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COMPARATIVE STUDY OF ENERGY, UTILIZATION AND EMISSION

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Abstract— Natural or artificial energy is the first essential component for development. That is why man always tries his best for the utilization of all possible sources of energy for the fulfillment of his every day needs. Due to this reason today we are getting the most new and advanced sources of energy which compensate certain amount of energy problems due to the limitations of organic fuel sources. This project is aimed to see the different sources of energy, then for requirement how it is utilized by different conversion methods and during conversion unwanted thing comes in the form of waste and emission which is most challenging to the present society. We look in this project how; we can make a balance cycle by regeneration of waste and pollution because this is practical example of the beautiful earth. In this report we analyze the total fuel energy basically (coal) utilized in India to meet the required demand and thus amount of emission generate by the combustion of coal in different power plants. Then in the next part how the emissive gases and waste can be controlled and re-utilized for various industrial or other applications. Due to which there may be the maximum utilization of waste and emission control can possible. After various analysis and calculation it is found that the use of natural gas for power plants and for other industrial application is more beneficial over the coal and diesel which generates 10 to 15% less emission by consuming half of fuel rate.

Keywords-Natural Gas; Emission; Fossil Energy; Heating Value

I. INTRODUCTION

A. General Background

Development means how fast and accurate one can complete the requirement. For doing fast we required energy and time. Energy we are searching by exploring different sources where as time we have no control. So exploring energy to complete the requirements is the measurement of development. If we relate with time we called consumption of energy is unit of measurement of development. But in universe the second law of thermodynamics places a restriction that is if we consume something for getting some output there will be certainly something out which we do not require that we called as pollution or waste. Natural or artificial energy is the first essential component for development. That is why man always tries his best for the utilization of all possible sources of energy for the fulfillment of his every day needs. Due to this reason today we are getting the most new and advanced sources of energy. So, the scientists are again searching the new methods by which our conventional energy sources can be fully utilized

and the wastages can be reused for the production of energy also.

B. Recent Trends

Presently development in not on the base of energy utilization or production but it is on the base of production of pollutants also. Now society development is taking care of environment that's why we are taking sustainable development. At present we are searching the cleaner fuel that means energy with less pollution. In cleaner fuel we are talking about renewable fuel like hydrogen, bio fuel, biogas etc. This can only possible when we know the quantitatively analysis of energy and pollution. In this project we try to summarize the possible ways energy generation and their waste. From the laws of conservation of energy it is known that "energy can neither be created nor be destroyed, it may convert from one form to another". So, experimentally it is found that whatever the method adapted from very ancient days to this modern technology some amount of emissive gases and solid wastes may generate during the energy conversion due to the limitations of laws of thermo dynamic. And some amount of energy wills loss through the wastage and emission. So, in this report we are calculating such amount of energy loss by the combustion of various organic fuels and try our best for the utilization of these emissive gases and wastages for many industrial and commercial uses. This may indirectly solve some percentage of our energy problems and can create a clean atmosphere and surroundings also.

II. MAJOR ENERGY SOURCES

Today it is proved everything comes from energy by Well established relation $E= mc^2$ has given scientific prove. That's why it is said sun is mother of all living thing, so visible or invisible. Substance which is directly or indirectly available and is used for the existence of the entire living creature is called as energy. Like an example of plants which absorb energy from sun for its existence. Some of the many forms that energy takes are Mechanical energy, which includes

- Potential energy, stored in a system
- Kinetic energy, from the movement of matter
- Radiant or solar energy, which comes from the light and warmth of the sun
- Thermal energy, associated with the heat of an object.

- Chemical energy, stored in the chemical bonds of molecules
- Electrical energy, associated with the movement of electrons.
- Electromagnetic energy, associated with light waves (including radio waves, microwaves, x-rays, infrared waves).Mass (or nuclear) energy, found in the nuclear structure of atoms

A. Major Electrical Power Plants, Fuel Plants, Fuel used and their Capacity

India is the one of the largest populated country with nearly one-sixth of world population and low per capita income. In recent years, it has witnessed an impressive growth rate in population. This necessitates a matching growth in the availability of energy. Further, the development process, is also driving, as expected, a shift in energy use from non-commercial energy sources to commercial sources, particularly electricity. But the situation in India is more complex because of high density of population, continuing growth of population and demographic shift from rural to urban areas. Electricity is the main driving force for development in today’s industrial world. Per capita gross national product is directly related to the per capita electricity production in the country. Analysis of statistics also indicates that per capita electricity consumption is directly related to life expectancy. So, in India exploring the new energy sources or electricity is main thrust area. By calculating the total power generated from all possible energy sources in India is more than 108719 MW. Different sources of this energy [1] and the percentage contribution for each source is representing in the table I.

