Environmental Examination of Solar Energy Application in three major GHG Emitter Countries of the World

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Abstract— This paper quantifies the pollution generation in the three major industrialized nations (India, China & US) by releasing CO_2 & GHG gasses into the atmosphere from the power sector. The consequence of this pollution generation has also been discussed in this paper. It has already been known that Electricity and heat generation together contribute 42% of world CO_2 & GHG emission and 22% emission is contributed by the transport sector. India ranked fourth as GHG emitter in the world and emits more than 5% of world's total CO_2 emission. India accounts for 10% of global emission with the trend of rapid increase by 3.4% per year from 2011 to 2035 as per projection of World Energy Outlook, 2013 [2] This paper also examines the possibilities of emission reduction by producing power from renewable energy, an alternative energy sources, mainly from solar energy, to save environment and to reduce our health hazard.

Key words: Examination, Largest Emitting Countries, Emission Effect on Environment and Public Health, Solar Energy as Alternative Sources to Save Environment and Health Hazard

I. INTRODUCTION

According to WRI analysis the top 3 largest emitting countries of the world are China, United State and India. In global context, top 10 emitters contribute 72% of total atmospheric GHG. Greenhouse gasses from Energy sector contribute more than 75% of Global emission. Thus, Electricity generation is the largest single sources of CO_2 the potent GHG emission by burning fossil fuel. Six of top emitters are developing countries. China contributes 25% of global emission as a top emitter. [3]

The 29% of world Total Primary Energy Sources (TPES) comes from coal and accounts for 44% of global CO_2 emission and more than 80% of worlds total energy supply comes from fossil fuel. CO_2 accounts for the largest share of global GHG emissions.[4]

A. World Primary Energy Supply and CO_2 Emissions: shares by fuel in 2012

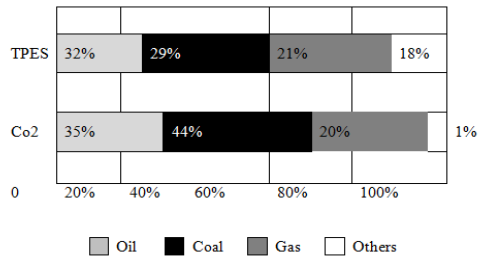

Fig. 1: A Source: IEA, CO_2 Emission from Fuel Combustion Highlights (2014 Edition)

Statistics says, in 2012 among most emitting countries of the world the first three countries are China ranks 1st, United States(US) in 2nd Position and India hold 3rd position. Global CO_2 emission data of 2013 represents China produces 10.3 billion ton of CO_2 , US produces 5.30 billion ton of CO_2 and the third largest producer India emits 2.01 billion ton of CO_2 [5].

Per capita emission is one of the biggest challenges for Climate issues. Unite State is in the highest position for per capita emission of CO_2 (16.1 ton of CO_2/capita) followed by China (6.1 ton CO_2/capita) and India (1.6 ton of CO_2/capita)[6]. In 2013 CO_2 emission growth rate of China was 4.2%. And growth rate in 2014 in compared with 2013 is 2%.[7]. The thermoelectric power plants are water intensive. Water use for power generation is almost 10% of total water supply of China[8].

In 2012 the U.S. electricity sector accounts for one-third of all GHG emissions and 38% of total CO_2 emissions. [9]

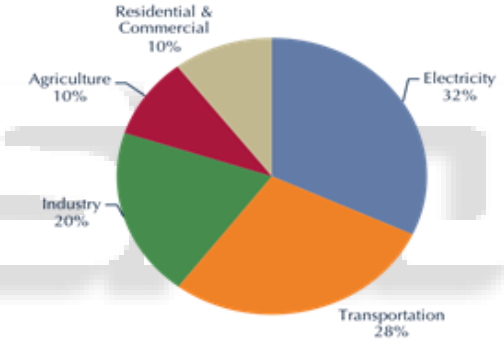

Fig. 2: U.S. Greenhouse Gas Emissions by Sector (2012)

Source: U.S. Environmental Protection Agency (EPA), Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, Table ES-7, 2014.

