Statistical Evaluation of Renewable Energy Technologies and Initiation Programs in Rural Area of Lakhimpur-Kheri, Uttar Pradesh, India: Prevailing Schemes, Barriers Faced and Future Scope

Utkarsh Awasthi, Faraz Yusuf Khan, Noman Ahmad, Shrish Bajpai

Abstract : This paper scrutinizes the present scenario of Renewable Energy Technologies, usage of Renewable Energy Technologies, hindrance and future of Renewable Energy Schemes launched by the Government of India and Government of Uttar Pradesh in rural areas of India, using responses of 200 individuals residing in Lakhimpur-Kheri, an agriculture based rural district in the most populated state of India, Uttar Pradesh. Respondent's view towards Government's policies, educational background, environmental issues which have been covered in this paper. Role of Private and Public sectors in order to spread knowledge about the usage of renewable energy technology and to accelerate their adoption has also been analyzed. Role of biogas energy in rural areas of India by considering area-specific economic growth, employment generation and availability has been taken into consideration.

Keywords: Lakhimpur-Kheri, Awareness, Rural Economy, Renewable Energy Technology

I. INTRODUCTION

A viable supply of energy in rural areas is a step towards reacting to the rising global and national environmental problems. In rural areas Biogas Energy may ought to be proved as a viable option in terms of eco-friendly technology. As it has proven, Renewable Energy Technology helps to reduce the emission of Green House Gases like Carbon dioxide, Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur Hexafluoride etc. As well as it is cheaper in cost to the energy produced by the coal and other fossil fuels [1-2]. To raise awareness among people some international treaties like Agenda 21 and Kyoto Protocol have been signed by major and emerging economies of the world for laying stress over the need to develop and promote the utilization of Renewable Energy Resources. India being a part of United Nations Sustainable Development Goals (UNSDGs) is committed to its policies, 17 Sustainable Development Goals and 169 targets have to be completed till 2030 i.e. to provide clean and green energy despite of the economic challenges [3]. This paper analyses the factors which are acting as barriers in midst of Renewable Energy Technology. Government of India has launched various schemes which aims to promote the usage of renewable energy, but the efforts of government have not shown desirable results , India needs to lift it up in terms of using Renewable Energy Technology [4]. Lack of Awareness and Lack of Promotion from the side of public and private sectors alike proved to be a major barrier along with the literacy rate of people have a direct affect on the implementation of Renewable Energy Technology. India has the natural resources that provide it the cushion against energy security concerns [5]. In India, Biogas can be produced by degradable organic wastes such as cattle dung, kitchen waste and poultry waste etc. Biogas also helps to increase the nutrient content and fertility of the soil [6]. Biogas waste can also be used in some other manner like as a bio-fertilizer. Biogas can be easily supplied to both rural and urban areas of India and can act as a shield against hike in the prices of fossil fuels as in the recent case 2017-18 there is a hike in the prices of fuel, also it can increase the economy of rural areas in multiple ways such as by providing more earnings from dung and by improving crop production through the involvement of organic fertilizer [7]. Biogas due to its flammable nature can be used in energy production and transport. The efficiency of biogas is approximately 85%. Of the total energy of the biogas 30-40% is converted into electricity and 45-55% is converted to heat and this heat can be used for heating purposes [8]. The largest biogas plant is situated in Methan village of Gujarat which saves 500 metric tons of Fuelwood annually likewise, there are 1 MW Biogas Plant is situated in Ludhiana, Punjab, 2 MW Plant of Biogas is situated in Ankleshwar, Gujarat. In Maharastra, the biogas plant has a capacity to produce 2500 cubic meter biogas per day from 600 cubic meter of sugar waste, 3000 cum bio methanation project for solid waste management in Andhra Pradesh,

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Indian Government should think of planting more biogas plants like these in every state of India and main emphasis should be laid in rural areas.

In India a total of 65% electricity is generated by thermal power, 53.7% of commercial energy demand is dependent on coal, only 3% of the electricity is produced by inclusion of solar, wind and biomass power [9-10,25].

II. The History Of Biogas Production:

People were aware of the biogas since 17th century but the construction of biogas plants had started amid of 19th century. At that time the biogas systems like septic tanks were widely used for the waste water treatment. It was used where there was no sewerage system. In 1890's Donald Cameron constructed a special septic tank, from which the gas is collected and used for street lighting [11]. After the second world war there was a significant growth in the biogas industry, particularly in Germany, France and Britain. After that biogas technology also found its way in agricultural purposes such as running an engine for irrigational purpose [12-13].

III. Glimpse Of Lakhimpur Kheri :

India comprises of 712 districts as per the data record which was taken in this recent year 2018 [14]. Lakhimpur-Kheri stands at top in terms of area which is equal to 7,680 square kilometers becoming the largest district in Uttar Pradesh (India) [15,26]. Lakhimpur Kheri comes under a municipality board namely Nagar Palika Lakhimpur and it comprises of four sub-municipality boards namely Gola Gokaranath, Palia Kalan, Mohammdi. The city Lakhimpur is termed as administrative capital of Lakhimpur-Kheri. Lakhimpur-Kheri shares an international border with Nepal on the Northern side. The average temperature in Lakhimpur-Kheri is highest in month of May i.e. 32.3 degree Celsius and coldest month is January having average temperature of 15.4 degree Celsius. According to 2011 census data it has a population of 4,021,043 and a literacy rate of 60.56% approximately. Awadhi/Hindi is the language spoken by a majority populace of Lakhimpur Kheri [16-17].

The only National Park in Uttar Pradesh, the Dudhwa National Park is situated in Lakhimpur Kheri.Lakhimpur Kheri is the home to some of India's largest sugar mills such as Bajaj Hindustan Limited (BHL) Sugar Plant in Palia Kalan and Bajaj Hindustan Limited (BHL) Sugar Plant in Gola Gokaranath and Gobind Sugar Mill in Aira Estate. In Lakhimpur-Kheri district, agriculture is mainly dependent on these crops mainly like sugarcane, wheat, rice, maize, barley and pulses etc.

IV. DISCUSSION:

This survey consists of 200 respondents from the district of Lakhimpur Kheri, Uttar Pradesh, India.

As Fig. 1 illustrates, lion's share of respondents is taken by East Lakhimpur-Kheri which is at 40%. East Lakhimpur Kheri covers area like Isanagar, Amethi, Gulariya, Palia Kalan etc. Second position of respondents' origin is taken by North Lakhimpur at 35%. North Lakhimpur covers areas like Gauri Phanta, Phularia, Phanta, Sarkhana etc. Third position of respondents' origin covers Southern Lakhimpur which is at 12.5% and 4th position is taken by West Lakhimpur which is at 12.5%.The literacy rate of Lakhimpur Kheri is 60. 56 % as per the record data of 2011 data census, it lags behind the national literacy rate which is 74. 04%. As evident by the survey record, most of the people reside in their parent's houses at 40%, followed by self-owned houses at 30%. 17.50% respondent's reside in houses provided by cooperation and 12.50% respondents reside in rented accommodation as shown in Fig. 2. Uttar Pradesh Awas Vikas Parishad (UPAVP) scheme was implemented with the motives to promote to develop state of art townships at affordable prices, to enclose modern technologies in construction work with price affordability and to promote innovative and new ideas. Uttar Pradesh Awas Vikas Parishad (UPAVP) scheme of Uttar Pradesh Government provides housing to the lower middle class and lower class income groups as well as Pradhan Mantri Awas Yojana - GRAMIN (PMAYG) has a motive to promote "HOUSING TO ALL" till 2022 [18]. PMAY aims to provide pucca houses to all while fulfilling their basic needs too. PMAY-G is also continuously helping to provide homes to the lower income groups and provided relief to them.

On analyzing Fig. 2, we get to know that majority of their respondent's have their own house including both parent's house and self-owned house, this indicated that this group of respondents will face no hurdles from tenants and litigation purposes if they decide to adopt Renewable Energy Technology.

While surveying we get to know that the majority of the

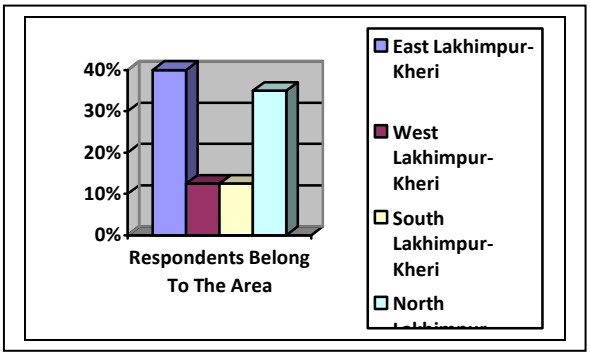

Fig 1 : Classification of responders in Lakhimpur

populace The Upper Middle Class usually resides in a 3BHK (Bedroom, Hall and Kitchen)House which is 33.50% and the Lower Middle Class in 2BHK House covers 27.30% as shown in Fig. 3.

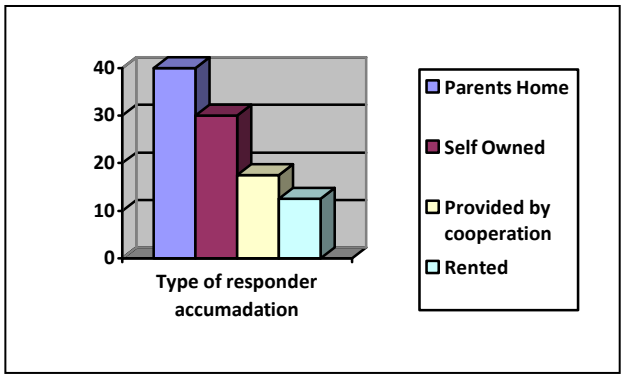

Fig. 2 : Type of respondent's accommodations

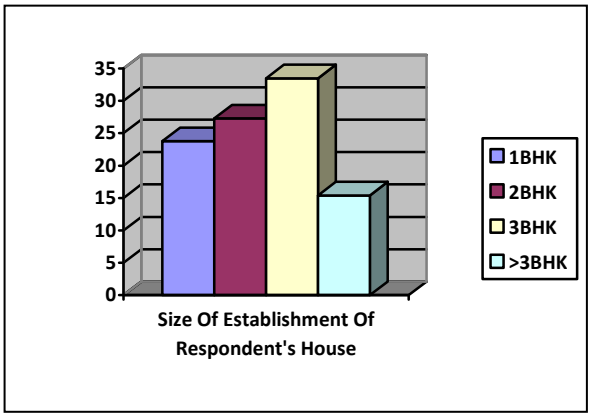

Fig. 3 : Size of establishment of respondent's house

V. EDUCATIONAL BACKGROUND OF RESPONDENT'S:

Lakhimpur Kheri is home to some reputed schools like Ajmani International School, Seth MR Jaipuria School, Don

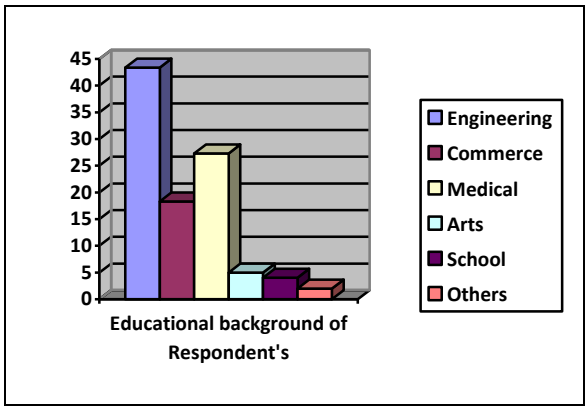

Fig. 4: Educational background of Respondent's

Bosco College and Government Inter College belonging to CBSE, ISC and U.P. board respectively and also some prestigious degree colleges namely Y.D. College, Rajkiya Mahavidyalaya, Ken Grover Nehru P.G. College enriching the quality of education. Educational background of a respondent is also taken into account as all streams of education are represented in this survey as seen in Fig. 4.Most of them are from engineering and medical background covering 43.40% and 27.30% respectively. The next part of this survey scrutinizes the future of Renewable Energy Technology in Lakhimpur-Kheri according to response of its populace. A positive trend appears in Fig. 5 when 66 % of respondents gave a positive response when asked about the installation plan of renewable energy technology in future. It is strange that 24% of the respondents voted that they had no information about renewable energy schemes and policies. It is surprising to know that most of the respondents from Lakhimpur Kheri are unaware regarding Renewable Energy Schemes which shows that government is not effectively promoting the policies of Renewable Energy. Jawaharlal Nehru National Solar Mission (JNNSM) was launched in 2008 by Government of India with a objective to establish India as a global leader in solar energy [19]. It was aimed to achieve a total installed solar capacity of 100GW till 2022 [20]. However, it does not receive its fair share of advertising which is why people in rural areas are still unaware of this policy.

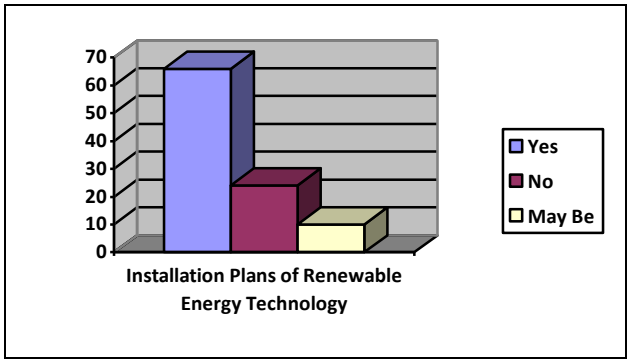

Fig. 5 : Installation Plan Of Respondents

As we can see from Fig. 6, Only 47.10% from the respondents are aware of the schemes while the major section

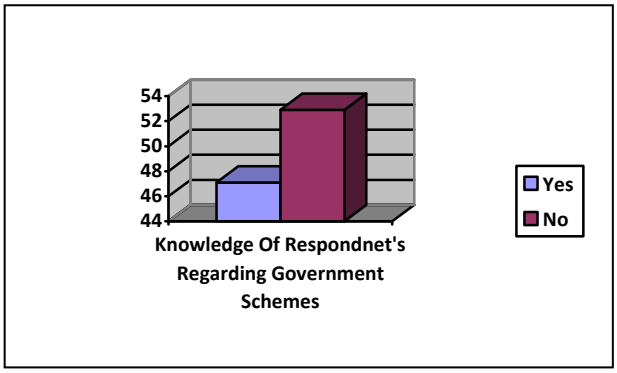

Fig. 6: Knowledge of Respondents Regarding Government Schemes

of the population is still unaware. Another policy was introduced by the government Pradhan Mantri Ujjwala Yojana which has formed to provide five crore LPG connections to the BPL card holders and the preference will be given to Scheduled Caste\Tribe mainly. The Duration of the scheme is only for three years from 2016-2019. Pradhan Mantri Ujjwala Yojana proved to be an effective policy for providing gain to the respondents, but still there is lack of knowledge among people of rural areas about other policies which may be advantageous for them [21].

VI. RESPONDENTS USAGE OF BIOGAS:

Biogas is an operable alternative for producing electricity and for cooking. Mainly two technologies are involved to generate the electricity from biogas i.e. Combustion and Cogeneration in sugar mill. The total installed capacity till 2018 of biogas is 9.54 GW from the total installed capacity of all Renewable Energy Technology of 73.35 GW. Biogas is clean, as it is good for climate and it can overcome sanitation problems by linking toilet with the biogas plants. According to data provided by the Government of India it is said, between 2014-15 about 20,700 cubic meters of biogas is produced in the country which is equivalent to the 5% of the total LPG consumed by the country. Apart from these, National Biogas and Manure Management Program under the twelfth five-year management program (2012-2017) the government of India aimed to set up 6.5 lakhs Biogas Plants across the nation with a budget of Rs. 650 crores [22]. It had been evaluated that by planting these biogas plants, about 1-6 cubic meter of biogas per day and 4745 lakh cubic meter biogas could be produced annually. The program is being implemented by the State Nodal Department and Khadi and Village Industries Commission (KVIC), Biogas Development and Training Centers (BDTCs).After Maharastra, Andhra Pradesh, Gujarat and Karnatka, Uttar Pradesh is ranked fifth in terms of using Biogas [23].

As per the survey record shown in Fig. 7, 70% of the respondents makes use of biogas for mainly agricultural purpose, cooking and for the purpose of heating water.

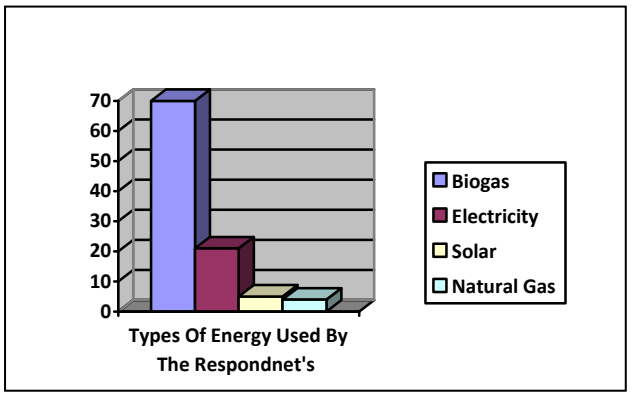

Fig. 7: Types Of Energy Used By The Respondents

VII. ENVIRONMENTAL CONCERNS OF RESPONDENTS

According to World Health Organization report 14 out of 20 most polluted cities are from India. According to this Uttar Pradesh's Kanpur top's this infamous list followed by Varanasi, Lucknow and Agra at 2nd,7th and 8th position respectively. Air pollution due to conventional sources is a major problem which gave rise to different non-communicable diseases like Asthma, Heart disease, Pneumonia, Cancer etc. As Fig. 8 illustrates, heart diseases and asthma occur to find major diseases 45% and 30% respectively due to pollution caused by conventional sources of energy. World Health Organization states that 7 million deaths were caused in the previous year due to outdoor and household pollution and it also states that in India there are five crore death are only due to unclean cooking fuels. Most number of diseases were caused by the heart disease which was around 34% and 21% were due to pneumonia and 20% people lost their lives due to stroke.

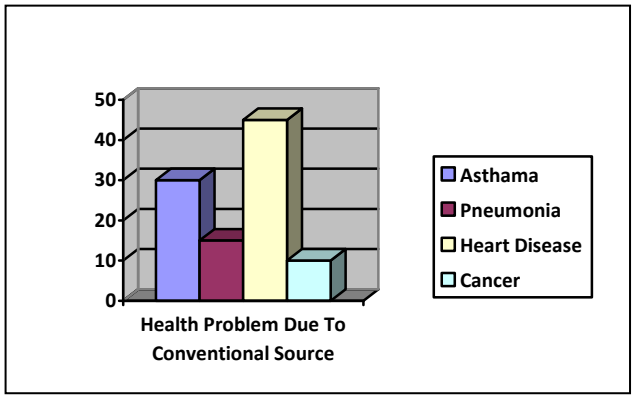

Fig.8: Health Problems Caused Due To Conventional Sources among Respondents

According to survey it is clear from Fig. 9, that the 83% of the respondents are aware about the pollution caused due to

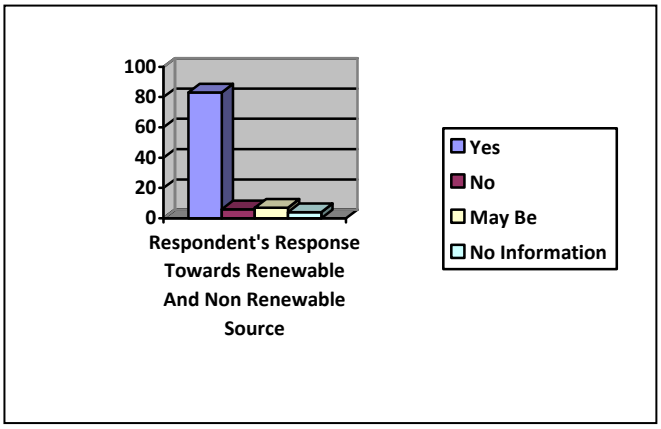

Fig.9: Respondent's Response Towards Renewable Energy And Non Renewable Energy Sources

the renewable source versus non-renewable source. Mainly these problems are occurring due to vehicular pollution and deforestation. They are aware about the pollution due to conventional sources but there is still lack of awareness regarding renewable energy technology which may later proved to be as a barrier for not producing and enhancing a better renewable energy technology.

VIII. FUTURE PERSPECTIVE:

Next part of this survey scrutinizes the future of renewable energy technology. According to Fig. 10, respondents in the survey are able to categorize the various renewable resources, according to the survey 97% are able to categorize because of inclusion of the subject such as Environmental Science till 10th standard in all boards namely CBSE,ICSE/ISC,U.P. board [24].

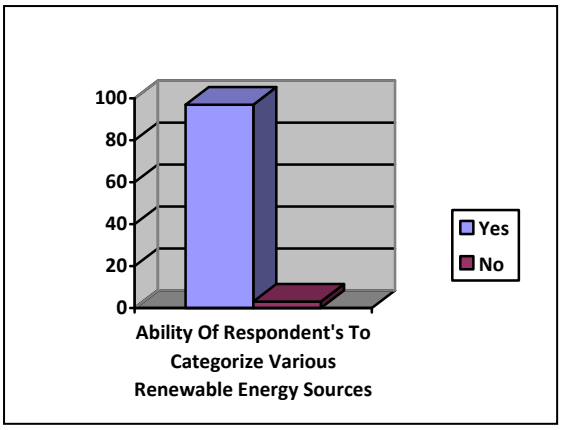

Fig. 10: Respondent's Ability To Categorize Renewable Energy Sources

They were asked whether they want to replace majority of conventional energy sources, around 97.30% respondents were in favor as shown in Fig. 11 of adopting renewable energy technology, but the cost maintenance is very effective, this may proved to be a major reason for not using renewable energy technology, also the government is not well promoting renewable technology schemes

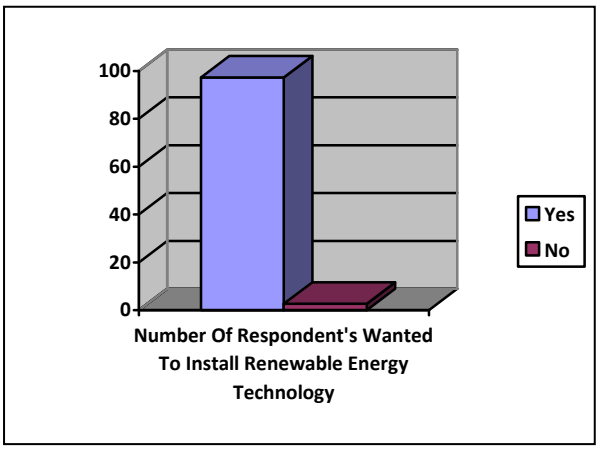

Fig. 11: Percentage Of Respondents Who Wanted To Adopt Renewable Energy Sources

Fig. 12 finds that the 73.3% respondents were aware of the fact by using renewable energy they can reduce the cost of their bills. The cost per unit of electricity through renewable source like (Biogas) versus coal electricity is Rs.2.44 per unit and Rs.4 unit respectively. Under report presented by International Renewable Energy Agency (IRENA), Government of India has developed 4,00,000 jobs by adopting renewable energy resources. UP government's Samajwadi E-Rickshaw scheme under which electric rickshaws were and will continue to be distributed among owners of cycle rickshaw is a fine example of Renewable Energy Technology which has brought positive socio economic change to the lower class of the society [10].Government of India may further look into to develop job opportunity for people in rural area by promoting biogas and by launching various schemes which may directly provide benefit to the people. Later on till government promises that they can create millions of opportunity of jobs if they succeeded in their project of producing 100GW electricity by Renewable Energy. In short, majority of responders wanted to adopt the renewable energy technology due to its multiple benefits. Respondents were asked that whether in their particular area have installed solar light or not then in this case it is a 60-40% response as shown in Fig. 13.

