CLEAN ENERGY: THE GLOBAL PERSPECTIVE

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ABSTRACT

Affordable and clean energy is goal seven of the Millennium Development Goals. It envisage clean and replenishable energy for the betterment of masses. Thus ambitious targets have been set to achieve this goal. This object is also linked with the fate of many developing countries , because 'dirty energy ' has put enormous burden on the economy of these countries, not to speak of trade war, geo politics and economic fluctuations. The carbon emission is a source of danger for humanity. The object of this paper is to trace the development of renewable energy, with global perspective in general and Indian perspective in particular. The global primary energy use has not been uniform. While OECD and non OECD countries have lesser growth, the Asia Pacific region has increased it significantly. Thus a time profile and sector specific analysis has been attempted .While the COVID has reduced energy use , the future requires more sustainable efforts.The four prominent sources of energy namely oil, solar, wind and geothermal have been analyzed for the period 2000 to 2019. The middle east still dominates in oil, Asia Pacific in solar and geothermal, while Europe in wind energy. The CAGR and regression equation has been calculated.

Keywords: Clean Energy, Green Energy, Solar Capacity, Wind Capacity, Geothermal Energy, Oil Production.

INTRODUCTION

One of the basic stance of Millennium Development Goals is clean or renewable energy. While the nature has endowed it in plenty and for years to come, its use in energy production is of recent history. The discovery of oil may have been proved boon to the industrial development but this has caused enormous issues relating to human environment (Nadeau, R.L. (2002)

The growing demand for clean or renewable energy is a byproduct of indiscriminate use of fossil fuels , initially explored from gulf countries. The twentieth century industrial development in the transport sector may largely be attributed to the oil . But the treasure of millions of years was explored with such a speed, that it was bound to be at brink level. It is true that new oil reserves have been explored , the new technologies have emerged and the peak reserves have not come for many countries , the depleting stocks have already given warning bell. It is in this context that the global quest for clean energy must be studied. No wonder there is global cooperation, trade dependence and coordinated research in this field.

The paper has been divided in three parts. Section A is introduction of the theme. Section B provides statistical analysis of global energy scenario with

special reference to India. Section C is summary , conclusion and a peep in to future development.

METHODOLOGY AND DATA SOURCE

The time series of energy sources is available since 1995 for almost all variables. This study has chosen the period from year 2000 to 2019, a database of two decades. For uniformity all the data are from BP Statistical review 2020. The data collected by BP Statistical Review are from wide sources.

To give insight into data the total figures along with Compound Annual Growth Rate

(CAGR) have been calculated. But this covers only data of beginning year and terminal year. To overcome this regression analysis has also been done .The rational being that there may be fluctuation if only selected data are taken. The results of regression equation are reported in Appendix. Charts and tables provide a feel towards development in each area.

STATISTICAL PROFILE OF GLOBAL ENERGY SCENARIO

With the passage of time global energy sources have increased. Thus we have more than one energy source. These include oil, solar, wind, geothermal, biomass, hydroelectricity etc. But from environmental point of view clean energy is desirable option. In this section the statistical profile of of first four resources has been analyzed..

GROWTH OF ENERGY RESOURCES

Oil Production

The oil production has increased from 3605.53 million tonnes in the year 2000 to 4484.49 million tonnes in 2019. The highest world population has increased. It is because OPEC tried to control production in order to restrict price from falling down in last two decades (From year 2000 to 2019)The world oil production was 4499 tonnes in 2018. Overall the oil production did not increase in the same pace as the production increased from 3605. Per Annum growth is 1.2 percent .This slightly higher than world population growth. The fear of carbon emission and growth of renewable energy are prominent factors . Oil has been a bone of contention in global power politics. Thus one can see the long and chequered history of wars,