U.S coal fire power plant provide around 39% of total electricity produced in the country.[10]

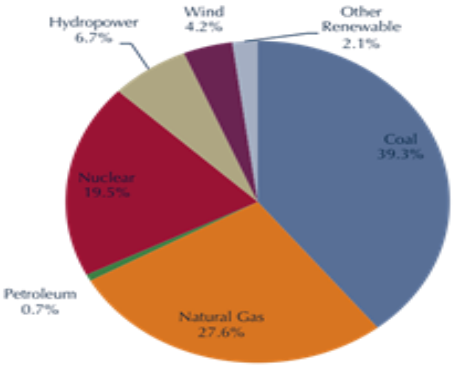

Fig. 3: U.S. Net Electricity Generation by Energy Source (2013)

Source: Energy Information Administration (EIA), Monthly Energy Review, May 2014, Table 7.2a, 2014.

CO_2 covers around 99% of GHG emissions from electricity generation and almost 80% CO_2 emissions comes from coal combustion for electricity generation in U.S.[11]

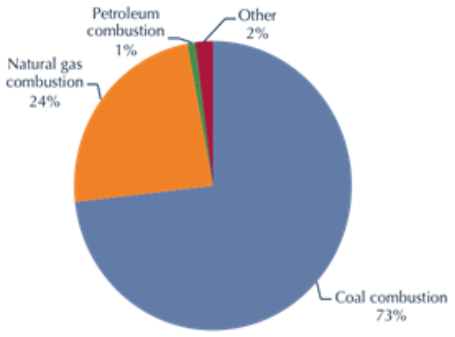

Fig. 4: GHG Emission for Electricity Generation (2012)

Source: EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, Table 2-13, 2014.

In India, Power produced from coal fired power plant accounts for 70% of total coal related CO_2 emission with growth rate of near 13% in 2012. Indian coal consumption share around 59% of total primary energy consumption from fossil fuel. India's CO_2 emission continued to grow by 4.4% which is equivalent to 2.1 billion tones of CO_2 emission and ranked as 4th largest CO_2 emitting country. [12]

Including captive and private power plant the capacity of electricity generation from coal and lignite based thermal power plant is 93772 MW as on March 2010. The capacity of 86 coal and lignite based thermal power plant is 77682.00 MW which accounts for 85% of total installed capacity in India as per information gathered from Central Electricity Authority (CEA 2010)

Based on data from CEA 2010 and research on 86 coal and lignite based thermal power plant we can find ----

In the Year 2009 – 2010 : For 86 Coal and Lignite based Thermal Power Plant

Electric Power Generated (GWh)	Total CO_2 Emission (Million Ton)	CO_2 Emission/Unit (Kg/kWh)	Consumption of Coal/Unit (Kg/kWh)	Total Coal Consumed (Million Ton)
533133.44	550	0.94	0.76	444

Table 1: CO_2 Emission and Coal Consumption for Generation of Electricity in India

With the consideration of 12% of carbon is lost as bottom and fly ash and are not oxidized, for 55,890.00 GWh electric power generations it emits 523 million ton of CO_2 in India recorded at 2007-08. If 12% carbon losses are not taken into account, then the CO_2 emission will reach to 677 million ton in that year [13]. It has been estimated that around 2.2 billion cubic meter of water withdraws for India's thermal power plant The average water consumption for the plant with cooling tower is 4 m^3/MWh but for China it is about 2.5 m^3/MWh.[14]

It was calculated that, 700 Kwh/capita./year was the average electricity use in 2010 but the global average electricity use was 2100 KWh/capita/year. As per National Energy Technology Vision 2035, India has taken a target to touch 2600 KWh/capita/year of average electricity consumption in 2035 to have better HDI (Human Development Index). It's clearly indicates that, the primary energy source will also increase around four times than present to achieve the target, in turn the amount fossil fuel burning will also increase and produce more CO_2, SOx, NOx , CH4, etc. which affect environment and public health more severe than present. In 2011-12 the Indian power sector consumed about 400 million ton of coal which was 75% of the total demand of 535 million ton of coal.

