular value of the F distribution, based on the chosen α level and degrees of freedom DFT and DFT.

The calculations are displayed in an ANOVA table, as follows:

ANOVA table

Source	SS	DF	MSS	F
Treatments	SST	K-1	SST(K-T)	MST/MSE
Error	SSE	N-K	SSE(N-K)	
Total(corrected)	SS	N-1		

Decision Rule

The decision will be to reject the null hypothesis if the test statistic from the table is greater than the F critical value with k-1 numerator and N-K denominator degrees of freedom. If the decision is to reject the null then at least one of the means is different.

POST HOC TESTS

A post hoc test is used only after we find a statistically significant result and need to determine where our differences truly came from. There are many different post hoc tests that have been developed, and most of them will give similar results. The most commonly used ones are

Critical Difference- If the factors show significant effect then we would be interested to find out which pair(s) of treatments differs significantly. For this instead of calculating Student's t for different pairs of treatment means, we calculate least significant difference (LSD)at the given level of significance.

The C.D between any two factors at level of significance α is given by multiplying variance of difference with tabulated value of t distribution with corresponding degree of freedom. If the difference between any two treatments means is greater than C.D it is said to be significant, otherwise it is not significant.

Entity	Year	Coal electricity per capita (kWh)	Gas electricity per capita (kWh)	Solar electricity per capita (kWh)	Nuclear electricity per capita (kWh)	Hydro - electricity per capita (kWh)	other electricity per capita (kWh)
China	1985	245.84	0.92	0.00	0.00	87.14	53.46
China	1986	277.99	1.57	0.00	0.00	87.73	49.80
China	1987	309.85	2.50	0.00	0.00	91.19	49.82
China	1988	334.85	1.84	0.00	0.00	97.83	54.07
China	1989	357.07	3.27	0.00	0.00	104.38	50.80
China	1990	382.47	2.40	0.00	0.00	109.86	43.66
China	1991	425.78	2.07	0.00	0.00	106.51	44.36
China	1992	479.24	2.08	0.00	0.00	110.39	45.06
China	1993	492.73	2.61	0.00	1.34	126.98	54.91
China	1994	574.35	2.61	0.00	12.22	138.68	40.24
China	1995	609.03	2.46	0.01	10.53	156.45	45.73
China	1996	671.00	2.30	0.01	11.67	153.03	41.07
China	1997	700.46	6.53	0.01	11.65	158.33	38.22
China	1998	715.15	4.89	0.01	11.31	159.52	43.11
China	1999	772.39	3.83	0.01	11.91	156.58	40.41
China	2000	838.75	4.56	0.02	13.24	175.94	39.87
China	2001	887.17	3.87	0.02	13.73	217.98	40.69
China	2002	1001.28	3.27	0.04	19.62	224.81	42.23
China	2003	1179.30	4.00	0.05	33.63	220.10	45.29
China	2004	1328.19	5.75	0.06	38.92	272.62	53.47
China	2005	1517.49	9.30	0.06	40.69	304.26	44.28
China	2006	1753.44	18.14	0.07	41.76	331.88	37.13
China	2007	2010.35	25.66	0.08	47.01	367.20	32.86
China	2008	2036.52	25.99	0.11	51.41	478.86	35.17
China	2009	2174.19	42.24	0.21	52.31	459.73	45.25
China	2010	2398.47	57.66	0.52	55.44	527.66	66.13
China	2011	2719.68	80.15	1.92	64.25	506.99	83.90
China	2012	2742.79	80.68	2.63	71.95	631.36	105.46
China	2013	2962.99	84.58	6.08	81.03	661.01	134.73
China	2014	3034.29	96.22	16.97	96.17	765.01	155.61
China	2015	2903.15	119.76	28.33	122.97	799.68	178.90
China	2016	2964.82	134.30	47.46	152.07	822.65	223.53
China	2017	3141.25	144.09	83.53	175.92	826.12	279.43
China	2018	3361.81	152.07	124.84	208.18	846.03	331.95
China	2019	3414.67	163.52	157.54	245.24	894.98	371.74
China	2020	3453.38	177.20	183.24	257.00	927.56	430.15
China	2021	3744.42	191.18	229.33	285.79	911.71	587.55
USA	1985	6411.61	1335.00	0.05	1717.59	1221.29	458.23
USA	1986	6273.94	1125.05	0.06	1834.97	1250.35	618.37
USA	1987	6562.17	1222.17	0.04	1998.02	1064.86	531.22
USA	1988	6837.39	1121.92	0.04	2289.46	942.62	660.82

USA	1989	6986.79	1547.93	1.03	2274.78	1121.53	730.19
USA	1990	6953.92	1615.68	1.49	2447.65	1178.15	559.47
USA	1991	6847.41	1630.91	1.90	2563.22	1142.18	523.72
USA	1992	6887.43	1702.71	1.60	2552.53	985.31	433.46
USA	1993	7076.33	1724.08	1.84	2482.47	1079.11	480.38
USA	1994	6986.11	1886.80	1.91	2570.40	988.82	447.45
USA	1995	6975.09	2007.81	1.94	2668.23	1171.49	313.79
USA	1996	7233.71	1819.09	2.01	2640.45	1292.08	337.59
USA	1997	7335.82	1892.40	1.96	2429.30	1306.82	377.55
USA	1998	7355.99	2070.96	1.90	2570.96	1167.69	513.17
USA	1999	7299.42	2142.96	1.86	2745.82	1134.05	470.95
USA	2000	6962.75	2177.74	1.74	2669.60	956.20	695.58
USA	2001	6669.55	2238.87	1.89	2693.20	729.11	725.01
USA	2002	6704.10	2396.43	1.91	2705.25	886.39	637.73
USA	2003	6780.05	2232.53	1.82	2623.51	918.11	734.29
USA	2004	6730.11	2415.73	1.97	2682.55	884.27	729.76
USA	2005	6780.93	2563.51	1.85	2634.36	888.55	723.82
USA	2006	6640.50	2723.71	1.70	2626.23	943.08	565.70
USA	2007	6660.62	2961.55	2.01	2663.71	794.77	600.77
USA	2008	6496.02	2888.44	2.81	2637.30	813.03	599.09
USA	2009	5691.51	2985.23	2.88	2589.36	871.34	630.06
USA	2010	5936.35	3174.02	3.89	2593.23	818.49	694.35
USA	2011	5522.65	3229.58	5.80	2517.55	996.98	754.44
USA	2012	4781.41	3871.42	13.67	2429.58	856.75	807.80
USA	2013	4950.64	3522.00	28.31	2470.51	826.24	900.88
USA	2014	4911.62	3498.42	89.80	2475.42	786.22	957.69
USA	2015	4166.26	4107.97	120.24	2455.83	751.65	979.37
USA	2016	3787.02	4212.31	167.69	2462.30	798.05	1064.79
USA	2017	3656.37	3931.09	234.33	2440.79	890.99	1133.93
USA	2018	3460.86	4423.22	281.09	2429.94	862.95	1191.88
USA	2019	2886.34	4743.39	319.72	2421.07	845.33	1222.48
USA	2020	2302.15	4834.67	389.11	2351.24	833.33	1324.84
USA	2021	2664.38	4686.56	487.90	2309.19	731.37	1441.82
India	1985	148.72	2.77	0.00	5.78	66.41	15.21
India	1986	162.81	4.61	0.00	6.29	65.89	14.42
India	1987	187.32	5.19	0.00	6.52	60.02	15.14
India	1988	197.52	4.32	0.00	7.29	65.51	14.79
India	1989	217.10	8.54	0.00	4.72	74.38	15.03
India	1990	220.15	11.44	0.00	7.35	76.28	15.33
India	1991	240.87	15.02	0.00	6.09	83.15	15.25
India	1992	252.78	17.91	0.00	7.06	77.20	16.42
India	1993	272.88	19.30	0.00	6.72	76.36	15.44
India	1994	279.93	23.15	0.00	5.23	84.86	16.86
India	1995	307.27	30.52	0.00	7.90	78.73	17.96
India	1996	317.54	32.57	0.01	8.54	70.23	21.08
India	1997	325.07	40.09	0.01	10.05	70.05	21.83
India	1998	329.42	49.12	0.01	11.13	81.88	21.65
India	1999	351.21	56.71	0.01	12.23	79.05	25.23

India	2000	368.27	52.81	0.01	14.88	72.66	29.01
India	2001	378.41	51.84	0.01	17.51	66.75	28.68
India	2002	388.51	57.25	0.01	17.62	62.40	29.28
India	2003	395.08	65.15	0.02	16.23	62.02	32.58
India	2004	407.48	67.40	0.02	18.71	88.57	32.40
India	2005	414.40	65.36	0.02	15.36	84.37	30.66
India	2006	431.14	63.72	0.01	15.04	96.06	29.01
India	2007	448.24	75.69	0.05	14.99	103.06	27.27
India	2008	474.93	71.17	0.05	12.62	95.44	32.28
India	2009	499.42	85.29	0.07	13.75	86.90	33.50
India	2010	518.27	95.14	0.09	18.60	87.65	35.90
India	2011	557.60	93.48	0.66	25.62	104.72	40.11
India	2012	617.61	75.52	1.65	26.00	90.84	45.07
India	2013	656.77	51.36	2.66	25.80	102.22	48.90
India	2014	726.67	48.97	3.76	26.54	106.33	53.15
India	2015	760.89	48.96	4.97	28.96	100.75	54.79
India	2016	802.01	54.25	8.64	28.31	95.90	57.95
India	2017	823.54	55.38	15.91	27.63	100.30	63.62
India	2018	875.72	52.05	26.54	28.52	102.08	68.47
India	2019	866.71	52.02	33.45	32.65	117.18	70.64
India	2020	806.20	53.32	42.02	31.95	117.24	68.38
India	2021	903.08	45.60	48.53	31.20	113.91	75.22
Russia	1985	968.20	3158.00	0.00	695.03	1117.77	793.14
Russia	1986	999.95	3261.54	0.00	730.47	1140.82	819.15
Russia	1987	1029.46	3357.82	0.00	858.17	1118.48	843.33
Russia	1988	1034.39	3373.88	0.00	920.45	1098.72	847.36
Russia	1989	1042.49	3400.30	0.00	925.32	1084.05	853.99
Russia	1990	1059.79	3456.73	0.00	799.46	1127.29	868.17
Russia	1991	1042.31	3376.85	0.00	808.21	1132.29	835.09
Russia	1992	1036.21	3094.20	0.00	804.34	1160.49	672.73
Russia	1993	996.60	2882.31	0.00	800.46	1170.53	556.66
Russia	1994	1091.75	2444.03	0.00	657.26	1182.07	492.31
Russia	1995	1079.02	2379.85	0.00	669.99	1186.44	456.33
Russia	1996	1083.63	2456.34	0.00	735.50	1040.99	381.21
Russia	1997	1061.39	2412.25	0.00	733.39	1064.17	350.09
Russia	1998	1103.61	2346.43	0.00	702.36	1073.30	358.52
Russia	1999	1095.05	2434.11	0.00	827.18	1089.29	277.61
Russia	2000	1129.22	2381.63	0.00	833.94	1117.37	213.29
Russia	2001	1090.43	2434.09	0.00	857.25	1189.18	195.30
Russia	2002	1105.16	2496.05	0.00	921.35	1114.22	180.09
Russia	2003	1119.65	2644.63	0.00	973.94	1074.60	180.89
Russia	2004	1049.71	2757.46	0.00	952.31	1217.98	161.82
Russia	2005	1085.60	2882.54	0.00	957.16	1200.83	145.13
Russia	2006	1176.51	3012.79	0.00	1009.15	1209.37	166.95
Russia	2007	1118.45	3204.50	0.00	1034.04	1237.09	120.11
Russia	2008	1296.56	3260.19	0.00	1062.71	1151.47	112.66
Russia	2009	1081.42	3090.59	0.00	1067.17	1216.65	112.04
Russia	2010	1093.74	3427.68	0.00	1112.87	1162.22	68.35