TABLE I.

Sources	Generated power (MW)	Percentage Share (%)
Thermal	99861.98	91.85
Nuclear	4560.00	4.19
Hydro	2955.00	2.71
Biomass	1073.00	0.98
Wind	259.00	0.23
Solar	9.84	0.009
Total	108718.8	99.96=100 say

Generated power and percentage contribution of different energy source

B. Fuel Sources, Amount and their availability

Since we are considering the case of coal as a major energy sources for power plants so, as a result of exploration [2] carried out up to the depth of 1200m a cumulative total of 267.21 Billion tones of Geological Resources of Coal have so far been estimated in the country in 2009[6].The state-wise distribution of various solid, liquid and gaseous fuel resources and its categorization are as follows in the respective tables.

TABLE II.

CRUDE OIL PRODUCTION(2009)×10 ³ TONNES		NATURAL GAS PRODUCTION(2009) (Million Cubic Metres)	
STATES	Onshore	STATES	Onshore
Gujarat	5944	Gujarat	2605
Assam/ Nagaland	4673.4	Assam/ Nagaland	2573
Arunachal Pradesh	102.4	Arunachal Pradesh	30
Tamil Nadu	265	Tripura	553
Andhra Pradesh	289	Tamil Nadu	1242
		Andhra Pradesh	1524
		Rajasthan	216
		West Bengal	20
TOTAL ONSHORE PRODUCTION (A)	11273.8	TOTAL ONSHORE PRODUCTION (A)	8763
COMPANIES	Offshore	COMPANIES	Offshore
ONGC	17801	ONGC	16738
JVC/Private	4431	JVC/Private	7348
TOTAL OFFSHORE PRODUCTION (B)	22232	TOTAL OFFSHORE PRODUCTION (B)	24086
GRAND TOTAL PRODUCTION (A)+(B)	33506	GRAND TOTAL PRODUCTION (A)+(B)	32849

The state-wise distribution of coal resources in India (million ton)

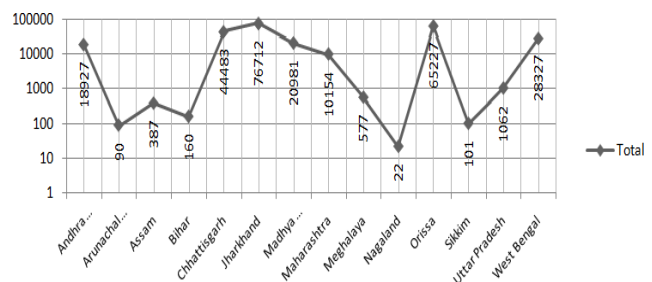


Figure 1. The state-wise distribution of coal resources in India (million ton)

III. UTILIZATIONS OF ENERGY IN DIFFERENT SECTORS

Power which generates by different energy sources of India is utilizes to full fill our daily requirements at domestic and industrial purposes. Basically by exploration [5] it is found that industrial and domestic sectors consumes maximum amount of power from the total amount of generated power. According to the Indian energy scenario [3] the percentage of energy consumption by various sectors of India is represented in the Figure 2.

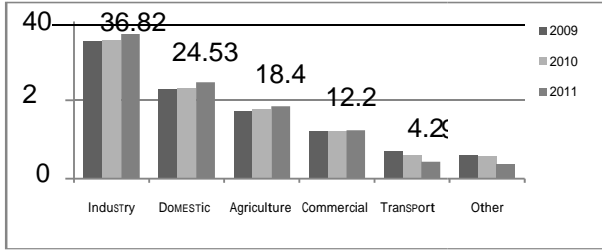


Figure 2. Percentage of Energy Consumption by Various Sectors in India (2009, 2010, 2011)

Since total power generates by various sources in India is calculated. So the total power generates and the portion of this energy shared by different sectors can be visualized as per the Table III and the graph represent below [9].

TABLE III.