In 2011 Coal accounted for 69% of total electricity generation and around 59% of installed capacity in 2013 [15]

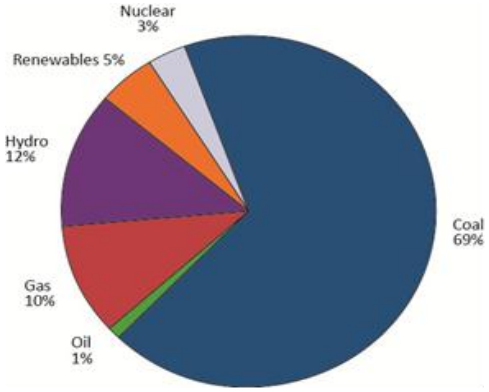

Fig. 5: Electricity generation in India in 2011 [13]

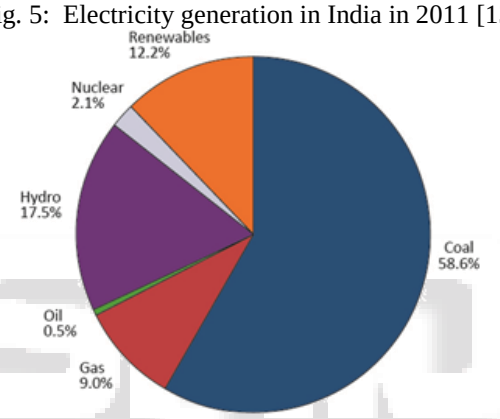

Fig. 6: Indian installed power generation capacity in India in 2013[13]

1) Health Impact

Air pollution in China accounts for approx. 2,57,000 premature death per year. It has been estimated by WHO in their "Global Burden of Disease report" that 1.2 million premature death occur in 2012 for the emission from Industry, Transport and Coal power plant. China depends 80% on coal as primary energy source, out of that almost 50% combusted for power plant. WHO analyzed that association with air pollution increases respiratory and cardiovascular disease , lung cancer and mortality rate.

In 2011, it has been estimated approx. 3,20,000 children and 61,000 adults suffering from Asthma, 36,000 babies born with under weight, 3,40,000 hospital admission, 2 million doctor visit and 141 days of sick leave as an effect of pollution from emission.

As per research published in Proceedings of the National Academy of Sciences (PNAS) life expectancy reduces 5.5 yrs per person on average due to air pollution and it is more than 2.5 billion years of life expectancy in China. It has been projected that 32,000 premature death per year will be added if production starts from 570 proposed coal power plant in China. [16]

Air pollution from coal fired power plant in U S accounts for more than 13,000 premature death, around 20,000 heart attacks and 1.6 million loss of working days.[17]

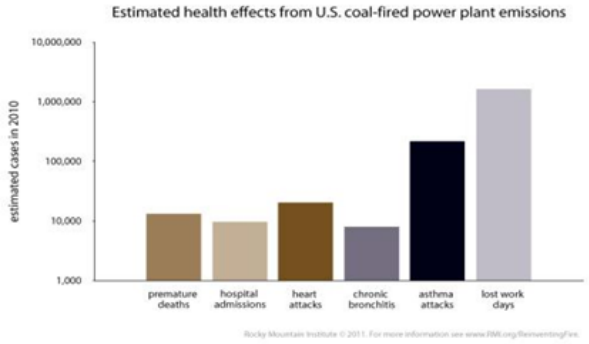

Fig. 7: Source: A 2010 study by the Clean Air Task Force

In US, one – third of all mercury emissions comes from coal fired power plant and responsible for between 3,00,000 to 6,30,000 children born with high blood mercury level which affects neurodevelopmental performance and loss of intelligence.[18]

In Dec 2012, Conservation action Trust, Urban Emission and Greenpeace India jointly published that emission from Indian coal fired power plant responsible for 80,000 to 1,15,000 premature death and more than 20 million people affected by Asthma in 2011 – 2012. The study also includes a large number of additional health impact like heart attack, emergency doctor visit , hospital admission , sick leave or loss of working days etc. associated with emission from coal fired power plant and estimated the moneytory cost of Rs. 16,000 to 23,000 cores/year for these health impact occurred due to emission from coal fired power plant in India.[19]

Effect	Health Impact	Health Cost (Cores of Rupees) Considered Rs.50/USD	Health Cost, (Million USD)
Total Premature Mortality	80,000 – 1,15,000	16,000 – 23,000	3300 - 4600
Child Mortality	10,000	2100	420
Respiratory Symptom	625 million	6200	1200
Chronic Bronchitis	1,70,000	900	170
Chest discomfort	8.4 million	170	35
Asthma Attack	209 million	2100	420
Emergency Room visit	9,00,000	320	60
Restricted Activity day	160 million	8000	1600

Table 2: Estimated annual health impacts and health costs due to PM pollution from coal-fired power plants in India, 2011-2012.