Russia	2011	1081.23	3415.77	0.00	1130.13	1156.77	187.28
Russia	2012	1109.73	3451.38	0.00	1157.77	1155.06	190.98
Russia	2013	1060.94	3473.54	0.00	1121.03	1258.36	63.21
Russia	2014	1035.31	3489.20	1.11	1171.78	1214.75	77.49
Russia	2015	1033.88	3454.52	2.35	1263.65	1161.21	73.20
Russia	2016	1113.99	3390.55	3.17	1268.36	1272.21	78.29
Russia	2017	1133.15	3361.78	3.85	1307.09	1271.96	52.59
Russia	2018	1151.85	3415.74	4.94	1247.90	1312.30	59.66
Russia	2019	1218.52	3328.68	8.78	1341.68	1336.06	63.95
Russia	2020	1139.42	3013.24	13.87	1481.55	1459.92	67.71
Russia	2021	1324.03	3213.17	15.85	1532.98	1478.26	87.94
Japan	1985	820.14	1057.17	0.00	1317.53	684.24	1518.01
Japan	1986	811.55	1074.97	0.00	1358.72	664.00	1485.85
Japan	1987	877.85	1104.44	0.00	1542.54	611.66	1568.62
Japan	1988	913.68	1155.82	0.00	1416.12	735.28	1734.95
Japan	1989	948.05	1213.49	0.00	1507.37	744.22	1880.39
Japan	1990	964.41	1398.14	0.01	1573.10	702.54	2324.73
Japan	1991	1012.07	1485.76	0.01	1682.01	760.97	2220.02
Japan	1992	1060.51	1479.85	0.08	1744.03	643.23	2267.20
Japan	1993	1123.82	1461.17	0.18	1985.10	741.95	1913.75
Japan	1994	1253.58	1591.44	0.23	2064.01	515.20	2246.80
Japan	1995	1344.14	1603.75	0.31	2287.17	628.16	1982.52
Japan	1996	1419.31	1693.49	0.43	2358.31	613.82	1887.12
Japan	1997	1492.80	1743.08	0.76	2548.30	685.88	1657.92
Japan	1998	1521.93	1821.73	1.13	2580.78	705.25	1523.35
Japan	1999	1672.10	1933.44	1.72	2506.69	662.10	1527.20
Japan	2000	1598.93	1734.88	2.76	2412.78	681.21	1364.15
Japan	2001	1699.44	1716.91	3.70	2391.36	655.72	1168.06
Japan	2002	1821.18	1740.82	5.26	2202.17	640.60	1339.73
Japan	2003	1934.63	1809.06	7.06	1788.28	734.57	1380.76
Japan	2004	1989.48	1736.73	9.32	2101.65	729.37	1302.49
Japan	2005	2091.50	1658.32	11.66	2194.86	592.42	1394.70
Japan	2006	2052.82	1846.41	14.00	2279.40	677.47	1201.54
Japan	2007	2187.47	2046.38	15.78	2088.49	572.39	1475.86
Japan	2008	2084.05	2028.61	17.57	1883.62	590.89	1249.24
Japan	2009	2008.40	2089.81	21.54	2053.20	594.22	860.15
Japan	2010	2289.05	2355.79	27.63	2172.90	651.26	950.86
Japan	2011	2090.66	2785.62	37.81	1198.21	660.51	1406.25
Japan	2012	2461.80	3206.95	51.70	118.26	595.84	1751.38
Japan	2013	2676.40	3126.98	100.88	81.69	619.05	1460.46
Japan	2014	2679.47	3397.40	180.03	0.00	652.35	1160.53
Japan	2015	2661.43	3177.97	273.48	25.46	681.72	1076.22
Japan	2016	2614.14	3194.17	360.33	117.09	623.18	1004.62
Japan	2017	2578.66	3225.74	434.78	219.09	658.60	849.11
Japan	2018	2549.98	3142.74	496.37	378.75	638.62	809.47
Japan	2019	2536.26	3002.19	551.55	507.82	634.54	655.77
Japan	2020	2477.47	2939.76	631.48	334.23	629.25	685.78
Japan	2021	2500.71	2701.41	711.81	491.28	635.09	651.78

Brazil	1985	36.15	0.00	0.00	24.72	1304.07	28.62
Brazil	1986	44.29	0.00	0.00	1.03	1306.32	72.96
Brazil	1987	37.97	0.00	0.00	6.83	1302.76	54.63
Brazil	1988	32.46	0.03	0.00	4.19	1370.65	49.52
Brazil	1989	36.81	1.45	0.00	12.36	1383.01	41.57
Brazil	1990	30.66	2.16	0.00	14.84	1371.59	33.64
Brazil	1991	36.09	2.43	0.00	9.40	1420.29	34.21
Brazil	1992	32.12	2.50	0.00	11.28	1432.60	40.62
Brazil	1993	30.98	2.45	0.00	2.79	1483.61	39.23
Brazil	1994	30.88	2.98	0.00	0.34	1507.67	40.02
Brazil	1995	33.28	3.42	0.00	15.41	1552.79	46.37
Brazil	1996	36.29	5.87	0.00	14.62	1600.66	56.19
Brazil	1997	43.37	6.98	0.00	18.80	1655.16	59.17
Brazil	1998	40.77	7.72	0.00	19.09	1704.10	65.57
Brazil	1999	58.11	15.29	0.00	22.92	1688.89	95.91
Brazil	2000	60.61	21.83	0.00	28.09	1713.50	123.84
Brazil	2001	60.88	52.47	0.00	80.07	1488.12	131.87
Brazil	2002	49.92	64.94	0.00	76.69	1569.34	124.61
Brazil	2003	49.06	67.95	0.00	73.37	1656.69	118.11
Brazil	2004	55.76	98.47	0.00	62.80	1719.29	127.16
Brazil	2005	57.87	94.76	0.00	49.25	1788.46	128.11
Brazil	2006	55.66	91.14	0.00	68.74	1828.83	137.22
Brazil	2007	55.46	76.32	0.00	61.07	1940.83	157.83
Brazil	2008	60.57	142.78	0.00	68.56	1898.87	189.13
Brazil	2009	50.69	65.34	0.00	62.82	1989.95	189.19
Brazil	2010	56.79	177.49	0.00	70.13	2053.90	243.03
Brazil	2011	63.63	121.40	0.00	74.68	2161.26	240.13
Brazil	2012	70.96	224.83	0.00	75.86	2076.93	287.53
Brazil	2013	106.04	327.88	0.00	72.62	1938.26	348.60
Brazil	2014	128.63	382.14	0.10	71.07	1835.45	442.45
Brazil	2015	127.30	369.22	0.29	67.79	1753.22	467.77
Brazil	2016	120.90	261.39	0.39	72.37	1841.39	465.82
Brazil	2017	118.18	300.81	3.98	71.27	1778.90	514.14
Brazil	2018	107.91	249.14	16.37	70.37	1850.77	532.43
Brazil	2019	110.77	273.82	31.12	71.58	1878.72	555.19
Brazil	2020	91.61	241.47	49.91	61.96	1858.99	577.78
Brazil	2021	117.67	424.73	78.15	68.59	1692.84	709.48
Canada	1985	3074.03	263.43	0.00	2341.79	11749.19	262.27
Canada	1986	2742.64	263.67	0.00	2728.86	11894.40	236.14
Canada	1987	3186.38	232.97	0.00	2922.47	11960.79	380.60
Canada	1988	3421.88	351.74	0.00	3090.31	11465.01	441.65
Canada	1989	3367.19	544.52	0.00	2911.31	10660.90	667.11
Canada	1990	2972.82	349.06	0.00	2619.93	10691.01	595.50
Canada	1991	3158.40	307.76	0.00	3010.41	10967.97	504.61
Canada	1992	3175.93	462.90	0.07	2822.88	11118.20	552.18
Canada	1993	2873.71	533.66	0.07	3253.93	11239.43	420.92
Canada	1994	2989.91	532.66	0.07	3694.96	11312.70	349.43
Canada	1995	3127.54	682.00	0.13	3317.38	11405.47	217.23