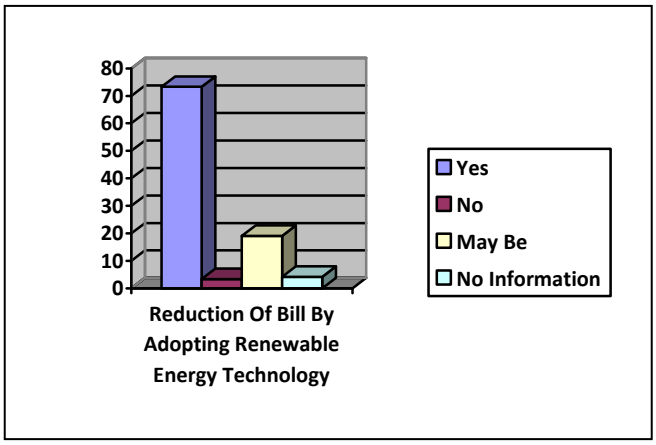

Fig. 12: Reduction Of Electricity Bill When Adopting Renewable Energy Technology

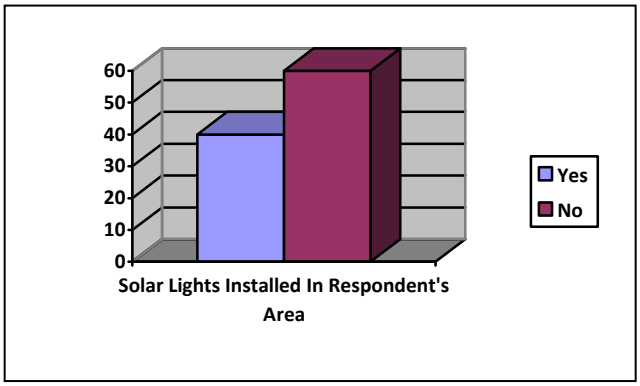

Fig.13: Installation Of Solar Light In Respondents Area

IX. CONCLUSION

There is a lot of scope of renewable energy technology in rural areas of India. In agriculture sector there are multiple instruments which are driven by the non-renewable energy resources. As we can drive the engines to pump water for irrigation in fields by using biogas energy, we can also make use of solar energy resources or wind energy but for as solar plate is expensive and it may require number of plates which may prove to be expensive and wind energy is not available everywhere, to generate electricity from wind it should flow at 15km/h and it is only possible in coastal areas [27-28]. For household purpose there are many expensive government schemes which the citizens should take the advantage and complete their daily needs of energy by the renewable energy resources. Renewable Energy should be taught as a subject in schools and all the bachelor's degree should include the subject on Renewable Energy Technology [4]. It should be mandatory in all institutions to promote and to raise awareness amongst the students regarding using renewable resources [25]. For increasing awareness amongst rural population of India.

Indian Postal Service should issue postage stamps Post Cards as Indian Postal Network is the largest postal network in India. Government should promote by giving Ads on the front page of National Newspapers and aware the people about advantages of adopting Renewable Energy Technology. Such techniques are bound to increase the usage of Renewable Energy Technology.

On taking account of all these matters Biogas proved to be the best option for generating energy in rural areas [29].

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Abstract. Present manuscript is a statistics-based approach towards the progression of Renewable Energy Technologies in the financial capital of India, Mumbai and the metro-city ecosystem that is based around Mumbai termed as the Mumbai Metropolitan Region. Factors which present themselves as bottlenecks and roadblocks towards the adoption of Renewable Energy Technologies by the populace of the Mumbai Metropolitan Region have been statistically analysed. 53% responses were in favour of installing Renewable Energy Technology however, 63% respondents had no awareness regarding Renewable Energy Schemes formulated by the Government of India. The authors of this manuscript have found parameters such as origin, awareness, educational background, usage of electricity and support for Renewable Energy Technology are some of the factors which are taken in account in this manuscript. Corrective measures have also been suggested to the authorities by the authors of this paper so that full utilization of schemes and subsidies provided by the Government of India to the citizens of the Mumbai Metropolitan region may be adopted and used to make India a negative carbon footprint nation.

Keywords: *Renewable Energy , Awareness, Mumbai, Public Opinion*

1. Introduction

Renewable Energy, as the word suggests is composed of two words, " renew " and " able ", signifying that renewable energy sources can be used time and again unlike conventional sources of energy [1]. We live in a world where Earth's average temperature has been rising in the past few years, major contribution towards rising average temperature has been global warming fuelled by the use of fossil fuels. Renewable energy presents itself as a near perfect alternative to conventional sources of energy, not only is the price of renewable energy cheaper in comparison to thermal energy it also does very little damage to the environment. It is fascinating to know that India began its journey in Renewable Energy in the year 1921 when construction started at Sidrapong Hydroelectric Park, Beadon Falls, Shillong [2]. Present manuscript deals with the responses of 300 citizens of the financial capital of India, the Mumbai Metropolitan Region. Mumbai Metropolitan Region comprises of Thane, Kalyan-Dombivali, Navi Mumbai, Mira-Bhayandar, Bhiwandi-Nizampur, Ulhasnagar, Vasai-Virar, Panvel and Mumbai itself, the aforementioned regions of the Mumbai Metropolitan region are governed by their own respective Municipal Corporations [3]. It is up to the present generation of population to contribute their share in Renewable Energy Technologies so that our future can be secure.

The Indian government has taken several steps towards the path of Renewable Energy Technology in the form of schemes subsidies and promotion. However, eight years since the launch of the Jawaharlal Nehru National Solar Mission, renewable energy has not been able to make a significant impact in the power generation industry as it was expected to [4]. Present manuscript analyses the roadblocks and bottlenecks faced by potential renewable energy consumers in the Mumbai Metropolitan Region. The authors of this paper have found lack of awareness amongst interviewees and lack of opportunities to be informed regarding life-changing Renewable Energy Technologies is fatal for the growth of Renewable Energy Technology . Parameters such as accommodation of the interviewee, interest in Renewable Energy Technology, support for installation of Renewable Energy Technology, awareness regarding Renewable Energy Technology and energy use have been recorded and scrutinized.

Awareness regarding Renewable Energy Technology pollution has also been explored in the paper. Schemes and policies initiated by the Government of India and Government of Maharashtra have been explained briefly along with overview of organizations responsible for implementing them.

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2. Discussion

Responses from all regions of Mumbai Metropolitan Region are taken as seen in Figure 1. Populace of Mumbai City takes the first part with 17% followed by Thane with 15%. Mumbai is regarded as the second most populous metropolitan area in India as of the Year 2016. Mumbai City houses offices of premier business institutions of India such as Oil and Natural Gas Corporation Limited, Tata Consultancy Services, Reliance Group, Larsen and Toubro as well as the oldest stock exchange in Asia, Bombay Stock Exchange. Thane is considered to be a feeder city of Mumbai with large population of working-class immigrants who moved to Thane due to comparatively low accommodation costs [5]. The world's largest planned city, Navi Mumbai is represented with 13%. Kalyan-Dombivali with 7%, Bhiwandi with 5%, Ulhasnagar with 11%, Vasai-Virar with 7%, Panvel with 10% and Mira Road with 15% of responses in this survey. The commercial success of Mumbai would not have been possible without the efforts of its working middle-class population. Figure 2 shows that 67% of respondents live in a 2 BHK (Bedroom, Hall, Kitchen) apartment while 23% of respondents live in a 1 BHK apartment. Maharashtra Housing and Area Development Authority (MHADA) is a Government of Maharashtra organization tasked with providing affordable housing to financially weak sections of Mumbai's population. MHADA has the responsibility for providing and maintaining housing in each of the seven revenue regions of Maharashtra namely, Mumbai, Konkan, Pune, Nashik, Nagpur, Amravati, and Aurangabad.

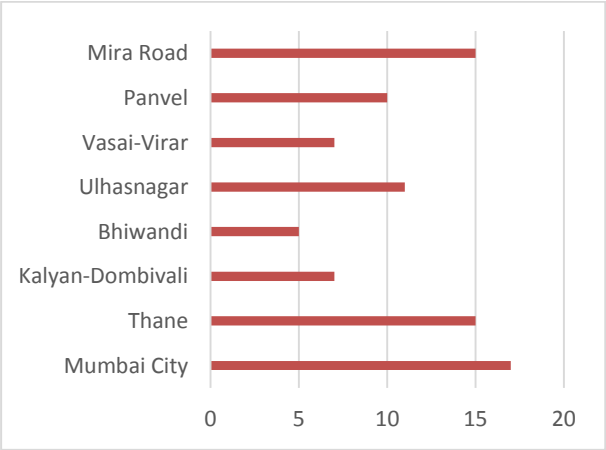

Fig 1.: Location of respondents

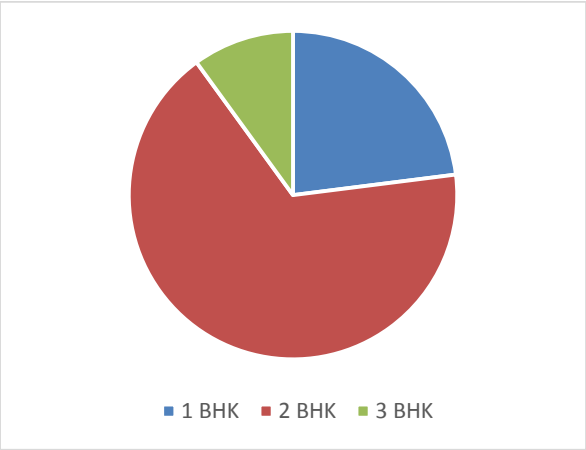

Fig 2: Size of Respondents' accommodation in percentage

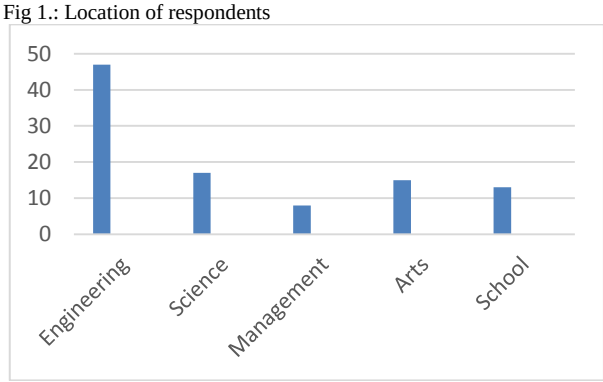

Fig. 3: Educational background of Respondents

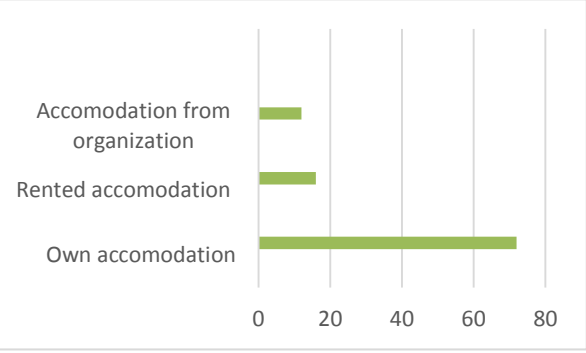

Fig. 4: Mode of establishment of respondents

Educational background of respondents is represented by Figure 3. Mumbai is home to some of the premium educational institutes of the country such as Indian Institute of Technology-Bombay, Tata Institute of Social Sciences, National Institute of Fashion Technology, Institute of Chemical

Technology and many more. Primary and secondary education comes under the aegis of Central Board of Secondary Education (CBSE) , Council for The Indian School Certificate Examinations (CISCE) and Maharashtra State Board of Secondary and Higher Secondary Education. In the recent years Mumbai has seen the emergence of International General Certificate of Secondary Education (IGCSE) and International Baccalaureate (IB) affiliated schools. Figure 4 signifies that 72% respondents have their own accommodation, if this group of people decide to implement Renewable Energy Technology in their place of residence, they will not face legal and other types of problem from their landlord.

3. Future perspective: Interest, support and awareness levels amongst respondents

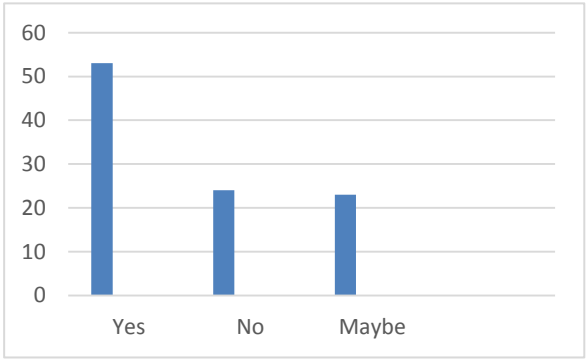

Fig. 5: Respondents' plans to install renewable energy technology NEMMP in their house

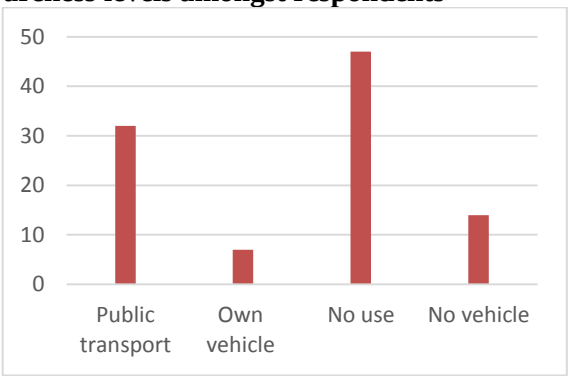

Fig. 7: Percentage of respondents who have used FAME and schemes

A positive trend for Renewable Energy Technology appears in Figure 5 as we see 53% respondents voting in favor of installing Renewable Energy Technology in their house. Tariffs for electricity generated through renewable energy are considerably low in comparison to electricity generated from conventional sources of energy. However, an overwhelming 63% respondents voted in favor of having no awareness of renewable energy schemes launched by the Government of India and Government of Maharashtra as seen in Figure 6. This represents the inability of government and private enterprises alike to spread awareness amongst potential consumers regarding renewable energy technology. National Electric Mobility Mission Plan (NEMMP) 2020 was launched by the Government of India in 2013 and it is aimed to boost the share of electric vehicles in the Indian Automotive Consumers market. NEMMP aims to provide fuel-security to the nation and protect the environment . Faster Adoption and Manufacturing of (Hybrid) Electric Vehicles (FAME India) is a subset of the NEMMP which aims to provide financial assistance to increase the share of electric vehicles and hybrid vehicles in the Indian Automotive market through manufacturing incentives at production level and tax reliefs at consumer levels [5]. Figure 7 displays the percentage of respondents who have taken advantage of the NEMMP and FAME with 32 % of the respondents having used an electric vehicle through public transport. Credit must be given to Brihanmumbai Electricity Supply and Transport (BEST),an organization which provides public transport and electricity to the citizens of Mumbai for implementing NEMMP and FAME schemes for its fleet of buses. The government of India has set to schemes like Jawaharlal Nehru Solar Mission for renewable energy in India [6].

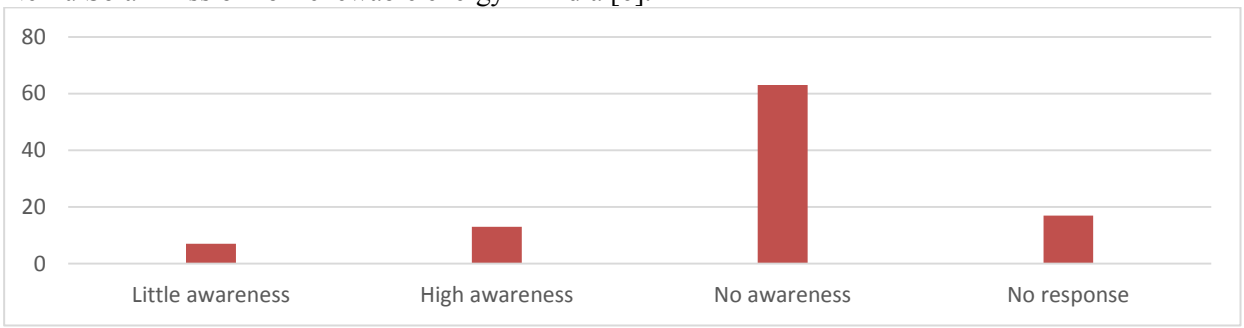

Fig. 6: Percentage of respondents having awareness of renewable energy schemes

4. Environmental concerns of respondents

As mentioned earlier, average global temperatures have been rising in the past few years, Figure 8 is concerned with respondents' awareness regarding climate change and global warming. 97 % respondents confirmed being aware about climate change, rising temperatures and global warming. According to the World Health Organization 14 out of Top 20 most polluted cities are located in India, Mumbai takes the 96th position in this infamous list. Awareness regarding climate change, rising temperatures and global warming can be attributed to the Environmental Science syllabus of the Indian Education System which features climate change and global warming subjects extensively. Considering rapid urbanization of the Mumbai Metropolitan Region 87% respondents confirm that they are aware of animal extinctions as shown in Figure 9. Changing temperatures have caused change of habitat of the animals at a rate which is far greater than the rate of adaptation [7].

Fig.8: Percentage of respondents having awareness regarding global Warming and climate change

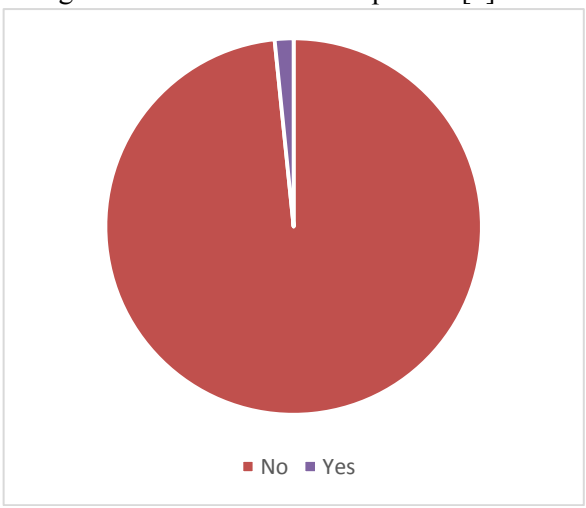

Fig.10: Percentage of respondents having knowledge of pollution from renewable energy sources

Renewable Energy Technologies such as solar power plants and wind farms help in decreasing pollution from conventional energy sources. However, these Renewable Energy Technology solutions are not free from polluting the environment themselves. Disposal of discarded solar panels and noise pollution from wind farms are some problems which require solving [8]. Figure 10 demonstrates that 73% of respondents voted that they have no information regarding pollution caused by Renewable Energy Technologies, such levels of information regarding pollution caused due to Renewable Energy Technology can be a roadblock for the development of better and more efficient Renewable Energy Technology as the upcoming generation of engineers and scientists may not be able to improve Renewable Energy Technology due to lack of Information and awareness.

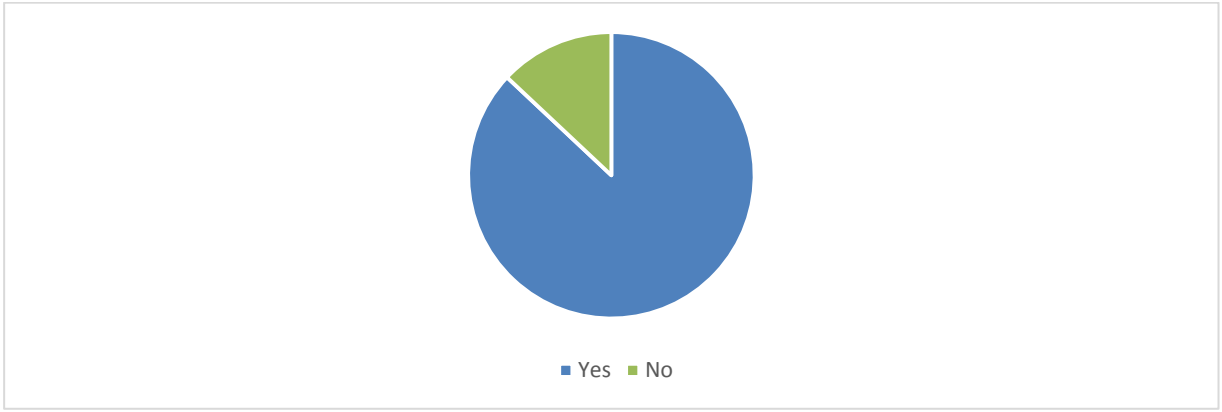

Fig. 9: Percentage of respondents having knowledge of animal extinctions

5. Respondents' usage of electricity

Figure 11 demonstrate the distribution of market share between Public Enterprises and Private Enterprises is concerned with electricity generation and transmission. 78% respondents receive electricity from a Private Enterprise such as Reliance Power and Tata Power while 22% respondents receive the electricity from a Public Enterprise such as BEST. Electricity Transmission from production level to consumer level is an underground transmission lines, does not only minimizes transmission losses but also prevents electricity theft. Government of India under the ministry of power has instituted Bureau of Energy Efficiency which has mandated that all consumer based electrical appliances have to display an energy service saving guide known as BEE Ratings. BEE ratings have quickly taken the top priority amongst the population of Mumbai who are interested to reduce the electricity bill through consumer electronics [9]. Figure 12 analyses the type of transportation used by the respondents of this survey; Public Transportation takes the top spot with 61%. Mumbai Metropolitan Region's public transport system consists of Suburban Rail-networks, locality-based buses and auto-rickshaws to provide last mile connectivity. Figure 2 demonstrated that that majority of respondents live in a 2BHK apartment, it is fitting to see that the middle-class population of Mumbai prefers Public Transport. However, only 7% respondents reported using Electric Rickshaws. Government of Maharashtra must take a cue from Government of Uttar Pradesh to launch an Electric Rickshaw Scheme to boost its share in the public transport domain [10].