Source:http://www.greenpeace.org/india/Global/india/report/Coal_Kills.pdf

Another study projected that, due to emission from coal fired power plant, it is expected that in 2017-18 total premature death will reach 1,12,500 to 1,26,000 and Asthma cases will be reached to 23.4 million . In 2030 the total premature mortality likely to grow 1,86,500 to 2,29,500 annually and Asthma cases will be reached to 42.7 million.[20]

Anticipated Health Impacts due to Emission from Coal Fired Power Plants		
Year	**Premature mortality**	**Asthma attacks**
2017-18	1,12,500 – 1,26,000	23.4 million
2020-21	1,32,500 – 1,53,500	28.4 million
2025	1,64,000 – 1,97,500	36.7 million
2030	1,86,500 – 2,29,500	42.7 million

Table 3: Source: http://www.urbanemissions.info/india-power-plants

B. Environmental Impact

China consumes ½ of the world's coal consumption, is the biggest consumer of coal as energy sources. China was the largest carbon emitter of the world in 2007 and in 2010, she became world's biggest consumer of energy. Sometimes visibility in China reduced to 50 meters and red alert for pollution was maintained for consecutive five days in same cities due to fugitive dust and emission from coal power plants.[21]

As per U S record, in West Virginia ,surface mining destroyed 3,00,000 acres of hard wood forest and around 1000 miles of streams. Air pollution of U S accounts for 1 million tons of nitrogen oxide (NO_x) and 52,000 tones of coarse and small particle with particulate matters (PM) from coal dust due to diesel fuel burning for transportation of coal. Further , coal dust form uncovered coal pile storage outside the power plant are contaminates land and water by settling dust on the nearby houses , on the yard and on the land outside the yard. [22]. In U S, CO_2 emission accounts for 84% of U S GHG emission and 3/4th of global GHG emission. In 2012, 32% of US total GHG emission comes from electric power sector with the increased rate of 11% since 1990.

A typical 600 MW capacity power plant with one through cooling system requires 70 to 80 billion gallons of water and it release back into the nearby lake, river or into the ocean which is 20 degree to 25 degree F hotter than receiving water of cooling tower resulting thermal pollution which increases heart rate in fish and decrease fertility.[24]

During 10th FYP forest land diverted or granted forest clearance (FC) for all mining project was 29,000 ha. But, during 11th FYP granted forest clearance was around 31,500 ha only for coal mining projects.[25]

1) Coal Mining and Forest Clearance during 11th FYP

State	No. of Projects Granted in-principal clearance	No. of Projects granted final clearance	Total no. of Projects	Forestland diverted (in ha)
Andhra Pradesh	6	13	19	5,139.82
Chhattisgarh	11	11	22	12,120.687
Jharkhand	16	26	42	6,949.2056
Madhya Pradesh	19	12	22	5,559.21
Maharashtra	3	1	4	407.04

Orissa	2	7	9	1,267.528
West Bengal	1	0	1	4.89
Total	49	70	119	31,488.38

Table: 4 Source: CSE, Centre for Coal Mining, http://www.cseindia.org/userfiles/02Coal%20mining.pdf

For coal fired power plant, Direct impacts starts from construction and operation stage. Environmental impact during construction is land erosion, loss of biodiversity, loss and change of soil quantity and quality, fugitive dust and noise pollution. During operation the impacts are high air pollution, emission of mercury, emission of GHG, waste generation and high rate of water consumption. Thermal power plants are water intensive. A 500 MW capacity thermal power plant consume 14 million m^3 of water yearly and for all thermal power plant the withdrawal of water is around 22 billion cubic meter which is half of domestic water requirement. Plant with cooling tower require 4 m^3/MWh where as average consumption of Chinese thermal power plants 2.5 m^3/MWh. Norms of particulate matter(PM) in India are 150-350 mg/Nm^3 but for China it is only 30 mg/Nm^3. It impact highly on river and ground water. Water heavily used for coal washing and cooling tower and to carry fly ash from power plant to ash pond or pit and contaminate surface and ground water with leachates, heavy metals and other poisonous effluents. Hot water release from costal thermal power plant adversely affect on marine ecosystem and affects fisherman and other communities who depends on sea for their livelihood. At present, thermal power plant in India generated around 170 million ton of fly ash and it is estimated that, plant will produce around 300 million tones of fly ash by 2021 – 2022.