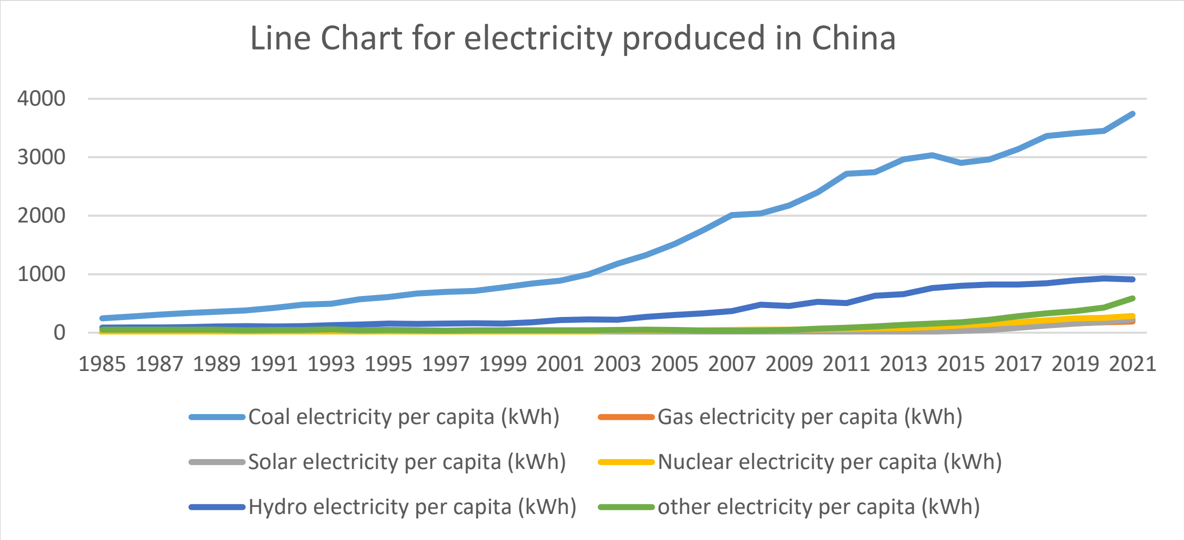
Canada	1996	3028.37	629.24	0.20	3112.88	11981.95	252.90
Canada	1997	3243.54	763.86	0.23	2742.54	11668.26	404.47
Canada	1998	3516.15	876.56	0.34	2355.05	10976.02	561.29
Canada	1999	3493.00	916.94	0.44	2400.68	11348.79	492.82
Canada	2000	3559.26	1097.01	0.65	2253.99	11567.20	699.08
Canada	2001	3388.08	1282.79	0.65	2350.11	10643.89	796.38
Canada	2002	3321.90	1164.98	0.64	2290.69	11079.93	784.42
Canada	2003	3252.43	1149.61	0.63	2250.20	10565.33	883.95
Canada	2004	2919.94	1182.01	0.31	2690.87	10573.87	883.69
Canada	2005	3078.29	1103.80	0.62	2695.25	11121.83	825.37
Canada	2006	2805.56	1182.23	0.61	2841.52	10737.78	649.21
Canada	2007	2992.47	1208.98	0.91	2683.61	11073.73	692.89
Canada	2008	2850.22	1120.76	1.20	2658.15	11249.14	629.47
Canada	2009	2337.03	1248.74	2.98	2534.09	10863.87	728.70
Canada	2010	2262.73	1381.49	7.36	2518.30	10242.49	718.42
Canada	2011	2056.32	1609.39	16.61	2572.29	10837.17	725.16
Canada	2012	1786.59	1629.20	25.08	2579.57	10851.53	776.84
Canada	2013	1797.87	1536.63	42.21	2782.94	11061.87	966.24
Canada	2014	1721.53	1624.93	59.31	2858.67	10695.78	1006.08
Canada	2015	1609.76	1777.39	80.32	2688.06	10589.07	1137.07
Canada	2016	1614.08	1650.07	110.48	2649.70	10566.12	1266.56
Canada	2017	1522.12	1489.29	96.84	2614.46	10686.56	1227.49
Canada	2018	1262.31	1678.67	101.52	2565.93	10315.04	1246.38
Canada	2019	1169.70	1699.51	107.67	2544.33	10020.10	1193.15
Canada	2020	905.02	1724.00	111.91	2445.32	10053.92	1231.24
Canada	2021	964.75	1894.64	133.93	2289.61	9884.94	1237.58

DATA ANALYSIS

Graphical Representation of data:

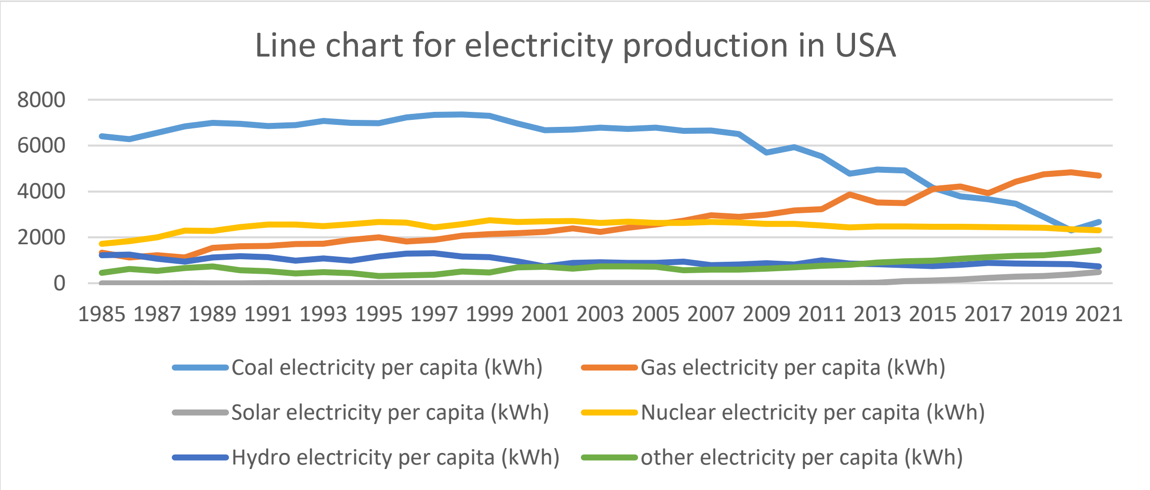
Now representing the data of different countries through line chart, so as to visualize the production of electricity through different methods.

Line Chart representation of electricity production by different methods in China:



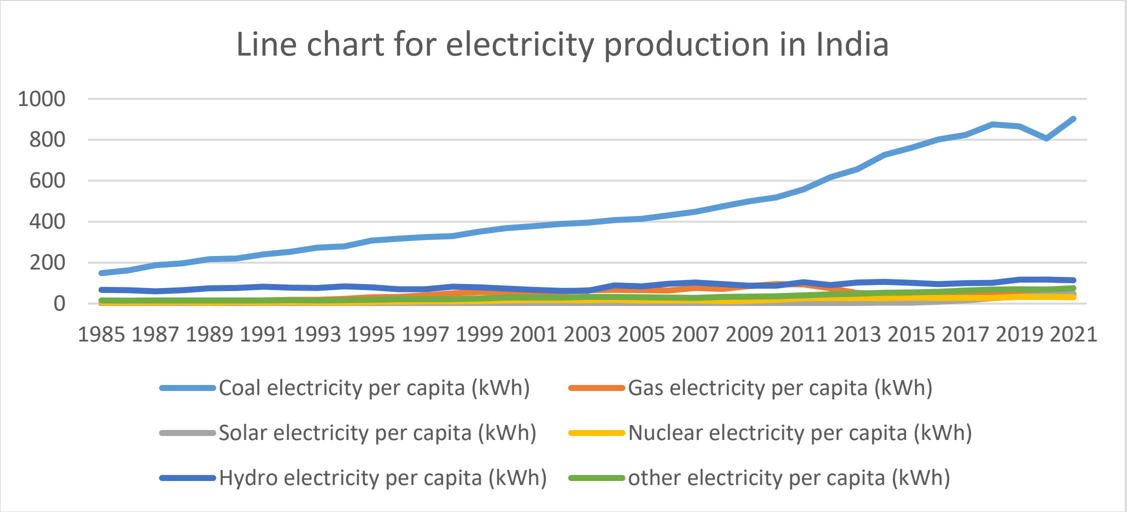
Interpretation: There is a steady increase in the production of electricity throughout the period of 1985 to 2021. The maximum electricity is produced in China by coal. The electricity production is uniformly increasing using nuclear energy and hydro energy.

Line Chart representation of electricity production by different methods in USA:



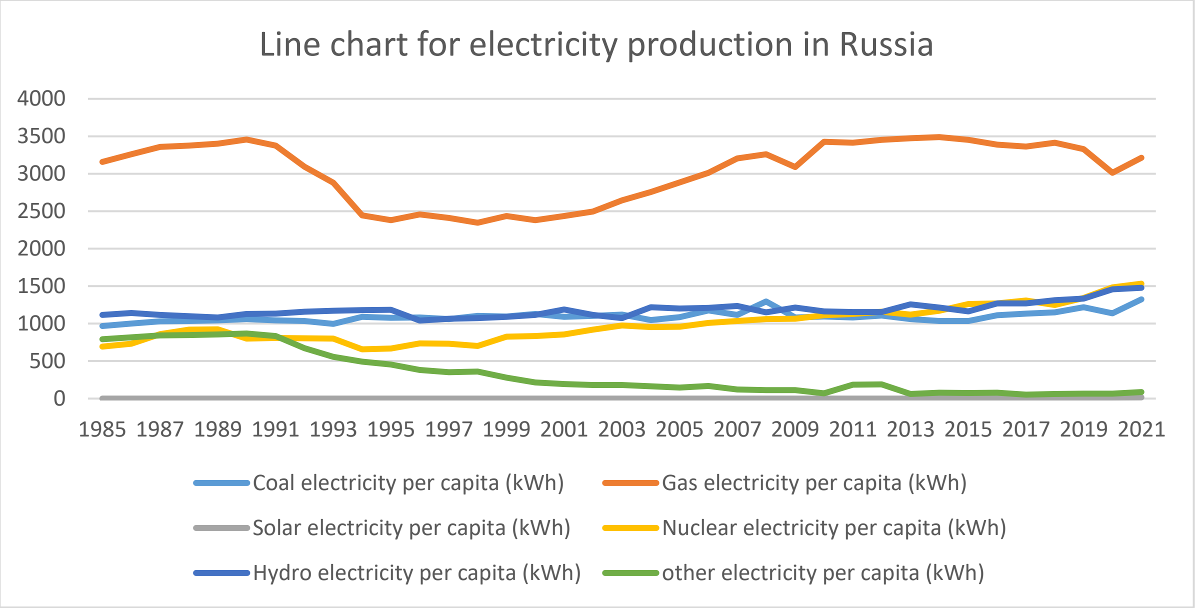
Interpretation: The electricity production using Coal was constant in period 1985 to 2008 and then started decreasing from year 2009 and continue till 2021. The electricity production using Gas shows an increase throughout the period of 1985 to 2021.

