

# GROWTH ANALYSIS IN TERMS OF ENERGY EFFICIENCY

## *Analytical Study of Five Countries from different Continents*

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**Abstract :** Since energy efficiency is not only a term but need of today and tomorrow, hence considering energy efficiency as factor of growth and development this paper contains the comparative analysis of India, United States, Australia, France and Ethiopia regarding their growth in terms of being energy efficient. It elaborates the net consumption of energy in each country in different forms and sectors. It will also elaborate their journey of making themselves energy efficient. This study explains that when did these countries started to produce energy from renewable sources and reduced their dependence on non-renewable sources of energy, how much of load is reduces on energy generated from oil, gas and other petroleum products to save them for better future and how much of wind, sun, water is converted into usable energy during their past years of major development. This analysis will bring an transparent picture of efforts made by these countries to facilitate their citizens with a cleaner environment for coming generations.

**Index Terms - Growth, Development, Clean Energy, Energy Efficiency.**

### I. INTRODUCTION

Growth is an basic attribute to all entities and in today's modernist society energy is powerhouse for growth. As we all know the traditional methods of energy generation are consuming our non-renewable sources very quickly. Sources such as crude oil and its products are running our society in every country in different sectors but as of studies till now it has been observed that growth is coming to us at a very high cost and hence an initiative of energy efficiency is the only idea that can give us growth and development on the nominal costs. The growth and development by depending upon renewable sources of energy such as energy of sun, wind, water and earth will be considered and evaluated as more efficient growth.

The need of energy efficiency is not only because of the exhausting non-renewable sources of energy but also because the renewable sources are providing us clean energy. Due to rapidly increasing population and increasing demand of energy the pollution after consumption is also increasing at a very high rate. The addition of carbon to our environment is leading to global warming which somewhere is a direct cause of rising sea levels and shifting seasons, weather it is the residential sector, industrial, commercial or transportation the consumption of energy generated from non-renewable sources is planting carbon and other harmful gases to our environment leading to many other diseases.

On the other hand the renewable sources have zero carbon footprints on our environment. Although energy efficiency is not a new concept, many of the countries have already substantial work done under this idea and are improving day by day but still the gap between the demand and supply is very high which leads many countries to use non-renewable sources of energy to meet energy demands. Here we are analyzing the growth of such developed, developing and under developed countries in the terms of energy efficiency. Countries with different profiles, population size, terrains, geographical conditions, economic statuses, social reforms but having a common agenda of growth and are working in different sectors with different methods for energy efficient growth and development.

This paper starting from the world energy consumption statistics will narrow down the area and will focus in detail about the five countries on different level of development and will conclude a comparative study of there growth as the the sources availability and use. This paper will also put up suggestive majors regarding the possible better growth rate of a particularly developing and under developed country with an comparison of a developed country.

### II. WORLD

From the source of World Energy Outlook 2014, energy consumption in industrial sector at international level is highest (51.7%), energy consumption in transport sector at national level is highest (30%), energy consumption in domestic sector at state level is highest (49%), and energy consumption in commercial sector at state level is highest (17%). Other sectors have major energy of energy at smaller level of state likely 8.4%.

The consistent demand of energy of the world population in different condition for various sectors and uses is always on rise and can not be met with one common source, hence various countries use multiple sources of energy to produce usable form of energy as required. Figure 1 below show the percentage of global energy use by different sources source.

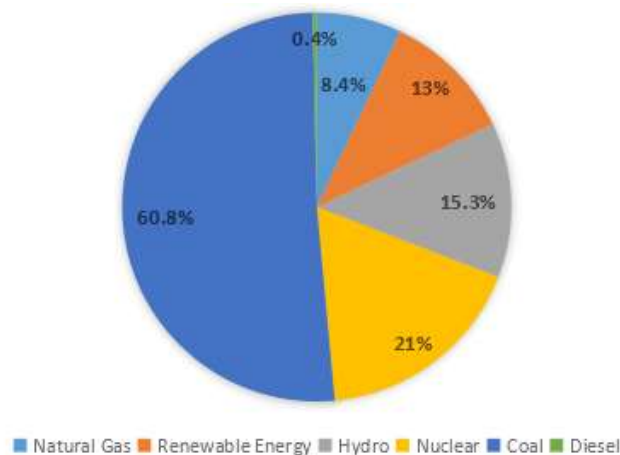


Fig. 1: Global percentage of resources used for energy generation (Source: CEA Monthly report June 2015)

Figure 1 above indicates the percentage of sources used to generate energy on a global scale. As indicated 60.8% of energy in usable form is achieved by natural gas. Australia and America are one of the pioneers in generating energy from natural gas. Although only 15.3% & 13% of the global energy energy demands are met using hydro energy and other renewable sources of energy respectively.

### III. INDIA

India is a young developing nation with a variety of society, seasons, terrains and geographical conditions and depending upon which the need and demands also differ. Sourced from World Population Prospectus: The 2017 Revision, population size of India is approximately 1.324 billion with annual growth rate of 1.19%<sup>[1]</sup>. The net geographical area of India is 3.287 million km<sup>2</sup> which consists coast line of 7516.6 km and highest peak of 8586 m (Kangchenjunga, Himalaya). These details clearly shows the wide variety of regions in India. According to the census commission of India 31.16 % is urban and 68.84 % is rural population in India.