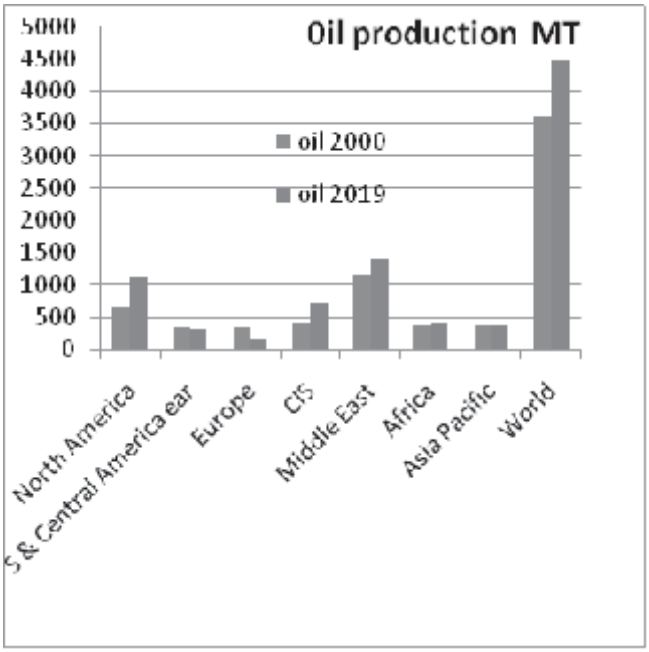
Table 1: Total Oil Production in Million Tonnes

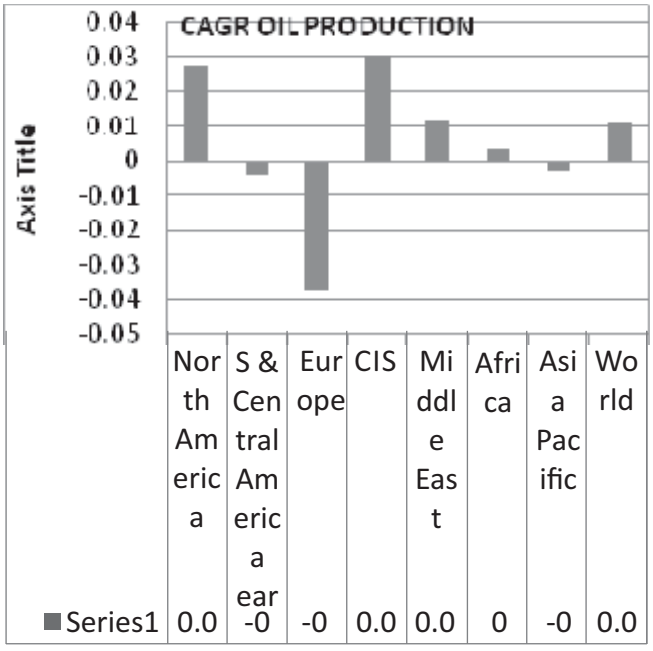
Year	North America	S & Central America	Europe	CIS	Middle East	Africa	Asia Pacific	Total oil Prduction World
2000	650.4	344.83	335.40	392.7	1128.9	371.5	381.6	3605
2019	1116.4	317.01	157.80	714.9	1417.4	399.0	361.8	4484
CAGR	0.0 A 2738	-0.004	-0.0337	0.0304	0.01144	0.00357	-0.003	0.01096

Source : BP Statistical Review of World Energy June 2020. CAGR calculated by authors.

cartels, groupism and economic recession (Heinberg, R. 2006) . For many developing as well as developed countries it created economic crisis and major change in national income and economic growth. However, with dwindling resources and energy resource substitution, the demand for 'black gold ' will be far lower after 2050. The renewable energy resources will make substantial headway by then. Though , there are different estimates about peak production, it is not in distant future (Deffeyes, K.S. 2005)

Chart 1: Oil Production and CAGR





oil production data from 2000 to 2019 show that Europe , south and central America and Asia pacific had negative Compound Annual Growth Rate (CAGR). The highest growth was exhibited by Commonwealth of Independent States (ex Russian federation countries (CIS) . The overall world growth was slightly more than 0.01. The golden age of oil will go (Campbell 1991). As far as conversion ratio is concerned it has been estimated that, 1 ton of oil equivalent = 41.868 gigajoules (GJ) or 11,630 kWh.

B.2 Solar Energy Growth

One need not to narrate the importance of solar energy for the future of mankind. The only snag is the regional climatic condition. The future of solar energy is as bright as mid day sunshine. It is a boon for the development prerequisites of many developing counties including India. The following table shows the installed capacity of solar generation in Megawatts. Though first solar cell was created in 1883, It was in 1953 that solar cells were commercially produced. In 1982 solar park was created in California. The there was progress in getting more energy efficiency. Thus, it must be known a priori that solar energy generation is recent technique hardly two decades as far as commercial and household use is concerned. Among the leading nations are USA, Germany China, Japan and India . China has 36 % of the total world share, followed by USA. India is ranked fourth with 6 percent contribution in 2019.

The total solar installed capacity was 651 MW in 2000 which increased to 586421 MW, a

tremendous growth of 900 times.