Line Chart representation of electricity production by different methods in India:



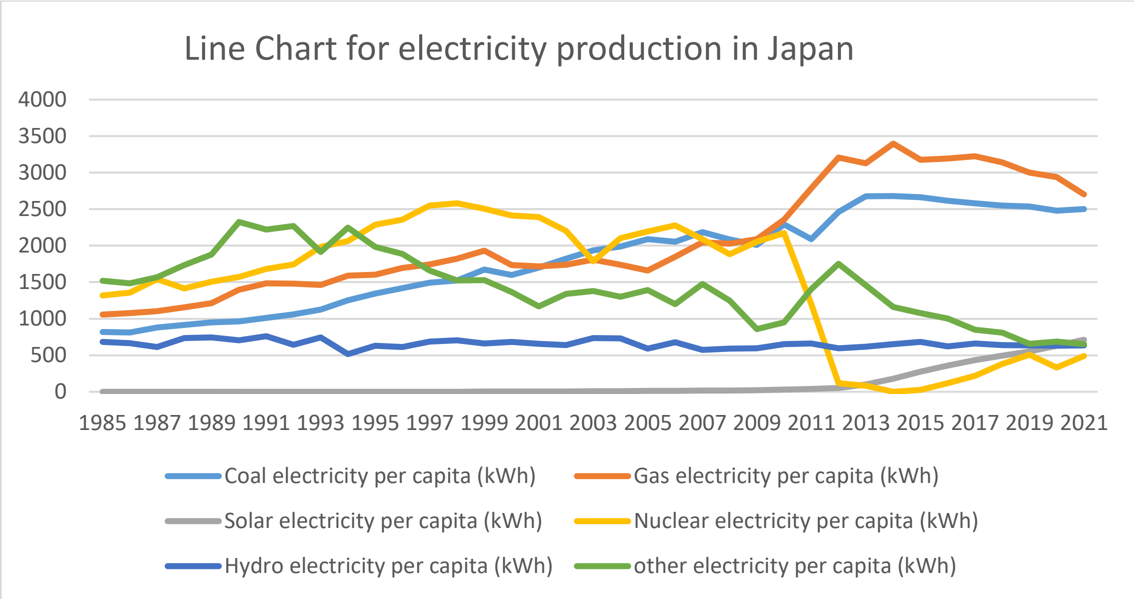
Interpretation: The chart shows that maximum electricity is produced by Coal in India. The electricity produced using hydro, gas, nuclear doesn't shows changes whereas the minimum electricity is produced using solar energy.

Line Chart representation of electricity production by different methods in Russia:



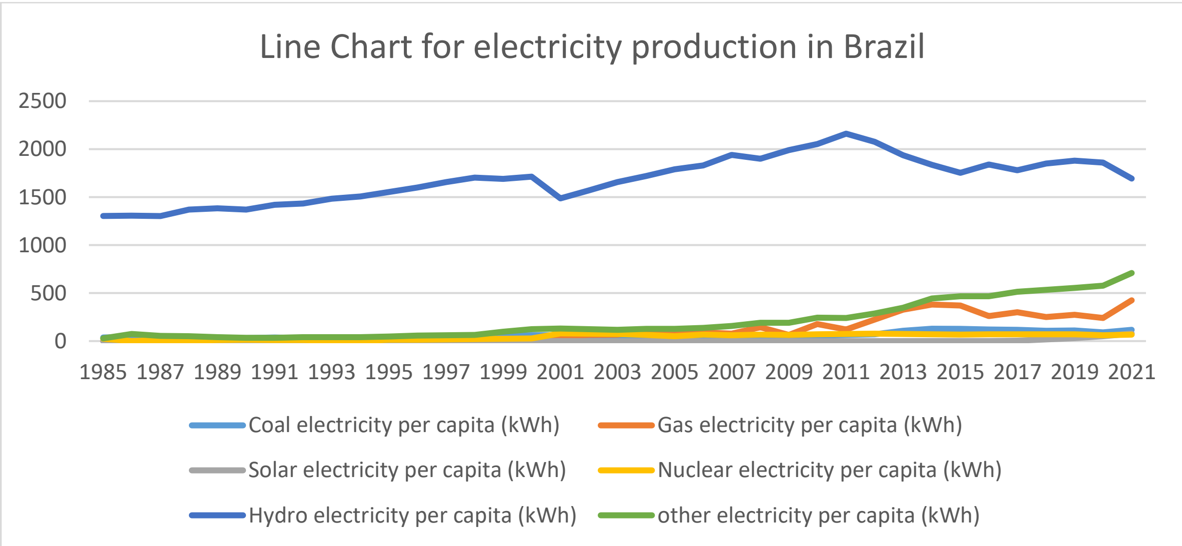
Interpretation: There is a fluctuation in production of electricity throughout the period 1985 to 2021 in Russia. The electricity production using gas also shows the changes over the time period. The electricity production remains constant using Gas, Coal, Hydro and Nuclear energy.

Bar Chart representation of electricity production by different methods in Japan:



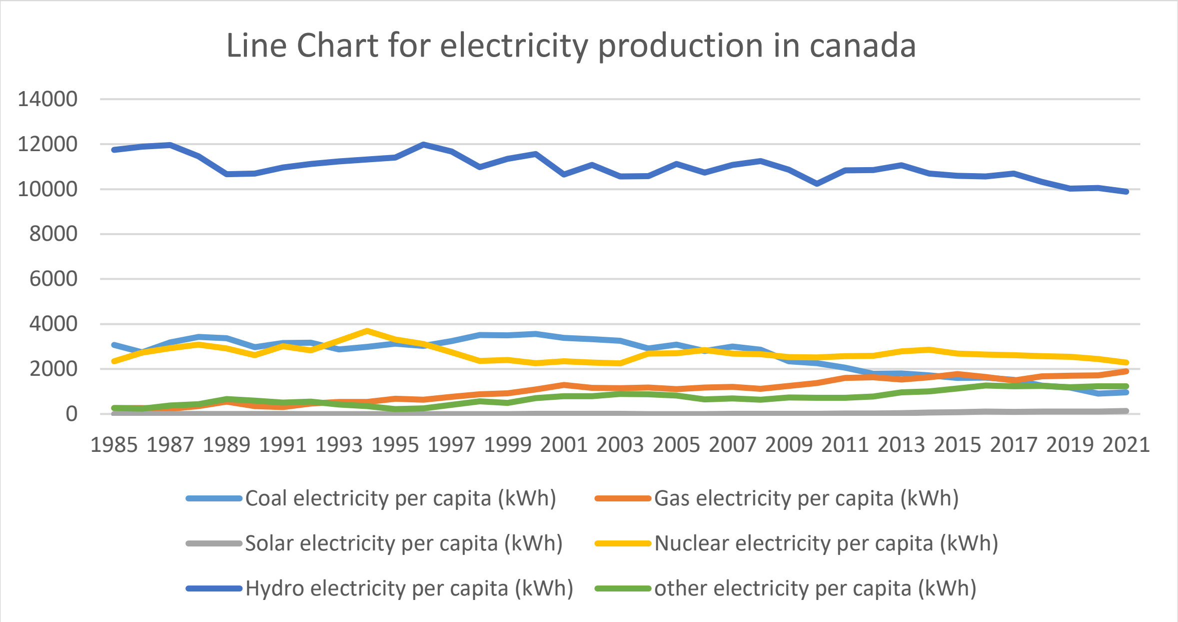
Interpretation: The electricity production in Japan using nuclear energy shows the downfall while the production using coal and gas shows the rise. There is very minimum production of electricity using solar energy. The electricity production by using hydro energy remains constant throughout the period of 1985 to 2021.

Line Chart representation of electricity production by different methods in Brazil



Interpretation: The maximum electricity is produced using hydro energy, while the minimum electricity is produced using solar energy. The electricity production shows a steady increase from 1985 to 2021. The electricity production using Gas, nuclear and coal shows a very little increment.

Line Chart representation of electricity production by different methods in Canada:



Interpretation: Canada is producing most of its electricity using hydroelectricity. The production using nuclear and gas doesn't show significant changes. The production of electricity using Coal is decreasing, the decrement started from 2009 and continues till 2021.

Comparison of Electricity Production by Coal in different Countries:

The null and alternative hypothesis are:

H_o: There is no significant difference between the average electricity produced by coal in different countries.

H_a: There is a significant difference between the average electricity produced by coal in different countries.