Since India is categorized as an developing country with a large population, hence the demand of energy is also very high. The figure 2 below shows the percentage distribution of energy consumption in different sectors in India. It clearly shows that the consumption in the Industrial sector is highest which clearly indicates the growing steps of country towards the tag of developed nation. In the Asian continent after China and Japan, India is the third emerging country towards growth and development. India has been working on the infrastructural development of energy generation from different sources of energy since 1<sup>st</sup> five year plan.

On the basis of data from 1990-91 to 2013-14 from various government agencies of India, Power systems in India are the most complex and 5<sup>th</sup> largest in the world with annual electricity production of 1031 Billion Units (BU) and is likely to reach 1900 BU by 2020.<sup>[2]</sup>

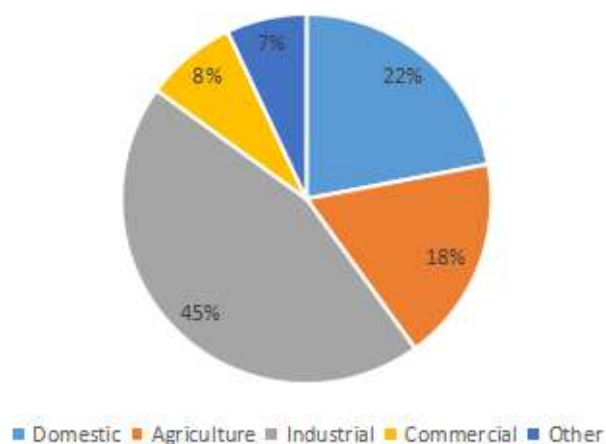


Fig. 2 : Energy consumption pattern in India (Source : Energy Policy Report, Planning Commission, India)

The table 1 below shows the hike in gross energy production in India at an interval of 5 years from different sources. It clearly shows the data of increasing dependence of India on coal as a major source of energy generation which is actually taking it away from the goal of energy efficiency. This effect is due to the large population size and the increasing energy demands in every sector. Being a rapidly developing nation the energy demands of India are also growing fast. Industrial sector acquires the tag of highest consumer of energy in various forms at 45%.

Table 1: Gross Production of Energy in India  
(Source : Ministry of Petroleum Natural Gas Economics and Statistics)

Gross Production of Energy 1990 - 2014						
Year	Coal & Lignite ( Million Tonnes)			Hydro Carbon		
	Coal	Lignite	Total	Natural Gas (MCM)	Crude Petroleum (@'000 Tonnes)	Petroleum Products (@'000 Tonnes)
1990-91	211.73	14.11	225.5	17998	33021	52201
1995-96	270.13	22.14	292.27	22308	35170	58320
2000-01	309.63	22.95	332.58	29477	32426	102514
2005-06	382.61	30.34	412.95	31763	33981	127116
2010-11	525.75	23.14	570.81	52219	37684	194821
2013-14	565.64	44.27	609.91	35407	37788	220756

The data in the table above clearly show the gradually increasing dependence of India on petroleum and its products since 1990 to meet the demands of energy for various sectors. Since the existing infrastructure supported only these sources for energy production and the population growth drastically increased the pollution level of India at an alarming position in many metro cities including the national capital New Delhi. Figure 3 below shows the data of infrastructure capacity for energy generation from different renewable and non-renewable sources till 2015.

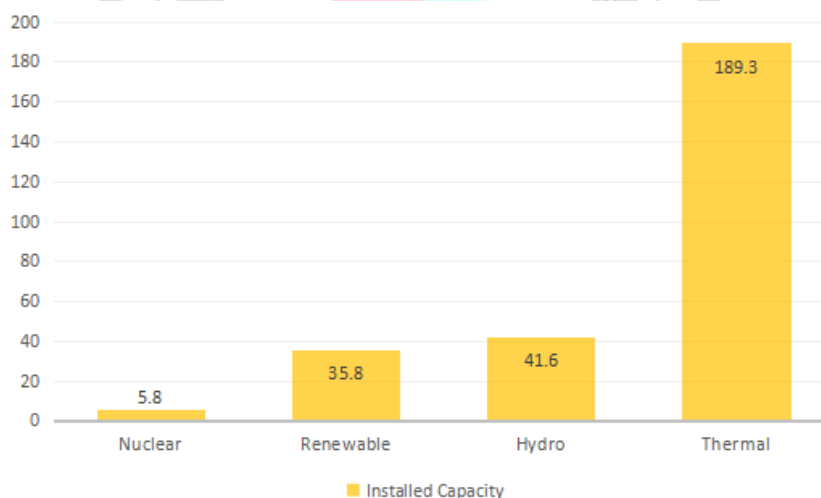


Fig. 3 : Installed Capacity of different sources of power 2015 (GW)  
(Source : Ministry of Coal, NHPC, Central Electricity Authority 2015)

The table 2 below shows the data of power generation in India for demands in various sectors using different sources, the decreasing dependence on hydro power and increasing dependence on thermal power is a negative trend for the tool of energy efficiency.