As far as CAGR is concerned though CIS and Middle East have higher value, it must be taken with a pinch of salt, because these had minuscule value. However, now every area is catching up. The following charts show the installed capacity and CAGRof solar PV.The growth of production from 2000 to 2019 shows that Asia pacific region has shown highest growth among all continents. Here China ,Japan and India are main players. The following table shows ten most important nations having highest share in solar energy generation

Table 2 : Solar Cumulative Installed Photovoltaic (PV) Power and CAGR

	Solar North America	Solar S. & Cent. America	Solar Europe	Solar CIS	Solar Middle East	Solar Africa	Solar Asia Pacific	Solar World
2000	39.5	4.3	199.8	0.01	0.4	10.98	396.3	651
2019	70048.1	8750.5	146666.2	1696.6	5582.5	7236.4	346440	586421
CAGR	0.4535	0.4636	0.3908	0.8259	0.6115	0.3833	0.4030	0.4051

Source : BP Statistical Review of World Energy June 2020. CAGR calculated by authors

Chart 2 : Solar CAGR and Installed Capacity

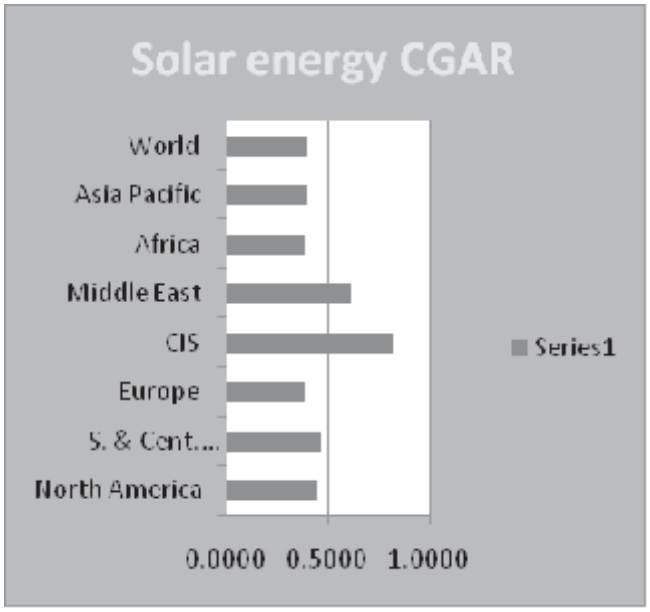


Chart 3 : Solar Installed Capacity between 2000 and 2019

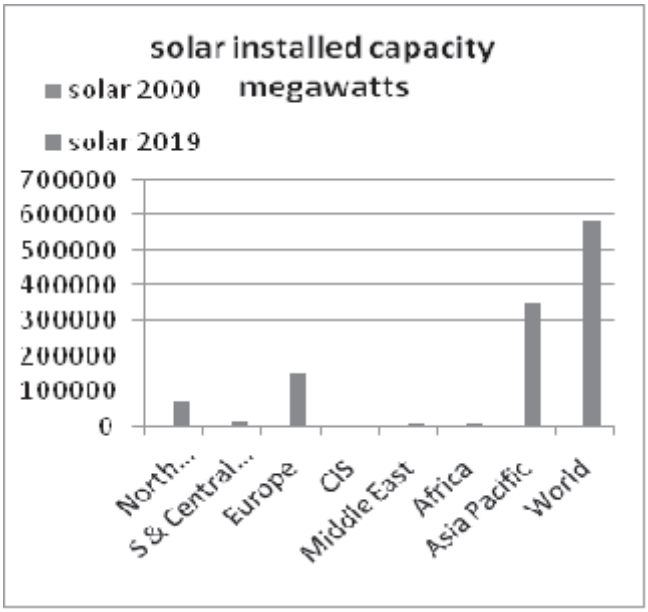


Table 3 : Percentage Share in PV Installed Capacity

Country Share in 2019 total PV	China	US	Japan	Germany	India	Italy	Australia	United Kingdom	Spain	France
	35.0	10.6	10.5	8.3	6.0	3.6	2.7	2.3	1.9	1.8

Source : BP Statistical Review of World Energy June 2020

It may be added that China is not only main producer of solar energy but also the main panel supplier. Countries like India are largely dependent on China for panels, inverters etc. In Appendix the regression equation has been calculated.

B.3 Wind Energy

Wind energy is another source of renewable energy. It is interesting to note that wind energy installed capacity is slightly higher than solar energy, though the former is catching up. The following figure shows the growth of solar and wind energy.