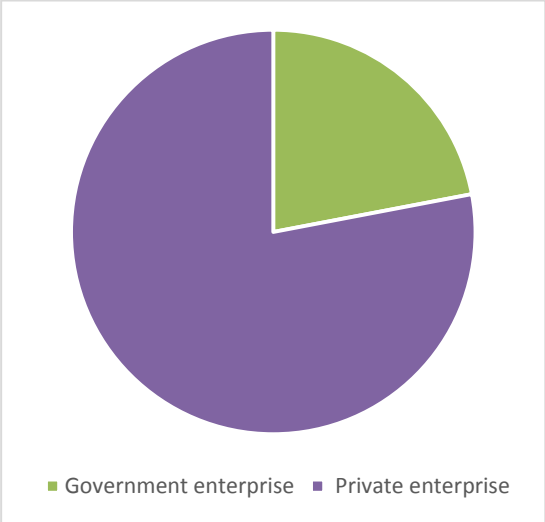

Fig. 11: Type of enterprise providing electricity to respondents in percentage

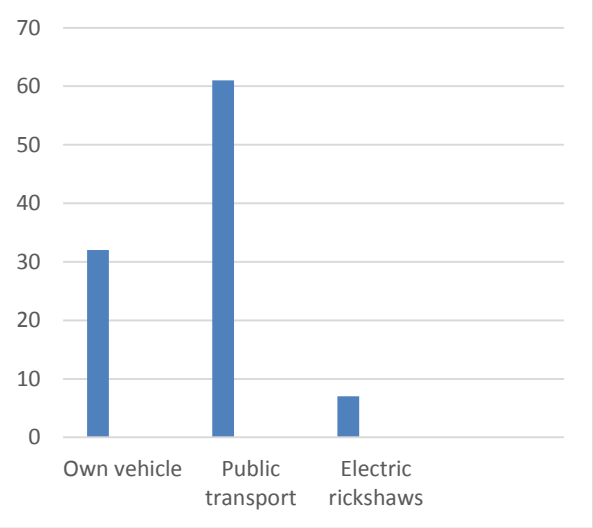

Fig. 12: Type of transportation used by respondents in percentage

6. Conclusion

Mumbai Metropolitan Region does not face any kind of social barrier in adopting modern technologies, as demonstrated by the use of induction cooking appliances in Figure 12. The authors of this paper feel that there is lack of awareness regarding renewable energy schemes. Respondents of this survey have not been able to take optimum advantage of SRISTI-Sustainable Rooftop Implementation for Solar Transmutation of India, Jawaharlal Nehru National Solar Mission and National Electric Mobility Mission Plan-2020. India's geographical position is a blessing for solar industries as well as consumers as it receives 300 days of direct sunlight [11]. In order to increase awareness regarding various renewable energy schemes the authors of this paper would suggest that the authorities include renewable energy in the environment science syllabus at school level, offer a diploma with respect to Renewable Energy Technology in the 4587 Diploma institutes of India, start a bachelor's program in Renewable Energy Technology for Engineering

and Technology students [12]. Bachelor of Technology in Power Engineering should be implemented with focus on Renewable Energy Technology [13] . " Renewable Energy Innovation Award " must be set up to attract brilliant mind for the betterment of Renewable Energy Technology " followed by a scholarship at school level and graduation level. Renewable energy should also be given focus for National level competitive exams such as Graduate Aptitude Test for Engineering syllabus of mechanical engineering electrical engineering and electronics engineering must be modified to accommodate Renewable Energy Technology. The platform of public transport must be used to spread awareness regarding Renewable Energy Technology through posters on the Suburban Rail Network and public transport buses. Indian Postal service which is the largest postal network in the world should issue postal stamps concerned with renewable energy to increase awareness in the rural areas of Mumbai Metropolitan region. Government of Maharashtra should take the initiative and install solar panels and windmills in police stations, post offices, railway stations and other type of government offices where people visit frequently in order to increase awareness regarding Renewable Energy Technology**.**

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Statistical Analysis of Effects of Make in India on Industrial, Manufacturing & Production Field in India: A Comparative Study

Statistical Analysis of Effects of Make in India on Industrial, Manufacturing & Production Field in India: A Comparative Study

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Abstract. After independence, India has developed a lot whether it's in defense field or railways; we are developing day by day in all the fields. And now a day's India is rapidly growing in technology and production field after the project of Make in India. In this paper, we have discussed the effects & change in statics due to Make in India project on Indian economy. We have also discussed the educational structure of Industrial Engineering, Manufacturing Engineering and Production Engineering in India and also discussed top BRICS institutes in the epilogue of this paper.

Keywords: Make in India, Industrial Engineering, Manufacturing Engineering, Production Engineering.

1. Introduction

Mechanical Engineering is a branch of engineering which conciliates with the principle of designing, analyzing and manufacturing of mechanical system. It is a discipline which is a combination of engineering, physics, mathematics, and material science. In ancient world, there were several persons whose work influenced mechanics such as Archimedes, Heron of Alexandria who created steam engine etc [1]. In antiquated times these all three were studied under the discipline of mechanical engineering (before World War Second).before some dickers from now the mechanical engineering is the mere discipline which holds all the principles of production, manufacturing, designing etc, but as the renaissance increased in Mechanical Engineering, the field becomes very vast that several courses or discipline have established their own department. Now multifarious fields are generated to deal with the different principle of Mechanical Engineering such as industrial engineering, manufacturing engineering, production engineering. These all three are interrelated and are subsets of mechanical engineering [2].

Industrial Engineering conciliates with the optimization of complex processes, systems, or organizations. The prime motive of engineers in this field is to eliminate waste of money, machine

time, material, energy resources etc [3]. Industrial engineering covers the fields of process engineering, system engineering, software engineering, safety engineering, data science, analytics and data mining etc.

Manufacturing Engineering is a field in engineering which deals with the methods of production and manufacturing processes of a product, it solicits the ability to plan practice and good skills to research and develop a tool for processing etc. The accountability of a manufacturing engineer in this field is to convert raw material into the final product in the most effective efficient and economic way [4].

Production Engineering is an enarthrosis of engineering, manufacturing technology, and management. The pursuit in this field is to effectuate the production in a sleek and economic way. Production engineering comprises of umpteen operations such as casting, metal forming, metal joining, metal cutting, tool designing etc. These operations have their execution in automobile part design, automation, machining systems etc [5]

These all three plays a capacious role in the development of a product and growth of a nation too. These three fields are superseding the old technology. The government has also initiated numerous projects; one of them is MAKE IN INDIA [6]. It is a spacious project whose main aim is to metamorphose our country into a manufacturing hub. Many foreign companies like Bosch, Ford, BMW, Haier etc have infused their capital in this project. So to build a country for such tidies task experts or professionals are required. To overcome the demands of engineers in fields of industrial, manufacturing and production engineering umpteen different discipline of education was set up at UG level & PG level. These all three fields differ by a meager with each other but all correlate with mechanical engineering [7].

2. Curriculum

2.1. At Under Graduate Level

In Industrial Engineering field at UG level (B.E or B.Tech) Operations research and optimization techniques, Engineering Economics, Management Sciences, Facilities design and work-space design, Computer-aided manufacturing, Production planning and control, System analysis and techniques, Project management, System dynamics and policy planning etc. are the core subjects which are covered in four year or eight semester sessions. In last semester students have to make a project on relative topics to their core subjects. Industrial Engineering necessitates on the areas of optimization, applied probability, stochastic modeling, the design of experiments, statistical process control, simulation, manufacturing engineering, ergonomics etc [3,11,12], some elective subjects offered during the session are machine learning, production systems, human factors and industrial design, and service systems etc.

In the Manufacturing Engineering field at UG level (B.E. or B.Tech), the first year is common to all branches. From second year onwards core subjects are introduced. Metrology, Fluid Mechanics, Thermal Engineering, Manufacturing by Shaping & Joining, CAD / CAM, Design of Machine Elements, Machine Tool & Machining, Non Traditional Manufacturing Process, Quality Production Methods, Metal Forming, Robotics & Robot Applications, Organizational Behaviour & Industrial Psychology, Work System Design & Human Factor Engineering etc. are some of the core subjects in manufacturing engineering. Lab work is done in fields of Mechanics of Solids Lab, Foundry & Welding Lab, Theory of Machine Lab, Design of Machine Elements Lab, Machining & Metrology Lab, Operations Research Lab, Computer Aided Design & Manufacturing Lab etc, last semester students have to make a working project on relevant topics to their subjects [4,14].

In Production engineering at UG level (B.E. or B.Tech) the core subjects onwards for sophomore students are Engineering Mechanics, Casting & Welding Technology, Machining Technology, Forming Technology, Tooling for Manufacturing, Quality, Reliability and Safety Engineering, Computer Integrated Manufacturing, Work Design and Facilities Planning etc Unconventional Machining Processes, Material Handling & Storage, Manufacturing of Composite Materials, Machine Tool Technology, Industrial Robotics, Plant Engineering, Non Destructive Testing, Micro Fabrication

Processes, Surface Engineering, Processing of Friction composites, Computational Fluid Dynamics etc. are some of departmental electives which are offered between sophomore to final year [3,13].

2.2. At Post Graduate Level

In Industrial Engineering at master's level, this course is further divided into 3 major parts for specialization, i.e. Analytics & Optimization, Product Life Cycle Management, and Operation Management. The core subjects covered under this program are Manufacturing Informatics, Optimization, Stochastic Modelling and Simulation, Quality Systems, Reliability Engineering, Value Engineering and Life Cycle Costing, Service System Design, Maintenance management, Supply Chain Management etc. the engineers in this sector have different profiles like management engineer, ergonomist, operations analyst, quality engineer [3].

In Manufacturing Engineering at master level Metal Cutting – Theory and Practice, Design and Analysis of Machine Tool, CNC Technology and Programming, Advanced CAD, Advanced Manufacturing Processes, Metrology and Computer Aided Inspection, Mechatronics and Robotics are the main core subjects. Lab work is done in fields of CNC Laboratory, Mechatronics Laboratory, Manufacturing Engineering Laboratory; CAD Laboratory etc. students have to submit their dissertation in masters which are examined by an external examiner. Rapid Manufacturing Processes, Tribology, Soft Computing Techniques, Precision Engineering, Tool Design, Fluid Power Systems, High-Speed Machining etc. are some of the electives offered in masters in manufacturing engineering [4].

In Production Engineering at the master level, the subjects are divided into two categories i.e. program core & program elective. Program core covers the subjects like Experimental Methods, Metal Forming Analysis, Machining Processes and Analysis, Computational Methods, Computer Aided Manufacturing, Metrology, Welding Science and Technology. whereas program elective covers the subjects like Nanomechanics, Mechatronics Product Design, Manufacturing Informatics, Injection Molding and Mold Design, Additive Manufacturing, Automation in Manufacturing, Quality Systems etc. Students at the master level have to submit their thesis in last semester which is done under the guidance of faculty and is examined by an external examiner [5, 16].

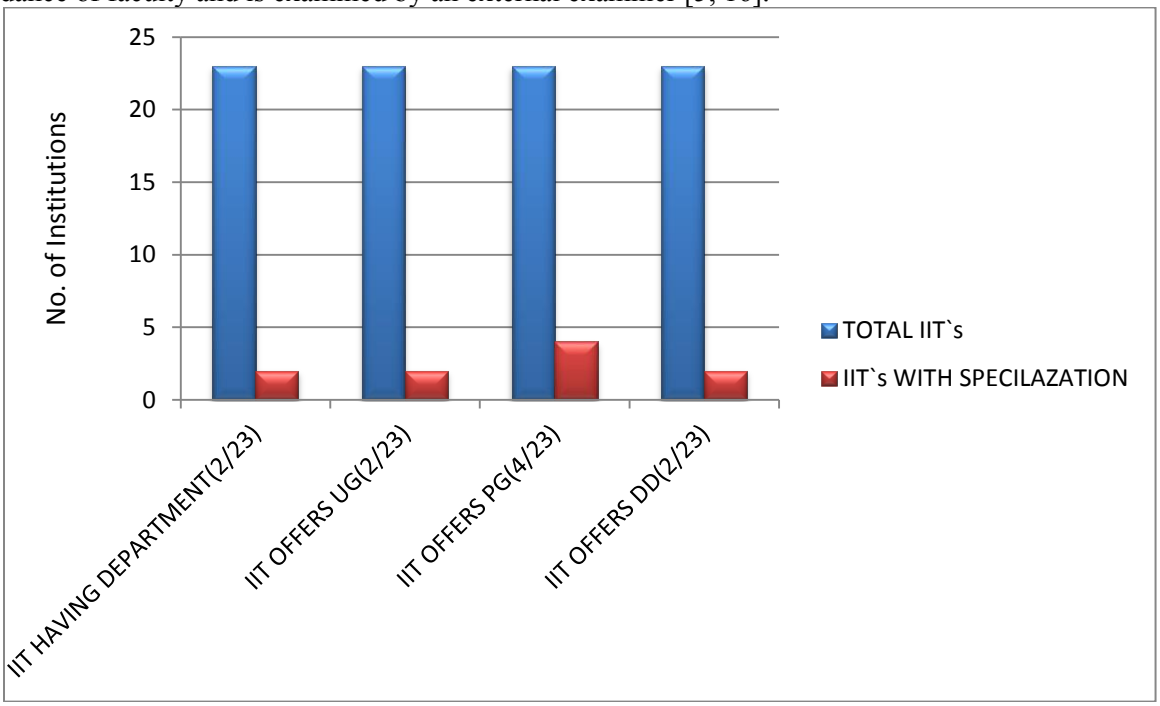

FIG 1: Industrial Engineering.

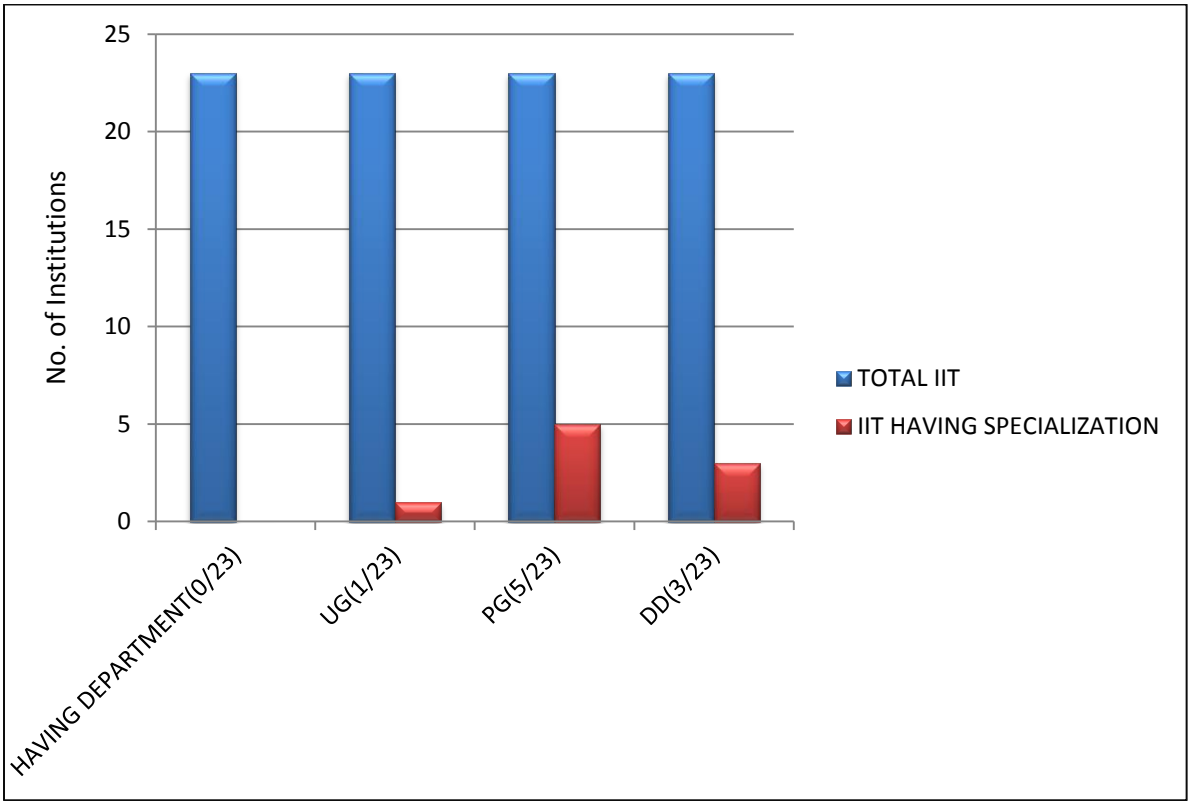

FIG 2: Manufacturing Engineering.

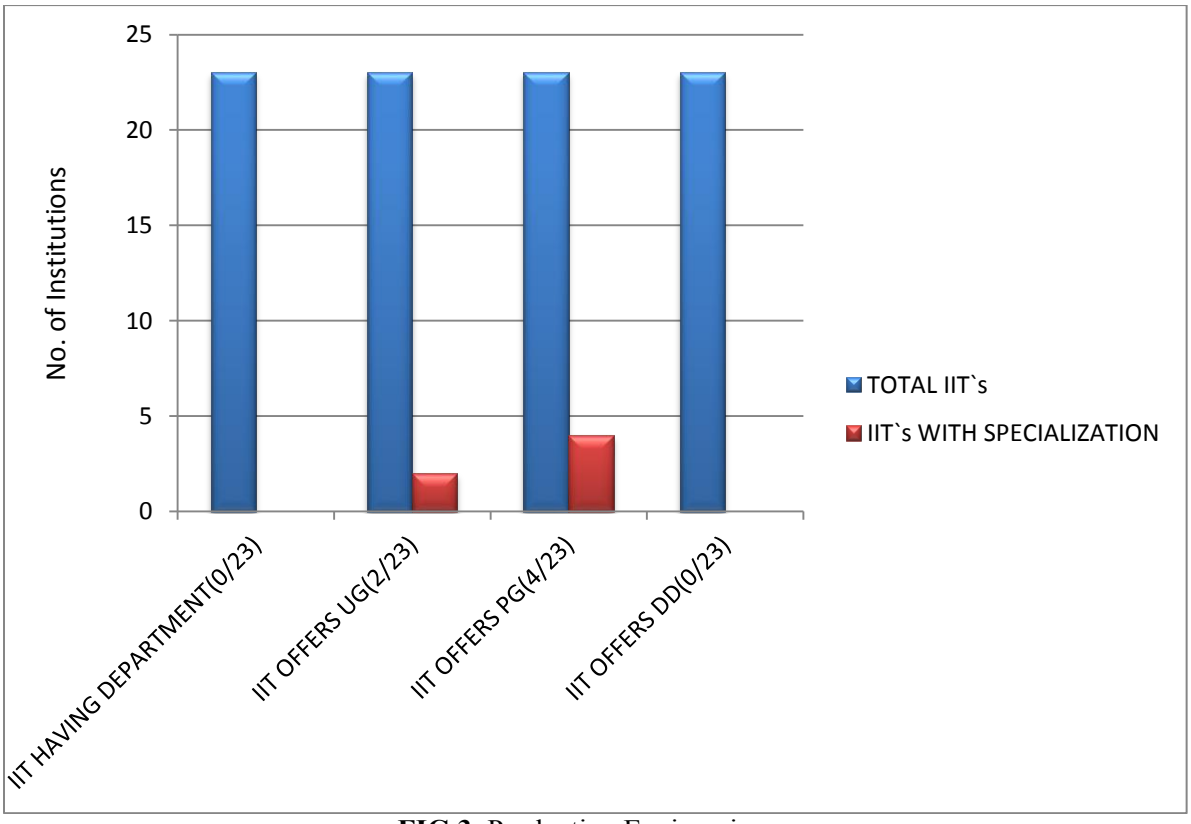

FIG 3: Production Engineering.

3. Tools and Web Resources:

Generally, simulation tools used in industrial, manufacturing and production engineering are common. For programming purpose CNC tuner & cut view miller are used. AutoCAD, CATIA, Creo parametric, Solidworks etc. are used for designing purpose. In the field of analysis, Ansys & Hypermesh is widely used. For numerical computational purpose MatLAB, Visual Studio, Minitab are used. For the purpose of automation, Automation Studio and SCADA are used. The government of India has also initiated multifarious endeavor for the better augmentation of knowledge in the fields of industrial, manufacturing and production engineering through NPTEL (National Programme on Technology Enhanced Learning). In the NPTEL database, there are total of 15 courses in manufacturing engineering. Inboard which CAD, Advanced Manufacturing Process, Mechatronics and Manufacturing Automation, Manufacturing of Composites, Micro System Fabrication, Green Manufacturing System, Product Design and many more are there as major subjects. There are only two courses (Theory of Production Process and Project & Production Management) for Production Engineering in NPTEL. For Industrial Engineering, NPTEL database holds only three courses which are Fundamental of Industrial Oil Hydraulics & Pneumatics, Industrial Engineering and Industrial Automation & control [15].

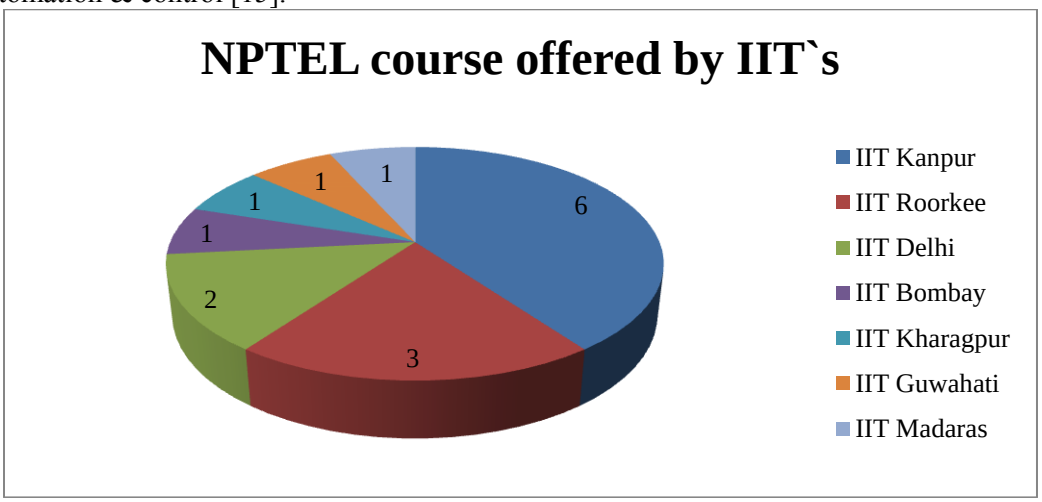

FIG 4: NPTEL courses offered in Manufacturing Engineering by different IIT`s.