Factor Information

Factor	Levels	Values
Factor	7	CHINA, USA, INDIA, RUSSIA, JAPAN, BRAZIL, CANADA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	6	846936140	141156023	213.50	0.000
Error	252	166611743	661158		
Total	258	1013547882			

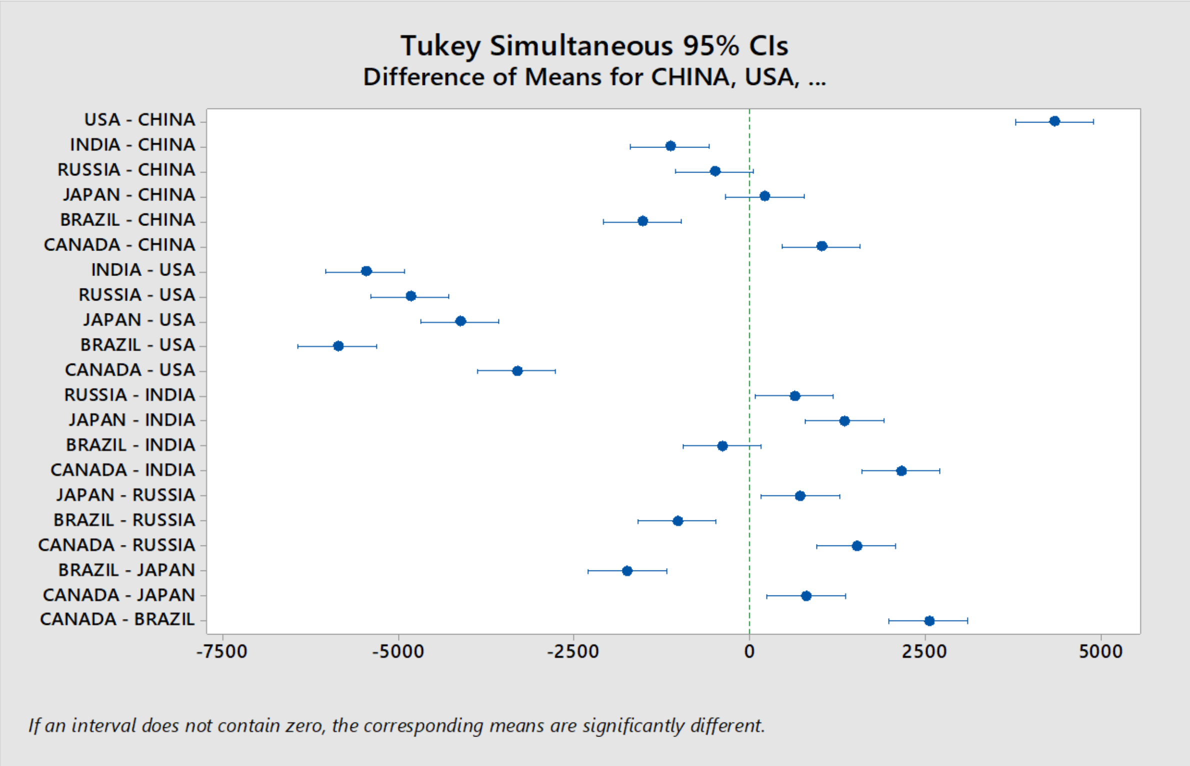
Here, we observed from the ANOVA table that the p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by coal in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by coal exists.

Tukey Pairwise Comparisons

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
USA - CHINA	4331	189	(3774, 4888)	22.91	0.000
INDIA - CHINA	-1135	189	(-1692, -577)	-6.00	0.000
RUSSIA - CHINA	-498	189	(-1056, 59)	-2.64	0.115
JAPAN - CHINA	214	189	(-344, 771)	1.13	0.919
BRAZIL - CHINA	-1529	189	(-2087, -972)	-8.09	0.000
CANADA - CHINA	1017	189	(460, 1575)	5.38	0.000
INDIA - USA	-5466	189	(-6023, -4908)	-28.91	0.000
RUSSIA - USA	-4830	189	(-5387, -4272)	-25.55	0.000
JAPAN - USA	-4117	189	(-4675, -3560)	-21.78	0.000
BRAZIL - USA	-5860	189	(-6418, -5303)	-31.00	0.000
CANADA - USA	-3314	189	(-3871, -2757)	-17.53	0.000
RUSSIA - INDIA	636	189	(79, 1194)	3.37	0.013
JAPAN - INDIA	1348	189	(791, 1906)	7.13	0.000
BRAZIL - INDIA	-394	189	(-952, 163)	-2.09	0.361
CANADA - INDIA	2152	189	(1594, 2709)	11.38	0.000
JAPAN - RUSSIA	712	189	(155, 1270)	3.77	0.003

BRAZIL - RUSSIA	-1031	189	(-1588, -473)	-5.45	0.000
CANADA - RUSSIA	1516	189	(958, 2073)	8.02	0.000
BRAZIL - JAPAN	-1743	189	(-2300, -1185)	-9.22	0.000
CANADA - JAPAN	804	189	(246, 1361)	4.25	0.000
CANADA - BRAZIL	2546	189	(1989, 3104)	13.47	0.000

Individual confidence level = 99.65%



Interpretation: The p- value of the difference between the electricity produced by coal in USA and CHINA, INDIA and CHINA, BRAZIL and CHINA, CANADA and CHINA, INDIA and USA, RUSSIA and USA, JAPAN and USA, BRAZIL and USA, CANADA and USA, RUSSIA and INDIA, JAPAN and INDIA, CANADA and INDIA, JAPAN and RUSSIA, BRAZIL and RUSSIA, CANADA and RUSSIA, BRAZIL and JAPAN, CANADA and JAPAN, CANADA and BRAZIL is less than 0.05. So, there exist a significant difference between the electricity produced by coal in these countries.

The p- value of the difference between the electricity produced by coal in RUSSIA and CHINA, JAPAN and CHINA, BRAZIL and INDIA is more than 0.05. So, there doesn't exist a significant difference between the electricity produced by coal in these countries.

Comparison of Electricity Production by Gas in different Countries:

The null and alternative hypothesis are:

H_o: There is no significant difference between the average electricity produced by gas in different countries.

H_a: There is a significant difference between the average electricity produced by gas in different countries.

Factor Information

Factor	Levels	Values
Factor	7	CHINA, USA, INDIA, RUSSIA, JAPAN, BRAZIL, CANADA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	6	377501633	62916939	200.09	0.000
Error	252	79241038	314449		
Total	258	456742671			

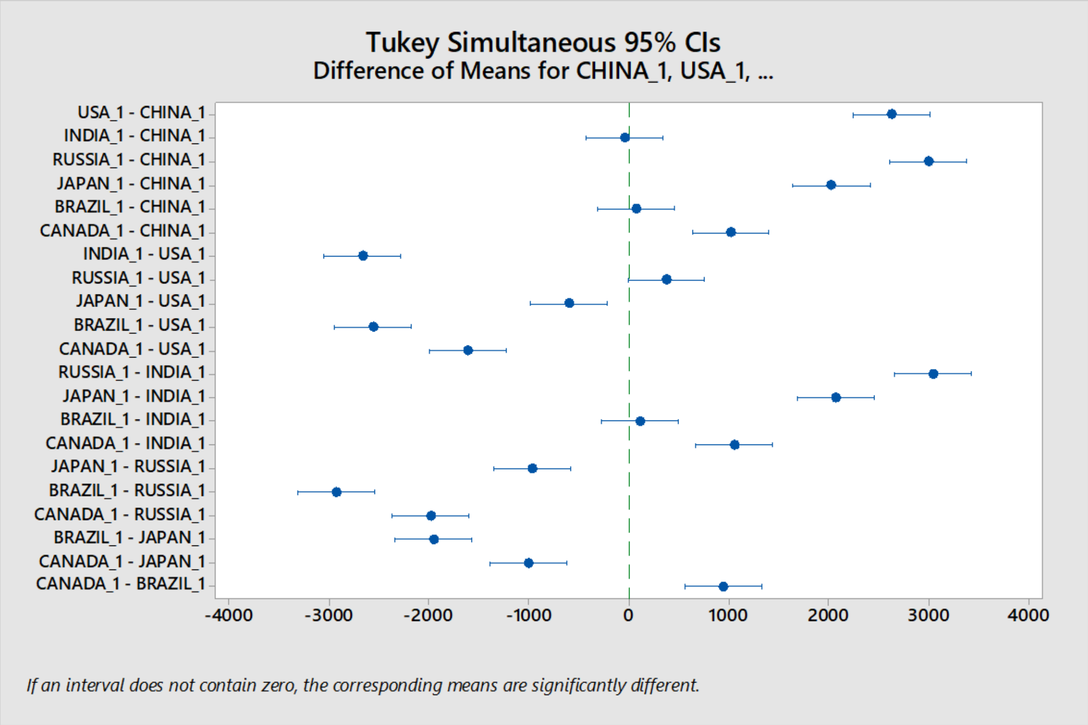
Here, we observed from the ANOVA table that the p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by gas in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by gas exists.

Tukey Pairwise Comparisons

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
USA - CHINA	2622	130	(2237, 3006)	20.11	0.000
INDIA - CHINA	-42	130	(-427, 342)	-0.32	1.000
RUSSIA - CHINA	2994	130	(2609, 3378)	22.96	0.000
JAPAN - CHINA	2022	130	(1638, 2406)	15.51	0.000

BRAZIL - CHINA	68	130	(-316, 452)	0.52	0.999
CANADA - CHINA	1013	130	(629, 1397)	7.77	0.000
INDIA - USA	-2664	130	(-3048, -2279)	-20.43	0.000
RUSSIA - USA	372	130	(-12, 757)	2.85	0.065
JAPAN - USA	-599	130	(-984, -215)	-4.60	0.000
BRAZIL - USA	-2554	130	(-2938, -2169)	-19.59	0.000
CANADA - USA	-1609	130	(-1993, -1224)	-12.34	0.000
RUSSIA - INDIA	3036	130	(2652, 3420)	23.29	0.000
JAPAN - INDIA	2064	130	(1680, 2449)	15.83	0.000
BRAZIL - INDIA	110	130	(-274, 495)	0.85	0.980
CANADA - INDIA	1055	130	(671, 1440)	8.09	0.000
JAPAN - RUSSIA	-972	130	(-1356, -587)	-7.45	0.000
BRAZIL - RUSSIA	-2926	130	(-3310, -2541)	-22.44	0.000
CANADA - RUSSIA	-1981	130	(-2365, -1596)	-15.19	0.000
BRAZIL - JAPAN	-1954	130	(-2338, -1570)	-14.99	0.000
CANADA - JAPAN	-1009	130	(-1393, -625)	-7.74	0.000
CANADA - BRAZIL	945	130	(561, 1329)	7.25	0.000

Individual confidence level = 99.65%



The p- value of the difference between the electricity produced by gas in USA and CHINA, RUSSIA and CHINA, JAPAN and CHINA, BRAZIL and CHINA, CANADA and CHINA, INDIA and USA, RUSSIA and USA, JAPAN and USA, BRAZIL and USA, CANADA and USA, RUSSIA and INDIA, JAPAN and INDIA, CANADA and INDIA, JAPAN and RUSSIA, BRAZIL and RUSSIA, CANADA and RUSSIA, BRAZIL and JAPAN, CANADA and JAPAN, CANADA and BRAZIL is less than 0.05. So, there exist a significant difference between the electricity produced by gas in these countries.