Table 4 : Wind Energy Installed capacity Megawatts

Year	North America	S. & Cent. America	Europe	CIS	Middle East	Africa	Asia Pacific	World
2000	2533	90	12750	3	12	133	1777	17303
2019	123588	22632.	203482	476	723	5748	266053	622704

Chart 4 : Growth of Solar Wind Energy

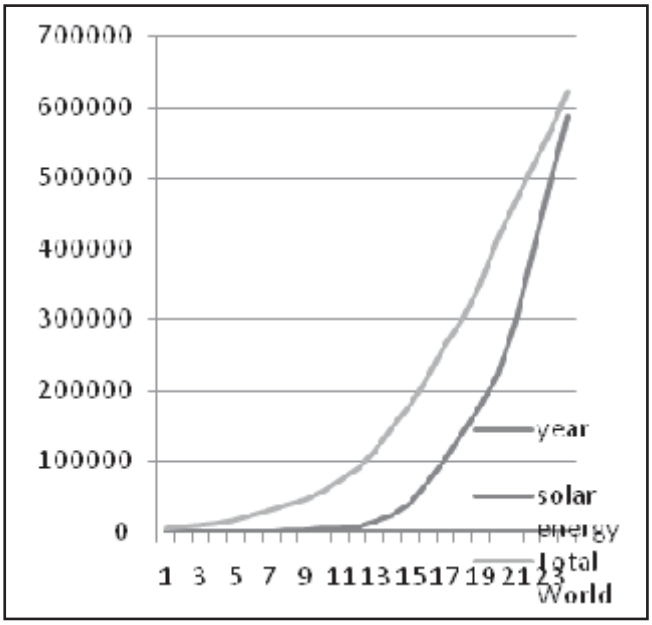
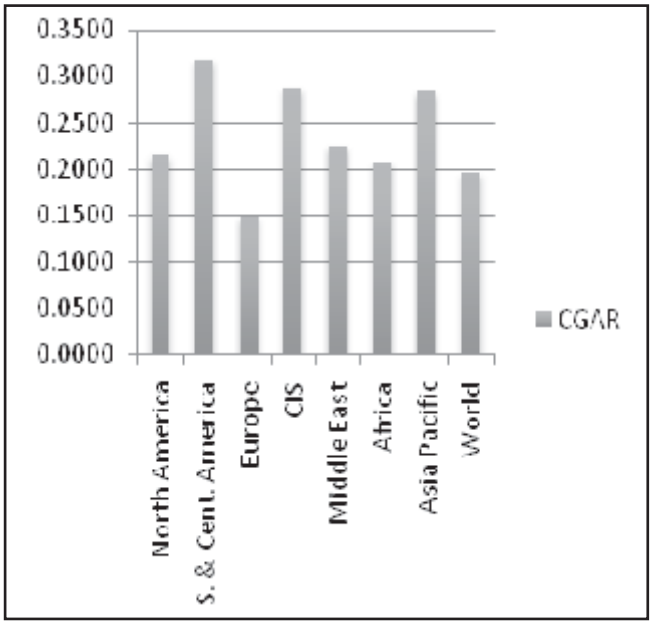


Chart 5 : CGAR of Wind Installed Capacity



Source : BP Statistical Review of World Energy June 2020. Charts prepared by authors

In wind energy the growth is impressive, as it is in solar energy. In the year 2000 the wind energy installed capacity was 17303 Megawatts which increased to 622704 in the year 2019. It was an absolute growth of 605400 MW, showing 36 times production. The leading regions are Asia Pacific, Europe and North America. The CIS and Middle East are minor players. However, The CAGR of wind energy shows that some regions had low base in 2000 but now these are catching up. The following table shows CAGR and the chart based on it.

Table 5 : CAGR of Wind Installed capacity

North America	S. & Cent. America	Europe	CIS	Middle East	Africa	Asia Pacific	World
0.2146	0.3180	0.1486	0.2883	0.2254	0.2070	0.2846	0.1962

Source : BP Statistical Review of World Energy June 2020. CAGR calculated by authors

Though Europe was leader in wind energy installation, the growth rate has declined while, S. & Cent. America is leading . Overall the growth in wind energy is less than solar energy.

B.4 Geothermal Growth

The geothermal energy is based on the unique concept of heat and steam found in the sub surface of earth. Wells are dug to get steam and hot water, to drive turbines used for electicity generation. heat. The main players are North America, Europe and Asia Pacific.But if CAGR is considered , Africa is making strides. Middle East and CIS have a very small contribution.

