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An Enumerative and analytical Study of the Sustainable Energy in an Economic Perspectives

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ABSTRACT: In this paper we are focused to study related to sustainable energy's economic impact on human centric activities. The human evolution is not possible without use of energy. Also, we know that Access and availability of Clean Energy for all till 2030.has recognized in an agenda point of the Sustainable Development Goals. We are focused to study enumerative study of energy consumption with using of the relevant annual reports, authentic information published by the various government and responsible organizations. For analytical study we are used the Analytical indicators such as AAGR, CAGR, and Percentage Distributions to interpret the relevant tables.

Keywords: Sustainable Development, energy, SDG, UN, Solar Energy. Per-Capita Energy Consumption and Energy Intensity, Energy Indicators, International Energy Agency, Clean Energy, Carbon, Emission.

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1. INTRODUCTION

The growth and development of life on the earth cannot possible without energy. The Goal no.7 of SDG ensures the access to clean and affordable energy to all. The Clean energy means generating energy without causing and producing any type of pollution, well balanced consumption of affordable, reliable, sustainable, energy while reducing greenhouse gas emissions and the carbon footprint, to achieve energy and climate goals requires policy formation and support in each of the country.

Goal No: 7 of SDGs: Sustainable energy:

The UN General Assembly adopted the document titled "Transforming our World: The 2030 Agenda for Sustainable Development "on 25th September 2015, this document consists of 17 Sustainable Development Goals (SDGs) and 169 targets. These SDGs are global goals focusing on Socio- economic and environmental development, out of these 17 SDGs Goal 7is realizing sustainable Energy. The goal is also covering the availability of clean and safe cooking fuels, using the modern technologies, and focusing on the energy efficiency. The promotion of using sustainable and modern energy for all, generated from renewable resources such as wind, water, solar, biomass and geothermal energy etc.

The following targets are set under Goal 7 of SDGs to achieve till the year 2030:

1. To make available and ensure universal access to affordable, reliable, and modern energy services to all.
2. Focus on increasing the share of renewable energy remarkably in the global energy mix.
3. Form policies and take efforts to double the global rate of improving the energy efficiency.
4. Taking efforts for international co-operation to speed up accessing to the clean energy and promote the investment in the infrastructure for clean energy technology, research, and development, it includes the renewable energy and energy efficiency, advanced cleaner fossil-fuel technology.
5. to expand the infrastructure facilities and upgrade the technology for supplying modern and sustainable energy services for all in developing countries, small island developing states and land-locked developing countries and especially in least developed countries as per their respective programmes of support.

2. RESEARCH METHODOLOGY:

As per the released data from Ministry of Statistics and Programme Implementation National Statistical Office and the Report titled Energy statistics India 2023, One of the Targets identified by the Sustainable Development Goals focuses on making affordable, reliable, and modern energy and ensuring the same government of India made available the electricity to all residents of the country.

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As per the updated data there are 6,40,930 villages are in India, out of which 597464 villages have electrified. It means 93 % of villages are now electrified. The highest number of villages electrified in the state of Madhya Pradesh with 51929 villages, whereas minimum number of villages found in the state of Goa with 320 Villages.as far as Union territories are concerned the highest number of villages electrified in the Union territory of Andaman & Nicobar Island with 396 villages, and minimum number of villages found in in the Union territory of Chandigarh with 5 Villages.

The Per-Capita Energy Consumption and Energy Intensity:
The Energy Intensity means is the amount of energy required to generate one unit of Gross Domestic Product (at constant prices). The „"Per Capita Energy Consumption (PEC)"" indicator is also taken in to consideration at the national and international levels. The PEC during a year is computed as the ratio of the estimate of total energy consumption during the year to the mid-year population of that year. Following *table No.2* depicts the energy Consumption:

TableNo.1 Per-Capita Energy Consumption and Energy Intensity

Year	Energy Consumption in Petajoules	Mid-year population (in Thousands)*	GDP at 2011-12 prices (Rs. crore) **	Per Capita Energy Consumption (in Megajoules)	Energy Intensity (Megajoules per rupee)
2011-12	24,121	12,20,171	87,36,329	19,769	0.2761
2012-13	25,805	12,36,220	92,13,017	20,874	0.2801
2013-14	26,302	12,52,267	98,01,370	21,003	0.2683
2014-15	27,841	12,68,310	1,05,27,674	21,951	0.2645
2015-16	28,665	12,84,350	1,13,69,493	22,319	0.2521
2016-17	29,556	12,99,434	1,23,08,193	22,745	0.2401
2017-18	31,153	13,13,815	1,31,44,582	23,712	0.2370
2018-19	32,805	13,28,206	1,39,92,914	24,699	0.2344
2019-20	32,729	13,42,586	1,45,34,641	24,378	0.2252
2020-21	30,354	13,56,980	1,36,87,118	22,369	0.2218
2021-22 (P)	33,508	13,70,311	1,49,25,840	24,453	0.2245
% Growth rate of 2021-22 (P) over 2020-21	10.39	0.98	9.05	9.32	1.23
% CAGR 2012-13 to 2021-22 (P)	2.94	1.15	5.51	1.77	-2.43

