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CHANGES IN ENERGY CONSUMPTION PATTERNS – A CASE STUDY OF INDIA AND CHINA

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Abstract: India and China are the biggest developing economies in the world apart from being the most populous nations. The population of China is expected to increase over 1.4 billion by 2050, and India may over take China and become the most populous nation at around 1.6 billion populace. These two nations are home to about 40 % of the total population in the world. Apart from this, India and China have attained remarkable success in the economic growth denoted by higher gross domestic product (GDP). The two nations together contribute about one-fifth of the world GDP. This paper discusses about the changes in the energy consumption pattern of developing countries like China and India aiming towards the sustainable development. Furthermore, this paper also analyses the most important drivers adding to the ecological problems, and gives a further glance at the ecological impacts of these in India and China. Over the last 50-60 years we have been emitting carbon dioxide at an accelerated pace. This has had an effect on the carbon dioxide concentration and other GHG gas concentrations, in the atmosphere. The paper also discusses about the effect of pollutants like NOx, SOx, Particulate matter and Mercury on the environment.
Keywords: China, Consumption pattern, Energy, Environment, India

1. INTRODUCTION

China is a very important role model and an interesting example to understand the linkage between the society aspirations and the energy consumption and the consequent effects on the environment and also how the energy usage develops. China is the biggest consumer of energy; it has been the most significant source of growth of global energy. Over the past 20 years, China has been driving the demand for energy, it has been buying up all kinds of resources renewable and non-renewable on the global market. As China shifts to most viable growth pattern, its energy needs are expected to change. As the economic prosperity and energy consumption are strongly linked; with economic prosperity, the population patterns will change, and that puts different kinds of demands on further use of energy and demand for energy, and that itself plays out in a different ways.

2. ENERGY CONSUMPTION PATTERNS

As the economic prosperity increases, although in the early days, there are double-digit growths, but one cannot continue to have double-digit growths for a very long period because then we will be hitting limits coming from natural resources. In the case of China, the demand for energy is projected to grow by less than 2% per annum over the next 15 years compared to over 6% per annum for the past 20 years. China has been, having a double-digit growth, so that is more than 10% growth for 25 consecutive years. China had a double-digit growth in economy, in GDP, so that meant also a very strong demand for energy. And we could see that as 6% over the past 20 years, but now that it has reached a certain economic level now that per-capita energy consumption of China is more than the world average and three times the per-capital energy of India in terms of energy consumption. Its demand for further energy is reducing, and it is expected to be more like 2% per annum for the next 15 years compared to 6% for the past 20 years, and this is partly due to reduction in GDP growth to about 5% over the next 15 years compared about 10% over the past 20 years. So, there is the linkage between the energy consumption and GDP [1].

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665
Universitatea Politehnica Timişoara

It is also partly due to continuing sharp decline about 3% per year in energy intensity, so energy intensity is a concept where what is the amount of energy that we are spending in order to produce so much of GDP, how many dollars of GDP can we get per so many mega joules of energy that is spent. And that depends on how we are generating that money, if we are generating that GDP dollars by making process which are heavily energy intensive then the energy intensity of the GDP will be high. But as the society matures and as the labour market becomes costlier than some of these energy intensive, labour intensive process will go to other countries, and so we will be looking more at the services and other kind of things which do not require as much of energy as some of the manufacturing processes take. So, that means that we may continue to increase a GDP but not at the same rate of energy demand. So, this reduction in energy demand, significant reduction 2% to from 6% is due to continuing severe decay in energy intensity as economic movement in China slowly shifts away from energy-intensive industrial output towards less energy intensive consumer and services activity.
It is also partly due to improvements in energy efficiency. This is the very same pattern of energy demand and then economic prosperity and the shifts in energy-intensive process in the many European countries and the US, and also in China and India. India's energy consumption growth is expected to be the highest among the major economies of the world at a value of 129 %, whereas the value for China is 47% as shown in Figure 1.