The 10 countries having highest production amongst all countries in the descending order are, USA, Indonesia, Philippines, Turkey, New Zealand, Mexico, Kenya, Italy, Iceland and Japan.Though geothermal energy is counted under

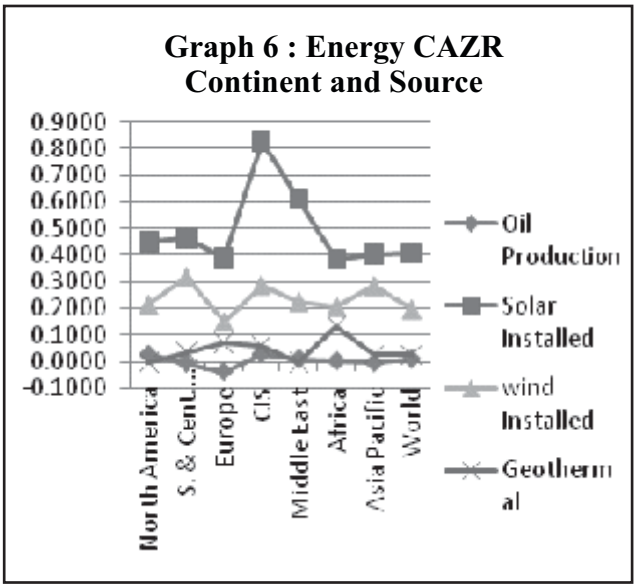
Table 6 : Geothermal Capacity In Megawatts

Year	North America	South & Central America	Europe	CIS	Middle East	Africa	Asia Pacific	World
2000	3648	360.8	794	23	0.1	65.3	3344.7	8235.8
2019	3490.9	761.2	3168.6	74	0.11	830.3	5631.51	13930

Source : BP Statistical Review of World Energy June 2020. CAGR calculated by authors

Geothermal energy is used in over 20 countries. The United States is the largest producer of geothermal energy in the world, and hosts the largest geothermal field. (Jack Unwin 2019) . It is carbon-free, renewable, sustainable form of energy that provides a continuous, uninterrupted supply of renewable energy , it has two major problems Apart from its limited availability , it produces sulphur