Power Sources	Generated power in (MW)	Utilization in Different Sectors in (MW)					
		Industry	Domestic	Agriculture	Commercial	Transport	Others
Coal ^a	81605.8	30047.	20017.	15015	10013	3500.	3003.
Gas ^a	17055.8	6279.94	4183.78	3138.26	2092.7	731.69	627.6
Nuclear ^c	4560	1678.9	1118.56	839.04	559.5	195.6	167.8
Hydro ^b	2955	1088.0	724.8	543.72	362.5	126.7	108.7
Oil ^a	1200.30	441.95	294.43	220.85	147.2	51.4	44.1
Biomass ^c	1073	395.07	263.2	197.4	131.65	46.0	39.4
Wind ^d	259	95.3	63.5	47.6	31.7	11.1	9.5312
Solar ^f	9.84	3.62	2.41	1.8	1.2	0.42	0.36
Total	108718.8	40030.26	26668.72	20004.262	13339.79	4664.03	4000.8

Power shared by different sectors of India

Source:

- a. Central Electricity Authority, Grid operation and Distribution wing Operation Performance Monitoring Division
- b, d. <http://fossil.energy.gov/international/indiover.html>
- c. http://en.wikipedia.org/wiki/Nuclear_power_in_India,
- e. Global energy network institute, October 2006
- f. solar power in India, <http://www.solarindiaonline.com/solar-india.htm>

Different energy conversion process produces different amount of emissive. Experimentally it is found that thermal power plants runs on fossil fuels like (Coal, Diesel, Gas) etc are produces highest amount of emission where as wind and hydro one contributes very negligible amount as compared to other major energy sources.

As per the [4] near about 1905 million tons of emissive gas generates on (2009-11) by various conversions process and their contribution from various sources are described in the table IV .

TABLE IV.

Process of conversion	% share	Emission amount in (million ton)
Thermal	83%	1581
Hydro	0.40%	8
Nuclear	2.32%	44.2
Wind	1%	19.04
Biomass	4.28%	81.52

Others	9%	171.43
Total	100%	1905.19

Emission from various conversion processes

Note: Other sources include (Domestic, Vehicular, Solar and Commercial sectors).

IV. CLASSIFICATION OF EMISSION ON THE BASIS OF UTILIZATION

The above diagram represents the emission from different sources of energy production, but as per there utilization and consumption in various sectors of India it should be classified also. According to the [4] the approximate emission shared by different sectors of India is represented in the diagram below. The first diagram represents emission from different sectors in (million tons) and the bottom one shows [9] its percentage of contribution from the total generated emission.

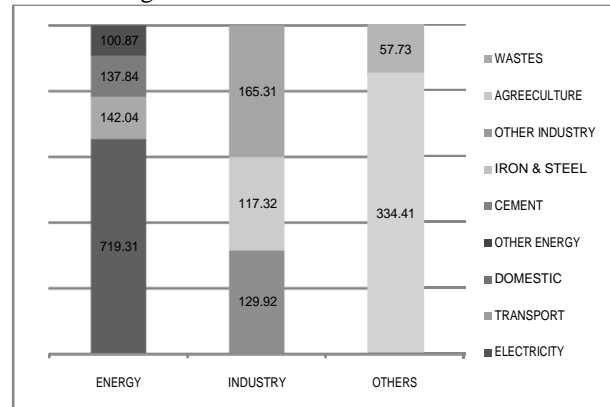


Figure 3. GHG Emissions from different sector of India in (Million tons) in 2009-10

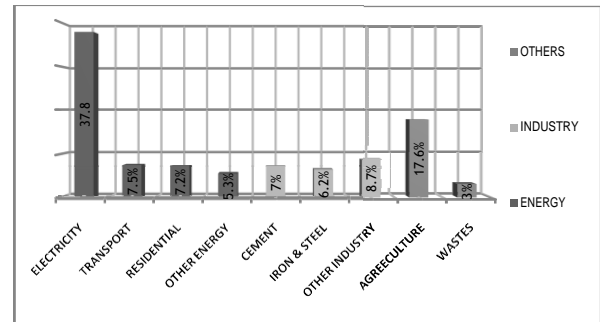


Figure 4. The % of emission of the category with respect to the equivalent emissions

Note:

Other Energy: Includes GHG emissions from petroleum refining, manufacturing of solid fuel, commercial & institutional sector, agriculture & fisheries and fugitive emissions from mining, transport and storage of coal, oil and natural gas.