Coal mining activities associated with the impact of water resources such as water runoff from coal washeries carry heavy metals which affect aquatic flora and fauna in lakes, rivers, oceans. and acid mine drainage pollute water bodies .

Air pollution from thermal power plant are two types such as point source pollution – pollutants are mostly Particulate matter (PM) , GHG emissions like So2 , NO_x, CO, CO_2, Hydrocarbons etc. and pollutant from non point sources are coming from transportation of coal, fly ash handling , coal storage yard etc.

Another major pollutant is emission of mercury affects environment. Out of total mercury emission from a typical power plant, emits 90% into the air and 10% on land. Indian thermal power plants releases around 65 tones of mercury into the atmosphere.[26] [27] [28][29]

II. Literature Survey

Research article " Estimates of Emission from Coal Fired Thermal Power Plant in India" by Moti L. Mittal, Department of Environmental and Occupational Health, University of South Florida, Tampa, Florida, USA and Chhemendra Sharma and Richa Singh, Radio and Atmospheric Sciences Division, National Physical Laboratory, Council of Scientific and Industrial Research, Dr K.S. Krishnan Road, New Delhi – 110012, India. ---- the study concentrates on emission from 86 operational thermal power plants in India based on their basic principals of coal combustion, characteristics of coal use and operating condition in those plants.

I have gone through another study with the subject "The Toll From Coal" Sep. 2010, by Conrod Schneider and Jonathan Banks, CATF (Clean Air Task Force) which is based on an assessment death and diseases from the dirtiest energy source of U S. This Study provides the burden of death and diseases of U S coal based electricity production.

A "issue brief" as an article "Opportunities to reduce water use and GHG emissions in the Chinese power sector" by Deborah Seligson, Hua "Willium" Wen, Craig Hanson and Kejun Jiang , published by WRI in January 19, 2015. Power sector of China is the largest source of GHG emission and a biggest industrial water user. As a conclusion of their study and analysis they offer suggestion on how to reduce the environmental impact of this growing industry and water implication in China and other countries and developed water-climate impact Bubble Chart.

The publication related to title "Trend in Global CO_2 Emission, 2014 Report" is the compilation of a series of annual publication by PLB – JRC. This CO_2 report series started in 2009 and provide up-to -date knowledge on trend of global CO_2 emission and estimated by PLB Netherlands Environmental Assessment Agency and The European Commission's Joint Research Centre (JRC) on the basis of energy consumption data from 2010 to 2013.

A research report "Future of Coal Electricity in India and Sustainable Alternatives" published by World Institute of Sustainable Energy (WISE), Pune. As per survey outcome it is found that they are focusing core area of sustainability and energy security and challenges of coal in India. The 12 months study covers the issues related to coal mining, processing and combustion for thermal power generation as well as environmental and climate externalities, the economics of coal, pathway of renewable energy based transition and energy security of India through new policy framework.

III. Methodology

For sampling, 43 article and web links were chosen as most relevant for my research article out of around 50 which are reflected in the reference section.

In depth analysis based on the available information and descriptive research on the variables provides the basis for discussion and conclusion as a result of the research.

IV. Result and Discussion

People living in the vicinity of coal fired power plants are not only affected but also emission can affect on health on those are living far from the power plant or far from source of emission because it can travel long distance even globally.

Emission of GHG (mainly CO_2 and N_2O) promotes increase of atmospheric global temperature which further promotes climate change results melting of polar ice and thawing of the arctic permafrost.