The p- value of the difference between the electricity produced by gas in INDIA and CHINA, BRAZIL and CHINA, RUSSIA and USA, BRAZIL and INDIA is more than 0.05. So, there doesn’t exist a significant difference between the electricity produced by gas in these countries.

Comparison of Electricity Production by solar energy in different Countries:

The null and alternative hypothesis are:

H_o: There is no significant difference between the average electricity produced by solar energy in different countries.

H_a: There is a significant difference between the average electricity produced by solar energy in different countries.

Factor Information

Factor	Levels	Values
Factor	7	CHINA, USA, INDIA, RUSSIA, JAPAN, BRAZIL, CANADA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	6	329928	54988	6.25	0.000
Error	252	2216389	8795		
Total	258	2546317			

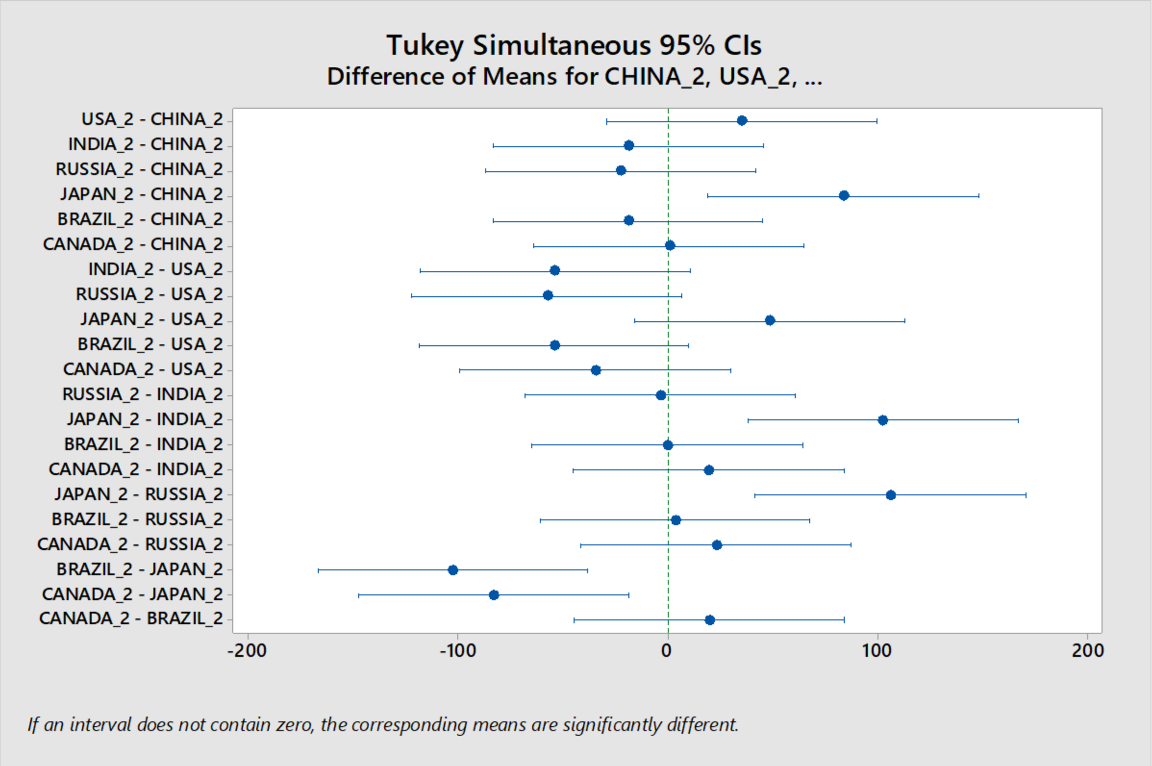
Here, we observed from the ANOVA table that the p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by solar energy in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by solar exists.

Tukey Simultaneous Tests for Differences of Means

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
USA - CHINA	35.1	21.8	(-29.2, 99.4)	1.61	0.676
INDIA - CHINA	-18.8	21.8	(-83.0, 45.5)	-0.86	0.978
RUSSIA - CHINA	-22.4	21.8	(-86.7, 41.9)	-1.03	0.948
JAPAN - CHINA	83.5	21.8	(19.2, 147.8)	3.83	0.002
BRAZIL - CHINA	-19.0	21.8	(-83.3, 45.3)	-0.87	0.977
CANADA - CHINA	0.6	21.8	(-63.7, 64.9)	0.03	1.000
INDIA - USA	-53.9	21.8	(-118.1, 10.4)	-2.47	0.170
RUSSIA - USA	-57.5	21.8	(-121.8, 6.8)	-2.64	0.115
JAPAN - USA	48.4	21.8	(-15.9, 112.7)	2.22	0.285
BRAZIL - USA	-54.1	21.8	(-118.4, 10.2)	-2.48	0.166
CANADA - USA	-34.5	21.8	(-98.8, 29.8)	-1.58	0.693

RUSSIA - INDIA	-3.7	21.8	(-67.9, 60.6)	-0.17	1.000
JAPAN - INDIA	102.2	21.8	(37.9, 166.5)	4.69	0.000
BRAZIL - INDIA	-0.2	21.8	(-64.5, 64.1)	-0.01	1.000
CANADA - INDIA	19.3	21.8	(-45.0, 83.6)	0.89	0.975
JAPAN - RUSSIA	105.9	21.8	(41.6, 170.2)	4.86	0.000
BRAZIL - RUSSIA	3.4	21.8	(-60.9, 67.7)	0.16	1.000
CANADA - RUSSIA	23.0	21.8	(-41.3, 87.3)	1.05	0.941
BRAZIL - JAPAN	-102.5	21.8	(-166.8, -38.2)	-4.70	0.000
CANADA - JAPAN	-82.9	21.8	(-147.2, -18.6)	-3.80	0.003
CANADA - BRAZIL	19.6	21.8	(-44.7, 83.9)	0.90	0.973

Individual confidence level = 99.65%



The p- value of the difference between the electricity produced by solar energy in JAPAN and CHINA, JAPAN and INDIA, JAPAN and RUSSIA, BRAZIL and JAPAN, CANADA and JAPAN is less than 0.05. So, there exist a significant difference between the electricity produced by solar energy in these countries.

The p- value of the difference between the electricity produced by solar energy in USA and CHINA, INDIA and CHINA, RUSSIA and CHINA, BRAZIL and CHINA, CANADA and CHINA, INDIA and USA, RUSSIA and USA, JAPAN and USA, BRAZIL and USA, CANADA and USA, RUSSIA and INDIA, BRAZIL and INDIA, CANADA and INDIA, BRAZIL and RUSSIA, CANADA and RUSSIA is more than 0.05. So, there doesn’t exist a significant difference between the electricity produced by solar energy in these countries.

Comparison of Electricity Production by nuclear energy in different Countries:

The null and alternative hypothesis are:

H_o: There is no significant difference between the average electricity produced by nuclear energy in different countries.

H_a: There is a significant difference between the average electricity produced by nuclear energy in different countries.

Factor Information

Factor	Levels	Values
Factor	7	CHINA, USA, INDIA, RUSSIA, JAPAN, BRAZIL, CANADA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	6	295246805	49207801	358.58	0.000
Error	252	34582341	137232		
Total	258	329829146			

Here, we observed from the ANOVA table that the p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by nuclear energy in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by nuclear energy exists.

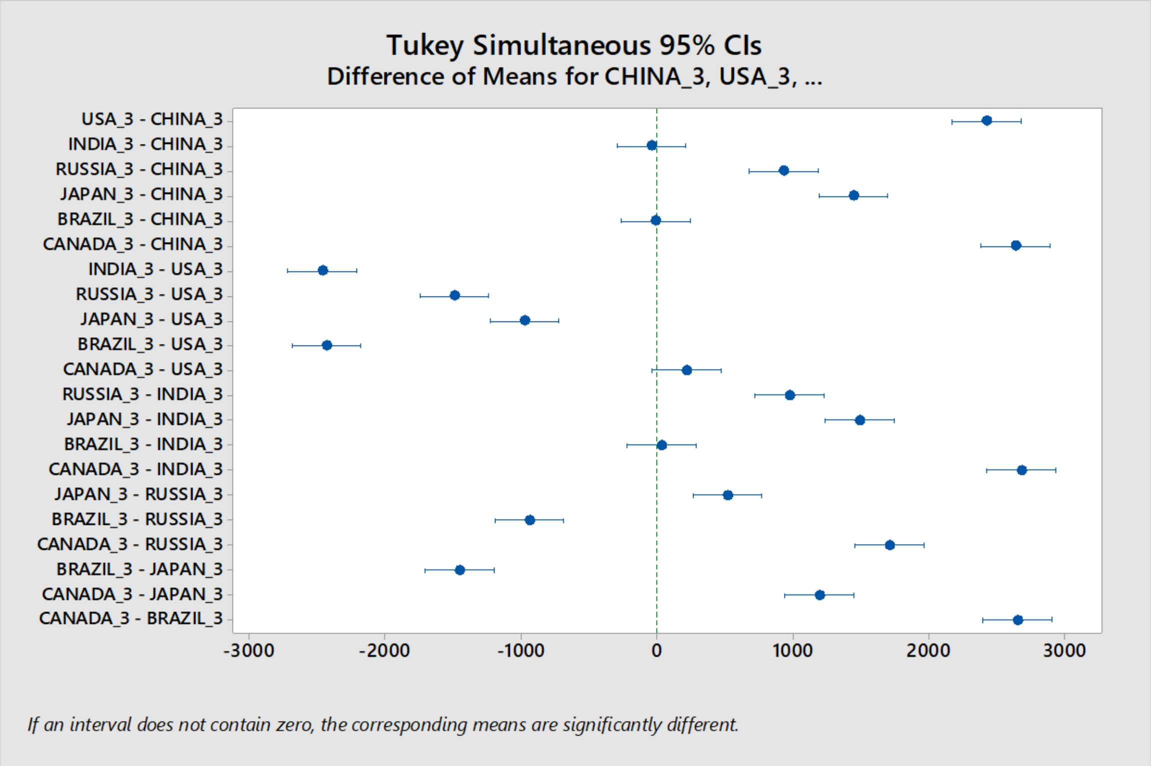
.