(P): Provisional: Energy Intensity=Amount of energy consumed for producing one unit of Gross Domestic Product.
* Mid-Year (as on 1st October) population has been taken from Population Projections for India and states 2011 – 2036 ; Report of the Technical Group On Population Projections , July, 2020
** GDP estimates are at base 2011-12 price as per the National Accounts Division's, NSO, MoSPI. NOTE:
1Joule: 0.23884 calories
1 Mega Joule: 10^6 joules = 238.84 x 10^3 calories

The *table no.1* given above has been illustrated with help of graph and diagram and *table no.3* given below: We are analysed the intensity and growth over previous year in both GDP and consumption pattern.

The Analysis of Growth over Previous Financial Year of is calculated of the data given in the table No.1 as follows: The Energy Consumption in the financial year 2011-12 was 24,121 Petajoules, and in the next financial year 2012-13, it is more of 1684 Petajoules. recorded with 25,805 Petajoules. Based on the data calculated regarding growth of Energy Consumption over Previous Financial Year, the researcher has calculated The Percent in Growth by using simple average method. For example, The Energy Consumption over the previous financial year recorded more of 1684 Petajoules in 2012-13. So percentage growth would be the difference between The Energy Consumption of financial year 2011-12 and 2012-13 i.e. 1684 Petajoules is divided by The Energy Consumption in the previous year and result is multiplied by 100 to convert it into percentage. i.e. (1684/ 24121) X 100 = 6.98 %, the same method of calculation is carried out for other years and items.

The highest consumption of energy and Gross Domestic Product (GDP) is seen in the financial year 2021-22 with 3154 Petajoules of energy consumption with GDP of Rs 1238722 crore, it is also highest percentage of growth over the last 10 years.

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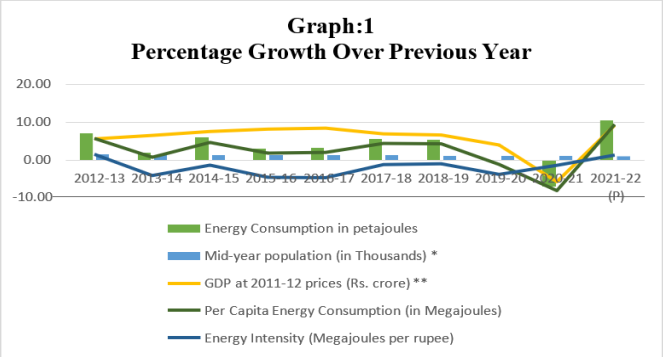


The above Graph No.1 illustrate the trend of Growth over previous year in percentage terms, it shows that there is negative (decrease) in the Energy Consumption, GDP, Per Capita Energy Consumption and Energy Intensity in the financial year2020-21.and Mid-year Population size constantly positive over the last ten years.

The status of Total Emissions related to Energy Sector in India: The status of Total Emissions related to Energy Sector in India is given below in *table no.4* shows the data released and the latest estimates by MoEFCC in February 2021.

Table No.3 India's Total Emissions related to Energy Sector (GgCO2 Equivalent) 2016

GHG Sources And Removals	2011	2012	2013	2014	2015	2016	Total
2. Manufacturing Industries& Construction	338816	343603	356771	351910	394092	397739	2182931
3. Transport	221202	236020	241253	250173	261517	274434	1484599
4. Other Sectors	120228	119202	122783	128643	202286	213490	906632
B. Fugitive Emission From Fuels	47,426	43,047	38,771	38,057	37,084	37,179	241564
Solid Fuels	16,388	16,086	15,568	16,547	16,614	17,121	98324
Oil And Natural Gas	31,037	26,961	23,203	21,511	20,470	20,058	143240
Total Energy (A+B)	1651928	1747686	1813559	1909766	2092102	2129428	11344469

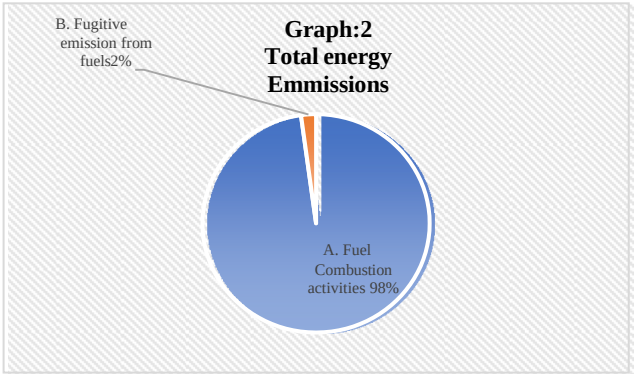
Source: Ministry of Statistics and Programme Implementation National Statistical Office Report, Energy statistics India 2023. https://www.mospi.gov.in/