Table 2 : Annual Gross Generation of Power by Source in India  
(Source : Ministry of Statistics and Programme Implementation, Govt. Of India)

Annual Gross Generation of Power by Source in India (MU Units)						
Year	Hydro %	Steam %	Sun & Wind %	Gas %	Nuclear &	Thermal %
1990-91	27.10	67.46	0.04	3.07	2.32	0.00
1995-96	19.14	72.03	0.19	6.54	2.10	0.00
2000-01	8.20	39.29	0.42	5.32	1.86	44.92
2005-06	9.25	39.03	0.18	5.39	1.55	44.60

2010-11	8.12	38.06	0.20	6.79	1.78	45.05
2013-14	7.13	40.52	0.11	3.74	1.87	46.63

On the long term basis the growth on Indian economy is 4.5% since 1980 afterwards. With increasing demand of electricity at annual growth rate of 8% the installed generation capacity is grown at annual rate of 9% whereas generation capacity annual growth rate is 10% compounded.<sup>[3]</sup>

**IV. UNITED STATES OF AMERICA**

United States in the 242<sup>nd</sup> year of independence comprised of 50 states and 3<sup>rd</sup> largest country in the world by geographical area is one of the pioneer nations in the use of energy efficient systems and technology for energy generation in various sectors. Sourced from World Population Prospectus: The 2017 Revision, population size of United States is approximately 325.7 million with annual growth rate of 0.7%<sup>[1]</sup>. The net geographical area of United States is 9.8 million km<sup>2</sup> which consists coast line of 19928 km and highest peak of 6190 m (Denali, Alaska). These details clearly shows the wide variety of regions in United States of America. According to the United States census bureau 80.7 % is urban and 19.3 % is rural population in United States.

Being one of the most developed nations and a land to the cities with highest standard and cost of living. The country also have the highest energy consumption statistics. United State is continuously growing its installed and generation capacity using different fuel methods and a big portion of the energy generation is dependent on the renewable sources of energy.

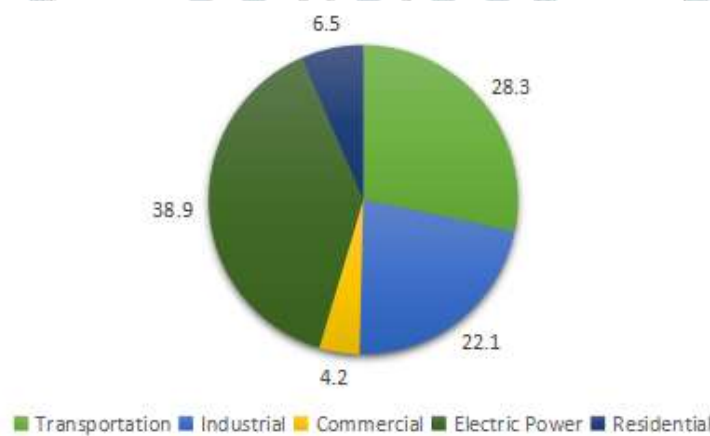


Fig. 4 : United States sector wise energy consumption (%)  
(Source : United States Energy Information Administration, USEIA)

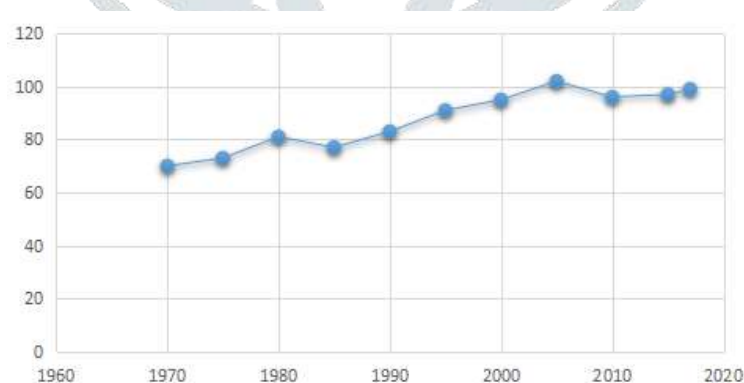


Fig. 5 : United States energy consumption 1970 - 2017 in Quadrillion Btu  
(Source : United States Energy Information Administration, USEIA)

According to the EIA statistical data, United states generates most of its energy needs from petroleum and its products. The energy generated from petroleum as source alone is more then the energy generated jointly by sources such as natural gas, coal and solar power.