Quality of life increases with the increase of average electricity use by the population and with the increase of HDI (Human Development Index). Human development index is the combination of life expectancy at

birth, education and disposable income per capita. Access of electricity of people worldwide has the positive impact on health and well being but it is quiet disappointing that the use of coal affect negatively on human health during every stage from mining to post combustion disposal to generate electricity. Emission and other pollution from the complete cycle of operation reduces our life expectancy , increase premature death, increase heart attack , increase asthma and lung cancer , respiratory and cardiovascular disease , loss of intelligence , reduce neurodevelopmental performance, increase infant mortality and so on.

As per article published by Brian Kahn in 'Climate Central" in Nov,9th 2015, the rise of 2°C (3.6F) of global temperature above normal temperature is set by the scientists as benchmark and targeted as "safe" climate change. Record shows that through September 2015 planet is running 1.02°C (1.8°F) above normal. Thus it is certain that 2015 will end up as the hottest year with more than 1°C above pre industrial level.

As per research released by Climate Control that if global worming touches at 2°C ,it will affect land and home of approximate 130 million people due to rise of sea level. It is estimated that, 6ft. rise of sea water level, around 5 cores people living in coastal area will lost their home in India. In China it will affect severely and around 14 core people will lost their home.

In global context, around 28 cores people will be homeless and around 100 cores people will be under poverty line within 2013. Global worming responsible for 8 inches rise of global sea level since 1880 and the rate is accelerating year after year. Rising of sea level will dramatically increase the flood from storm surges and worsen effect of flood will occur by 2030. World Meteorological Organization (WMO) announced that CO_2 and other greenhouse gasses contribute to global warming to reaches at high level. It is first time that this year the global Co2 reaching 400 ppm (parts per million). It is expected by WMO, the global CO_2 average will cross 400 ppm in 2016. Further , if it reaches at 4°C(7.2°F) temperature above pre industrial level, it will affect land where 470 million to 760 million people living presently.[30] [31]

We can easily replace the source of electricity generation from fossil fuel to solar energy to avoid several complications including negative impact on environment and health and lower the electricity cost as the cost of source (solar energy) is free.

Transport linkage, fuel linkage and output-side effluents streams are not required for Solar PV system. Solar energy use for electricity generation confirm for no environmental and resource destruction or local community structure degradation[36]. As such there are no global warming emissions associated with generating electricity from solar energy, While life cycle emission for photovoltaic system are between 0.07 and 0.18 pound of carbon dioxide(CO_2) per kilowatt-hour and emission for concentrating solar power are between 0.08 and 0.2 pound of carbon dioxide(CO_2) per kilowatt-hour ,this is far less than the lifecycle emission rates to generate electricity from natural gas ranges from 0.06 to 2.0 lbs of CO_2/Kwh and from coal ranges from 1.4 to 3.6 lbs of CO_2/Kwh[37]

Solar PV based electricity price in India falling to as low as Rs. 4.63 / Kwh(unit) to sell electricity from a 500 MW project and it accelerating India's $ 160 billion clean energy drive . It will save our consumer to pay higher rate charged for electricity produced by fossil fuel base power plants.[38].

V. CONCLUSION

It has been estimated that, the amount of solar energy received by the planet is almost 3500 times the energy expected to consume by the human in 2050 [40]

China's solar power potential is around 19,536,000 TWh /year as per estimate of World Energy Council, 2007 as the annual solar radiation more than 1750KWh/m2 received by 17% of main land China.[39]

India's solar energy potential is about 7,48,990 MW, estimated by The Ministry of New and Renewable Energy (MNRE),India.[40]

China and India has taken a target of installation of 100 GW of solar PV capacity by 2020 and 2022 respectively as a leader of global solar revolution. [39]

India aim to renewable energy generation capacity to touch 175 GW by 2022 (100 GW – solar energy, 60 GW – wind energy, 10 GW – biomass energy, 5 GW – hydro energy). Electrification of 20,000 villagers included with this target of 100 GW of solar energy generation by 2022. It is the initiative started by the Govt. of India to fulfill the mission to reach the electricity for around 300 million people has no electricity till date. India may plan for a target to build 350 GW (250 GW – solar power, 100 GW – wind power) renewable energy generation plant by 2030. If so, then 40% of countries total capacity will come from renewable energy.[42] to avoid the Health and Environmental degradation.

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