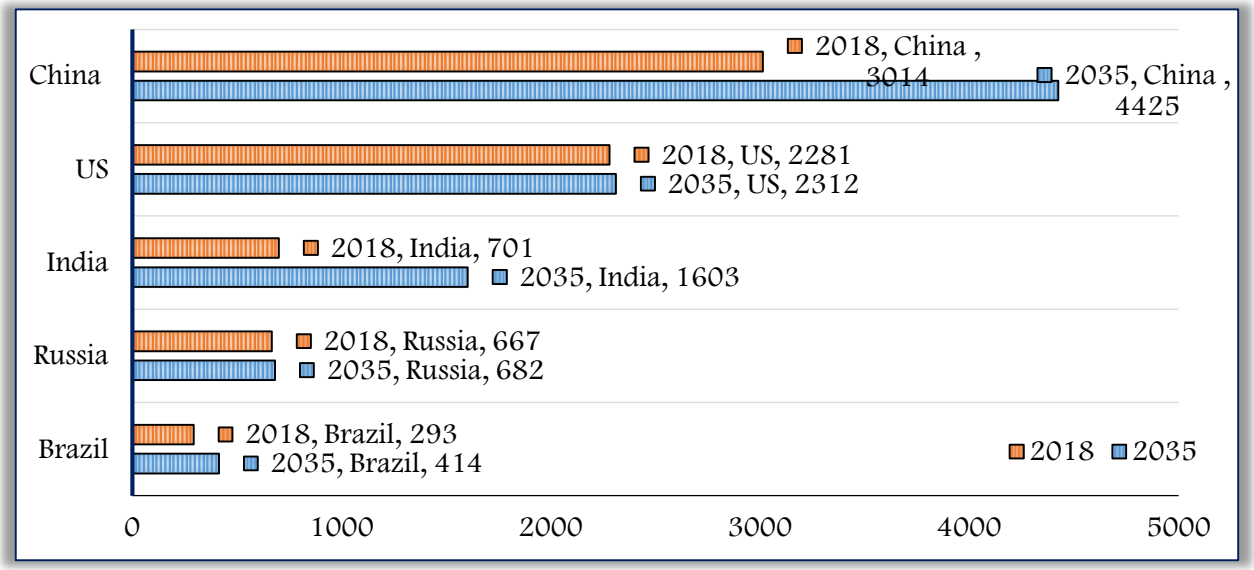

Figure 1: Total Energy Consumption (units in Mtoe)