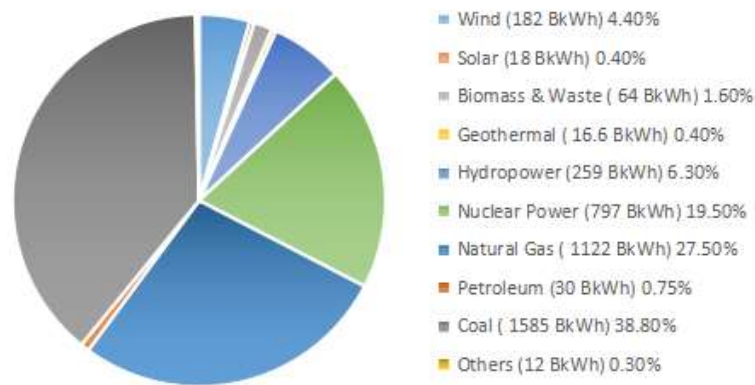


Fig. 6 : United States energy generation by source  
(Source : United States Energy Information Administration, USEIA)

According to the energy facts revealed by EIA, doubling every 20 years, energy market in United States is third largest industry in the country. In year 2014 United States met 89% of energy demands and 11% were dependent on petroleum imports. Renewable sources generate 11% of the net energy generation and hydro power tops all other renewable energy sources with 6.30%. Since 2007 till 2014 energy production added to 11% of United States economy. United States spends a huge budget annually on clean energy initiatives and according to the Bureau of labor and statistics 3.4 million jobs are due to clean energy initiatives. Further according to the EIA data, United States is the largest producer of geothermal energy and biomass power in the whole world. Despite of huge population difference United States is the second largest energy consumer country after China. Also United States produces most of nuclear power than any country in the world.

### V. AUSTRALIA

Australia, federated in 1901 the land of famous Opera House is a multicultural, multi-religion and with mixed ideological social groups have remarkable achievements in development. Sourced from World Population Prospectus: The 2017 Revision, population of Australia is approximately 24.6 million with an annual growth rate of 1.6%<sup>[1]</sup>. The net geographical area of Australia is 7.686 million km<sup>2</sup> which consists of a coast line of 29751 km and highest peak of 2228 m (Mt. Kosciuszko, New South Wales). These details clearly show the wide variety of regions in Australia. According to the Census Population of Housing, Australia the urban and rural population is 89.55% and 10.45% respectively.

According to the Australian energy update 2018, Australia's net energy production in 2016-17 was three times more than the net consumption. Figure 7 below shows the data of net energy consumption in Australia in different sectors. Transport sector is on top for energy consumption with 39.5% whereas the construction sector is having the lowest consumption with 0.6%.

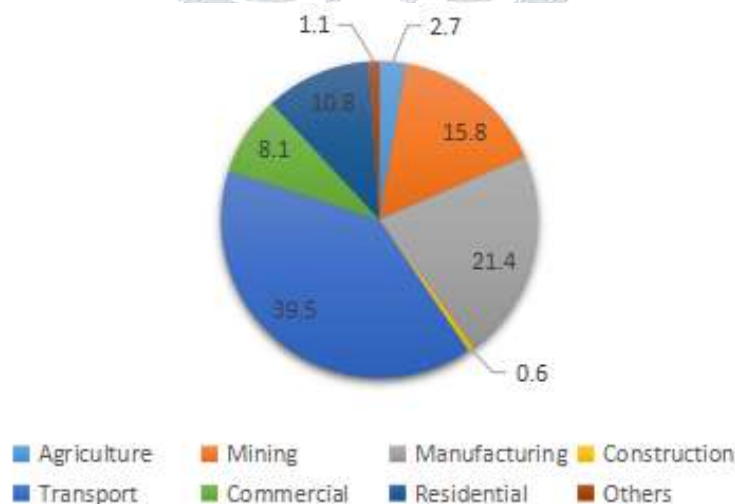


Fig. 7 Australian net energy consumption (%) sector wise

(Source: Department of Environment & Energy, 2018 Australian Energy Statistics)

Putting focus on the type of fuels used for energy generation figure 8 below clearly indicates the dominance of non-renewable products. However the 15.1 % of renewable sources generates enough energy to meet approximately 50 % of end user consumption need in different sectors using energy.

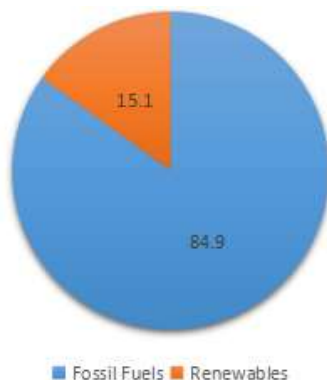


Fig. 8 Australian net energy generation (%) based on fuel type  
 (Source: Department of Environment & Energy, 2018 Australian Energy Statistics)

As per the data from department of environment and energy the total energy generation from renewable sources is 39087 GWh. This number includes the energy generated from hydro, wind, biomass, solar & geothermal. The energy generation from hydro is highest with 13933 GWh as indicated in Figure 9 below. The main sources of renewable energy generation are hydro and wind which is approximately 60% of the net energy generated from all renewable sources.