Graph 6 : Energy CAZR Continent and Source



Graph 7 : Wind Installed Capacity Megawatts

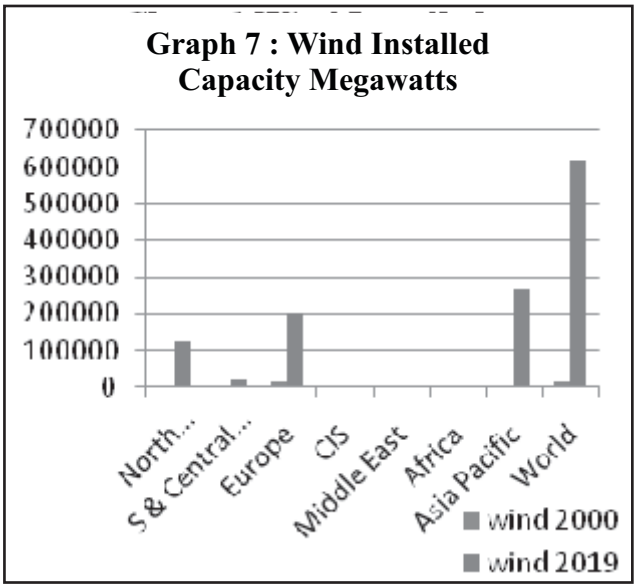


Chart 8 : Geothermal CGAR

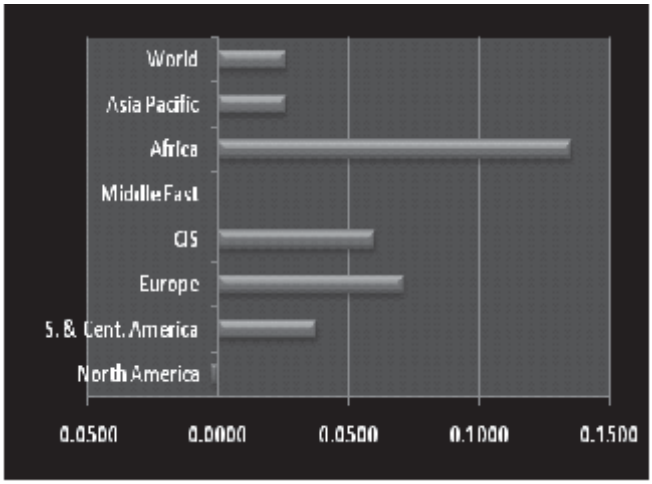
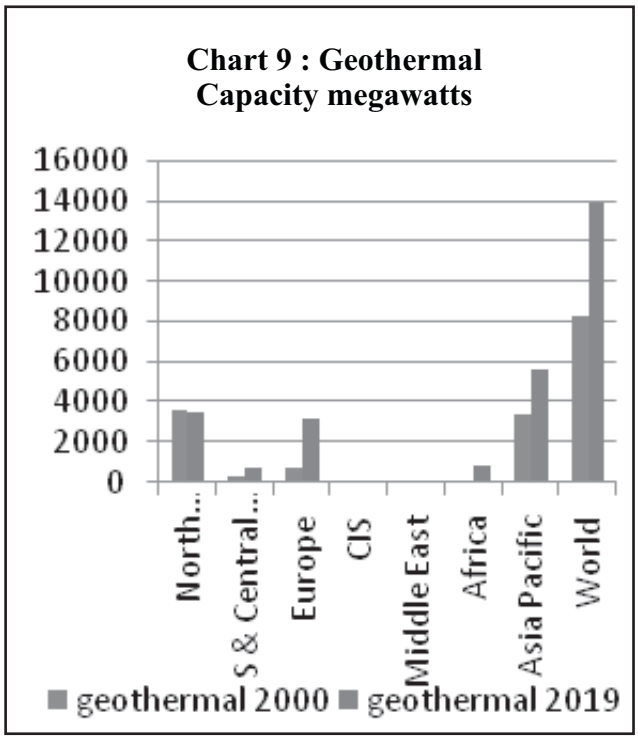


Chart 9 : Geothermal Capacity megawatts



Source : BP Statistical Review of World Energy June 2020. Charts and Graphs by authors

SUMMARY & FUTURE PERSPECTIVE

From the above analysis , it may be concluded that future lies in using non convention sources of energy. The solar and wind energy are not only clean but renewable too. The coal and oil are not only environmentally unacceptable but dwindling resource too. The future of economic growth can not be hanged upon limited availability. Wind and solar energy fulfil this gap. In fact the contribution in this area is a boon to humanity. The delinking is possible , thanks to scientific and technical progress. As Mc Kinsey has put it,

"But past is not always prologue. Our latest global energy perspective—part of a multiyear research effort examining the supply and demand of 55 types of energy across 30 sectors in some 146 countries—suggests that we're beginning to see a decoupling between the rates of economic growth and energy demand, which in the decades ahead will become even more pronounced "(Namit Sharma et al 2019).

But by 2050 the demand for energy will flatten. And contrary to our experience of last two centauries, rate of economic growth will not depend on energy demand. The stated reason in the literature are decline in energy intensity, increase in energy efficiency, rise in electrification for multiple applications and growth of service sector in comparison with industrial growth.

The path of clean energy will ultimately find its final destiny in solar energy in most of the countries , in wind energy in some other countries and geothermal, bio energy etc. But the future is a huge investment in technology.

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Appendix

Regression Equations of sources of energy

Continent	Constant	Trend	Standard Error constant	Standard Error trend	R^2
Oil North America	525	21.7	39.6	3.30	0.706
Oil South and Central America	363	0.377	10.1	0.839	0.011
Oil Europe	335	-10.5	8.72	0.931	0.91
Oil CIS	455	15.1	17.8	1.48	0.852
Oil Middle East	1.05 e+03	21.8	23.9	2.0	0.869
Oil Africa	433	-1.18	21.2	1.77	0.024
Oil Asia Pacific	385	0.0922	5.69	0.475	0.002
Oil World	3.54e+03	47.2	34.7	2.90	0.936
Solar North America	18007	3105	5684	474	0.704
Solar S Central America	2031	326	820	68.4	0.557
Solar Europe	3814	8263	7771	649	0.90
Solar CIS	-275.593	41.3503	157.01	13.1069	0.356
Solar Middle East	-1123.29	454.256	183.314	37.9205	0.564
Solar Africa	-1738.37	641.403	287.152	53.5433	0.615
Solar Asia Pacific	-83258.6	30754.8	13819.5	2567.36	0.618
Solar World	-144575	43461.9	26023.4	3628.13	0.741