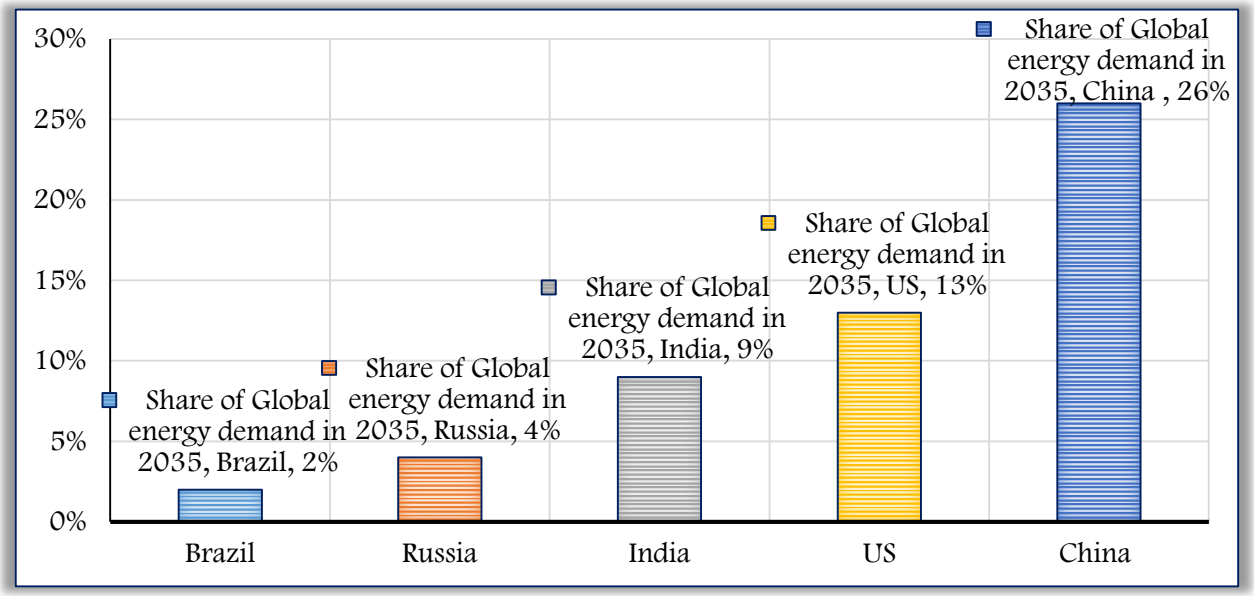

Figure 2: Share of Global energy demand in 2035

India's share of the global energy demand is set to rise to 9% by 2035. Coal will remain the dominant fuel in India with about 65 % share of total production in 2035 as shown in Figure 2.
China's energy mix is also expected to change significantly over the next 15 years. Energy mix is where we draw energy from what source we have to draw from, and that depends partly on what the source is that that are at our disposal, what is the cost in terms of dollars, and what is the cost in terms of environment, how much we need in, how we can allocate. And this change is partly due to changing economic structure and a policy commitment to move to cleaner and lower carbon fuels. China has jumped on to the world commitment towards reducing carbon dioxide emissions, and as a result of this the dependence on coal is likely to be going to become lesser and lesser.
Recently China was consuming 46% of the total world production of coal. The coal share in the energy mix is going to go down from 66% to 45% by 2035; it still is a large part 45%. Share of nuclear, hydroelectric and renewables is to increase from 12% to 25%, China is the world leader in terms of renewables, but even that kind of thing sustain for the next 15 years is going to increase the share to 25% only and that is not coming just from renewables but also from hydroelectric and especially nuclear. And share of natural gas, natural gas is a much cleaner fuel compared to coal, and that is going to increase although it is a fossil fuel and GHG, greenhouse gas emission fuel, its share is going to increase from 6% to 11%.
These are some of the factors that come into the demand for energy, and how it changes and how it is likely to emerge over the next short term of 15 years and over the next long-term of 50 to 100 years. There is a lot of concern about short-term immediate pollution from energy generation using a number of fuels, and there is also equally strong concern about longer term (50 to 100 years) in terms of global warming scenario [2].

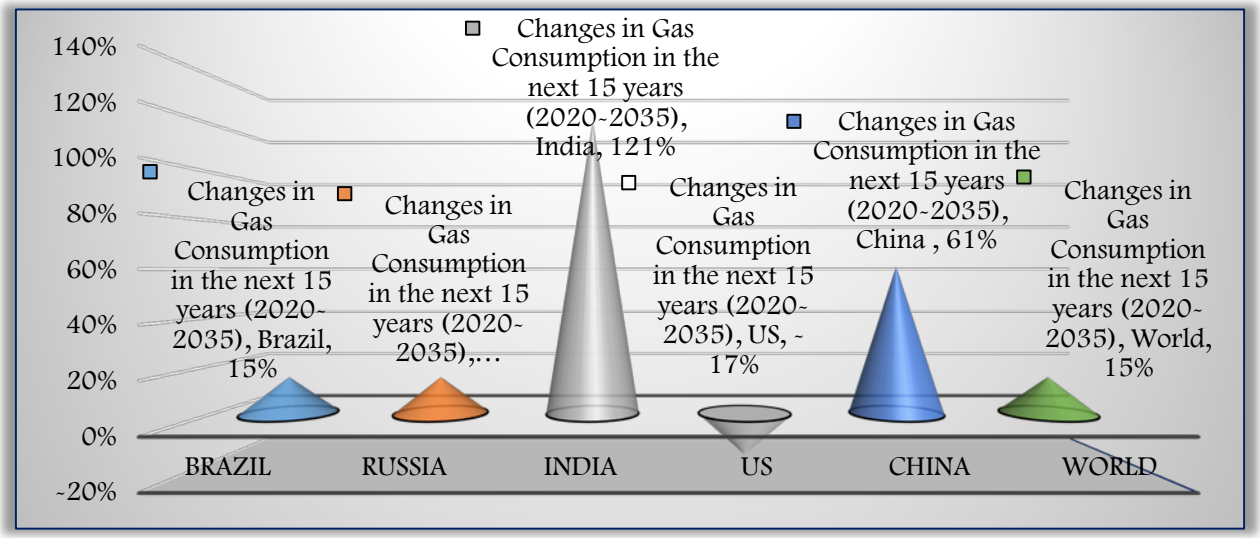

Figure 3: Changes in Oil Consumption in the next 15 years (2020-2035)