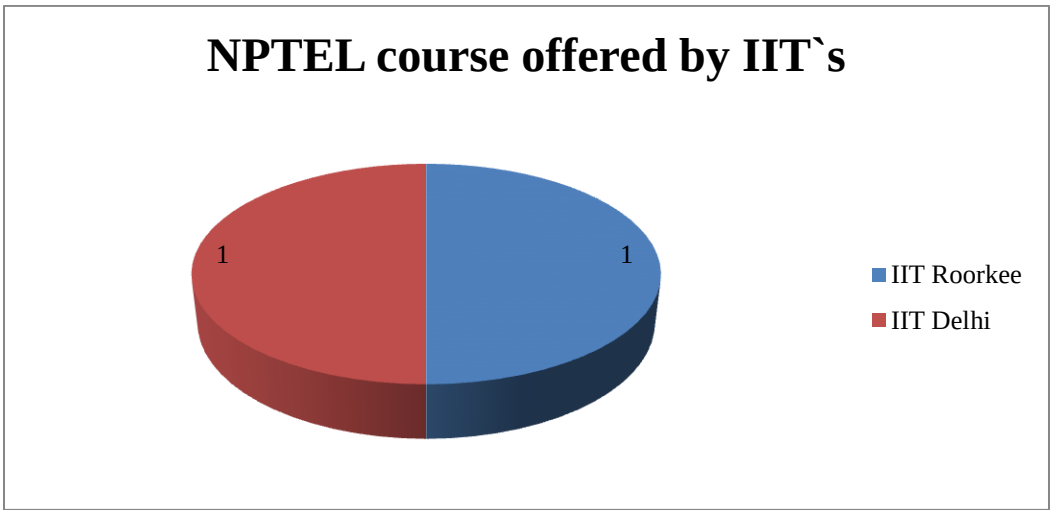

FIG 5: NPTEL courses offered in Production Engineering by different IIT`s.

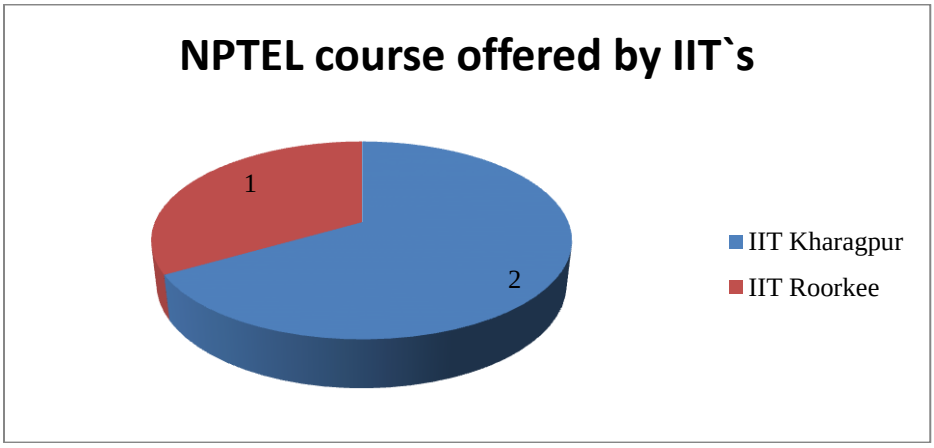

FIG 6: NPTEL courses offered in Industrial Engineering by different IIT`s.

4. Make In India:

There are numerous sectors which are developing under the project of MAKE IN INDIA. Automobile, Biotechnology, Defence Manufacturing, Electronics System, Renewable Energy, Railways etc [17] are some of the prime sectors in it. According to the statistical growth of the automobile sector, it's a prospect to protrude the production of two-wheelers and three-wheelers to 0.95 million units and 50.6 million units respectively by the year 2026. According to Compound annual growth rate (CAGR), the numerical data of production of public vehicle & two-wheelers are appraised to be 3.2% & 4.4% respectively [17-18]. This project is going to alteration these figures in a very blusterous manner. India`s average annual production of the vehicle in 2016-17 was 25 million units in which 3.47 million units are exported. Talking about the contribution in GDP, automotive industry accounts 49% to manufacturing a gross domestic product (GDP), 7.1% to the country`s gross domestic product (GDP) and 26% to the industrial gross domestic product (GDP). The statics of employment and deputation is also as higher as production in this sector. Approximately this sector provided 32 million jobs via direct or indirect employment in the year 2016. For making this project well-turned umpteen countries and companies are contributing to it. Some foreign investors are Suzuki (Japan), Nissan (Japan), BMW (Germany), Ford (USA), Toyota (Japan), Mercedes (Germany) etc.

Coming up to the defense sector, the defense is on the map parameter for the safety of any country and it also requires umpteen different types of tools and doohickey and also the land, air & water vehicle to protect a country from all side of the borders. In last few decades India had done the conciliation on air vehicle(Ilyushin I1-78, Lockheed Martin C-130J Super Hercules, Boeing C-17 Globemaster III, Mikoyan MiG-27, Mikoyan MiG-29, Sukhoi Su-30MKI and many more) & water vehicles(Chakra Akula II class, Sindhughosh class etc.) for better protection of our country. According to the UNION BUDGET 2016-17, the defense sector had allocated approximate USD 34.53 billion. Some foreign investors in this sector are Airbus (France), BAE India Systems (UK), Pilatus (Switzerland), Lockheed Martin (USA), Boeing India (USA), Raytheon (USA), Israel Aerospace Industries (Israel), Rafael Advanced Defence Systems Ltd, (Israel), Dassault Aviation SA (France) [20].

The electronic market in India is anticipating reaching USD 400 billion; currently, this electronic market is in the list of the largest electronic market across the globe. The electronic market holds the products of Consumer Electronics, Industrial-Electronic, Electronic Components, Semiconductor Design, and Electronic Manufacturing Services. Approximate the investment in this sector in 2017 was stood to be INR 1.57 lakh crores and it also promises to the growth rate of 27% over a year [21-22]. There are several foreign investors who are coming forward to uplift this sector in India; some of them are Qualcomm (USA), Bosch (Germany), Mitsubishi (Japan), Haier (China) etc.

To scoot any industry or any project the preparative requirement is "ENERGY"[23], but the cauterization of fuels to produce energy is scathingly the environment and also begetting the depletion in the ozone layer. So to isolate this problem and overcome from it the world is moving towards

"Renewable Energy", which is eco-friendly and is infinitely available [24]. A country like India is also working on sledding of renewable energy (wind energy, solar energy etc.) through several projects and hence it is also kept under the project of MAKE IN INDIA so that we can preferment the generation capacity of energy. Talking about its statics in INDIA, so India has the largest wind power capacity 5.5 GW (approx) in 2016-17 [25] and it's estimated to exceed this target by 38%. Now India is at the 4th position after China, USA and Germany in wind power installed capacity. There is an upcoming project in Make in India on solar which has the capacity of 23.6 GW power generations. Foreign investors who are helping us to reach our goals are Enercon (Germany), Vestas (Denmark), Applied Materials (USA).

The railway is one of the biggest sectors which had set up before the independence of India (i.e. before August 1947). At that time it was the only passable medium through which goods and products were transported [26]. Since then several renaissances takes place in this sector and also several things altered. Now coming up to the statistical data in Make in India project, so there is 1, 21,407 Km total length of rail tracks throughout India. Indian Railways also have 70,937 coaches; 2,77,987 wagons and 1.3 million employees in its hands [27]. There are 48 trains who had speeded up to superfast train category with an average speed of 55 kmph and above in 2017-18. Some foreign companies who help India in developing the railway sector are GE (USA), Siemens (Germany), Alstom (France) etc.

5. Brief Comparison of Industrial, Manufacturing & Production Engineering Education status in top universities of BRICS countries

We have used Quacquarelli Symonds (QS) ratings for the analysis in top colleges across BRICS countries [28]. In this paper, we deem BRICS colleges under top 100 ranking. There are only five colleges of BRICS countries fewer than 100 ranking by QS, inside which four colleges are from China and only one college is from Russia. Rest others are beyond the 100 ranking.

The report of the year 2018 says that within BRICS countries Tsinghua University, China is on top. This University of China proffers mechanical engineering & industrial engineering and it also has its segregate institute for the study of mechanical & industrial engineering aka 'School of Mechanical Engineering'. This institute was established in 1996. It propounds skills and research in areas of robotics, automation, CAD etc. Shanghai Jiao Tong University, China proffers program in industrial & mechanical engineering. In this university, masters are done in fields of Mechanical Manufacturing and Automation Mechatronics, Machine Design and Theory Vehicle Engineering etc. Zhejiang University is one more in the top list rankings of QS which offers Industrial Engineering and have its separate department. It was established in 1897. The scholar research scientist of this university designed first dual inner water cooled turbo-generator in 1958.

Rest coming up to India then Indian Institute of Technology, Bombay (IITB) is at 162 ranking in QS. This institute does not offer any UG or PG program but it gives its benefaction in web resource knowledge through NPTEL in the design of manufacturing. Universidade de São Paulo (USP), Brazil have a program for manufacturing engineering and this university is at 118 ranking across the globe. Whereas the University of Cape Town is on the top in South Africa but do not offer any programs regarding industrial, manufacturing or production engineering.

The overall conclusion is that China is the only country who has a clear perspective and plans regarding industrial engineering for present and future industries. Rest other countries have to focus on these sectors for better growth and development. Focusing on Indian curriculum for these three engineering courses, the government have to fill the voids through introducing the UG and PG program in all government institutes within some years so the project of MAKE in INDIA could be a success.

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Statistical Evaluation of Renewable Energy Technologies in Lucknow: Prevailing Schemes, Barriers and Future Scope

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***Abstract*—Present manuscript deals with the progression of Renewable Energy Technologies in the Indian city of Lucknow which is the capital of India's most populous state, Uttar Pradesh. India has adopted many Renewable Energy Technologies, but major portion of those technologies is composed of large renewable energy-based power plants and usage of renewable energy technologies is very less by the common citizens of India. This paper provides an analytical approach towards factors which present themselves as roadblocks in the way of adoption of renewable energy technologies by the common citizens of Lucknow. Schemes and subsidies provided by the Government of India, intended for the common citizens of Lucknow have been mentioned and the reason for sub-par adoption of these schemes has been statistically explained. Origin, awareness and educational background of 200 citizens of Lucknow have been used as parameters for this study. The authors of this paper have provided several corrective measures for full utilization of Schemes and Subsidies provided by the Government of India to the common citizens of Lucknow in order to increase the usage of Renewable Energy Technologies and make India a less pollutive nation.**

Keywords—Lucknow, Awareness, Renewable Energy Technology

I. INTRODUCTION

The renewable energy resources are considered as inexhaustible sources of energy. The word "renewable" itself indicates that these sources of energy can be renewed and regenerated without being exhausted. The renewable energy resources are also termed as non-conventional sources of energy. These energy resources occur naturally, are restorable and infinite so they are referred to as "renewable energy" resources. The renewable energy resources such solar energy, hydroelectric, biomass fuels, wind and geothermal energy are naturally replenished on a human timescale[1].

This paper deals with the current scenario, obstacles and the future issues related to the renewable energy resources faced in the capital city of Uttar Pradesh, Lucknow. Uttar Pradesh was earlier known as United Provinces under the British rule and today it is the most populated state of India . According to the census in 2011, the population of Lucknow was 28,17,105. The administration of Uttar Pradesh is divided into 18 administrative divisions which are subsequently divided into 75 districts. The administrative division of Lucknow consists of Hardoi, LakhimpurKheri, Raebareli, Sitapur ,Unnao and Lucknow itself [2]. The decisions and policies implemented in Lucknow resonate through the entire stretch of Uttar Pradesh. According to the World Health Organization (W.H.O.),Lucknow stands 7th in the list of world's most polluted cities. As India is a signatory to the Kyoto Protocol and Paris Climate Change agreement ,it is the responsibility of the capital of the most populated state of Uttar Pradesh to set an example in the fight against pollution, but this is not the case[3]. Poor literacy rate, lack of awareness and negligence among the people are some of the major causes due to which the renewable energy resources have been neglected by the people. Various government schemes on renewable energy resources have been launched which lay emphasis on the advantages in the usage of renewable energy while the energy resources like coal, fuel, petroleum also have adverse effects on the environment. They cause pollution on a large scale and degrade the quality of air further causing various air borne diseases among the people. On the other hand, the renewable energy resources are environment friendly. The electricity generated from renewable energy resources produces between 90-99% less greenhouse gases when compared with the electricity produced by the power plants. Not only this, the renewable energy resources cause 70-90% less pollution when compared with the traditional resources.

This survey comprises of 200 respondents from the capital city of Uttar Pradesh, Lucknow. Lack of awareness and negligence regarding renewable energy resources can be seen among the people in this survey. Althoughvarious schemes are launched by the Government of India regarding renewable energy resources, but people seems to be unaware regarding the government schemes. A majority of people have no idea about the recent schemes which were launched by the government of India ,as monitored in the survey.

The various schemes related to the renewable source of energy which the government of India has proposed are:-

1) The Ministry of New and Renewable Energy has proposedSRISTI-SUSTAINABLE ROOFTOP IMPLEMENTATION FOR SOLAR TRANSFUGATION OF INDIA. The scheme proposed to incentivise the installation of the rooftop solar power plant project all over the states of India. The scheme aims to achieve a national solar rooftop target of 40 GW till the year 2022. This rooftop solar power plant is schemed to be installed only in the

residential areas of the country. The total outlay of the scheme is 23,450 crore rupees for 40,000 MW of roof top solar installation[4].

2) The Jawaharlal Nehru National Solar Mission has been implemented by the government of India to establish India as a global leader in the solar sector by creating the policy norms. An ambitious target of deploying 20,000 MW of grid connected solar power plant by the year 2022 has been set[5].

The government of India has even provided subsidy on the installation of solar power plants both off grid and on grid. About 50% of subsidy is provided to the people of general category, 75% of subsidy is provided to the people of scheduled caste and 90% to the people belonging to the category of scheduled tribe.

II. DISCUSSION

A. *Areas from which the respondents belong*

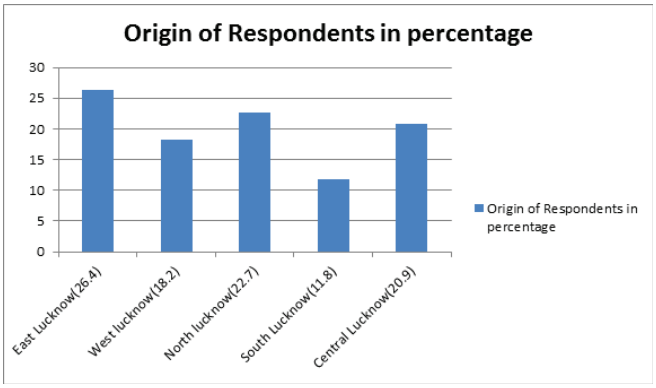

Fig. 1. Origin of Respondents

The survey in Fig 1, consists of 200 respondents from all the regions of Lucknow. Among these 200 respondents, about 26.4% belong to Lucknow East which includes parts of Gomtinagar, Indra Nagar, Mahanagar, Nishatganj, Khurram Nagar, 18.2%of the respondents belong to West Lucknow which includes areas of Rajajipuram, the old city areas, Chowk etc, about 22.7% of respondents belonging to North of Lucknow which includes the areas of Jankipuram, Aliganj, Faizabad Road, Sitapur Road , Husinabad and other areas, 11.8% of the respondents belong to South Lucknow which includes the areas of Alambagh, VidhanSabha, RDSO colony, Kanpur Road and other areas and 20.9% of the respondents belong to Central Lucknow which includes the areas of old city, sectors of Hazratganj, Gomti Nagar and other attached areas.

B. *Size of the house*

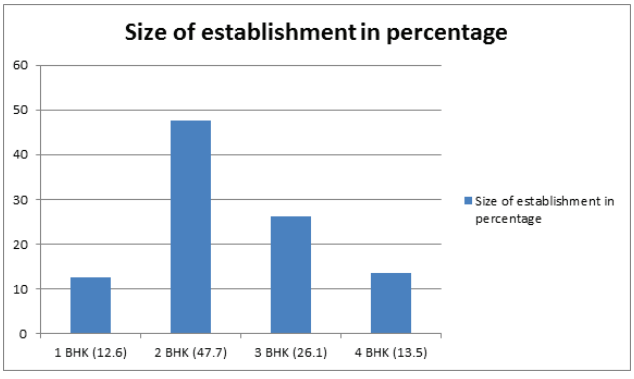

Fig. 2. Size of Respondent's establishment

In Fig 2, about 12.6% of the respondents reside in a 1 BHK house, 47.7% of the respondents stay in a 2 BHK house. About 26.1% of the respondents reside in a 3 BHK house. Whereas 13.5 % of the respondents are lodged in a 4 BHK house. The Pradhan MantriAwasYojna was launched by the Prime Minister of India, Mr Narendra Modi, in the year 2015, behind which the objective was to provide affordable houses to the people, under the government scheme[6]. These houses will be affordable to the people under the Middle-Income Group, Low Income Group and Economically Weaker Section. Since the middle-class population is on an increase in comparison to the other classes, we can see the maximum percentage of the respondents reside in a 2 BHK house.

C. *Educational background*

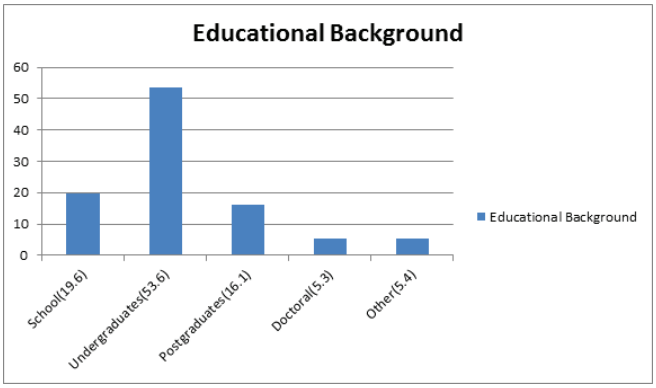

Fig. 3. Educational background of Respondents

In Fig 3, about 19.6% of the respondents are school going pupil, the maximum number of the respondents that is 53.6%, are undergraduates. About 16.1% of the respondents are post graduates,5.3% of the respondents are doctoral students and 5.4% of the respondents belong to the other categories.

D. *Awareness regarding renewable energy resources*

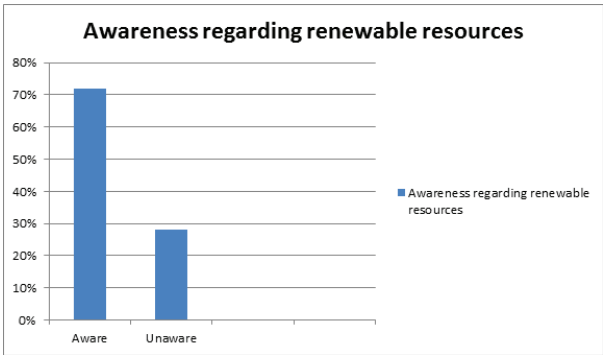

Fig. 4. Respondent's awareness regarding renewable energy

In Fig 4, as we can see the bar graph, about 72% of the respondents are aware regarding renewable energy resources whereas 28% of the respondents do not have even a basic idea regarding the renewable energy resources.

Since the non-renewable energy resources are easily available and thus are being depleted on a large scale, the only other alternative left is renewable energy resources. The non-renewable energy resources take millions of years to get replenished whereas the renewable energy resources replenish naturally and over relatively short time periods, so

people must have general awareness regarding these energy resources and their beneficial outcomes[7].

E. Effects on environment

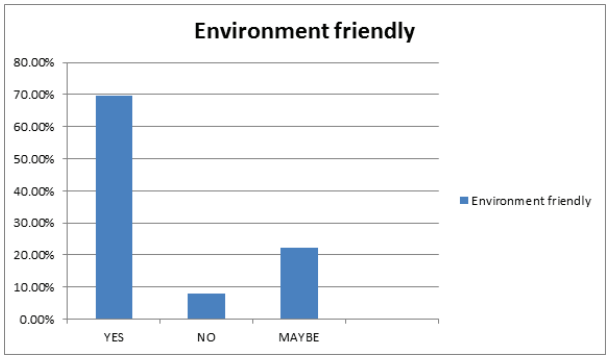

Fig. 5. Respondent's awareness regarding Renewable Energy

In Fig 5, about 69.6% of the respondents are aware of the fact that renewable energy resources are environment friendly. Pollution levels can be decreased if the non-renewable resources can be replaced by renewable ones. 8% of the respondents disagree on the fact that renewable energy resources safeguard the environment and about 22.3% respondents are unsure whether the renewable energy resources are environment friendly or not.

On the contrary, the traditional resources of energy like fossil fuels, coal, petroleum etc have been the major cause of air pollution since ages, therefore switching to the non-conventional energy resources would definitely ensure lesser air pollution and safeguard the environment.

F. Replace non-renewable resources with renewable ones

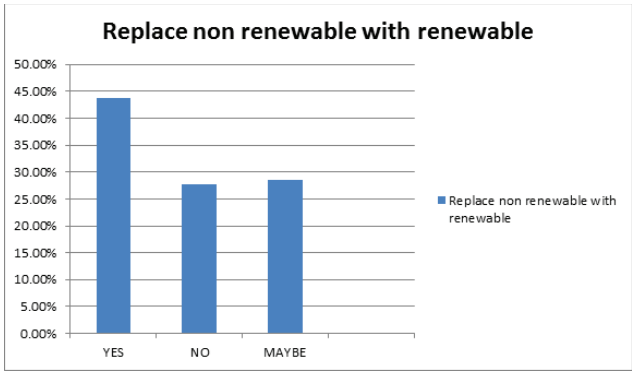

Fig. 6. Future plans regarding renewable energy

In Fig 6, about 43.8% of respondents plan to replace the non-renewable energy resources which they use in their day to day lives with renewable ones, 28.6% of respondents wish to stick to the traditional sources of energy rather than switching to renewable energy resources and 27.7% are unsure whether to switch to renewable energy resources or not.

We can observe that a number of people lack awareness regarding the beneficial outcomes of switching the non-renewable energy resources with renewable ones.