Tukey Simultaneous Tests for Differences of Means

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
USA - CHINA	2417.0	86.1	(2163.0, 2670.9)	28.06	0.000
INDIA - CHINA	-44.3	86.1	(-298.2, 209.7)	-0.51	0.999
RUSSIA - CHINA	925.3	86.1	(671.3, 1179.2)	10.74	0.000
JAPAN - CHINA	1439.8	86.1	(1185.9, 1693.8)	16.72	0.000
BRAZIL - CHINA	-15.7	86.1	(-269.6, 238.3)	-0.18	1.000
CANADA - CHINA	2633.6	86.1	(2379.7, 2887.6)	30.58	0.000
INDIA - USA	-2461.2	86.1	(-2715.2, -2207.3)	-28.58	0.000
RUSSIA - USA	-1491.7	86.1	(-1745.7, -1237.8)	-17.32	0.000
JAPAN - USA	-977.2	86.1	(-1231.1, -723.2)	-11.35	0.000
BRAZIL - USA	-2432.7	86.1	(-2686.6, -2178.7)	-28.25	0.000
CANADA - USA	216.6	86.1	(-37.3, 470.6)	2.52	0.154
RUSSIA - INDIA	969.5	86.1	(715.6, 1223.5)	11.26	0.000
JAPAN - INDIA	1484.1	86.1	(1230.1, 1738.0)	17.23	0.000
BRAZIL - INDIA	28.6	86.1	(-225.4, 282.5)	0.33	1.000
CANADA - INDIA	2677.9	86.1	(2423.9, 2931.8)	31.09	0.000
JAPAN - RUSSIA	514.6	86.1	(260.6, 768.5)	5.97	0.000
BRAZIL - RUSSIA	-940.9	86.1	(-1194.9, -687.0)	-10.93	0.000
CANADA - RUSSIA	1708.4	86.1	(1454.4, 1962.3)	19.84	0.000
BRAZIL - JAPAN	-1455.5	86.1	(-1709.5, -1201.6)	-16.90	0.000

CANADA - JAPAN	1193.8	86.1	(939.8, 1447.8)	13.86	0.000
CANADA - BRAZIL	2649.3	86.1	(2395.4, 2903.3)	30.76	0.000

Individual confidence level = 99.65%



The p- value of the difference between the electricity produced by nuclear energy in USA and CHINA, RUSSIA and CHINA, JAPAN and CHINA, CANADA and CHINA, INDIA and USA, RUSSIA and USA, JAPAN and USA, BRAZIL and USA, RUSSIA and INDIA, JAPAN and INDIA, CANADA and INDIA, JAPAN and RUSSIA, BRAZIL and RUSSIA, CANADA and RUSSIA, BRAZIL and JAPAN, CANADA and JAPAN, CANADA and BRAZIL is less than 0.05. So, there exist a significant difference between the electricity produced by nuclear energy in these countries.

The p- value of the difference between the electricity produced by nuclear energy, INDIA and CHINA, BRAZIL and CHINA, CANADA and USA, BRAZIL and INDIA is more than 0.05. So, there doesn’t exist a significant difference between the electricity produced by nuclear energy in these countries.

Comparison of Electricity Production by hydro energy in different Countries:

The null and alternative hypothesis are:

H_o: There is no significant difference between the average electricity produced by hydro energy in different countries.

H_a: There is a significant difference between the average electricity produced by hydro energy in different countries.

Factor Information

Factor	Levels	Values
Factor	7	CHINA, USA, INDIA, RUSSIA, JAPAN, BRAZIL, CANADA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	6	3322227191	553704532	8286.01	0.000
Error	252	16839660	66824		
Total	258	3339066851			

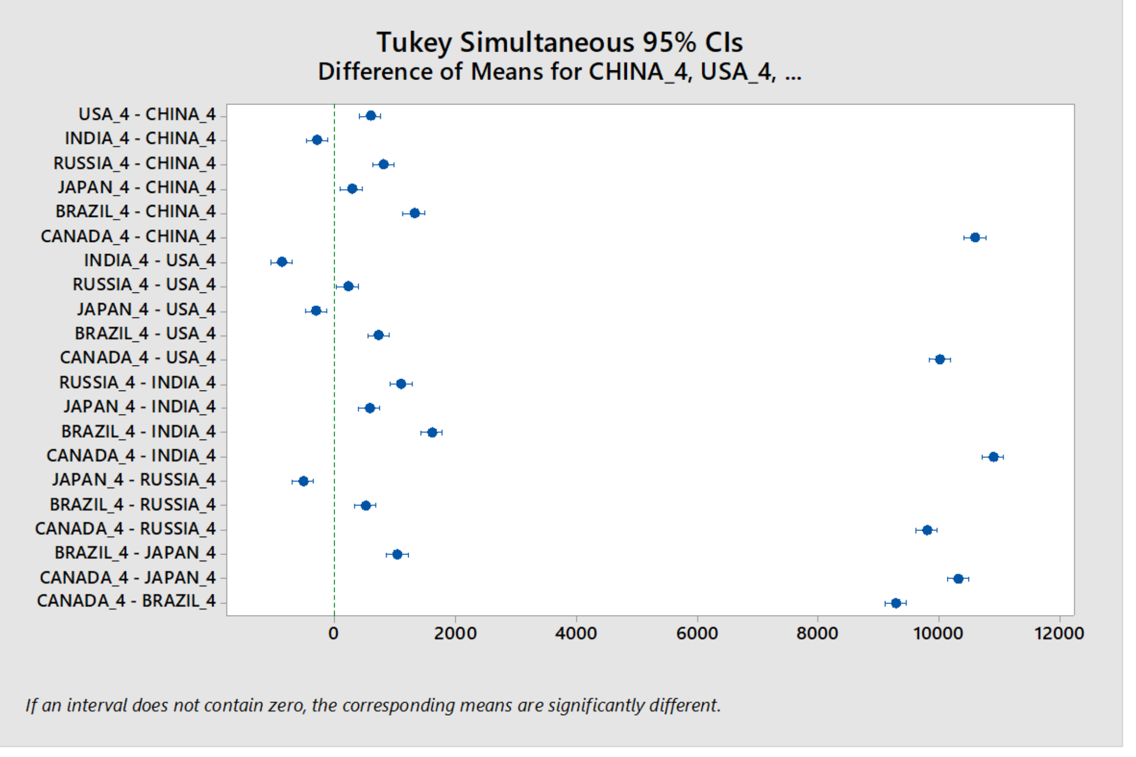
Here, we observed from the ANOVA table that the p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by hydro energy in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by hydro energy exists.

Tukey Simultaneous Tests for Differences of Means

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
USA - CHINA	586.8	60.1	(409.6, 764.0)	9.76	0.000
INDIA - CHINA	-293.3	60.1	(-470.5, -116.1)	-4.88	0.000
RUSSIA - CHINA	803.7	60.1	(626.5, 980.9)	13.37	0.000
JAPAN - CHINA	276.4	60.1	(99.2, 453.7)	4.60	0.000
BRAZIL - CHINA	1307.6	60.1	(1130.4, 1484.8)	21.76	0.000
CANADA - CHINA	10586.6	60.1	(10409.3, 10763.8)	176.15	0.000

INDIA - USA	-880.1	60.1	(-1057.3, -702.8)	-14.64	0.000
RUSSIA - USA	216.9	60.1	(39.7, 394.1)	3.61	0.006
JAPAN - USA	-310.3	60.1	(-487.5, -133.1)	-5.16	0.000
BRAZIL - USA	720.8	60.1	(543.6, 898.0)	11.99	0.000
CANADA - USA	9999.8	60.1	(9822.6, 10177.0)	166.38	0.000
RUSSIA - INDIA	1097.0	60.1	(919.7, 1274.2)	18.25	0.000
JAPAN - INDIA	569.7	60.1	(392.5, 746.9)	9.48	0.000
BRAZIL - INDIA	1600.8	60.1	(1423.6, 1778.1)	26.64	0.000
CANADA - INDIA	10879.8	60.1	(10702.6, 11057.1)	181.03	0.000
JAPAN - RUSSIA	-527.2	60.1	(-704.4, -350.0)	-8.77	0.000
BRAZIL - RUSSIA	503.9	60.1	(326.7, 681.1)	8.38	0.000
CANADA - RUSSIA	9782.9	60.1	(9605.7, 9960.1)	162.77	0.000
BRAZIL - JAPAN	1031.1	60.1	(853.9, 1208.3)	17.16	0.000
CANADA - JAPAN	10310.1	60.1	(10132.9, 10487.3)	171.55	0.000
CANADA -BRAZIL	9279.0	60.1	(9101.8, 9456.2)	154.39	0.000

Individual confidence level = 99.65%



The p- value of the difference between the electricity produced by hydro energy in USA and CHINA, INDIA and CHINA, RUSSIA and CHINA, JAPAN and CHINA, BRAZIL and CHINA, CANADA and CHINA, INDIA and USA, RUSSIA and USA, JAPAN and USA, BRAZIL and USA, CANADA and USA, RUSSIA and INDIA, JAPAN and INDIA, BRAZIL and INDIA, CANADA and INDIA, JAPAN and RUSSIA, BRAZIL and RUSSIA, CANADA and RUSSIA, BRAZIL and JAPAN, CANADA and JAPAN, CANADA and BRAZIL is less than 0.05. So, there exist a significant difference between the electricity produced by hydro energy in these countries.

Comparison of Electricity Production by other methods of electricity production in different Countries:

The null and alternative hypothesis are:

H_o: There is no significant difference between the average electricity produced by other methods of electricity production in different countries.

H_a: There is a significant difference between the average electricity produced by other methods of electricity production in different countries.