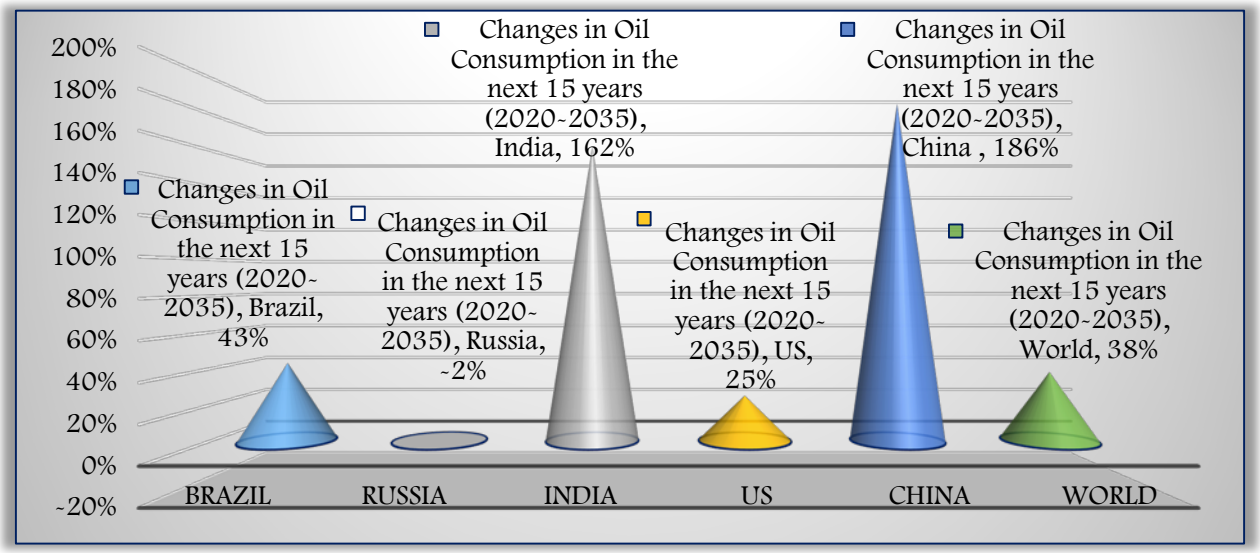

Figure 4: Changes in Gas Consumption in the next 15 years (2020-2035)

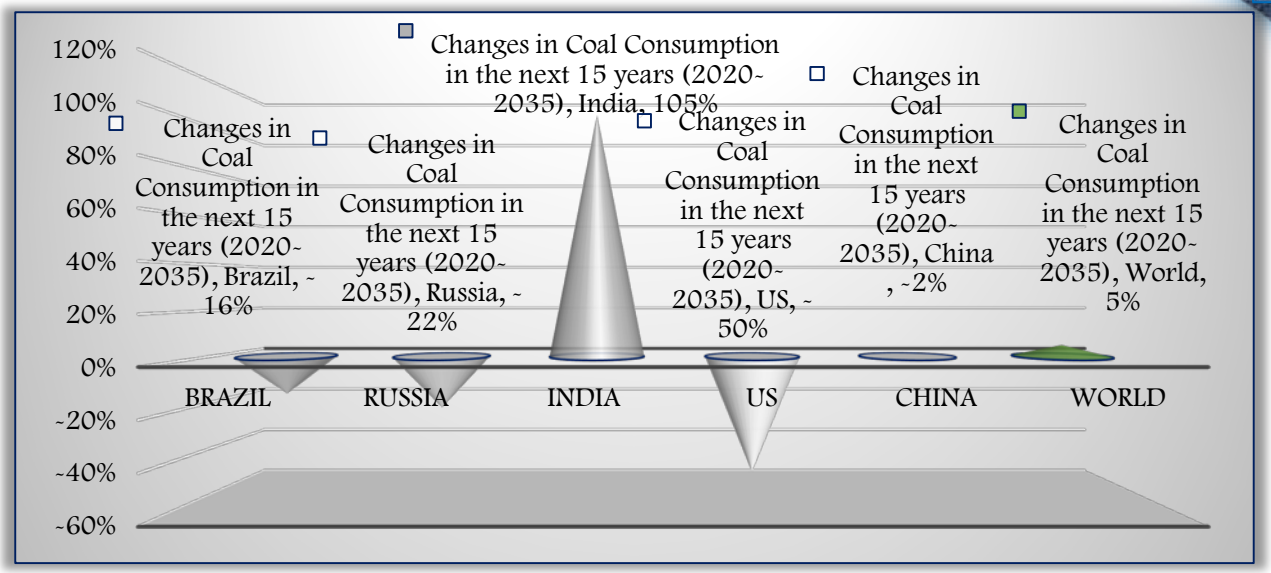

Figure 5: Changes in Coal Consumption in the next 15 years (2020-2035)