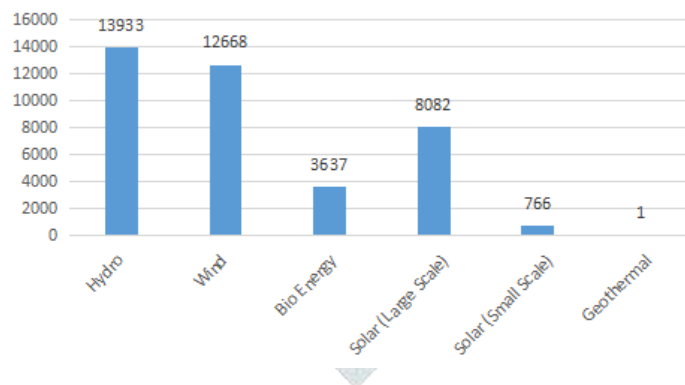


Fig. 9 Australian renewable energy generation (GWh)  
 (Source: Department of Environment & Energy, 2018 Australian Energy Statistics)

Figure 10 below clearly indicates the growing amount of energy generation done on the basis of renewable sources. Since 1976-77 it is constantly increasing and the share in net energy generation of renewable sources is also increasing which is an positive factor in the economic growth of the country.

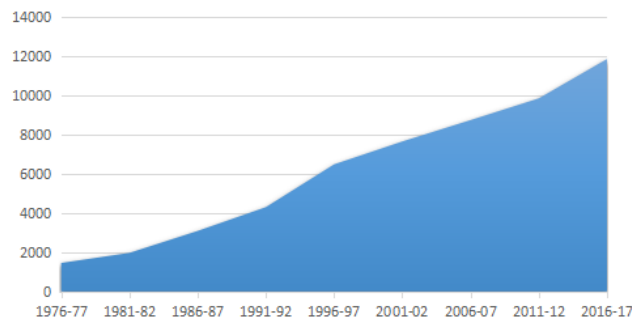


Fig. 10 Australian renewable energy generation growth chart year wise (PJ)

(Source: Department of Environment & Energy, 2018 Australian Energy Statistics)

Australia is a country with three times generation capacity compared to the consumption and the major source is natural gas. Hence the export of energy and generating raw products is also very high. The concerned authorities are targeting to equalize the amount of energy consumption with the number of energy generation by renewable sources by 2050. Which finally will bring the Australian energy export above 90% profit adding to the economic growth and development of the country.

**VI. FRANCE**

France, in Western Europe, encompasses medieval cities, alpine villages and Mediterranean beaches and famous for its Art and Fashion with Lascaux’s ancient cave drawings. Sourced from World Population Prospectus: The 2017 Revision, population size of France is approximately 67.12 million with annual growth rate of 0.4%<sup>[1]</sup>. The net geographical area of France is 643,801 km<sup>2</sup> which consists coast line of 3,427 km and highest peak of 4808 m (Mt. Blanc). These details clearly shows the wide variety of regions in India. According to the INSEE - The french national Institute of statistics and economic studies 79.75% is urban and 20.25% is rural population in France.

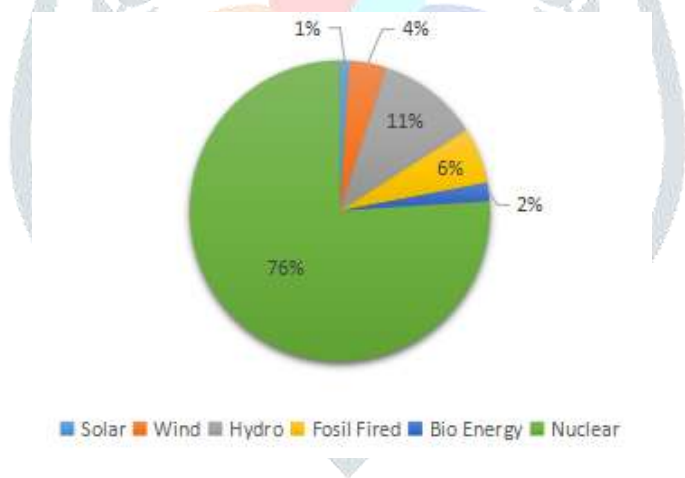


Fig. 11 France Net Energy Production fuel wise (%)

(Source: Annual electric report 2015 RTE, French Government)

France is one of the highest consumer of energy generated from nuclear reserves. As shown in figure 11 above 76% of the net energy consumption is generated using nuclear power. However the dependence on renewable sources of energy is nearly 18% which includes solar (1%0, Wind (4%), Hydro (11%), Bio energy 2%.

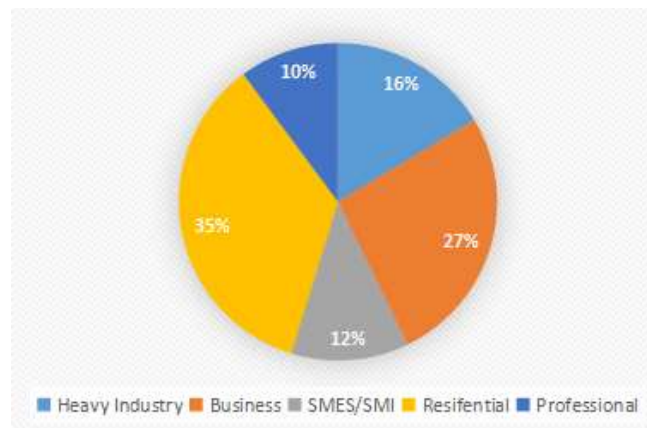


Fig. 12 France sector wise net power consumption industry wise (%)

(Source: Annual electric report 2015 RTE, French Government)

France is one of the import economies. Hence instead of industry or business the residential sector tops the energy consumption statistics as provided by french government in 2015 annual electric report. As shown in figure 12 above nearly 35% of the energy consumption in France is by residential sector which is closely followed by business sector by 27%. Industry in France consumes nearly 16% of the net energy consumption.