Other Industry: Includes GHG emissions from production of glass and ceramics, soda ash, ammonia, nitric acid, carbides, titanium dioxide, methanol, ethylene oxide, acrylonitrile, carbon black, caprolactam, Ferro alloys, aluminum, lead, zinc, copper, pulp and paper, food

processing, textile, leather, mining and quarrying, non specific industries and use of lubricants and paraffin wax.

Agriculture: Includes GHG emissions from livestock, rice cultivation, agricultural soils and burning of crop residue.

Waste: includes GHG emissions from municipal solid waste (MSW), industrial and domestic waste water.

Waste: includes GHG emissions from municipal solid waste (MSW), industrial and domestic waste water.

V. RELATION OF ENERGY CONVERSION WITH EMISSION

A. Mass Flow Rate of Fuel Used

Mathematical Analysis.

The rate at which fuel is used for the required power production can be calculate by empirical formula

For solid and liquid fuels

$$\text{Rate of fuel used} = \frac{\text{Generated Energy} \left(\frac{\text{kJ}}{\text{s}}\right)}{\text{calorific Value of fuel} \left(\frac{\text{kJ}}{\text{kg}}\right)} = \frac{\text{kg}}{\text{s}}$$

For gaseous fuels

$$\text{Rate of fuel used} = \frac{\text{Generated Energy} (\text{kJ/s})}{\text{calorific Value of fuel} (\text{kJ/m}^3)} = \text{m}^3/\text{s}$$

Since we had calculated the typical heating values [7] of different types of fuel with their grades so the rate of fuel used is calculate by putting the values of individual fuel in the above formula.

TABLE V.

Fuel used	Heating value (KJ/Kg)	Generated Energy (MW)	Mass flow rate of fuel used		
			D grade coal in (ton/s)	E grade coal in (ton/s)	F grade coal in (kg/s)
Coal	9871-D	81605.880			
	13150-E				
	16386-F		8.267	6.205	4.98
Oil (diesel)	40752	1200.300	Diesel oil in (ton/s)		
			0.029		
Natural gas	38620	17055.80	Natural gas in (m ³ /s)		
			441.63 m ³ /S=0.35		

B. Volume flow rate of emissive gases

Mathematical Analysis

In the same way the amount of emissive gas generation or volume flow rate of emissive gas also calculate by formula such as

For solid and liquid fuels

$$\text{Rate of fuel used} \left(\frac{\text{kg of fuel}}{\text{s}}\right) \times \text{Amount of emissive gas evolved} \left(\frac{\text{m}^3}{\text{kg of fuel}}\right) = \text{m}^3/\text{s}$$

For gaseous fuels

$$\text{Rate of fuel used} \left(\frac{\text{m}^3 \text{ of fuel}}{\text{s}}\right) \times \text{Amount of emissive gas evolved} \left(\frac{\text{m}^3}{\text{m}^3 \text{ of fuel}}\right) = \text{m}^3/\text{s}$$

By the above formula ‘volume flow rate’ of different grades of fuel for required amount of power production in India can be calculated and the respective values is represented in table VI.

TABLE VI.

Fuel used	Generated power In (MW)	Rate of fuel Used (ton/s)	CO ₂ in (m ³ /s)	SO _x in (m ³ /s)	NO _x in (m ³ /s)	Total dry flue gas in (m ³ /s)
D-Grade	81605.880	8.267	4807.4	32.04	20998	25837.44
E-Grade	81605.880	6.205	4387.5	22.34	21221.1	25630.94
F-Grade	81605.880	4.98	3889.3	18.924	21663	25571.224
Diesel	1200.300	0.02944	47.25	0.06	283.2	330.51
Natural Gas	17055.800	441.63*= 0.35	494.6	0	3917.2	4411.8

Volume flow rate of emissive gases generates for required power generation

Note: *rate of fuel for natural gas is in, m³/s

VI. RELATION BETWEEN FUEL CONSUMPTION, EMISSION AND COST OFEXPENSES

A. For Fuel Consumption Rate Analysis

As from the calculation it is calculated that total amount of power generation from coal based plant is near about 81605.88 MW from different region of the country where as1200.2 MW and17055.80 MW power generates from oil and gas based power plant respectively. Now for our analysis purpose we assume that if the total energy which produced by best grade of coal operated power plants is replaced by oil (diesel) and by different grade of natural gas based power plants then what will be effect on fuel rate, cost of operation and emission which is analyzed below.