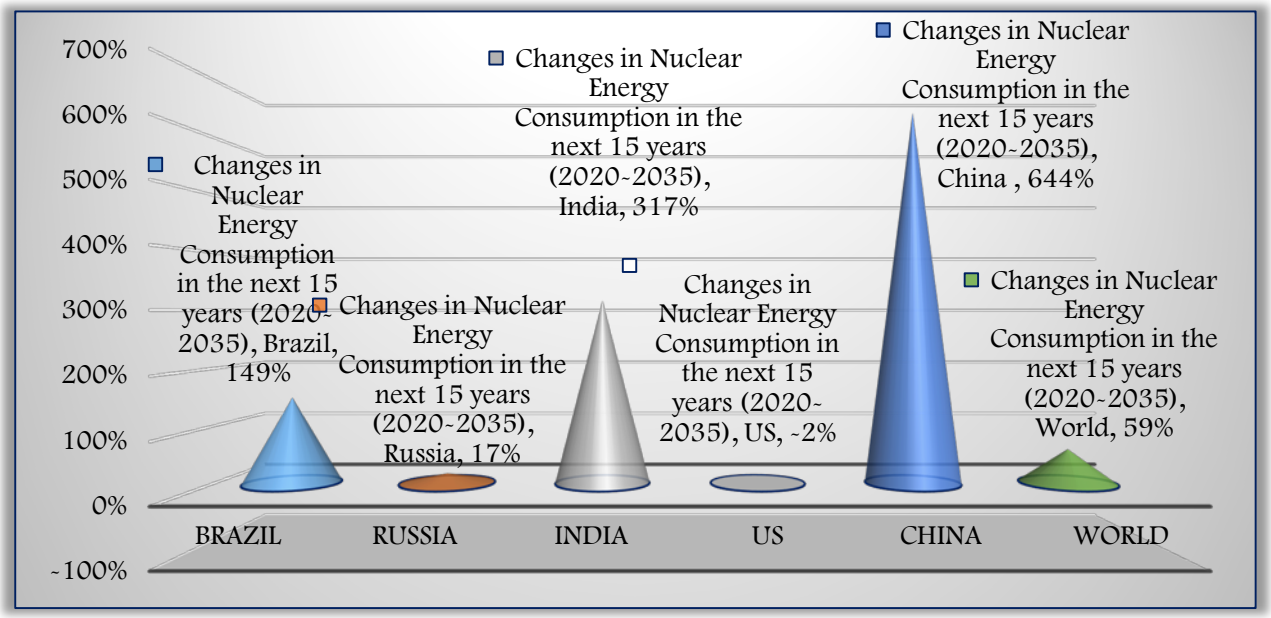

Figure 6: Changes in Nuclear Energy Consumption in the next 15 years (2020-2035)