According to the data from french government in 2015 annual electric report, France is continuously practicing the facility of energy generation from renewable sources of energy for making the economy more energy efficient. Data as per french government claims that in 2007 energy generated from renewable sources was 13.4 % which was up at 14.9% in 2010 and in 2015 it was at 18.7% . However the maximum percentage of share for energy generation by renewable sources was achieved in 2014 at 19.6% as shown in figure 13 below.

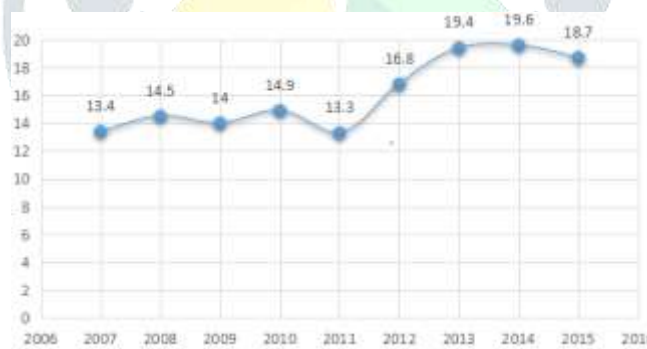


Fig. 13 Percentage share of renewable generation in total energy generation (%)

(Source: Annual electric report 2015 RTE, French Government)

Since the infrastructure for renewable sources of energy is not very much increased in France in past decade hence the average percentage share for renewable sources is nearly 15 % only. The sources includes hydro, wind solar & biomass as shown in figure 14 below.



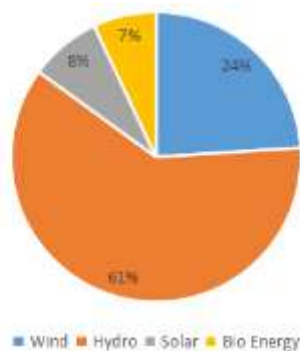


Fig. 14 Break down of renewable generation

(Source: Annual electric report 2015 RTE, French Government)

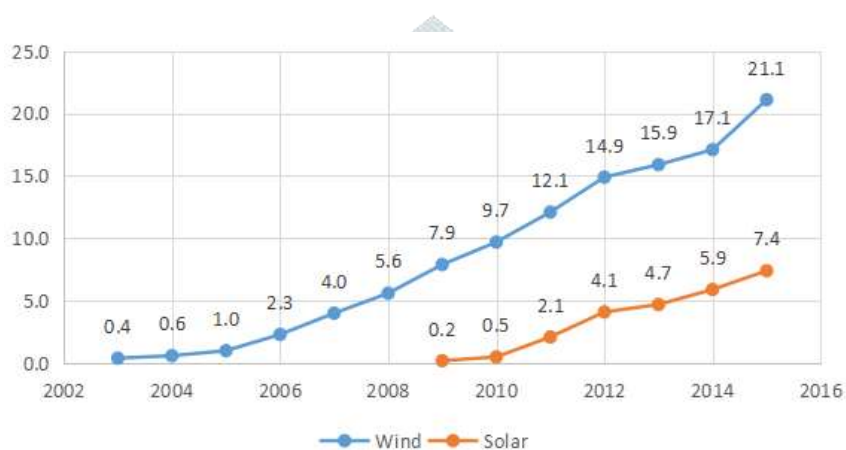


Fig. 15 Wind & Solar power generation (TWh)

(Source: Annual electric report 2015 RTE, French Government)

Figure 15 above shows the growth in power generation from wind and solar energy since 2003 till 2015, the chart clearly shows the annual growth in both in past decade. However in figure 16 below the numbers showing the power generation statistics from hydro is fluctuating.

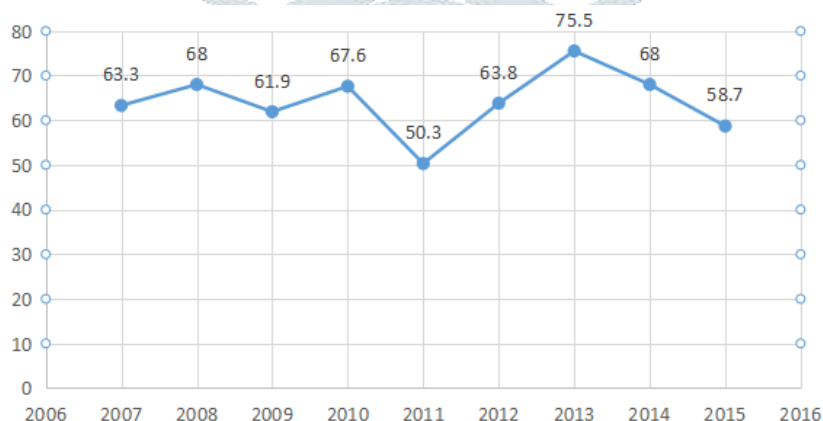


Fig. 16 Hydro power generation (TWh)

(Source: Annual electric report 2015 RTE, French Government)

Figure 17 below shows the trend of decreasing CO<sub>2</sub> emission in the air which clearly justifies the data from figure 15 & 16.