G. Awareness regarding environmental hazards

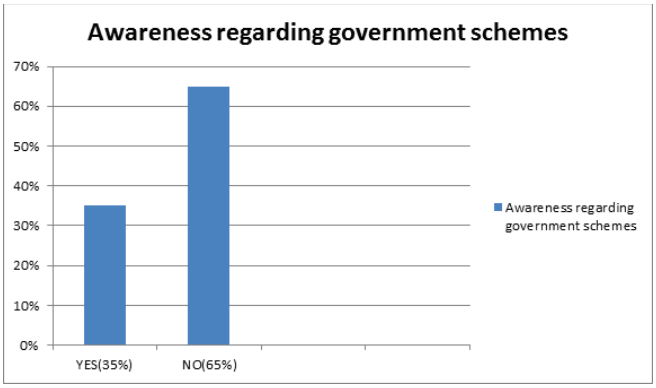

Fig. 7. Respondents awareness regarding Renewable Energy

In Fig 7, about 81% of the respondents are aware regarding the environmental hazards and still due to their negligence, less than half the majority of the respondents are planning to switch to the renewable energy resources as we can see in our survey whereas only a handful respondents that is 19%, are unaware of the environmental hazards and their adverse effects on the environment.

We can see a high ratio of awareness regarding pollution and environmental degradation at school and undergraduate level is due to the introduction of Environmental Science course, a subject which basically emphasizes upon human interaction with their environment and deals in solving complex environmental problems; in their respective syllabus.

H. Awareness regarding government schemes

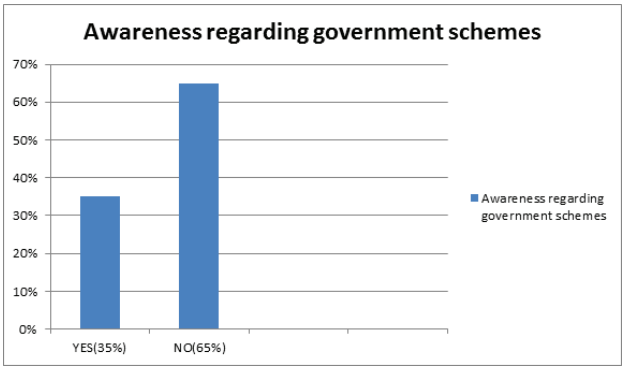

Fig. 8. Respondent's awareness regarding Government Renewable Energy Schemes

The Government of India has launched many schemes regarding renewable energy resources, few of which are mentioned earlier in the paper, but we can observe in Fig. 8, that the majority of respondents that is 65%, are unaware regarding the various government schemes on renewable energy resources and due to this negligence among the people, the renewable energy resources are not fully utilized. Only 35% of the respondents are aware regarding the schemes launched on renewable energy resources and thus a huge capital amount is being wasted as the people lack awareness. Not only this, the young generation too, lacks awareness regarding the government schemes and thus have no contribution towards the development and betterment of the Renewable Energy Technology.

I. Solar panels installation in residential areas

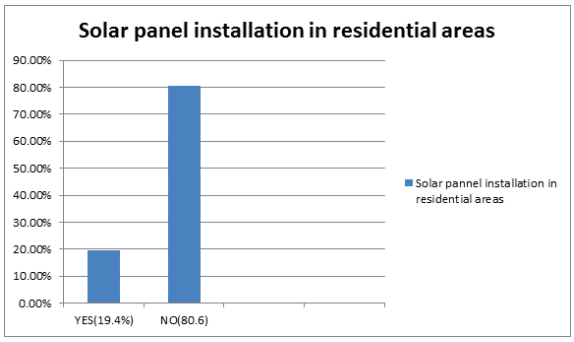

Fig. 9. Installation of Solar Panels in residential areas

As it can be seen in the survey in Fig 9, about 80.6% of the respondents do not have any installation of the solar panels by the government scheme, these respondents are from all over the area of Lucknow as mentioned earlier but still a majority of them do not have the solar panels installed in their residential areas, only a handful of respondents that is 19.4% , have the facility of solar panels in their respective residential area.

This survey also points towards the mismanagement regarding spreading of awareness and its practical implementation by the government of India.

J. Reduction of electricity bills with the usage of renewable energy resources

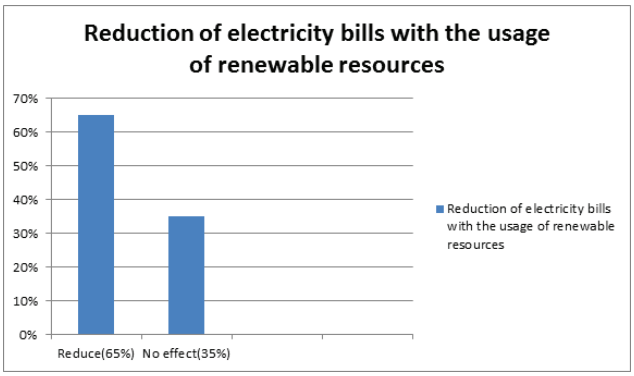

Fig. 10. Respondents' views on reduction of electricity bill with usage of renewable energy

As observed in the survey in Fig 10, about 65% of the respondents are aware of the fact that the usage of non-conventional sources of energy will decrease their electricity bills when compared to the conventional or traditional sources of energy whereas 35% respondents are still unaware that their electricity bills could actually be reduced if they switch to the renewable energy resources.

We all must be aware of the fact that the geographical area of Lucknow receives sunlight for 300 days on an approximation and by investing in the renewable energy resources like in the installation of solar panels, energy can be generated on a large scale and thus the usage of non-renewable energy resources can be reduced, and electricity bills can be decreased.

III. RESULT AND CONCLUSION

The Central and the State Government must ensure that renewable energy resources and the related technology must be implemented in the syllabus at basic schooling levels. IIT's and NIT's must introduce Renewable Energy Technology at undergraduate level. Advertising campaigns must be initiated with separate focus on the rural population as majority of the people in India reside in the rural areas.

There are major drawbacks of non-renewable energy resources, they cause adverse effects on the environment, pollute the air and takes years to replenish. On the contrary the renewable energy resources are infinitely available and are environment friendly. Every second, the sun produces enough energy to sustain the earth's need for 500,000 years and this energy can be harnessed only if people are aware regarding renewable energy resources and its beneficial outcomes[8]. In rural areas where electric power is not easily available, installation of solar panel is a boon. Electricity can be easily accessed in an eco-friendly manner and not only this, installation of solar panels by the government subsidy schemes in the rural areas, especially for the farmers who require electricity for large scale irrigations have become much easier, but the only thing required is awareness. Many are still unaware regarding the subsidies provided by the government of India and still rely on the non-renewable energy sources which are actually not under their approach.

The help of Non-Governmental Organizations should be taken to spread awareness regarding the renewable energy resources especially among the rural areas and in accelerating the renewable energy technology programs so that the resources can be more beneficially utilized.

"Let's go green to get our globe clean."[9]

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Role of Renewable Energy in Indian Economy

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Role of Renewable Energy in Indian Economy

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Abstract. Renewable energy sources are non-conventional energy sources which are the need of the hour. Renewable energy sources contribute a lot in the reduction of green house gases emission along with having several socio-economic advantages when compared to carbon-based fossil fuels. Renewable energy sources are the answer to India's energy demands which are growing and are expected to grow exponentially in the future. Through the "Make in India" initiative of the Indian Government, Renewable Energy will account for significant job creation in urban areas as well as rural areas along with several other renewable energy policies which cover Solar Energy, Wind Energy among other renewable energy sources. Renewable energy is responsible for sustainable jobs resulting in a boon for the youth of India. This paper highlights the significance of renewable energy, impact of renewable energy on the social and economic landscape of India and the government initiatives for the promotion and expansion of renewable energy sources in the country.

Keywords: renewable energy, fossil fuels, Indian economy, Government effort.

1. INTRODUCTION:

Energy is the basic exigency in any work field. Energy is preponderating of two types that is: Renewable and Non-Renewable Energy. Our main focus and pursuit is on Renewable Energy.
Renewable Energy has its rootlet in nature and it can be replenished time to time. Renewable can be used in any field, like power generation, transportation, etc. In today`s epoch there are several technologies developed just like Solar panel, Wind Mill, Wind Turbine etc. for generation of renewable energy. Renewable Energy can be proliferating from sunlight, wind, tidal, waves, biomass etc. Today the world is moving towards the renewable energy due to its easy and infinitely presence in nature.

In 19th century, coal was used as an energy evacuation but in last few years renewable energy is superseding the coal, petroleum as well as fossil fuel energy. As this field is accenting diurnally the jobs are also skyrocketing [1].

2. ENERGY DEMAND OF INDIA DUE TO POPULATION:

It is a well-known fact that India has the second largest population in the world and is also the fastest growing population in the world. It is estimated that India's population will overtake China's by the year 2025. India has done well to provide adequate energy for its growing population being the third biggest electricity consumer in the world, however India has the lowest per capita electricity consumption (Unit) among the developed and developing countries in the world. India's median age is 27 years, having a considerable amount of youth population it will need to satisfy their growing energy needs. One must also remember that India is an active participant of the Paris Climate Agreement hence through renewable energy India is looking forward to bringing down its greenhouse gasses emissions ushering socio-economic change.

Thermal energy provides for 61% of total installed capacity, considering the Indian Government's commitment to renewable energy policies such as Jawaharlal Nehru National Solar Mission and Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME), the involvement of Thermal Energy is set to decrease.

Not only will the investment in renewable energy pay off it will also decrease the burden on India's foreign reserves most of which are spent on purchasing fossil fuels, in addition to creating a massive amount of sustainable jobs for the exponentially growing youth population of India.

India's geographical position is a blessing for the utilization of renewable energy as it has almost 300 sunny days which are a boon for the solar energy industry in India and a coastline of 7500KM for the installation of wind energy farms. India's gargantuan rural population will also contribute to its energy needs through Bio-Gas plants. With the even distribution of production of energy in India which has been made possible through renewable energy, India's per capita electricity consumption (Unit) will also increase signalling a positive socio-economic trend.

3. RENEWABLE ENERGY IN INDIA:

Taking lessons from the 1979 energy crisis, several countries began exploring the possibilities of Renewable Energy with an increased zeal. India formally began its journey into the world of Renewable Energy in 1981 when The Commission on Additional Sources of Energy (CASE) was established additionally the Department of Non-conventional Energy Sources (DNES) set up in 1982. Financial aspects of the Indian renewable energy sector were to be the responsibility of IREDA

(Indian Renewable Energy Development Agency) which was founded 1987. The Ministry of Non Conventional Energy Sources (MNES) which later became the Ministry of Non-Conventional Energy Sources were initiated in 1992 as a separate ministry with a Minister of State in charge.

India stands 3rd in the list of countries that produce the most electricity as of 2016; it's the 5th largest wind energy producer having wind energy potential of 102.8 GW. It has Hydro energy potential of 19.7 GW, Bio power potential of 22.5 GW, Solar power potential of 6 GW and it is expected that 22,000 MW of solar power would be generated by 2022 [3]

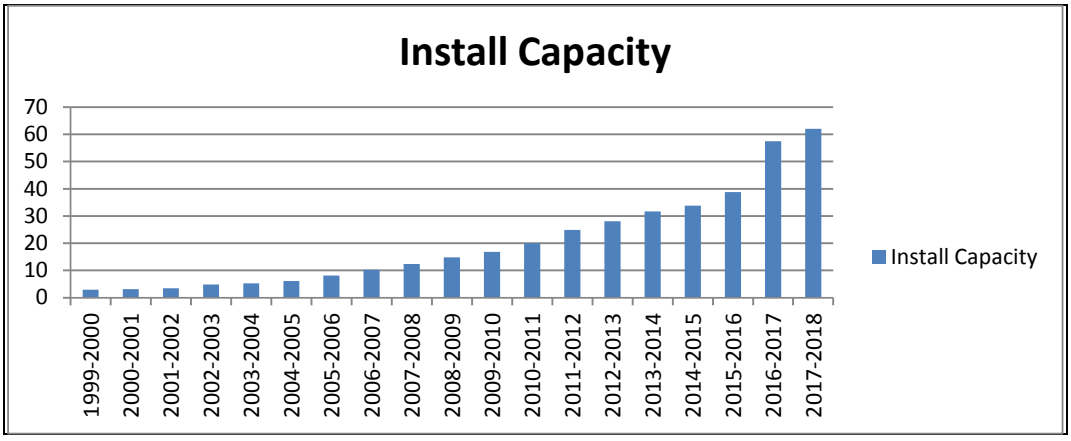

Fig 1: Renewable Energy Installed Capacity Growth for 18 Year to Year (in GW) [4]

4. GOVERNMENT EFFORTS TO REDUCE POLLUTION AND TO PROMOTE THE CONCEPT OF RENEWABLE ENERGY:

In last few years, India is working on making environment pollution free through use of renewable energy. Government of India has taken umpteen steps towards it; they have started with automobile sector which is a major part responsible for pollution. Battery Operated Vehicle is one of the government initiatives to slacken the defile environment.

Jawaharlal Nehru Solar Mission [5], Faster Adoption and Manufacturing of Electric Vehicles (FAME) etc. are the epochal prelude in renewable energy field. Whereof increasing focus on renewable resources in order to reduce reliance on conventional fuels, coal in particular, for the long-term [6].

Presently, there are huge investments opportunities in the Indian RE sector. Infrastructure growth has been made a national priority by our new Union Government, which is led by Prime Minister Narendra Modi. This sector is expected, including the manufacturing, to drive the economy in the next five years. Keeping up with this vision, MNRE has scaled up renewable targets manifold to about 175 GW by 2022 which accounts to 90 per cent of this volume dedicated to solar and wind-based power.

5. JOB CREATION:

Due to the neoteric underlay of Renewable energy field, there are agglomeration jobs in this sector which not only lead to power evulsions but also a good realm for deputation of Indian youth in energy sector. Energy is the initial thing which all industries requires, no any machine or doohickey can run without energy (except manual machines). So, for the generation of energy companies and government have to employ the roustabout. Government has taken umpteen initiatives for development of renewable energy in India through "MAKE IN INDIA" project. Tata Power Solar Systems, Waaree Solar etc. are the major companies who are outbidding the solar energy sector in India. Vestas India, Inox Wind etc. are the major companies who are superinducing the wind energy sector in India. Institutional & Domestic Biogas Plant, FRD Biotech etc. are the major companies who are developing the biogas energy sector in India.

6. CONCLUSION:

Indian government is interested to generate the employment in the power sector which is unstrapped till now. Still India depends upon foreign oil export to run automotives and industries, which ate a large portion of foreign currency earn by the India through exports. Since sun is shining all 12 months in major portion of India, Solar energy is a good alternative of generation of energy. India has a coast line of 7500 KM, which is a good place to generate the wind energy. According to census 2011 around 69% of Indian citizens lives in rural area and involved in husbandry and agriculture.

Above three renewable energies are new to Indian market and can generate a lot of employment in manufacturing, installation and maintenance of renewable products at the dedicated site. Indian Government is pushing this sector because energy generation through this does not create green house gases, creates clean environment and are infinitely available.

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A Novel Design for Highway Windmill through Re-engineering

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A Novel Design for Highway Windmill through Re-engineering

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Abstract: The purpose of this project is to design a wind turbine which recaptures wind energy from vehicles on the highway. Wind energy is considered as the fastest growing clean energy source; although it is limited by variable natural wind. Highways are good source of wind which left behind wind by the fast-moving vehicle traffic. This wind is useless till it can be used to drive the fan of the wind turbine. This energy is not only unmeasured in potential but also being witnessed going to waste. This energy is unused and could prove to be a boon for power related problems. A preliminary investigation of the characteristics of this VAWT has been done, and a data set has been collected. The objective to design this prototype wind turbine through the re-engineering is to generate power from the wind of the moving vehicle which remains unused. The design of the wind turbine is simple, and it is a low-cost wind turbine. Previously, these wind mills were established in rural areas. The main motive of this project is to install this wind mill in cities for better production of electricity. The wind draft behind the turbine is used as a source, which rotates the blades of wind turbine. This project idea is going to supersede the profanation in atmosphere which was indicted due to scalded fossil fuel.

Keywords: Wind Power, Re-engineering, Highway, Windmill Component.

1. Introduction:

From the advent of 21st century, the need of power rose to levels like never before. As much as new ways were developed still billions of people are living without electricity. According

to estimates that number is about a quarter of total population living on the planet which is both shocking and disturbing. In India only 78.7% of population has access to electricity which translates to thousands of villages still living without even a bulb [1]. With ever increasing population and depleting natural resources it is an alarming situation especially for country likes ours, India and other developing nations as well. The reason being our primary sources for generating electricity are fossil fuels [2]. This project or design started as an exploration about ten months back. Here the authors would like to stress on the word – 'reengineering', by reengineering they targeted to make a model which was unlike any made before, using materials which were usable and lying in machines that were not usable. The authors later realized how useful such small wind turbine could be in rural coastal areas.

2. WHY WIND ENERGY AS A SOURCE OF ENERGY:

Wind is a source of energy which is extracted from the blowing wind and is then converted into electricity. This conversion is carried out with the help of wind turbines, wind pumps etc. which are connected with blades which rotates when moving air applies a force on it. The main cause of taking wind as a source for power production is the rapid consumption as well as less availability of the non-renewable resources in present days [3]. This kind of natural fuel has come out to be an excellent alternative fuel and is considered to be extremely beneficial with its super merits which include:

- Wind energy is naturally available and can be easily used at a huge demand with negligible human effort.
- It doesn't pollute nature at all due to zero greenhouse gas emission.
- Round the clock availability everywhere on earth`s surface.
- It can be used in large as well as small scale power production.
- As per return of interest (ROI) the best renewable resource.

Wind is among the best possible source which can be utilized anywhere, anytime and places from high attitude areas to coastal areas through wind turbines. It can be used again and again as many times needed. Wind energy has even helped for employment for the people in manufacturing sector from the constructions, development, installations of the wind turbines to the maintenance criterion [4].

Wind energy has also overtaken many power generation systems like solar panels, gas products etc. with its higher availability, low maintenance and it has even stood high on the scale where the need of petroleum and diesel has been in so much need. Today wind energy is

answered, emphasized and recommend as the first option in any kind of power generation system by every developed and developing countries.

According to the latest study it's been observed that the wind power generation has increased by 2.5% of the world's electricity in 2011, before it was 0.5% in 1997 which jumped up to 1.5% in the year 2008. The wind energy usage is continuously increased by the new techniques and modern engineering ideas. Many countries like Denmark and Portugal, wind power has contributed around 20% of the total electricity production and it is even increasing with every day [5,6].

The only demerit faced while using wind as a source is the speed at which it blows. The lesser speed of the flowing wind the lesser it the power production or may even pause the production work.

Hence, with the fastest growing mode of power/electricity production and helping to lighting up so many houses and streets, wind is chosen to be the best source in every possible case.

3. DESIGN OF BLADES OF OUR DESIGN:

Modified standard Savonius type blades have been used; the blades have been curved at the bottom and twisted at certain angles. These blades are cut out of used buckets of paint. So,

Fig. 1: Blades of wind mill made by plastic paint cans.

essentially it was a HDPE grade plastic from a raw material perspective. This not only keeps it lightweight but also aligns with the goal of keeping this project green as much as possible. This new modification contributes in getting more drag force.

4. ELECTRICAL GENERATOR USED: DYNAMO

A dynamo is used in this assembly for conversion of mechanical energy to electrical energy. Its rating is 12 V. Dynamos basically are DC generators. Staying committed to making this a reengineering project; the dynamo has been procured from an old model lying dusted. Any alternator, permanent magnet generator with low rpm could have solved this purpose.

Fig. 2: Gear mechanism used in wind mill.

5. GEAR MECHANISM:

Teeth ratio of the VAWT design is set to 3:1. The driving gear has double the number of teeth compared to that of driven gear. The driven gear is then connected to the shaft of dynamo. Gears have been sourced from building block games used for making robots or cars. A higher teeth ratio was intended to be implemented in this VAWT Turbine but due to unavailability of parts the idea was dropped.

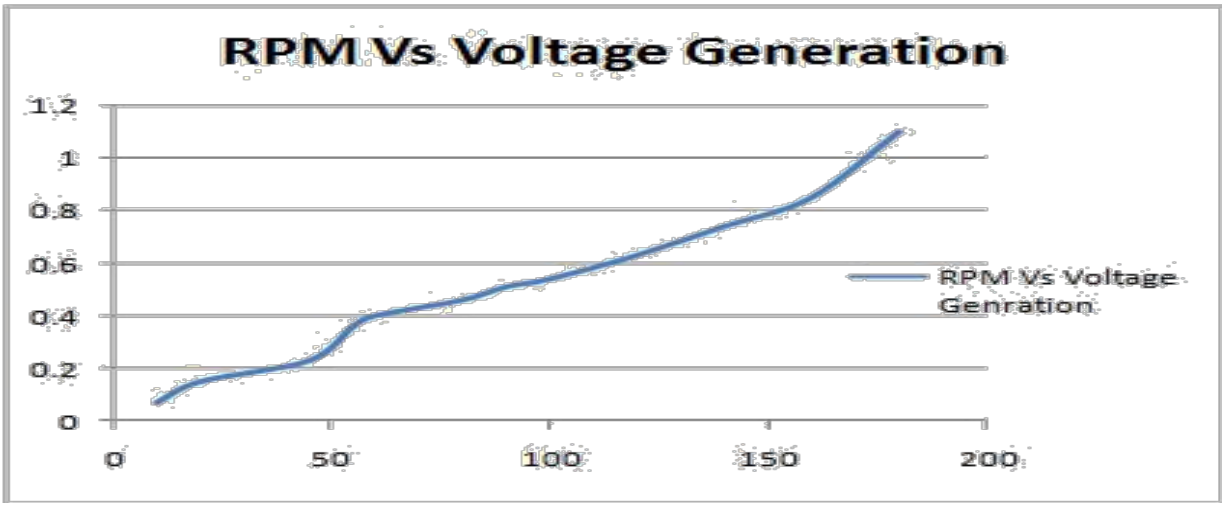
6. THE COMPLETE MODEL

Fig 3: Working model of our wind mill.

In this design, a shaft has been used to support the blades on top. Two bearings are there to rectify any changes in moment of inertia as speed of rotation increases. A custom tripod stand design has been welded to support the complete structure. Cost of the project has been minimized to the highest extent possible by using reusable parts.

7. EXPERIMENTAL ANALYSIS:

This data has been generated by simulating the wind sources. Cars and two-wheelers were used to create a substantial flow of wind. In further testing other artificial sources of wind were used. The results are encouraging. Digital tachometer has been made use for RPM measurement and Digital Multimeter has been used for volts measurement. Results have been shown in the Graph 1 & Table 1



Graph 1: RPM vs Voltage Generation

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S. No.	RPM	Volt generated (V)
1	10	0.07
2	20	0.15
3	45	0.23
4	55	0.36
5	60	0.4
6	80	0.46
7	90	0.51
8	100	0.54
9	120	0.63
10	140	0.74
11	160	0.85
12	180	1.1

Table 1: RPM Vs. Volt Generated.