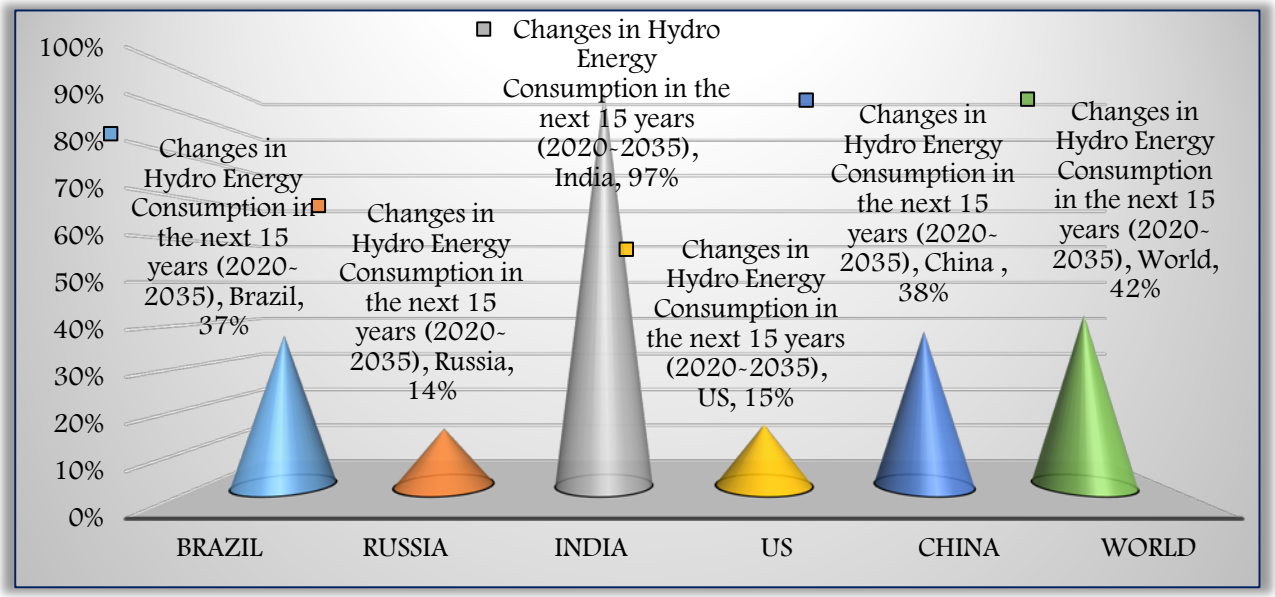

Figure 7: Changes in Hydro Energy Consumption in the next 15 years (2020-2035)

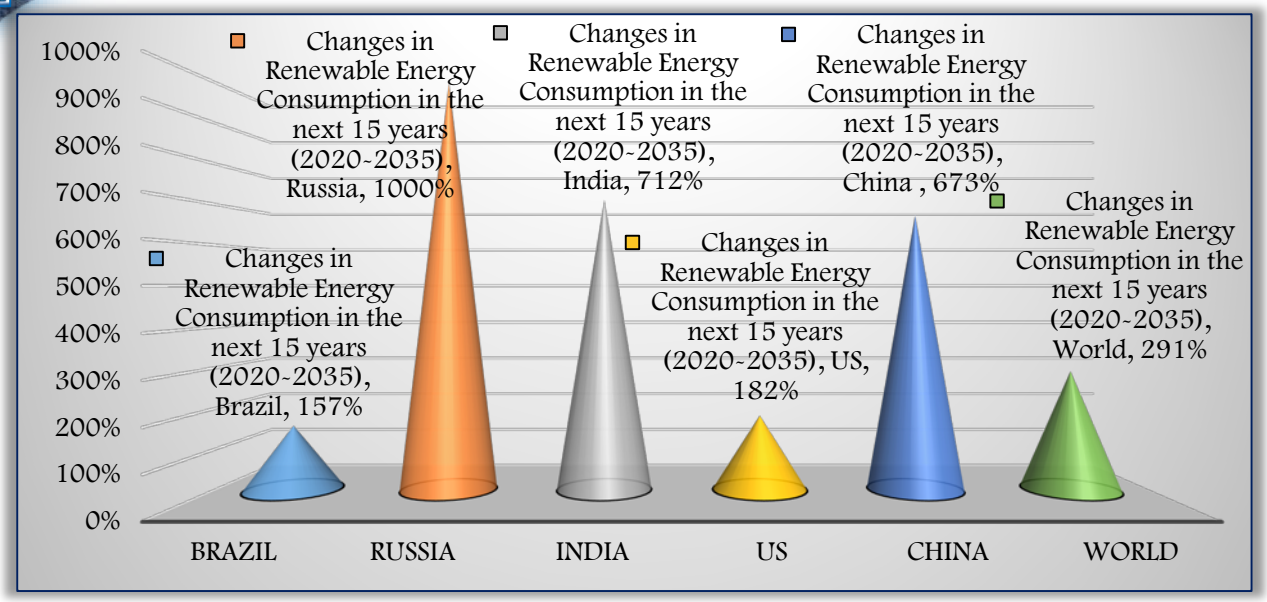

Figure 8: Changes in Renewable Energy Consumption in the next 15 years (2020-2035)

We have been drawing energy primarily from oil, natural gas, and coal for the past 50 years and this tendency is expected to go up, although we have an increasing contribution from renewable energies as shown in Figures 3-8. We expect that in the near future for the next 30 to 40 years fossil fuels are expected to continue to contribute to the energy demand and also contribute significantly to the increased demand of energy. In this case, in such a scenario, why are we concerned, people talk about the finiteness of the fossil fuel reserves, but the reserves of whether it is oil, gas, or coal are such that they can easily see us through for the next one century, including oil. There are so many reserves of oil that at the current demand and the future expected demand; these fossil fuels can take us into the next century without any problem. So, the problem is not in terms of the finiteness, but in terms of the effect of drawing this much of energy from fossil fuels on the environment.