*GgCO2 Equivalent : Gigagrams of carbon dioxide equivalent

Table No.2 India's Total Emissions related to Energy Sector (GgCO2 Equivalent) 2016

GHG Sources And Removals	2011	2012	2013	2014	2015	2016	Total
A.Fuel Combustion Activities	1604503	1704639	1774788	1871709	2055017	2092250	11102906
1.Energy Industries	924258	1005813	1053981	1140983	1197123	1206587	6528745

Above *table 3* depicts that The Total Emissions from the Energy Sector in India rose from 16,51,928 GgCO2 Equivalent in year of 2011 upto 21,29,428 GgCO2 Equivalent in year of 2016. The total over last six years recorded 11344469 GgCO2 Equivalent. On the basis of information in the table above The Graph No.2 depicts that 98 percent of Emissions related from the source of Fugitive Emission from Fuels and 2 % from Fuel Combustion Activities.



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Based on *table 3*, We are analyzed growth of Total Emissions from the Energy Sector in India over Previous, the Analysis of Growth over Previous Financial Year of is calculated of the data given in the *table 3* as follows: Green House Gas emissions from the source of Fuel Combustion Activities is 1604503 GgCO2 Equivalent in year of 2011. In the next succeeding year, it is more of 100136 GgCO2 recorded with 1704639 GgCO2 Equivalent in year of 2012.

Also, calculated The Percent in Growth by using simple average.

The method of Average annual growth rate (AAGR) is used to find out the average annualized rate of emissions flow over time. Average annual growth rate (AAGR) is calculated by taking the simple arithmetic mean of a series of returns. Average annual growth rate (AAGR) helps in finding the long-term trends, for calculation of AAGR an average of growth % age over last year is considered (i.e. 6.24+ 4.12+ 5.46 + 9.79 + 1.81 divided by 5 = 5.48 %) the same method of calculation is carried out for other years and items, and given below in *table.5.*

The researcher has also calculated the Compounded Annual growth rate (CAGR) to find out the compounded annualized rate of growth in the emissions flow over time. The CAGR formula is equal to (Ending Value/Beginning Value) ^ (1/No. of Periods) – 1. Therefore (2092250/1604503) ^ (1/5)-1 = 5.45%. The same method of calculation is carried out for other years and items, and given below in *table 4.*

	2012		2013		2014		2015		2016				
GHG sources and removals	GOPY	%	GOPY	%	GOPY	%	GOPY	%	GOPY	%	Simple Average	AAG R	CAG R
A. Fuel Combustion activities	100136	6.24	70149	4.12	96921	5.46	183308	9.79	37233	1.81	1850484	5.48	5.45
1. Energy Industries	81555	8.82	48168	4.79	87002	8.25	56140	4.92	9464	0.79	1088124	5.52	5.48
2. Manufacturing industries & construction	4787	1.41	13168	3.83	-4861	-1.36	42182	11.99	3647	0.93	363822	3.36	3.26
3. Transport	14818	6.70	5233	2.22	8920	3.70	11344	4.53	12917	4.94	247433	4.42	4.41
4. Other sectors	-1026	-0.85	3581	3.00	5860	4.77	73643	57.25	11204	5.54	151105	13.94	12.17
B. Fugitive emission from fuels	-4379	-9.23	-4276	-9.93	-714	-1.84	-973	-2.56	95	0.26	40261	-4.66	-4.75
Solid fuels	-302	-1.84	-518	-3.22	979	6.29	67	0.40	507	3.05	16387	0.94	0.88 %
Oil and natural gas	-4076	- 13.13	-3758	- 13.94	-1692	-7.29	-1041	-4.84	-412	-2.01	23873	-8.24	- 8.36 %
Total Energy (A+B)	95758	5.80	65873	3.77	96207	5.30	182336	9.55	37326	1.78	1890745	5.24	5.21 %

3.THE ENERGY INDICATORS FOR SUSTAINABILITY

The International Atomic Energy Agency, United Nations Department of Economic and Social Affairs, International Energy Agency, Eurostat and European Environment Agency, has identified set of energy indicators, it is also called Energy Indicators for Sustainable Development, and published as "Energy Indicators for Sustainable Development: Guidelines and Methodology, Vienna, 2005". These indicators are designed to provide information on current energy related trends in a format that aids decision making at the national level to help the countries to form and assess effective energy policies for action on sustainable development. The economic indicators have two themes: Use & production patterns and Security. The first has the sub theme of Overall Use, Overall Productivity, Supply Efficiency, Production, End Use, Diversification (Fuel Mix) and Prices. The second has the sub themes of Imports and strategic Fuel stocks.