Factor Information

Factor	Levels	Values
Factor	7	CHINA, USA, INDIA, RUSSIA, JAPAN, BRAZIL, CANADA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	6	53623643	8937274	118.06	0.000
Error	252	19075955	75698		
Total	258	72699599			

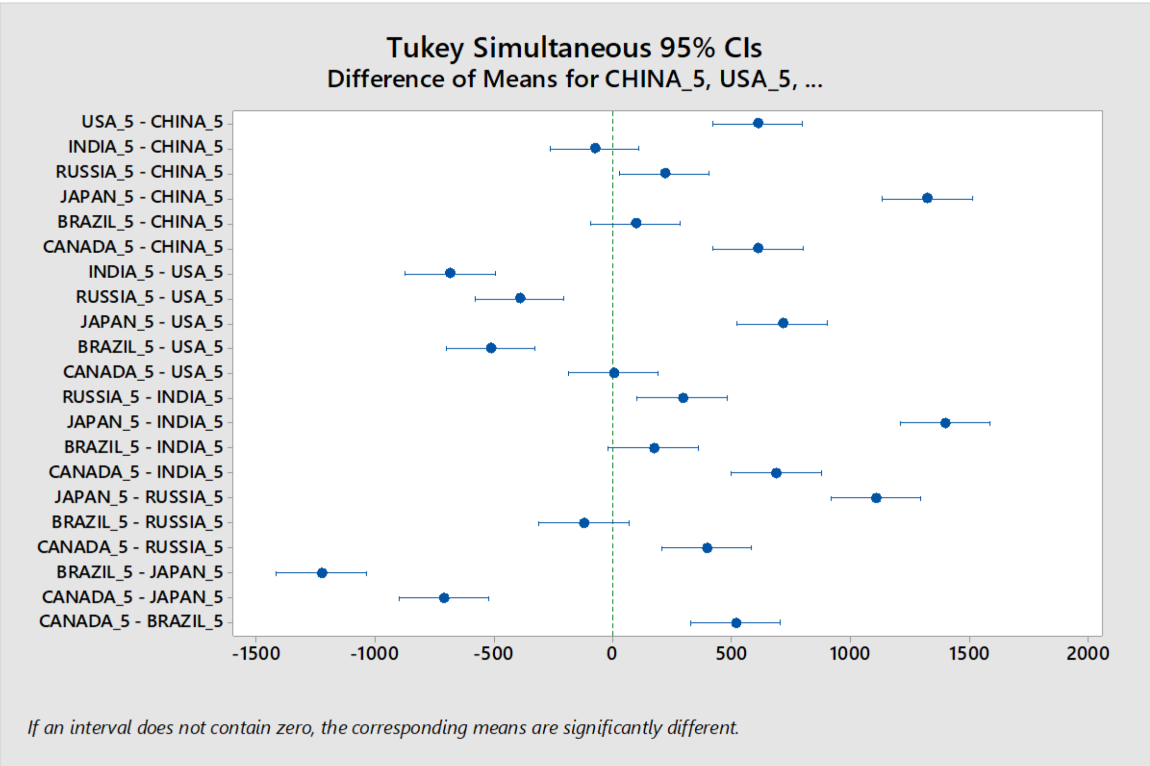
Here, we observed from the ANOVA table that the p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by other methods of electricity production in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by other methods of electricity production exists.

Tukey Simultaneous Tests for Differences of Means

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
USA - CHINA	608.4	64.0	(419.8, 797.1)	9.51	0.000
INDIA - CHINA	-76.0	64.0	(-264.6, 112.6)	-1.19	0.899
RUSSIA - CHINA	216.3	64.0	(27.7, 405.0)	3.38	0.013
JAPAN - CHINA	1321.0	64.0	(1132.4, 1509.6)	20.65	0.000
BRAZIL - CHINA	94.9	64.0	(-93.8, 283.5)	1.48	0.755
CANADA - CHINA	610.4	64.0	(421.8, 799.0)	9.54	0.000
INDIA - USA	-684.4	64.0	(-873.0, -495.8)	-10.70	0.000
RUSSIA - USA	-392.1	64.0	(-580.7, -203.5)	-6.13	0.000
JAPAN - USA	712.6	64.0	(523.9, 901.2)	11.14	0.000
BRAZIL - USA	-513.6	64.0	(-702.2, -325.0)	-8.03	0.000

CANADA - USA	1.9	64.0	(-186.7, 190.6)	0.03	1.000
RUSSIA - INDIA	292.3	64.0	(103.7, 480.9)	4.57	0.000
JAPAN - INDIA	1397.0	64.0	(1208.4, 1585.6)	21.84	0.000
BRAZIL - INDIA	170.8	64.0	(-17.8, 359.5)	2.67	0.106
CANADA - INDIA	686.4	64.0	(497.8, 875.0)	10.73	0.000
JAPAN - RUSSIA	1104.7	64.0	(916.1, 1293.3)	17.27	0.000
BRAZIL - RUSSIA	-121.5	64.0	(-310.1, 67.1)	-1.90	0.481
CANADA - RUSSIA	394.1	64.0	(205.4, 582.7)	6.16	0.000
BRAZIL - JAPAN	-1226.2	64.0	(-1414.8, -1037.5)	-19.17	0.000
CANADA - JAPAN	-710.6	64.0	(-899.2, -522.0)	-11.11	0.000
CANADA - BRAZIL	515.5	64.0	(326.9, 704.2)	8.06	0.000

Individual confidence level = 99.65%



The p- value of the difference between the electricity produced by other methods of electricity production in USA and CHINA, JAPAN and CHINA, CANADA and CHINA, INDIA and USA, RUSSIA and USA, JAPAN and USA, BRAZIL and USA, RUSSIA and INDIA, JAPAN and INDIA, CANADA and INDIA, JAPAN and RUSSIA, CANADA and RUSSIA, BRAZIL and JAPAN, CANADA and JAPAN, CANADA and BRAZIL is less than 0.05. So, there exist a significant difference between the electricity produced by other methods of electricity production in these countries.

The p- value of the difference between the electricity produced by other methods of electricity production in INDIA and CHINA, BRAZIL and CHINA, CANADA and USA, BRAZIL and INDIA, BRAZIL and RUSSIA, is more than 0.05. So, there doesn’t exist a significant difference between the electricity produced by other methods of electricity production in these countries.

CHAPTER-5

Conclusion

The graphical representation of electricity production using different methods of electricity production like Coal, Solar energy, Nuclear energy, Hydro energy, Gas and others (bioenergy, wind energy, oil etc.) of different countries concludes the following results:

1. China: There is a steady increase in the production of electricity throughout the period of 1985 to 2021. The maximum electricity is produced in China by coal. The electricity production is uniformly increasing using nuclear energy and hydro energy.

2. USA: The electricity production using Coal was constant in period 1985 to 2008 and then started decreasing from year 2009 and continue till 2021. The electricity production using Gas shows an increase throughout the period of 1985 to 2021.

3. India: The chart shows that maximum electricity is produced by Coal in India. The electricity produced using hydro, gas, nuclear doesn’t shows changes whereas the minimum electricity is produced using solar energy.

4. Russia: There is a fluctuation in production of electricity throughout the period 1985 to 2021 in Russia. The electricity production using gas also shows the changes over the time period. The electricity production remains constant using Gas, Coal, Hydro and Nuclear energy.

5. Japan: The electricity production in Japan using nuclear energy shows the downfall while the production using coal and gas shows the rise. There is very minimum production of electricity using solar energy. The electricity production by using hydro energy remains constant throughout the period of 1985 to 2021.

6. Brazil: The maximum electricity is produced using hydro energy, while the minimum electricity is produced using solar energy. The electricity production shows a steady increase from 1985 to 2021. The electricity production using Gas, nuclear and coal shows a very little increment.

7. Canada: Canada is producing most of its electricity using hydroelectricity. The production using nuclear and gas doesn’t show significant changes. The production of electricity using Coal is decreasing, the decrement started from 2009 and continues till 2021.

From the graphs of the electricity production of different countries we observe that the production of electricity is increasing with increasing in the number of year. We also observed that there was a sudden fall in the production of electricity in the year 2019, the reason behind this fall was COVID-19. This fall is mostly observed in case of electricity production using coal, because the supply of coal was disturbed in that year.

The data related to production of electricity in different countries using different methods have been analyzed by using Analysis of Variance. The study reveals the following:

1. Coal - The p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by coal in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by coal exists.

2. Gas - The p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by gas in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by gas exists.

3. Solar - The p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by solar energy in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by solar exists.

4. Nuclear - The p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by nuclear energy in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by nuclear energy exists.

5. Hydro - The p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by hydro energy in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by hydro energy exists.

6. Others - The p-value of F-statistic is less than 0.05. So, we reject the null hypothesis at 0.05 level of significance and conclude that there is a significant difference between the average electricity produced by other methods of electricity production in different countries. So, we will apply the Tukey post-hoc test to find the exact pairs of countries where the difference between the average electricity produced by other methods of electricity production exists.

Overall conclusion: From the above conclusions we observe that the electricity production is increasing with increasing in the number of years. We also conclude that there is a significant difference between the average electricity produced by solar energy, nuclear energy, hydro energy, coal and other methods of electricity production in different countries.

Suggestions: As we see that the most of electricity is produced using coal, which is non renewable resource and the production of electricity using coal is one of the main causes of air pollution. So, it is suggested that the use of renewable resources of electricity like wind energy, solar energy, biomass, hydropower, tidal energy etc. should be increased so that the use of nonrenewable resources can be minimized and that will also result in reducing the air pollution.

References:

1. Gupta, S. C., & Kapoor, V. K. (1971). *Fundamentals of Mathematical Statistics: For Honors.; Degree and post graduate students of all Indian universities and Indian Administrative and Indian Statistical Service Examinations*. Sultan Chand & Sons.
2. Goon, A. M. (1987). *Fundamentals of Statistics*. The World Pr. Private.
3. Gupta, S. C., & Kapoor, V. K. (1971). *Fundamentals of Applied Statistics: For Honors.; Degree and post graduate students of all Indian universities and Indian Administrative and Indian Statistical Service Examinations*. Sultan Chand & Sons.
4. https://ourworldindata.org/electricity-mix
5. https://www.scribbr.com/statistics/one-way-anova/