The installed power generation capacity of India is mostly coming from coal. It is 60% in terms of actual amount of energy drawn it is more than 70% and much less in terms of gas and oil, but primarily coal and gas together constitute more than 70 to 80% of the total energy there. This is of concern because when we combust coal we not only get energy in terms of electricity, but we also get a lot of pollutants, and these are oxides of sulphur, nitrogen oxides, carbon monoxide, carbon dioxide, particulates coming from ash, mineral matter that is present in the coal which can be significant in the Indian context, aerosols of trace elements, many of which are environmentally harmful to the water bodies, to the air bodies, and to humans by direct ingestion and so on. The production of this pollutant is causing concern in terms increasing amount of energy from fossil fuels [3].

— Effects of Pollutants: SOx

When we consider sulphur oxides, we normally mean especially from our power generation type of situation, especially from coal and oil where they can be a significant amount of sulphur. Most of emissions will be in the form of sulphur dioxide and a small percentage maybe in the form of sulphur trioxide SO3, and these are known to have a detrimental impact on environment and human health. So, the major health concerns associated with exposure to high concentrations of sulphur dioxide include respiratory illness, breathing difficulties and aggravation of existing cardiovascular diseases. Humans are directly influenced by this.

In addition to this, common direct health impact on human beings in terms of immediate health concern, there is also undesirable consequences of sulphur dioxide in terms of acid rain, which leads to acidification of streams and lakes and damages agricultural crops and tree foliage. Acid deposition accelerates decay of monuments and buildings. The concern about Taj Mahal and other monuments that are being affected in North India by lot of pollution coming from power plants is an example of this particular case. This again is one of the problems fogs, smoke, and visibility problems especially in winter and especially in North India which leads to a lot of traffic congestion, train congestion and so on. These are all the immediate consequences that we have been facing, and whosever has been using coal has also been facing. In Europe and the US in early parts of the,

in the middle of last century and currently in China and India we have this kind of problems associated with excessive usage of coal for power generation [4].

— Effects of pollutants: NOx

Another major pollutant that comes from coal and also oil and even from the use of natural gas, which is relatively cleaner fuel among the three coal, diesel and – coil, oil and natural gas. Natural gas is the cleanest, but even with natural gas we have NOX problem, from an environmentally pollution point of view, NOX includes the three nitrogen oxides, NO, NO2 and N2O these are together called NOX. These gases are produced during combustion and reach the atmosphere in this form as NO, NO2, and then N2O, and then they go through transformations. Of these NO, and NO2 are toxic, both are short-lived with a lifetime of about four days, and NO is less toxic and causes eye and throat irritation, in terms of immediate impact, Nitrogen dioxide is highly toxic, and can cause acute lung injury even in short doses. High outdoor concentration can lead to respiratory, cardiovascular problems and mortality.

N2O is not toxic, but it is a greenhouse gas, with a global warming potential of 270, and it has an atmospheric lifetime of 100 to 200 years. So, if we are producing too much of N2O from various uses of fossil fuels, whether it is for transport application or electricity generation or heat production, heat generation in industrial processes and so on. There can be production of N2O which can be, can have a big impact in terms of greenhouse gas emissions.

NOX emissions contribute to many environmental problems like acid rain, photochemical smog, ozone depletion, acidification of local bodies, greenhouse effect and eutrophication indicated by algal blooms and oxygen deficiency of water bodies and even soil. Short-term effects on humans includes sore throat and phlegm, acute lower respiratory illness is possible on short-term exposure to NOX concentration of 150 micrograms per cubic meter [5].

Health effects in terms of pulmonary illnesses are also produced from exposure to ozone produced from NO2, Phytotoxicity of ozone leads to reduced agricultural output. NOX has a number of bad effects all the way from immediate effect on the humans, and also long-term effect in terms of greenhouse gases, and in terms of ozone depletion, in terms of acid rain and also in terms of decreased agriculture output. So, these are all some of the known and appreciated quantified side effects of NOX.

— Effects of Pollutants: Particulate Matter

Particulate Matter comes from coal combustion resulting from the mineral matter that is present, that is dug up along with coal and it can vary anything between 5% and 50% and especially in the Indian coal sites of the order of closer to 30 to 50%. So, that means that half the coal that is burnt will come out in the form of ash, either as a bottom ash or a fly ash. In fly ash the particles are coming in extremely small sizes from fraction of micron to 10 microns or maybe higher. This is what we call us particulate matter pollution, it is also known as particulate pollution, predominantly includes tiny particles of fly ash expelled from pulverized coal fire plants, nearly 80% of the ash from mineral matter in the coal leaves with the flue gas.