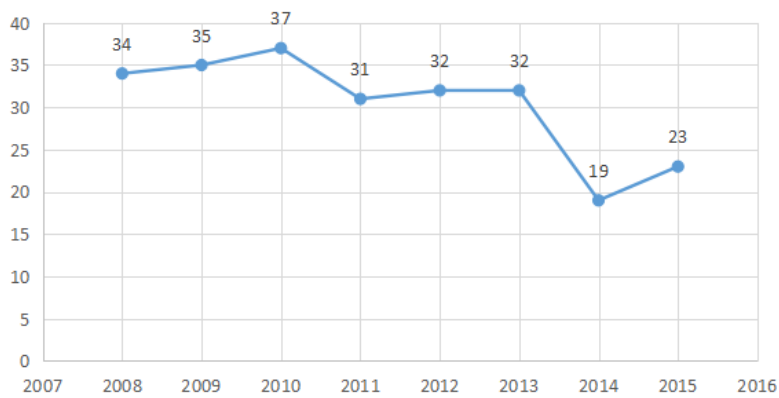


Fig. 17 Trend of CO<sub>2</sub> Emission since 2008 in Millions of Tonnes

(Source: Annual electric report 2015 RTE, French Government)

### VII. ETHIOPIA

Ethiopia, a landlocked country in the horns of Africa (East of Africa) with rich ancient culture and the land of rock cut Architecture having famous example of Lalibela Church is home to the majority of orthodox Christian society. Sourced from World Population Prospectus: The 2017 Revision, population size of Ethiopia is approximately 105 million with annual growth rate of 2.5 %<sup>[1]</sup>. The net geographical area of Ethiopia is 1.104 million km<sup>2</sup> which consists zero coast line length and highest peak of 4550 m (Ras Dashen, Simien Mountains Range). These details clearly shows the wide variety of regions in Ethiopia. According to the Central Statistical Agency 19.92 % is urban and 80.08 % is rural population in Ethiopia.

Ethiopia is considered as the fastest growing economy in the African continent. Despite of its hilly terrain and unpredictable weather conditions the growth rate of the country’s economy is impressive. For the need of power mainly in the form of electricity Ethiopia depends upon three resources which are Biomass, Petroleum and Hydro power as shown in figure 18 below. Being majority of population living in rural areas the access to facilities in the country is very poor.

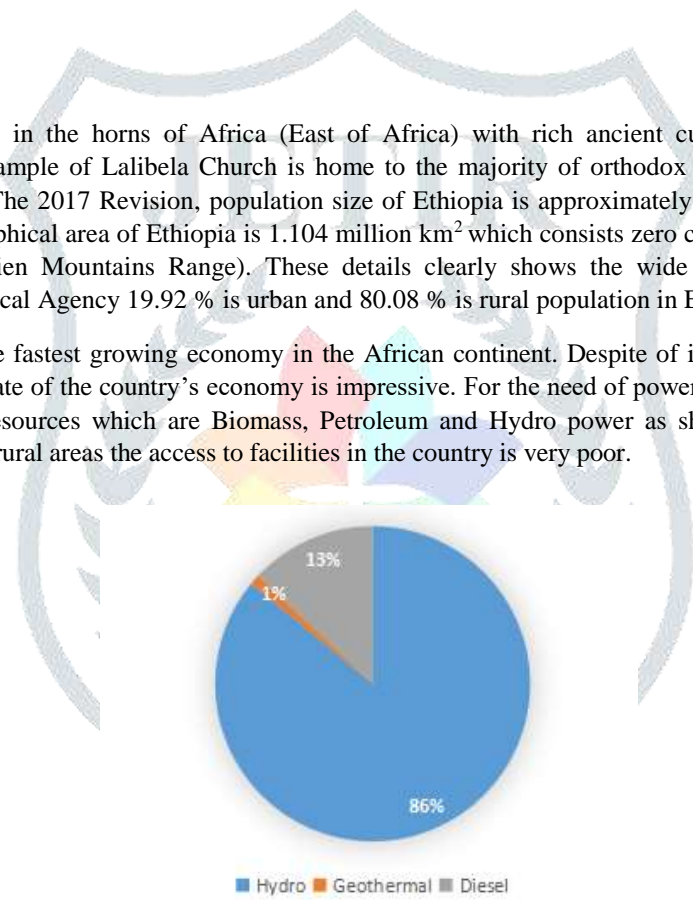


Fig. 18 : Sources of power generation in Ethiopia

(Source : English translation of ‘Study of energy sector in Ethiopia by Embassy of Japan, Ethiopia)