Mathematical calculation

Since from the formula we get rate of fuel [8]

For solid and liquid fuels

$$\text{Rate of fuel used} = \frac{\text{Generated power} \left(\frac{\text{kJ}}{\text{s}}\right)}{\text{calorific Value of fuel} \left(\frac{\text{kJ}}{\text{kg}}\right)} = \frac{\text{kg}}{\text{s}}$$

For gaseous fuels

$$\text{Rate of fuel used} = \frac{\text{Generated Energy} (\text{kJ/s})}{\text{calorific Value of fuel} (\text{kJ/m}^3)} = \text{m}^3/\text{s}$$

In the same way we calculate the rate of fuel used for both grades natural gas for the same amount of generated power by coal. By utilizing different type of fuels for the replacement of coal the rate of fuel analysis a standard values are generate which shown in table VII.

TABLE VII.

Fuel Types	Generated power (MW)	Rate of fuel consume (ton/s)
Lignite	81605.88	8.267
Diesel	81605.88	2355 Ltr=2.002

Natural Gas (H)	81606.88	2113.04 m³/s=1.69
Natural Gas (L)	81605.88	1971.96 m³/s=1.57

B. For Cost Of Expenses Analysis

From ‘Coal India Limited’ and ‘Gas Authority of India Limited’ we take the recent cost for different types of fuel which is represent in the table VIII.

TABLE VIII.

Fuel	Price as on (26/09/12)
Lignite	1200 to 1800 Rs/ton
Diesel	55 Rs/Ltr
Natural Gas	6.18 Rs/m ³

Price list of different fuels in India

Note: price of coal includes mining, handling, pulverizing and washing

Result Discussion

By putting the respective values of different types of fuel with their price and rate of consumption an overall table has generate which gives that it will be wiser one to set up a gas operated power plant in place of power plant run on coals. A standard table IX is generated by taking all the factors into consideration to have a clear idea.

TABLE IX.

Fuel Types	Power produce (MW)	Fuel Consume rate (ton/s)	Cost of expense (Rs/s)	Emission rate (m ³ /s)		
				CO ₂	SO _x	NO _x
LigniteD1	81605.88	8.267	12400	4807.4	32.04	20998
Diesel	81605.88	2.002	101281	3203.2	4.08	19259.24
Natural Gas-L	81605.88	1.69	10058	2366.6	0	18742.6
Natural Gas-H	81605.88	1.577	9860	2330.8	0	18457.5

Fuel cost verses emission by different type of fuel

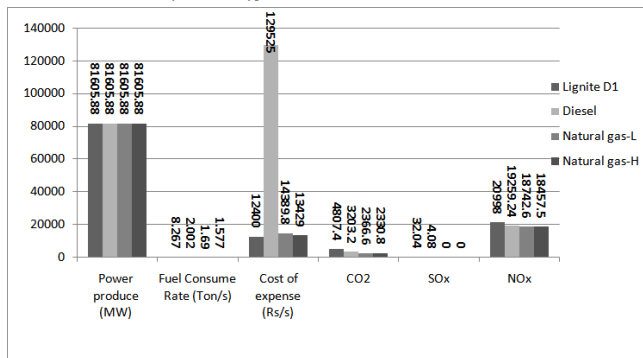


Figure 5.

CONCLUSION

From the above analysis we conclude that by utilizing ‘Natural Gas’ and diesel oil fuel consumption rate and other emissive gases is decrease up to an appreciable value but cost of diesel is increases up to 10 times of coal whereas gas cost is less than two times . It is a great challenge for us that resource of natural gas is limited and it also affects the cost

of production. But for we the leaving beings safe and good living condition must be a first priority as compared to the cost of living. Because there are no of examples where people are more serious about safety in spite of the costs. So if we focus on the emission only then these two fuels can greatly solve the recent emission problems up to great extent. So it will be wiser to replace the fuel of major thermal power plants runs on coal whose efficiency is very poor or where emission is great challenge with respect to fuel used. Many research is still required to solve these issues, and it hopes that emission can be reduces by adopting others techniques on all sectors of emission generation.

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