Table 5 Energy Indicators of India for Sustainability from 2012-13 to 2020-21 (Based on Domestic Conversion Factors and Final, Audited data):

Theme	Sub- theme	Indicator	Category	Unit	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22 (P)
		electricity	Hydro	%	10.27	11.48	10.12	9.09	8.71	8.51	8.53	9.62	9.43	8.84

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			RE (other than Hydro)	%	5.34	5.73	5.96	5.09	5.96	7.02	8.23	8.91	9.66	10.43
Security	Imports	Net energy import dependency	Overall	%	34.21	35.55	37	37.98	31.16	40.07	40.64	42.26	42.01	40.9
			Crude Oil	%	83	83.36	83.49	84.59	85.59	86.07	86.88	87.59	86.56	87.71
			Natural gas	%	30.22	33.46	35.6	39.88	43.79	45.66	46.65	52.08	53.53	47.49
			Coal	%	23.2	24.91	28.52	27.07	25.46	28.2	28.72	28.94	27.33	27.95
			Electricity	%	0.43	0.47	0.39	0.39	0.4	0.34	0.32	0.46	0.6	0.44
	Strategic Fuel Stocks	Stocks of critical fuels per orrespondi ng fuel consumption	Coal	%	8.84	7.51	7.22	7.81	9.18	6.9	5.95	8.52	12.03	6.7

Note: 1.The difference in the figures computed by MoPNG and MoSPI arises due to methodological differences - MoSPI using data from supply side and MoPNG using consumption side
2.The Energy Use indicates Total Primary Energy Supply (TPES), Total Final Consumption (TFC)
Source: Ministry of Statistics and Programme Implementation National Statistical Office Report, Energy statistics India 2023. https://www.mospi.gov.in/

The Statement of AAGR and CAGR of Energy Indicators for Sustainability from FY: 2012-13 to FY: 2020-21:

Based on information and data given in table 6, the researcher has used the method of Average annual growth rate (AAGR) is used to find out the average annualized rate of energy use over time. Average annual growth rate (AAGR) is calculated by taking the simple arithmetic mean of a series of returns. Average annual growth rate (AAGR) helps in finding the long-term trends, for calculation of AAGR an average of growth % age over last year is considered. The researcher has also calculated the Compounded Annual growth rate (CAGR) to find out the compounded annualized rate of growth in the emissions flow over time. The CAGR formula is equal to (Ending Value/Beginning Value) ^ (1/No. of Periods) – 1.

Table No:6 Statement of AAGR and CAGR of Energy Indicators for Sustainability from FY : 2012-13 to FY : 2020-21

Theme	Sub-theme	Indicator	Category	AAGR %	CAGR %
Use and Production Pattern	Overall Use	Energy use per capita	TPES	0.01	0.02
			TFC	0.01	0.02
			Electricity	31.02	0.04
	Overall Productivity	Energy use per unit of GDP	TPES	0.00	-0.03
			TFC	0.00	-0.02
			Electricity	-0.02	0.00
	Supply Efficiency	Efficiency of energy conversion and distribution	All	-0.26	-0.01
	Production	Reserves-to-production ratio Resources-to-production ratio	All	3.89	0.02
			coal	2.11	0.01
			lignite	2.44	0.02
		Resources-to-production ratio	All	-0.78	0.00
			Crude oil	0.22	0.01
			Natural Gas	0.00	0.00
			Coal	-8.11	-0.02
			Lignite	4.78	0.01
			Industry	0.00	-0.02

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	End Use	Sectoral Energy Intensities	Agriculture	0.00	0.01
			Transport	0.00	0.01
		Sectoral Electricity Intensities	Industry	-0.13	-0.01
			Agriculture	0.11	0.01
			Transport	-0.01	0.00
	Diversification (Fuel Mix)	Fuel shares in TPES	Crude Oil	-0.64	-0.02
			Natural Gas	-0.12	-0.01
			Coal	0.12	0.00
			RE &Others	0.16	0.04
		Fuel share in TFC	Oil Products	-0.06	0.00

4. CONCLUSION

The International Energy Agency predicts that the world needs almost 60% more energy in the year 2030 than in 2002, and fossil fuels will still meet most of its needs. Facts and figures published in various reports are implicit on soaring global energy demand, making available energy at cheaper rate for poor people is essential for ending poverty, therefore policy formation regarding generating power at competitive prices in a sustainable manner with innovative eco-friendly technologies must be initiated. The government must form a policy regarding energy efficiency and clean energy systems to mitigate the environmental and health issues arising due to excessive use of hydrocarbons force. The government of all Countries should encourage sustainable efficient management of energy resources available by making more investment, building infrastructure, reforms in trade regimes and focus on to achieve self-sufficiency with import substitution.

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