Fugitive dust from ash ponds and coal handling, complex oxidation reactions involving gases, such as nitrogen oxides and sulphur dioxide also significantly contribute to particulate pollution in and around the power plant. So, the SO2 and NOX that are produced can also be converted into condensate matter, and they may come out in the form of particulate pollution. The health and environmental impacts of particulate matter the following upsurge in respirational problems such as intensification of chronic bronchitis, asthma, reduced lung function, and premature death, impaired visibility in areas surrounding power plants [6].

Settling and deposition of particulate material on streams, lakes, soil leading to changes in water and soil nutrient balance, harming farms and forests, which affect the diversity of the regional ecosystem. So, we name is whatever bad effects that we see are caused by this kind of pollutants that are coming from power plants.

— Effects of Pollutants: Mercury

We also have the mercury emissions from coal power plants which is not been regulated in many countries. Mercury is among the least abundant elements in coal, it occurs in trace quantities, ppm level, but it is among the most studied elements in coal due to its extremely toxic effects and its tendency to bio-accumulate through the food chain. So, although it is in small quantities, it's released in small quantities, it can accumulate through the bio-route and then it can cause us harm. Mercury is coming under increasing scrutiny of the legislatures and some countries have total limit on how much mercury can be emitted in the flue gases, but in many other countries it is not there,

partly because pollution deduction technologies for mercury have not been so widely established on a plant scale, power plant scale.

So, when we look at fossil fuel combustion, they generate a lot of pollutants which have immediate consequences both in terms of time and also in terms of the zonal dependence. If we have a power plant in Delhi then people of Delhi are going to suffer, maybe surrounding states and villages and towns, but there is also another aspect of fossil fuels combustion which results in a global problem, which is emission of carbon dioxide and other greenhouse gases. And carbon dioxide is a global problem because its concentration currently is very low despite what people are claiming, it is very low, but only as far as direct impact on human health is concerned, we are not affected by the small fractions of percentage of carbon dioxide concentration, but in terms of other effects that it has in terms of especially the global warming point of view it is a major concern for us. It is seen us a challenging problem associated with energy, there is been a concerted effort over the past 50 years on understanding the carbon dioxide causes and then greenhouse gas emissions, and a number of studies have been made. And so because of this, carbon dioxide emissions has become one of the primary problems associated with fossil fuel combustion, and energy generation [7-8].

If we look at the 2010 global emissions of carbon dioxide we have released all over the world. In 2010, 49 gigatons of carbon dioxide equivalent, including methane and N2O together in terms of the carbon dioxide equivalent in terms of greenhouse gas contribution was 49 gigatons. Every aspect of the human societal sector has a contribution, transport has 14% of this emission, buildings; so all the heating and cooling, and other domestic use of energy, electricity and heat generation for industrial things contributes about one-quarter of this. Industry which is essential for our current human society, the advanced stage of human society contributes 21%, so and out of this electricity and heat production we can see that industry consumes 11%, people buildings consume 12%, and so in that sense, these are also essential parts of our thing. The very life of our society is full of carbon dioxide emissions and it is present in almost every sphere of human activity. Cement generations, cement productions, steel production generate a significant amount of carbon dioxide. So, for this kind of activities which are, which can be associated directly with our human society and human industry oriented towards humans, we can see that over the past century 1850 to 1950 there is been a small contribution of it in terms of gigatons of carbon dioxide per year, a very slow increase. But over the last 50 to 70 years there is been a rapid increase in this, and we can see compared to what we have been emitting in 1850 to what we have been emitting in the year of 2010, there is been a huge increase in terms of carbon dioxide emissions coming directly from this modern industrialized lifestyle of humans [9-10]. Whereas forestry and other land use have contributed relatively, there is a small increase, but it is not that much. It is this part associated with the industrialized society of the current human lifestyle which is causing a lot of concern.

3. CONCLUSION

India and China are the biggest developing economies in the world apart from being the most populous nations. These two nations are home to about 40 % of the total population in the world. Apart from this, India and China have attained remarkable success in the economic growth denoted by higher gross domestic product (GDP). The two nations together contribute about one-fifth of the world GDP. The changes in the energy consumption pattern of developing countries like China and India were discussed aiming towards the sustainable development. Furthermore, the most important drivers adding to the ecological problems were also analyzed. In addition, the effect of pollutants like NOx, SOx, Particulate matter and Mercury on the environment were also discussed. Considering these complementary situations is a pre-condition for reaching a global accord on the environment change affecting these nations. In order to mitigate environmental problems, it is highly recommended to change the energy consumption patterns towards sustainable development.

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ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665