According the the data from World Energy Resources (WEC) 2013 and Renewable Energy and Energy Efficiency Partnership (REEEP) 2014, In 2000 with annual yield of 50 million tonnes Ethiopia’s national woody biomass stock was 1,149 million tonnes. But the depleting forest reserves have already created an alarming situation. The hydrocarbon reserves are very few hence not dependable. Figure 18 above clearly shows the dependence of Ethiopia on hydro power. Since the beginning the Ethiopia government had invested a lot to increase infrastructure and installed capacity in hydro power sector and since 2012 the government is also investing in other renewable sources of energy for increasing installed capacity such as solar and wind.

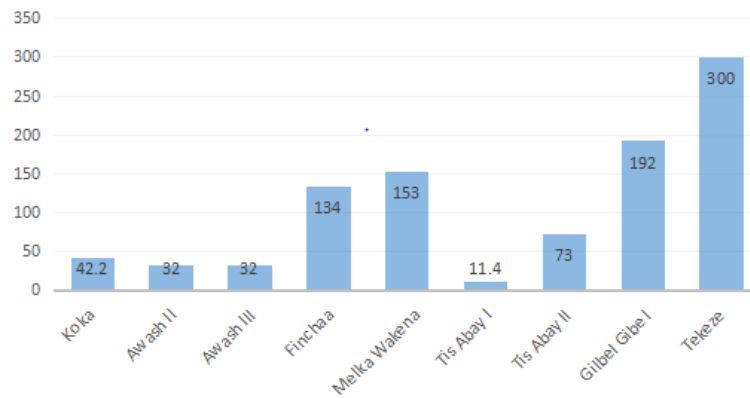


Fig. 19 : Hydro power installed capacity of Ethiopia (MW)  
(Source : Ethiopian Electric Power Corporation)

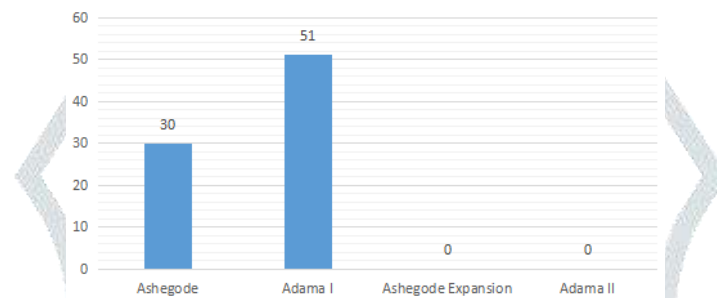


Fig. 20 : Wind Farm installed capacity of Ethiopia (MW)  
(Source : Ethiopian Electric Power Corporation)

Fig. 19 & 20 above clearly shows the installed capacity of each hydro power plant and wind farms in Ethiopia. This also indicates the amount of clean and renewable energy Ethiopia is generating. Sourced from EEPCo (Ethiopian Electric Power Corporation) Ethiopia is generating approximately 2000 MW and they are also selling electricity to neighbouring countries such as Sudan (10 MW) & Djibouti (100 MW) which makes a very healthy profitable business to boost country’s annual profit and economic growth. These things clearly shows that being an under developed country Ethiopia is in the right direction of growth and one of the leading power houses in African continent.

**VIII. CONCLUSION**

Energy is a key for running the economy of a country. In each sector energy is the basic requirement. Analyzing the data of five different countries provide mixed results.

India being 2<sup>nd</sup> highest populated country with high energy demands and a developing country is forced to be dependent on the petroleum products. The growth rate of renewable sources infrastructure is lacking behind the population growth rate which is creating a gap between demand and supply. Hence using and importing non-renewable sources of energy for power generation is part of this economy.

United States of America is one of the pioneering nation in the energy sector. The infrastructure of the energy generation through renewable sources of energy is huge and with this development rate in next 20 or 30 years the primary need of energy consumption may become equal to the energy generation from renewable sources of energy.

France since long is depending upon the nuclear power, being nuclear energy is good for cheap power generation but the hazardous effects of nuclear waste on environment and the risk of radiation leakage is a matter of concern. Hence the initiatives of increasing renewable sources installed capacity to generate more from them is a need for the nation.

Australia is having energy generation at a very massive scale. It not only generate but generates thrice their requirement. This helps them to earn from the exports of raw energy products and generated energy also. Which no doubt is a major plus to the economy of the country.

Ethiopia being a not so populated, underdeveloped but the fastest growing economy in the horns of Africa seems to be on the right track to boost the economy by investing massively in renewable energy infrastructure. Major energy demands of this country are fulfilled by the hydro power plants and more of the infrastructure on large scale is in pipeline depending upon renewable sources of energy.

Some interesting facts observed are, Australia, France & Ethiopia are far more ahead to mark their independence from non-renewable sources of energy. Whereas, India is facing a contrast situation and lot of initiatives are required and USA is not to far from achieving the goal which will prove an energy efficient growth.

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