8. CONCLUSIONS:

The concerned VAWT model has produced quite satisfactory results. On seeing positive early stage results, attempts were made to enhance those results and fortunately those attempts were successful. At the completion of this project, the authors have learnt something new and are ready to apply this knowledge in future engineering projects as well as in various challenging aspects of life. Similar designs are already being used for testing purposes in many nations around the world. Arizona State University also conducted research in this direction. In Germany too, such designs are seen. They also found a way to look up for maintenance in future by giving it such a design that advertisement hoardings could also be put up on the structure. So, it is safe to say that future looks promising for such designs.

The presented VAWT has yielded quite good results in highway applications. It will be quite successful in areas which are naturally windy such as coastal areas. The model itself can be designed in some modified ways. The authors had a limited knowledge of aerodynamics and blades design. So, may be with more knowledge in future a better design could be come up with. On the applications prospective, wind energy generation is getting much traction in recent times. After solar energy it has the highest throughput among other non-conventional energy resources [7]. The presented wind turbine can also be used in conjunction with solar energy to make it perform better giving it an autonomy period in case wind energy is not available. This model could also be used in metro subways. This was a potential that will be explored since wind generated by metros is quite high compared to other.

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ELECTRICAL ENGINEERING EDUCATION IN INDIA: PAST, PRESENT & FUTURE

ABSTRACT

The present paper deals with the issue of Electrical Engineering, particularly its impact and standard of education in India from its initiation till present date. We have explored the transition of Electrical Engineering from disciplines of science to a discipline of engineering and technology. A comprehensive study of Electrical Engineering education framework in India at various stages has been done along with a comparison of educational institutes among BRICS nations, namely Brazil, Russia, India, China and South Africa. We have also acknowledged Electrical Engineering as an important domain of engineering and technology. Indian Government's efforts to improve the quality of Electrical Engineering education in India through internet based interactive online tools and its endeavors to decrease the rising levels of greenhouse emissions for the betterment of our environment has been appreciated in this paper. We have analyzed a plethora of Electrical Computer Aided Design (*ECAD*) *simulation tools, available for the welfare of electrical engineering academia, as well as industry based electrical engineering applications. Electrical Engineers are destined to play a decisive role in the socio-economic future of India and the world, as they have been doing this since the 19th century. Keeping this fact in mind, we have decided to refer to the present employment opportunities available in India covering the private sector as well as the public one. The role of renewable energy in the creation of numerous sustainable jobs for the already huge and exponentially growing youth population of India has a mention in this paper. In conclusion we have formulated some recommendations to educational institutes and Indian Government which will help Electrical Engineering academia-industry flourish in the near future.*

***Keywords*:** *Electrical Engineering, Technical Education System, Engineering Education in India.*

INTRODUCTION

Human civilization's foray into the world of electricity began as early as 600 B.C.E when Thales of Miletus, a Greek philosopher, discovered static electricity by rubbing fur on substances such as amber. Since then the harnessing and utilization of electricity has

been the bedrock as well as the driving technology behind human civilization's quest to better itself. However, it wasn't until 1800 that the first breakthrough was provided by Alessandro Volta when he invented the electrical battery. Electricity soon began to influence the mannerisms of human life with Francis Ronalds' building the first working electric telegraph in 1816, Pavel Yablochkov inventing the electric carbon arc lamp in 1876 and Alexander Graham Bell inventing the telephone in the same year (Bell, 1876; Borisov; 2016; Thue, 2016). Early electrical inventions and discoveries were concerned with 'electrification' where fossil-fuel powered devices such as lamps and generators were replaced with more efficient electrical alternatives. This trend would continue into the late 19th century and early 20th century when electric railway locomotives started replacing conventional coal and fossil fuel powered railway locomotives. The American Institute of Electrical Engineers (AIEE) was founded in 1884, in New York City, USA. Its founders included Nikola Tesla, Thomas Alva Edison, Elihu Thomson, Edwin J. Houston, and Edward Weston. These personalities had already been involved in related fields such as physics, chemistry, and mechanics and decided to promote, explore and discover the new field of Electrical Sciences along with its industrial applications through AIEE. We witnessed two great minds competing against each other in the late 1880s and early 1890s with Thomas Edison's direct current on one side and George Westinghouse's alternating current on one side. George Westinghouse's alternating current won the battle as it proved to be an inexpensive and more efficient model for the utilization of electricity (Keithley, 1999; Seely, 1999).

The 20th century witnessed mankind's first modern war, The First World War, and naval vessels could then use precise electrical signaling lamps in order to communicate with other ships instead of the vague flames and flares, Electric lamps also enabled these ships to communicate with the help of codes, thereby outwitting enemy ships. Pioneers of war strategy found defensive capabilities in electric searchlights which could be used to detect enemy aircraft during night time. Radio became an indispensable part of war for it could then be used to transmit voice rather than code which was made possible by electron tube, oscillator and amplifier. Even before the United States entered World War 1 its scientists had developed a two-way radio system for aircrafts which could exchange radio signals over a range of 160 miles. This technology proved invaluable in the development of air traffic control several years later. In the year 1918, Kurt Huldschinsky found the solution for the problem of rickets which plagued children of Berlin through mercury-quartz lamps which emitted ultraviolet light. Years later researchers found out that vitamin D was necessary to produce calcium in bones, the process which was initiated by ultraviolet light (Holmøy, & Moen, 2010).

India stands second on the list of most populous nations, seventh on the list of the largest countries by total surface area and third on the list of the largest economies by Purchasing Power Parity (PPP). According to India's most recent census (2011), it has a populace of 1.2 billion and counting with 74 % of its occupants being classified as literate (Khare et al., 2015). India has one of the largest populations of young generation in the world. Today India has 29 states with seven union territories. Introduction of electricity in India began with the establishment of Calcutta Electric Supply Corporation (CESC) on the 17th of April 1899 (Sarkar, 2015). The first concrete step towards urban electrification in India was taken soon after the introduction of electricity when Harrison road in Calcutta became the first electrically illuminated street in India in 1891. As soon as the concept of electrical power was introduced in Calcutta it started replacing horse driven trams, gas-

illuminated street lighting and fossil fuel powered motors which were used for industrial purposes by 1920 (Sarkar, 2017). The idea of generating electricity via force of running water was first implemented in 1882 at Niagara Falls, USA, by 1887. This technology was implemented near Darjeeling through Sidrapong Hydroelectric Plant. Work commenced on a Hydroelectric Powerplant at Beadon Falls, Shillong, in 1921. In October 1923 Shillong witnessed electric illumination (Singh, 2015). India has taken rapid strides in the field of electrical technology in terms of research and development, as well as electrification since its independence. While 94 percent of Indians living in urban areas have electricity, only 67 percent in rural areas have access to electrical facilities. However, with the implementation of several nationwide rural electrification schemes such as the Deendayal Upadhyaya Gram Jyoti Yojana (DUGJY), which absorbed the erstwhile Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), the latter statistic is set to increase. The electrification of rural areas has been one of the top priorities of the Indian Government since independence, as investment in rural electrification results in numerous economic benefits, as well as social development since 68.84 % of India's population resides in rural areas (Palit, & Bandyopadhyay, 2017).

THE AIM OF THE STUDY

Our study is aimed to find the prevalent status specific to electrical engineering field and electrical engineering education in India, its impact on the present and future socio-economic landscape of our country. We have also outlined the steps taken by the Indian Government in promoting and exploring various aspects of Electrical Engineering such as renewable energy. The changing scenario of automotive industry from conventional fossil fuel-based engines to electric engines presents a golden opportunity for electrical engineers in India. Also, the booming sector of renewable energy in India is generating employment for undergraduate & postgraduate students (Bajpai, & Kidwai, 2017).

THEORETICAL FRAMEWORK AND RESERCH METHODS

The problem of electrical engineering education has been covered by many researchers (C. Canizares, A. Chakraborty, Z. Faur, V. Murti, M. Roy, M. P. Singh, F. Terman, W. Thue et al.). The principles of this research are to collect data related to electrical engineering education associated with its status in India from the technical institute in India. Similar type of work has been performed by the researchers in the field of control, production, manufacturing, industrial, renewable engineering. Data for subjects in courses related to RF and Microwave Engineering has been sourced from websites of regulating bodies concerned with Engineering and Technology, such as All India Council for Technical Education (AICTE) and University Grants Commission (UGC). Syllabus for courses concerned with Electrical Engineering has been analyzed from website of National Institute of Technology-Tiruchirappalli while syllabus for PG courses in Electrical Engineering has been scrutinized from webpages of various Institutes of National Importance. The obtained information has been processed with the help of such methods as deduction and induction, synthesis and analysis.

RESULTS

There exist a total of 4587 Polytechnic institutions in India which offer a Diploma in Engineering Degree across India as of the year 2017–18. This course involves 3 years/6 semesters and covers 25–30 theory subjects, 10–15 laboratory subjects and a final year project. Students must pass their 10^{th} board exam to be considered for a Diploma in Engineering Degree. Undergraduate degrees in engineering and technology are provided by a total of 4397 institutions in India as of the year 2017-18. Minimum criteria to be eligible for an undergraduate degree in engineering or technology is that students must pass their 10+2 board exams and a national level Joint Entrance Exam (JEE) which is held in two stages – a main stage and an advanced one. Performance of a student in JEE along with

their 10+2 results are used as a measuring scale for admissions to the country's Institutes of National Importance, solely dedicated to engineering and technology. They include Indian Institute of Technology (IIT), National Institute of Technology (NIT), Indian Institute of Information Technology (IIIT) with some other technical premier universities & institutions (AICTE Report, 2017). India has 29 states and most of these states conduct their own entrance examination for UG programs offered by institutions under their jurisdiction. Several private institutes conduct their own entrance exams in conjunction with JEE for admissions to undergraduate programs for engineering or technology. A national level Graduate Aptitude Test in Engineering (GATE) is conducted by any one of the IITs for admission to post-graduate engineering or technology programs. Upon passing the GATE cut-off, a candidate is also required to pass an interview held by the IIT to which he has applied for post-graduation. GATE score-card is the measuring scale for admissions in post-graduate technology or engineering programs offered by the country's Institutes of National Importance dedicated to engineering and technology. Admissions to doctoral programs are conducted through several exams held by the concerned institute's department based on the specialization chosen by the candidate after an interview. UG programs such as B.E/B. Tech include 25–35 theory courses with 15–25 laboratory courses along with the final year major project. PG programs such as M.E./M. Tech include 10 theory & 2 laboratory courses with the final semester completely dedicated to the chosen specialization in their specific chosen field (Khare et al, 2014). Financial support is provided in the form of scholarships to meritorious students by institutions as well as the government. Candidates must work under the guidance of a supervisor for the completion of their doctoral degrees which are offered in full time as well as part time versions. Scholarships for students of doctoral degrees are offered by institutions and may demand passing various national level exams to avail grants for their research (Khare et al, 2016).

B.E./B. Tech courses present 10–15 core courses which are directly involved with Electrical Engineering. The rest of the courses are related to electronics engineering, mechanical engineering, instrumentation engineering, and management and, in some cases, humanities (Bajpai et al., 2016). Lab affiliated courses involve student working on electronic devices, DC machines, transformers, power electronics and power systems. First year UG curriculum includes major subjects from science, engineering and humanities background. Basic Electrical is offered as a compulsory subject to all engineering branches during freshman year which covers the inceptive concepts related to electrical engineering. Second year subjects are related to engineering mathematics, electronic devices and basic electrical instrumentations. Third year core subjects are focused on power system, communication system, control system and microprocessor. A couple of electives have been offered by the department which is more focused on the area in which students want to work and design the project. Final year elective subjects include open electives and perpetual electives. Subject related to electronic devices, instrumentation and computer networking have been offered as compulsory subjects. Control Systems, a subject which is more focused on controlling of a system through feedback without any human interaction, is offered as a compulsory subject for Mechanical Engineering and Electronic Engineering UG students (Murti, 1972). In pre-final year, courses related to renewable energy, which include solar energy, wind energy and bio-mass energy, are offered as open elective subjects to other departments' UG students. Final year major project calls for the students working on both core and future aspects of Electrical Engineering such as induction motors, industrial power

consumption, renewable energy systems and wireless power transfer. National Institute of Technology in Tiruchirappalli has indoctrinated a model syllabus for undergraduate programs in Electrical Engineering, inculcating core electrical engineering subjects, mechanical engineering and electronics engineering subjects (EE department, 2018).

Since Electrical Engineering is a mother-branch of engineering, PG courses, such as M.E./ M.Tech, are offered by most institutions across India. Figure 1 displays the variety of M.E./M. Tech offered by Indian Institutes of Technology in various specializations of Electrical Engineering. All Institutes of national importance concerned with engineering and technology offer or plan PG course in Electrical Engineering. Curriculum for PG in Electrical Engineering changes with respect to technological advancements and industry requirements of the time. Second year of PG in Electrical Engineering is devoted to dissertation and project activity in a chosen field. Candidates can apply for doctorate in Electrical Engineering in different subject matters, such as Electrical Energy and Power Systems, Power Conversion, Microelectronics and Nanostructures along with many more fields. Students enrolled in such doctoral programs perform theoretical or real-time practical analysis for their doctoral thesis. Industries investing a substantial amount in research through doctoral educational programs are BHEL, NTPC, Tata Power and many others. This amalgamation of industries and research scholars helps to escalate the growth of Indian economy and create an innovative atmosphere in the country.

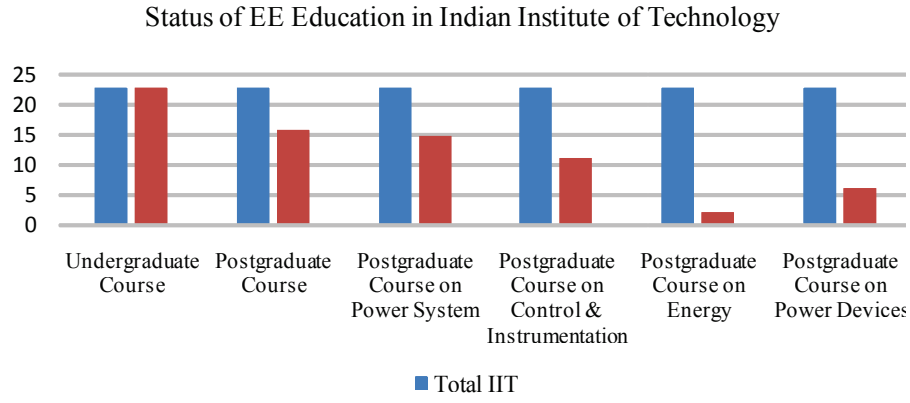

Fig. 1. Status of EE Education in Indian Institute of Technology

First year UG curriculum includes major subjects with science, engineering and humanities background. Basic Electrical is offered as a compulsory subject to all engineering branches during freshman year and covers the inceptive concepts related to Electrical Engineering. Second year subjects are related to engineering mathematics, electronic devices and basic electrical instrumentations. During the third year core subjects focused on power system, communication system, control system and microprocessor are covered. A couple of electives are offered by the department, which are more focused on the area in which students want to work and design the project (Terman, 1976). Final year elective subjects include open electives and perpetual electives. Subject related to electronic devices, instrumentation and computer networking are offered as compulsory subjects.

Control Systems is a subject which is more focused on controlling the system through feedback without any human interaction. It is offered as a compulsory subject for Mechanical Engineering and Electronic Engineering UG students. During a pre-final year, courses related to renewable energy (solar energy, wind energy and bio-mass energy) are offered as open elective subjects to other departments' UG students (Chakraborty et al., 2018). Availability of UG courses for Electrical Engineering in National Institutes of Technologies is shown in Figure 2.

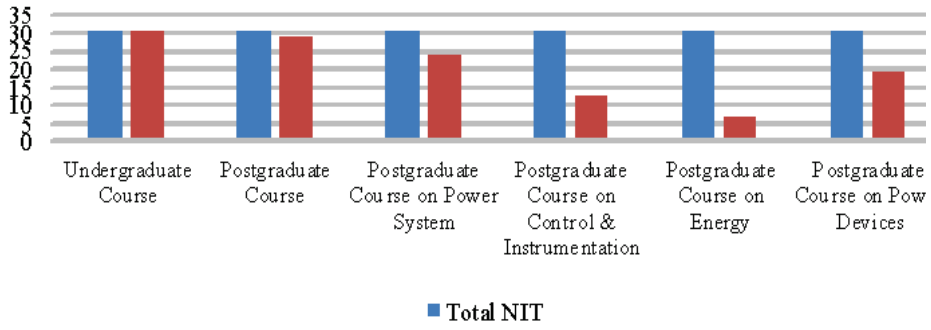

Fig. 2. Status of EE Education in National Institute of Technology

MATLAB and Mathematics are the go-to choice for Electrical Engineering academia-industry for solving mathematical computation problems through simulation (Canizares et al., 1997). Scilab, GNU Octave, Maxima, SageMath are some open source tools useful for solving mathematical computation problems (Khare, 2016). Indian Government has taken a plethora of steps for the betterment of education infrastructure in the country. NPTEL is one of these significant steps. NPTEL is a brain child of IITs and IISc and is funded through Ministry of Human Resource Development (MHRD). By means of NPTEL these institutions have created an online free for all databases of engineering and science subjects (Sheeja, 2018). NPTEL has solved the problem of accessibility to higher education for the rural population of India. Anyone with an internet connection and zeal to learn can access the gold mine of knowledge that is NPTEL. NPTEL offers about 30–35 courses included in the curriculum of Electrical Engineering with their content based on the syllabus prescribed by All India Council for Technical Education (AICTE) in addition to the syllabus of NPTEL-affiliated educational institutions (Bajpai et al., 2015). Disciplines such as Power Electronics, Control and Instrumentation, Power Systems, Power Drives, Energy and other core Electrical Engineering subjects are covered in addition to inter-disciplinary and elective subjects. There are instances of the same discipline being offered by two different institutions which gives students flexibility to choose between two different syllabi. In 2016 Indian Government's MHRD, Department of Space, Doordashan under the Broadcasting Ministry of India's Prasar Bharti coordinated the launch of Direct to Home (DTH) channels which will telecast lectures originating from IITs. If implemented, this project will aid aspiring

engineering students, UG students, PG students and industry personnel in an unprecedented manner (Sharma, 2009). Free and Open Source Software in Education (FOSSEE) is a program initiated through National Mission on Education through Information and Communication Technology (ICT) which is responsible for creating free and open source tools for students and researchers. One of such free and open source software created by FOSSEE is eSIM (previously known as Oscad or FreeEDA). eSIM is an electronic design automation tool ordained for students and researchers in the field of Electronic Engineering and Electrical Engineering (Moudgalya, 2014).

Electrical Engineering is one of the main branches of engineering and as it was in the 20th century, Electrical Engineering has its own distinctive impact on the 21st century. However, with the overwhelming growth of software companies and information technology industry in India, it is very common for Electrical Engineering UG graduates to take up jobs in the exponentially growing information technology industry in India. The first olive branch towards the Indian economy was extended by former Finance Minister Dr. Manmohan Singh in 1991 when he presented a budget which liberalized Indian economy. This opened the doors for private enterprises such as Adani Power to foray into the massive power generation and distribution industry of India which in turn created numerous sustainable jobs for electrical engineers throughout India (Murthy, 2004). Students who are in their final year and students who have completed their UG program in Electrical Engineering can apply for a multitude of jobs in numerous Public-Sector Undertakings (PSUs) offering a diverse range of job profiles upon passing Graduate Aptitude Test for Engineering (GATE) under the condition of successfully completing selection procedures for the PSU that they have applied for. Notable PSUs which recruit through GATE are Bharat Heavy Electrical Limited, National Thermal Power Corporation Limited, and Oil and Natural Gas Corporation Limited. Students can also apply for Indian Engineering Services through Engineering Services Examination (ESE) which is considered one of the most onerous exams of India and offers elite job profile for its postgraduate students. Indian Défense Service of Engineers, Indian Railway Service of Electrical Engineers and Indian Naval Armament Service are some reputable organizations which recruit electrical engineers through Engineering Services Examinations. India became committed to bringing down greenhouse gas emissions when it became a signatory to the Paris Climate Agreement. This is the second olive branch extended to the Electrical Engineering community of India. India plans to reduce its reliance on thermal energy by replacing it with clean renewable energy. Jawaharlal Nehru National Solar Mission (JNNSM) is a project dedicated to generating 100 GW of electricity through solar power which will generate numerous sustainable jobs for electrical engineers in India (Saraswat et al., 2018). Electrical engineers of India will also play a leading role in the utilization of India's 7500 km long coast line which is being capitalized for installation of Wind Energy farms (Chari, 2010). Indian Government's National Action Plan on Climate Change is dependent on electrical engineers for they are considered the ones who can bring success and positive socio-economic change in India.

We have used the latest update of Quacquarelli Symonds (QS) ratings to determine the position of Indian engineering and technology institutions in compression with BRICS countries. China leads the way in terms of offering high quality engineering and technology education as it is apparent in the QS rankings. Institutions from the People's Republic of China occupy the first five positions, namely Tsinghua University, Peking University, Fudan University, University of Science and Technology of China and Shanghai Jiao Tong University

in the given order. These rankings are an indication of how systematic and productive China's academia-industry relationship is, they also are an ode to China's manufacturing policy. Indian Institute of Science-Bangalore is the sole representative of the world's second most populous nation in the Top-10 positions of these rankings, signaling that even though concrete steps have been taken by the Indian Government to provide quality education to its youth, it will require more efforts to improve its ranking when compared to BRICS nations as well as other nations of the world. Similar to India, Russia and Brazil also have a single representative in the Top-10 educational institutes of BRICS nations in the form of Lomonosov Moscow State University and Universidade de São Paulo respectively. South Africa is represented by University of Cape Town at the 14th position.

CONCLUSIONS

Having conducted thorough research we came to the conclusion that Indian Government should make it mandatory for institutes and industry to coordinate with each other for the betterment of the country's economy and students' future. A healthy and highly functioning academia-industry relationship will complement the rapidly growing manufacturing industry in India as well as assist "MAKE IN INDIA" to become an astounding success. We also urge Indian Government to provide adequate funding to the world's 4th largest Ph. D holder population so that India can keep up with other countries in terms of research and development innovation.

Electrical Engineering is a core engineering branch which is vital for other engineering branches to flourish and is considered an evergreen branch by aspiring engineers. It is imperative for electrical engineers to use their ability as much as possible to bring positive socio-economic change to the country. Electrical Engineering academia and industry have done a lot to adapt to changing technological and economic scenarios and continue to be the force for good in the society.

India derives most of its electricity needs from fossil fuels. However, with the implementation of Jawaharlal Nehru National Solar Mission launched by India's former Prime Minister Dr Manmohan Singh India is moving towards a future where renewable energy technology will take over thermal energy. The authors of this paper would like to emphasize the role of electrical engineering students in the successful implementation of renewable energy technology in India. Digital India is an ambitious scheme launch by the Government of India which aims to spread digital literacy and smart ways of doing day to day regular activities using digital techniques. One of such components of this program is the implementation of Smart Grids. Electrical Engineers of India have contributed towards research and development of smart grids, Tata Power Delhi Distribution is an organization which is committed to provision of smart grid services and employs electrical engineers. Electrical Engineering Academia should include elements of cybersecurity and data privacy in order to help the upcoming generation of electrical engineers in India to actively contribute towards the development of smart grid technology in India. Indian Institute of Technology-Kharagpur and Indian Institute of Technology-Madras are working in collaboration with IBM for smart grid research in which electrical engineers make a significant contribution. Another challenge for Electrical Engineering Academia arises as a result of the rapid spread of renewable energy technology in the automotive sector. As fossil fuel-based internal combustion engines are being replaced by energy efficient induction motor engines, UG and PG curriculum of Electrical Engineering must be revised to accommodate automotive subjects so that electrical engineers adapt to the electric car industry demand. Electrical

Engineering elective subjects in UG and PG programs of Mechanical Engineering should be added, as well as elective subjects concerning automobiles should be introduced in UG and PG programs of Electrical Engineering. All these aspects and ways of their implementation are going to be outlined in our further research.

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MICROWAVE ENGINEERING AS PART OF UNDERGRADUATE CURRICULUM FOR ELECTRONICS ENGINEERING AND AS SPECIALIZATION DISCIPLINE FOR POSTGRADUATE STUDIES IN INDIA

ABSTRACT

The establishment and development of Radio frequency (*RF*) *and Microwave Engineering* (*ME*) *from its inception in Electrical and Electronics Engineering to having its own distinct identity in the 21st century has been explored in this paper. Overview of contributions by India to the field of RF and Microwave Engineering have been mentioned. Present paper deals with the field of RF and Microwave Engineering, especially the standard of its education in India. This paper explores the multidisciplinary nature of a RF and Microwave engineer and analyses how an RF and a Microwave engineer can contribute to the industry. Hierarchy and structure of Indian education system concerned with Engineering and Technology have been reviewed along with options and incentive available to aspiring researchers in the field of RF and Microwave Engineering. Nuances of dual degree program have been discussed. Job opportunities in government sector and private sector have been analyzed. A RF and Microwave engineer can find employment opportunities in premier government bodies such as Indian Space Research Organisation* (*ISRO*) *and Defence Research and Development Organisation* (*DRDO*) *along with private corporations in the rapidly growing telecom sector of India. Handheld device-based apps and web-based database programs*

initiated by the Government of India have been discussed. It has been concluded that RF and Microwave engineers will play a decisive role in the development of India. Performance of a RF and Microwave engineer will be a major factor in deciding the magnitude of performance of the Indian Defence Forces. The authors of this paper have suggested some steps to the Government of India which can help RF and Microwave Engineering education reach its maximum potential.

Keywords**:** *RF and Microwave Engineering, Technical Education System, Engineering Education in India.*

INTRODUCTION

RF and Microwave Engineering involve constituting electromagnetic waves (1GHz-300GHz) for the development of microwave systems, components and circuits. Microwave Engineering's application has helped Human Civilization in numerous ways. It has enabled mankind to achieve efficient modes of communication by improving directivity and reducing antenna size, transmitting messages around the world and perhaps the most seen product of Microwave Engineering is the Microwave Oven which can be found in every third house of any developed city (Pasachoff, 2015).

The foundations of RF and Microwave Engineering are rooted in Electromagnetic Theory. In 1873 a retired Scottish college professor named James Clerk Maxwell unveiled to the world that combining electrical energy and magnetic it was possible for a wave to travel in space. A German scientist by the name of Heinrich Hertz confirmed James Clerk Maxwell's theory which is used by academia-industry till this day. The next major contribution came from an English Electrical Engineer, Oliver Heaviside who adapted Maxwell's equation into a vector-calculus form which then found application in the Transatlantic Cable and Telegraph Systems (Maver, 1918).

India contributed to the development of Microwave Engineering through Sir Jagdish Chandra Bose who demonstrated ringing a bell and blowing up gunpowder from a remote location using wavelengths ranging from 2.5 cm to 5 mm. Sir Jagdish Chandra Bose's work has stood the test of time as an exceptional feat since his work was based on a frequency of 60Hz in the late 19th century (Mukherjee, & Sen, 2007). Russell and Sigurd Varian, popularly known as the Varian brothers, are credited with inventing the Klystron tube. Modification of Varian brother's Klystron tube is utilized to administer millimeter wave power to this day (Caryotakis, 1998). Microwave Engineering got its due attention during World War II when it was applied in weapons development and radar technology. Radio Proximity Fuse was used by participating parties as an efficient way to detonate a shell near its target. Chain Home Radar Air-Defense System can be credited to saving numerous British lives by detecting enemy aircrafts during the Battle of Britain. This incident brought the world's attention to the potential of Microwave Engineering. HAH Boot and JT Randall, two British scientists, are credited for inventing the "Cavity Magnetron" utilizing oscillating principles to generate electromagnetic waves at the magnitude of 1000 times, which is the power of any available microwave generator at that time (Boot, & Randall, 1976). Microwave Engineering technology, developed during World War II, proved to be a boon for civilian applications as Percy Lebaron Spencer invented a household device used for heating food through microwaves, aptly called the Microwave Oven. Key developments in the sphere of RF and Microwave Engineering took place during the turn of the 20th century. Leo Esaki who won the Nobel Prize for Physics in 1973 is a house old name for Microwave Engineers for inventing the Esaki Tunnel Diode while

being employed at Sony Corporation, Japan. JB Gunn's invention of the "Gunn" Diode proved instrumental in the manufacture of pocket friendly microwave oscillators. A Microwave Engineer of the 21st century possesses the conceptual knowledge of an electrical engineer, electronic engineer and telecommunication engineer. A microwave engineer is responsible for application of these concepts in the production and design of Microwave Systems (Sinha, 2018).

India stands second on the list of world's most populated country, seventh on the list of world's largest country and first on the list of largest population in the world. But from a socioeconomic development perspective the key fact is that India has one of the largest populations of engineering students in the world. After achieving independence in 1947 India's leaders supervised the rapid industrialization of the country (Khare et al., 2016). During the late part of the 20th century India witnessed the first telecom revolution and during the early part of the 21st century India is witnessing electronics revolution and second telecom revolution. Indian government's premier initiative "Make in India" program aims to generate employment for local population by calling multinational companies to setup manufacturing stations with research and development units in India. For the success of "Make in India" program it is imperative for microwave engineers of India to contribute their best abilities towards telecommunication sector, electronic sector and defense sector. Robust framework of engineering and technology education in India has allowed a smooth transition from gaining knowledge to their implementation in industrial applications (Bajpai et al., 2016).

THE AIM OF THE STUDY

Our study is aimed at: finding the prevalent status specific to RF and Microwave engineering education in India; collecting data related to RF and Microwave Engineering from various premier institutions of India such as Indian Institute of Engineering Science and Technology and Indian Institute of Space Science and Technology; overviewing hierarchical framework of RF and Microwave Engineering Education in India and scope of job opportunities in public sector as well as a private one.

THEORETICAL FRAMEWORK AND RESEARCH METHODS

The problem of engineering education has been studied by prominent researchers all over the world (S. Bajpai, P. Bharati, A. Chatterjee, S. Khare, W. Maver, S. Sinha, A. Srivastava et al.). The principles of this research are to collect data related to the RF and Microwave engineering education associated with its status in India from the technical institutes in India. Similar type of work has been performed by the researchers in the field of control, ceramic, manufacturing, material science and renewable energy engineering (Srivastava et. al, 2018). Data for subjects in courses related to RF and Microwave Engineering have been taken from websites of regulating bodies concerned with Engineering and Technology, such as All India Council for Technical Education (AICTE) and University Grants Commission (UGC). Syllabus for UG and PG courses concerned with RF and Microwave Engineering has been analyzed from websites of Institutes of National Importance in India, while syllabus for Doctoral studies in RF and Microwave Engineering has been scrutinized from Indian Institute of Technology Kanpur's webpage. The obtained information has been processed with the help of such methods as deduction and induction, synthesis and analysis.

RESULTS

As of the year 2017–18, India has managed to establish 4587 Institutions which offer a Diploma in Engineering degree to interested students (Handbook, 2012). Microwave engineering is offered as a compulsory theory subject in some three-year diploma courses (Khare et al., 2015). At the time of writing there are no institutions which offer a Diploma in Engineering degree with respect to RF and Microwave engineering. To be eligible for diploma degree a student must pass their 10th board exam from a recognized educational

board with math and science as compulsory subjects. Students are required to perform exceptionally well in their 10 + 2 examinations from a recognized educational board with math and science as compulsory subjects to be eligible for Joint Entrance Examination held by The Central Board of Secondary Education (CBSE) in two stages – a main one and an advanced one. Performance of a student in Joint Entrance Examination (JEE) is used as the sole parameter for admissions to India's Institutes of National Importance concerned with engineering and technology, namely Indian Institutes of Technology (IIT), National Institutes of Technology (NIT) and Indian Institute of Information Technology (IIIT) along with several other institutions (Bajpai et al., 2016).

Indian Institute of Technology provides engineering education with the concepts of Engineering and their application in industry at par with the best universities of the world. A graduate of Indian Institute of Technology is expected to solve real world problems of social and economic nature. Admissions for a postgraduate program in Engineering and Technology are carried out in 2 stages: 1) a candidate has to pass Graduate Aptitude Test in Engineering held by an IIT every year upon clearing the cut off for his desired institution; 2) a candidate faces an interview for admission in the program that he has applied for (Bajpai, & Akhtar, 2017). Selected candidates for post-graduation in Engineering and Technology are provided with monthly financial assistance of Rs.12400 for 8 hours of work per week.

Postgraduate admission for Engineering and Technology is held by the institute's concerned department. Only candidates with a Cumulative Grade Point Average (CGPA) of 6.00 on a 10-point scale or 60 % aggregate during their Master's degree are eligible. Candidates must pass National level cut-off of GATE, University Grants Commission-National Eligibility Test (UGC-NET), Council of Scientific & Industrial Research-National Eligibility Test (CSIR-NET) and Junior Research Fellowship examinations for admissions to doctoral programs at the institute of their choice (Bajpai & Kidwai, 2017). Financial Assistance in the form of Institute Assistantship (IA) of Rs.25000 is provided for the first two years which is incremented by Rs.3000 for the next two years resulting in IA of Rs.28000. Indian academia works in collaboration with Indian industry in a good way to increase economic growth. This relation extends to providing financial assistance to Post Graduate students and Doctoral Students for their academic endeavours. Public sector bodies such as Council of Scientific & Industrial Research (CSIR), Department of Atomic Energy (DAE), Ministry of Human Resource Development (MHRD), Defense Research and Development Organisation (DRDO), Directorate of Education (DOE) and Naval Research and Army Technology Board are some of the many enterprises that take pride in providing financial assistance to Master's and Doctoral Students in order to accelerate as well as promote the research and development of their academic efforts. Students can opt for diploma in Microwave Engineering from a few polytechnics across India since the structure of Microwave Engineering is composed of common subjects related to Electrical Engineering and Electronics Engineering (Bajpai, & Kidwai, 2018). Set up in 1945, India Council for Technical Education regulates diploma level courses on Microwave Engineering. At bachelor level Microwave Engineering is an integral part of Electrical Engineering curriculum and Electronics Engineering curriculum. Students are introduced to basics of Microwave Engineering through the subject known as Electromagnetic Theory or Electromagnetic Engineering. In second year RF and Microwave Engineering is a compulsory subject for electronics engineers and electrical engineers. Lab work is done in the field of RF and Microwave Engineering involving Esaki tunnel diode, Schottky diode, E-Plane waveguide, H-Plane waveguide, E-H Plane waveguide and other types of microwave systems. For

completion of graduate degree in Microwave Engineering students must assemble a project in their final year. Project work generally involves wireless communication, robotics, remote sensing and home automation. A quintessential course structure for postgraduate program in RF and Microwave Engineering has been provided by Department of Electronics and Communication Engineering, Indian Institute of Technology-Roorkee. During the first year Post Graduate program theory subjects include Microwaving Engineering, Advanced EMFT, Designing of Transmitting and Receiving Antennas. Subjects which constitute laboratory course work involve students' performing experiments in Microwave Lab and Wireless Communication Lab. Elective subjects from the field of Electronics Engineering, Communication Engineering and Applied Sciences, such as Fibre Optic System, Radar Signal Processing, Microwave Imaging, Digital Communication Systems, RF CMOS Transceiver Design and Advanced Applied Mathematics are included. Second year post graduation for RF and Microwave Engineering is entirely dedicated to dissertation of a chosen topic. Dissertation of the concerned student is verified by an examiner from another institution in India. Undergraduate degree program and post graduate degree program are amalgamated to form a 5-year dual degree course in RF and Microwave Engineering, which is provided by some premier Institutes of National Importance concerned with Engineering and Technology.

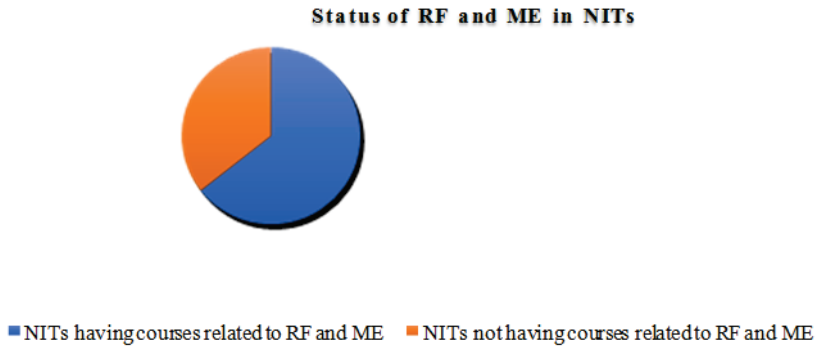

Fig. 1

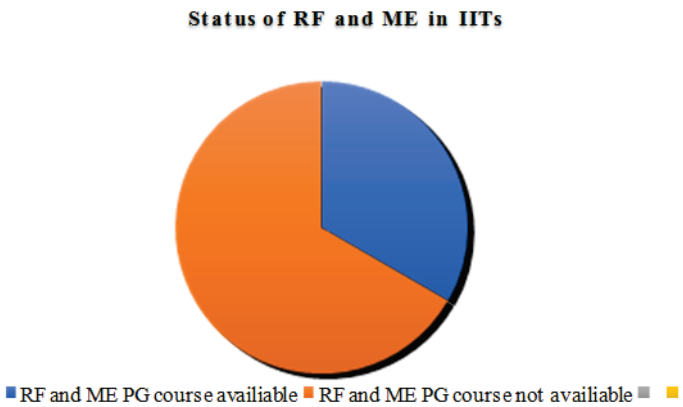

Fig. 2.

Availability of UG and PG programs for RF and Microwave Engineering in India's premier institutes classified as Institutes of National Importance has been illustrated in Figure 1 and Figure 2 respectively.

At doctoral level a student is required to perform theoretical and real time analysis of their chosen topic for doctoral analysis. Indian Institute of Technology (Kanpur) has developed emulation worthy model for research in RF and Microwave Engineering. Areas of specialisation in RF and Microwave include microwave material processing, nanophotonics, nanoplasmonics, printed antennas, computational electromagnetics, wireless power transfer and dielectric resonators.

Considering that RF and Microwave Engineering origins lie within Electrical and Electronics Engineering it is not at all surprising that some part of RF and Microwave Engineering curriculum is the same as Electrical Engineering curriculum, Electronics engineering curriculum and Telecommunication Engineering curriculum. Interdisciplinary relation has allowed RF and Microwave Engineering students to refer to standard textbooks related to Electrical Engineering, Electronics and Telecommunication Engineering from renowned international authors, including Adel S Sedra, DM Pozar, Michael Steer, De Los Santos and RL Boylestad. Engineering students across India often referred to books from international authors for deep understanding of concepts. Technical universities of India, such as Gujarat Technical University (GTU), Rajasthan Technical University (RJTU) and Dr. A.P.J. Abdul Kalam Technical University (APJAKTU) use text books authored by Wali Sandeep, Khedkar Ashok, Joshi Jayshi, Urvashi Shah and M Kulkarni for RF and Microwave Engineering curriculum. National Program on Technology Enhanced Learning (NPTEL) was launched at the end of the 20th century and the beginning of the 21st century. Seven oldest IITs of India in conjunction with Indian Institute of Science (Bangalore) decided to take advantage of India's first Telecom revolution and launch a web-based database of Engineering and Applied Sciences curriculum as prescribed by All India Council for Technical Education. Arrival of NPTEL was and continues to be a blessing for aspiring engineers and engineering students across India. Being a web-based database, NPTEL has saved a colossal amount of spending on infrastructure (Ananth, 2011). The Second Telecom revolution of India during which mobile networks were improved in proportion to mobile data charges being decreased has acted as a force multiplier for NPTEL. RF and Microwave Engineering students have access to video lectures provided by IIT Kharagpur and IIT Bombay on NPTEL. Duration of courses dedicated to RF and Microwave Engineering is generally 8 weeks. Students are subjected to weekly tests, assignments and pan-India online examination. Upon achieving required passing marks a candidate receives a certificate validating the successful completion of his/her course. Some institutions in India offer extra credits to students for successful completion of a NPTEL course.

Ministry of Human Resource Development (MHRD), Government of India in collaboration with All India Council for Technical Education (AICTE) have recently launched Swayam – an online platform similar to NPTEL which caters to school level courses, graduation level courses and post-graduation level courses. Swayam has no age restrictions and can be accessed by anyone with Internet connection. Government of India has also provided the SWAYAM platform with handheld device applications which can be downloaded at no cost from Android Play Store, Apple's I-store and Microsoft's Windows Store (Sahoo et. al, 2018).

Employment opportunities. Public Sector Undertaking which is controlled by the Government of India recruits RF and Microwave engineers through National Level

Graduate Aptitude Test in Engineering followed by a selection procedure including personal interview. Graduate Aptitude Test in Engineering marks form the majority of selection criteria in the entire recruitment process for public sector undertakings. Bharat Sanchar Nigam Limited and Maharashtra Telecom Nigam Limited are major Public Sector Undertakings concerned with telecom sector in India. Both of these corporations recruit RF and Microwave engineers. India's premier institution for development of weapons systems, the Defence Research and Development Organisation (DRDO), recruits RF and Microwave engineers and employs them for various laboratories, mainly Microwave Tube Research & Development Centre (MTRDC), Electronics & Radar Development Establishment (LRDE), Laser Science & Technology Centre (LASTEC), Defence Electronics Research Laboratory (DLRL) and Defence Avionics Research Establishment (DARE). Candidates can also find employment opportunities in Indian Defence Forces Military Engineering Service. Since the Rapid acceleration of Information Technology sector in India the trend has been that RF and Microwave Engineering graduates have abandoned their core branch and opted for widely available jobs in software and consulting corporations (Fig. 3).

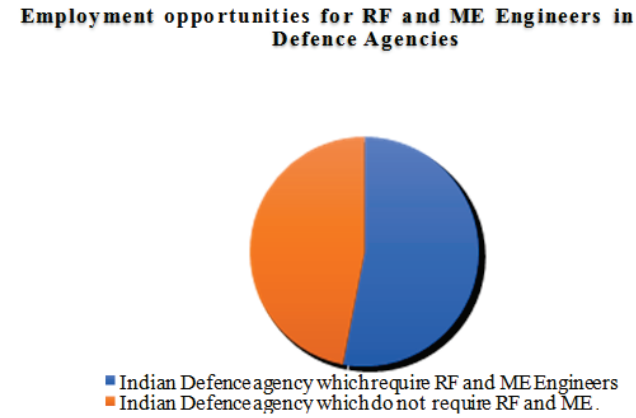

Fig. 3

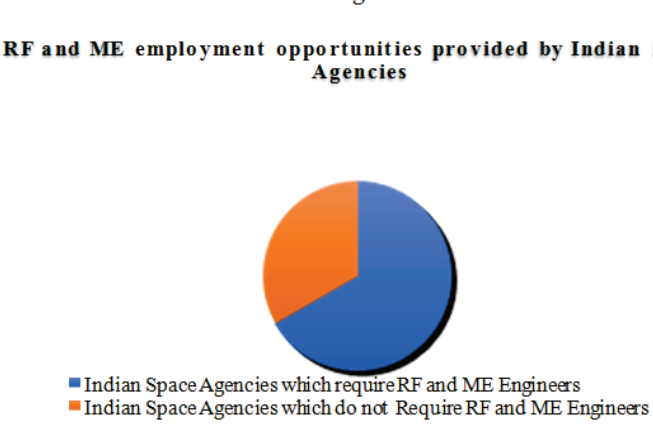

Fig. 4

Indian Space Research Organization (ISRO), widely known as the institute that made headlines for successful launch of its pocket friendly Mars Orbiter Mission (MOM) at the first attempt, recruits RF and Microwave engineers where they render their services in various satellite organizations of ISRO, namely ISRO Satellite Centre (ISAC), Space Applications Centre (SAC), National Remote Sensing Centre (NRSC), Laboratory for Electro-Optics Systems (LEOS) and Indian Institute of Remote Sensing (IIRS) (Fig. 4).

Among private corporations, telecommunication sector in India has the majority of RF and Microwave engineers employed. RF and Microwave engineers in India were also employed by Reliance Jio, a mobile network operator that dramatically changed the face of Telecommunication industry in India by offering 4G VOLTE connectivity at inexpensive rates and competitive prices (Kumar et. al, 2018). RF and Microwave engineers are highly desired and heavily recruited by the telecom sector as India forms the second largest subscriber base with the third highest number of internet users, most of whom access internet on their handheld devices.

It is through the dedication and hard work of RF and microwave engineers that we are at the doorstep of 5G communication. Although 5G communication networks are still under development, their spectrum has been formulated between 6 gigahertzes and 100 gigahertzes. Tis range of frequency lies well within the range of applications that microwave engineers have already been working under (Pandey et al., 2015). India has the largest youth population in the world with the rapid advancement of telecommunication networks in the country aspiring engineering graduates to look at RF and Microwave Engineering as a lucrative option to achieve employment.

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CONCLUSIONS

RF and Microwave Engineering plays a crucial role in advancement of weapon systems, military communication systems and civil and communication systems. It is an

emerging field in terms of Engineering and Technology. There are few colleges which provide bachelor's degree in RF and Microwave Engineering. The majority of dream institutions provide a post-graduation degree in RF and Microwave Engineering. Research areas for specialisation in RF and Microwave Engineering include lasers, computational electromagnetics, finite-difference time-domain (FD-TD), technique and metamaterials. Given how fast the defense industry is growing in India, RF and Microwave Engineering presents itself as a possibility of employment for aspiring engineers. The authors of this paper would like to suggest that Microwave Engineering should be offered as an elective subject to Computer Science Engineering and Automobile Engineering students so that inter-disciplinary nature of RF and Microwave Engineering can expand. Special attention should be given to RF and Microwave Engineering with respect to Consumer Electronics with respect to Electronics and Communication Students.

We live in time when Internet of Things has enabled us to spend our regular day to day activities in a very convenient manner. RF and Microwave Engineering Academia should include Internet of Things based subjects in RF and Microwave Engineering UG and PG curriculum with a focus on consumer electronics in order to make the transition from academy to industry easier for the upcoming RF and Microwave engineers. Elective subjects such as Artificial Intelligence and Programming in Computer Science and Engineering should be added in RF and Microwave Engineering UG and PG curriculum. Keeping the Indian Defense industry in mind RF and Microwave Engineering elective subjects should be offered to electrical, electronics and communication engineering branches. Recommendations for practical implementation of the suggested ideas are going to be presented in our further research publications.

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POWER ENGINEERING EDUCATION IN INDIA: PAST, PRESENT AND FUTURE SCENARIO

ABSTRACT

The present paper deals with the sphere of Power Engineering and it's past developments, current status and future scope of Power Engineering education in India. The aim of this manuscript is to explore the prevalent status of Power Engineering education in India from the grassroot level to Industry level applications, data has been collected from India's premier Institutes of National Importance for this purpose. Introduction to Power Engineering has been given with India-specific past developments and current obstacles faced by the nation's Power Engineering community in order to achieve a hundred percent electrification rate through clean and efficient means. India ranks second on the list of countries with the most population and seventh on the list of countries with the most land area, it is imperative that India becomes independent in terms of energy production, energy transmission and most importantly energy management. Electric power transmission-loss remains a major roadblock in the delivery of sufficient electric power to India's citizens and the Power Engineers of India have to contribute to the best of their abilities in order to solve the problem of electric power transmission-loss in the worlds second most populated and seventh largest country. Challenges faced by Power Engineering aspirants and students who are pursuing undergraduate and postgraduate courses in Power Engineering have been analysed for every level of technical education available for students in India. Requirements for a Power Engineering Undergraduate aspirant currently in twelfth grade or currently pursuing a Diploma degree

and requirements for a Power Engineering Post-Graduate currently in graduation have been explained separately using data from their syllabus which is verified by the All India Council for Technical Education (*AICTE*)*, a regulatory body formulated by the Government of India to guide, promote and scrutinize technical education syllabus' in all institutes and organizations of India concerned with science and technology. Since a large portion of India's population resides in rural areas and indulges in agrarian based employment practises, the importance of the Deendayal Upadhyaya Gram Jyoti Yojana (DUGJY) which is an initiative specifically formulated by the Government of India for electrification of India's villages and rural areas has been explained, India is the second most populated country in the world and predominantly most of this population lives in villages ,many of which are located in remote areas and thus it becomes nearly impossible to supply continuous electricity to these areas. As mentioned earlier a major part of India's economy depends on agrarian products and by-products, thus it is imperative that Power Engineers of India contribute in the development of these areas through continuous supply of clean electrical power which helps in keeping the rural environments of India's villages clean and green. Government of India's approach towards marginalised sections of the Indian society for the implementations of these schemes so that they can offer last-mile connectivity has been statistically explained. Jawaharlal Nehru National Solar Mission* (*JNNSM*) *is being approached and implemented for using the sun as a source of electrical power on war-footing by the Government of India to meet the demands of the second most populated nation on the planet. Power Engineers have actively participated for the efficient utilization of India's 7500-kilometre coastline in order to generate electrical power from the force of blowing wind, employment opportunities for Power Engineering aspirants, Power Engineering Graduate and Power Engineering Postgraduate students have been disclosed in this manuscript. Initiatives of the Government of India in developing and redefining Power Engineering courses through massive open online courses through National Program on Technology Enhanced Learning* (*NPTEL*) *which is an online based platform for students and academia alike, NPTEL lectures are available in video format and are delivered by faculties from India's designated Institutes of National Importance. Past involvement of power engineers in the electrification of India and their role in research and development of new technologies such as ultra-high voltage direct current and superconductors has been scrutinized. In conclusion, future scope of Power Engineering and new technological research and developments have been mentioned with regards to Industrial Revolution 4.0. Possibilities of Power Engineering's contribution in research and development of Smart-Grids, Micro-Grids and Electrical Power Management sourced from academia, which includes the fourth largest Ph.D. population on the planet and industry alike have been explored in this manuscript.*

Keywords**:** *Power Engineering, Technical Education System, Engineering Education in India.*

АНОТАЦІЯ

Дослідження стосується галузі енергетики, її розвитку, сучасного стану та перспектив розвитку енергетичної освіти у майбутньому. Дані для дослідження були зібрані провідними інститутами національного значення у цій галузі. Актуальність дослідження зумовлена тим фактом, що Індія займає друге місце у світі за населенням і сьоме за площею, тому для неї надважливим є отримання незалежності в рамках вироблення енергії, її передачі та управління. Головною

проблемою залишається втрата енергії при передачі її для населення. У статті подається статистичний аналіз та графічна презентація вищої та пост-вищої освіти у галузі енергетики, описується діяльність інститутів національного значення, у яких така освіта реалізується. Окреслено роль енергетиків у забезпеченні позитивних соціально-економічних змін. Охарактеризовано діяльність уряду Індії у виробленні, передачі та розповсюдженні енергії, а також перешкоди на цьому шляху. Визначено вклад енергетики як науки у галузь відновлювальної енергії Індії. Проаналізовано проблеми, з якими зіштовхуються студенти та аспіранти, які вивчають енергетику. Вимоги до випускника енергетичної спеціальності обґрунтовано у відповідності з навчальним планом та програмами, затвердженими індійською Радою технічної освіти. Визначено, що енергетик 21 століття повинен мати базові знання механічної інженерії, практичні навички інженера-електрика, далекоглядність комп'ютерного інженера. У статті проаналізовано програму навчання, яка включає всі три галузі інженерії. Наголошено, що оскільки Індія є аграрною країною, енергетична галузь має бути спрямована на забезпечення аграрного сектору чистою електроенергією, зокрема сонячною. Енергетики працюють над ефективним накопиченням та використанням електроенергії з 7500 кілометрової побережної зони з використанням енергії вітру. Окреслено можливості працевлаштування аспірантів галузі енергетичної освіти. Охарактеризовано ініціативи уряду Індії щодо розвитку та удосконалення онлайн освіти у енергетичній галузі. Розкрито фінансові заохочення для аспірантів галузі енергетичної освіти і процедуру їх отримання.

Проаналізовано сучасний підхід уряду Індії до політики відновлюваної енергії та перспектив її розвитку у майбутньому.

Ключові слова*: *енергетика, система технічної освіти, енергетична освіта Індії.

INTRODUCTION

Power Engineering is regarded as a specialist field Of Electrical Engineering where it encompasses the generation, transmission and usage of electricity and electric power (Ushakov, 2004). Earliest recorded evidence of electricity was found in Greece where Thales of Miletus discovered static electricity while rubbing fur on materials such as amber. Alessandro Volta's invention of the electric battery ushered in a century of electrical and power systems innovation. India's introduction to electricity began in the year 1899 with the establishment of Calcutta Electric Supply Corporation (CESC). Harrison Road in Kolkata became the first electrically illuminated street in the year 1891. Calcutta experienced a transition from horse driven trams and fossil fuel powered industrial motors to electric trams and electric motors for industrial applications. Expertise in Power Engineering was of the upmost importance as work began on the Sidrapong Hydroelectric Power Plant, Shillong which used Beadon Falls as a source of generating electricity. The transmission and distribution component of Power Engineering enabled Shillong to be illuminated by electric lights in the year 1923 (Khan, 2018).

India is the seventh largest country in the world in terms of total surface area and second largest country in the world in terms of population. According to the World Bank, India is the sixth largest economy in the world with 74 % of its populace being classified a literate in accordance with India's Census of 2011 (Khare, 2015). India has taken rapid strides in the field of Power Engineering since its independence in the year 1947. 97 % of India's urban populace has access to electricity, this statistic pales in comparison to 67 % of rural areas having electricity. Generation and transmission of electric power have been

subjected to various schemes and policies initiated by the Government of India such as the Deendayal Upadhyaya Gram Jyoti Yojana (DUGJY) which is the successor to the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY). India has made progress in field of Electric Power Generation notwithstanding the fact that it has yet to make the same magnitude of progress in the field of Electric Power Transmission, International Energy Agency and US Energy Information Systems tabled a report stating that India's electricity transmission and distribution losses are as high as 20 % of the electricity intended to be transmitted and distributed (Palit, 2016). To reduce the aforementioned statistic and increase efficiency of India's electric transmission and distribution network, National Load Dispatch Centre under Power System Operation Corporation Limited, a public sector enterprise was tasked with monitoring regional electricity girds, controlling dispatch and monitoring national electricity grids in the year of 2009. By the end of 2013, all of India's Regional Electricity Grids were interconnected and the National Smart Grid Mission was launched by the Government of India to accelerate the growth of better communication systems, decrease transmission and distribution losses, smart meters and other components of an efficient Smart Grid Network. Smart Grid Networks have had the attention of India's best and brightest Power Engineers since the inception of Industrial Revolution 4.0. A Power Engineer of the 21st Century has the responsibility of designing home electrical appliance which is Bureau of Energy Efficiency (BEE) Ratings compliant. BEE Ratings are a 5-point scale for home-based electrical appliances with regards to energy conservation (Kappagantu, 2015).

THE AIM OF THE STUDY

Our study is aimed at: finding the prevalent status specific to Power Engineering education in India; collecting data related to Power Engineering from various premier institutions of India such as Jadavpur University, National Institutes of Technologies and Indian Institutes of Technologies; overview of Power Engineering Education in India and scope of job opportunities in public sector as well as a private one.

THEORETICAL FRAMEWORK AND RESERCH METHODS

Scrutiny of engineering education for undergraduate courses and post graduate courses has been done in the past by well-known researchers. This research intends to assimilate information regarding Power Engineering undergraduate courses as well as post graduate courses. Syllabus of Power Engineering has been analyzed from websites of premier technological institutes and institutions classified as Institutes of National Importance. Framework for admissions into Power Engineering courses has been briefly discussed followed by syllabus of Power Engineering undergraduate and post-graduate courses. Doctoral syllabus and responsibilities of a Power Engineering Doctorate holder have been mentioned. Power Engineering is offered in some technological institutes of India to Diploma (Engineering or Technology) students as a compulsory subject. Out of the 4587 engineering and technology-oriented institutions in India, none of them offer a Diploma (Engineering or Technology) degree to students. Jadavpur University, a public university in the state of West Bengal, India offers a Bachelor of Technology degree in Power Engineering to interested students (Power Engineering Department-Jadavpur University, 2019). Admissions into Jadavpur University are done through West Bengal Joint Entrance Examination conducted by the West Bengal Joint Entrance Examinations Board, where students have to perform exceptionally well. First year syllabus of Bachelor of Engineering program for Power Engineering at Jadavpur University consists of subjects regarding advanced and applied sciences, engineering mathematics, engineering drawing

with computer aided drafting, and professional communication-oriented subjects. Students perform laboratory experiments as part of their Bachelor of Engineering (Power Engineering) first year course in the field of applied and advanced sciences as well as carpentry, fitting, welding and machining workshops. First year students of Bachelor of Engineering (Power Engineering) are introduced to basic electrical and electrical circuit concepts through subjects named Circuit Theory and Principle of Electrical Engineering, these subjects form the bedrock of complex electrical based theory and laboratory-based subject in the student's subsequent years. Students of Bachelor of Engineering (Power Engineering) indulge in core subjects regarding Power Engineering in their second year, Engineering Thermodynamics is offered to the students divided in two parts, Fluid Mechanics, Materials and Processes, Heat Transfer and Theory of Machines and Design are the subjects offered from Mechanical Engineering background. Subjects from Electrical Engineering domain are also offered such as Electrical Machines in two parts and Power Electronics. Contribution from Electronics Engineering includes Digital Electronics and Basic Electronics. Students perform laboratory experiments in the field of Basic Electrical Engineering, Basic Electronics Engineering and Machining Workshop Practice (Murti, 1972). Information Technology and Consulting is a sector that has found exponential growth in India. Keeping future job prospects from Information Technology and Consulting organizations in mind, Jadavpur University offers a Numerical Methods and Computer Programming subject in which students also have to perform laboratory experiments. All round development of the student is ensured when subjects such as Engineering Economics and Costing are offered to second year students of Bachelor of Engineering (Power Engineering) students. Pre-final year curriculum of Bachelor of Engineering (Power Engineering) is broadly focused on Electric Power Generation with subjects such as Steam Generators, Steam and Gas Turbines, Control Systems, Transducers and Measurement Systems and Microprocessor. Transmission and Distribution skills required by a Power Engineer are provided by Power Transfer Systems, a subject which covers the Mechanical and Electrical aspects of electric power transmission and distribution. Students of pre-final year have to perform laboratory experiments in the field of Transducers and Measurement Systems as well as using MATLAB to solve power plant related numerical problems. India is a signatory to the Paris Climate Change Agreement and the Kyoto Protocol, a congregation of countries who have decided to bring down their green -house gas emissions and slow down global warming. To achieve targets set under the Kyoto Protocol, India must gradually abandon the usage of fossil-fuel based electric power generation plants. Hydro Power Generation and Non-Conventional Power Generation are two subjects offered to pre-final year students of Bachelor of Engineering (Power Engineering) undergraduates in order to equip them with industry relevant knowledge and skills which will help them contribute to solving India's energy problems and saving the environment. Final year syllabus of a Bachelor of Engineering (Power Engineering) student is concerned with 21st century operations, maintenance and optimization of an electricity generating power plant with subjects such as Microcomputer and Digital Systems, Computer Aided Power System Analysis and Power Plant Simulation and Modelling. Undergraduate students of Power Engineering have to complete and submit two projects, one each from Mechanical Engineering domain and Electrical Engineering domain to attain their degree. Students undergoing Bachelor of Engineering (Power Engineering) are recommended a plethora of textbooks to refer from Indian authors and foreign authors alike. First batch of seven Indian Institutes of Technologies and Indian Institute of Science took advantage of India's first

telecom revolution in launching the National Program on Technology Enhanced Learning (NPTEL). NPTEL offers courses to students, academia and industry professionals in technological, management and humanities domain. Power Engineering enthusiasts can find Engineering Thermodynamics and Waste to Energy Conversion courses offered by Chemical Engineering Department of Indian Institute of Technology-Kanpur, Electrical Machines offered by Electrical Engineering Department of Indian Institute of Technology-Madras. Power System Engineering, Fundamental of Power Electronics and Power System Dynamics, Control and Monitoring offered by Department of Electrical Engineering of Indian Institute of Technology, Kharagpur. Additionally, a Power Engineering enthusiast can enhance his or her knowledge by taking up courses regarding Machine Learning and Artificial Intelligence in order to induce inter-disciplinary coursework. To be eligible for a seat in technology and science oriented educational institutes of India, a candidate must have scored 6.0 on a Cumulative Grade Point Average (CGPA) scale of 10 or score a minimum of 60% in his/her Undergraduate programme along with clearing national-level cut-off Graduate Aptitude Test in Engineering (GATE) conducted by any one of the seven Indian Institutes of Technologies and Indian Institute of Science-Bangalore. Monetary Assistance termed as Institute Assistantship (IA) of Rs.25000 is provided for the first two years which is increased by Rs.3000 for the next two years resulting in IA of Rs.28000. Indian Institute of Technology-Kanpur has crafted an emulation worthy model of Post Graduate studies in the field of Power Engineering, Master of Technology program in Power Engineering (Comprising Power Systems, Power Electronics and High Voltage Engineering) is a two-year program offered by IIT-K (Power Engineering Department, Indian Institute of Technology-Kanpur, 2019). First year syllabus of Master of Technology (Power Engineering) is concerned with Simulation of Modern Power Systems, Electrical Insulation in Power Apparatus and Systems and Basics of Power Electronic Converters, a post graduate student of Master of Technology (Power Engineering) has the freedom to choose a total of six elective subjects in his first year. Second year of Master of Technology (Power Engineering) is concerned with dissertation of the project chosen by the student for which he has to defend his thesis in front of a review board in order to complete his Master of Technology (Power Engineering) degree.

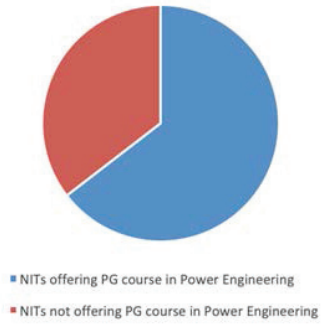

Fig. 1. Availability of Power Engineering Post Graduate Courses in National Institutes of Technologies

Doctoral students in the field of Power Engineering are involved in development and optimization next generation technologies such as Smart Grids, Superconductors for electric power transmission and distribution, Renewable energy technology, Energy systems and climate change, offshore energy systems, Nuclear energy systems and many more. University Grants Commission-National Eligibility Test (UGC-NET), Council of Scientific & Industrial Research-National Eligibility Test (CSIR-NET) and Junior Research Fellowship are some examinations that a Power Engineering doctoral aspirant has to clear for admissions to doctoral programs at the institute of their choice. Availability of Power Engineering undergraduate and postgraduate courses in IITs and NITs have been illustrated in Fig. 1 and Fig. 2 respectively.

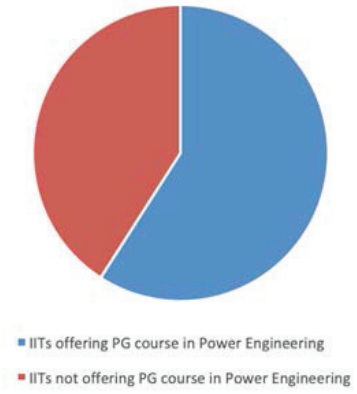

Fig. 2. Availability of Power Engineering Post Graduate Courses
in Indian Institutes of Technologies

RESULTS

Power Engineering graduates and undergraduates have the opportunity to work in the public sector and private sector. Public Sector Undertakings are corporations which are controlled and monitored by the Government of India mainly recruit Power Engineering enthusiasts by the means of Graduate Aptitude Test in Engineering (GATE) examination. Power Engineering have to clear cut-off set by various Public Sector Undertakings followed by an interview, an essential pre-requisite for landing a job in a Public Sector Undertaking is that aspirants must have a minimum of 6.0 out of 10 on the Cumulative Grade Point Average (CGPA) scale or have a minimum of 60% marks in their graduate degree. Oil and Natural Gas Corporation of India Limited (ONGC), Nuclear Power Corporation of India (NPCIL), National Hydropower Corporation of India (NHPC) and Bharat Heavy Electricals Limited (BHEL) are some Public Sector Undertakings which recruit Power Engineers. Liberalisation of the Indian Economy in 1991 arrived with a boon for the private sector in India. Power generation, transmission and distribution sector benefitted from the opening of the Indian Economy as was seen by the entry of many private sector enterprises in this sector. Tata Power, Adani Power, Reliance Energy are some private sector enterprises which have benefitted the economy of India and its electricity consumers. In order to make India self-dependent in Electrical Power production, the Public Sector and Private Sector has taken up acceleration of Renewable Energy

Technologies. The Jawaharlal Nehru National Solar Mission has been implemented by the Government of India to establish India as a global leader in the solar sector by creating the policy norms (Quitzow, 2015). An ambitious target of deploying 20,000 MW of grid connected solar power plant by the year 2022 has been set. The Government of India has even provided subsidy on the installation of solar power plants both off grid and on grid. About 50 % of subsidy is provided to the people of general category, 75 % of subsidy is provided to the people of scheduled caste and 90 % to the people belonging to the category of scheduled tribe. Solar Energy Corporation of India (SECI), a Public Sector Undertaking under the aegis of Ministry of New and Renewable Energy recruits Power Engineers to implement the program objectives of Jawaharlal Nehru National Solar Mission (JNNSM). Tata Solar, Adani Power, Reliance Solar and Suzlon Energy recruit Power Engineers to work in the Renewable Energy Technology domain. Power Engineers are an essential part of utilising India's 7500-kilometre-long coastline in order to generate electrical power sourced from the force of wind and can find employment in Suzlon Energy, a private sector organisation which specializes in generation of electrical power through wind turbines (Khan, 2018).

CONCLUSIONS

Power Engineers play a crucial role in making India a self-dependent nation in the terms of Electrical Power. Electrification of urban as well as rural areas have been one of the top priorities of Government of India since independence since electrification is responsible for bringing positive socio-economic change in the society. As mention earlier transmission and distribution losses amount to 20 % of the intended supplied electricity in India which is why reducing transmission and distribution losses remains a challenge for Power Engineers of India. Ultra-High Voltage Direct Current (UHVDC) for electric power transmission has emerged as a solution for India's transmission and distribution losses along with Superconductors. Electrical Engineering Department of Indian Institute of Technology-Kanpur has developed emulation worth model of Research and Development in the domain of Power Engineering. Power Management, Smart Grids and Microgrids are some research domains where research scholars work to create next generation technologies. In compliance with India's commitment to Renewable Energy, Power Engineers work on integrating Renewable Energy Systems with conventional source-based energy systems. Onset of Industrial Revolution 4.0 has brought the onus on Power Engineers to deliver environment friendly electric power to manufacturing industries of India and the world. Clean and Renewable Energy domain currently has the best and brightest of Power Engineering minds working to provide environment friendly electrical power to manufacturing units and residential areas alike. Smart Grids with Internet of Things enabled electrical appliances offer real-time statistics for usage of electricity and not only help Power Engineers design better components and electrical appliances but also conserve electrical power.

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Date: 28th November 2019

INTERNSHIP COMPLETION LETTER

We are glad to inform you that **Mr. Faraz Yusuf Khan** has successfully completed his internship with **Autosys Industrial Solutions Pvt Ltd** from **26th May 2019 – 22nd November 2019**

During his internship he was exposed to various activities related to Electronics and we found him sincere and hardworking during his tenure.

His association with us was fruitful and we wish him all the best in his future endeavors.

Sincerely,

AUTOSYS INDUSTRIAL SOLUTIONS PVT. LTD.

Brian D'silva
Head – Human Resource
Autosys Industrial Solutions Pvt. Ltd.