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STUDY ON FUNDAMENTALS OF RENEWABLE ENERGY HARVESTING SYSTEM AND THEIR APPLICATIONS

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ABSTRACT

Due to the scarcity of fossil fuels, environmental pollution, global warming, the researcher in the power sectors seeking alternate sources of power generation. Based on these crises, renewable energy power generation is the alternative source of energy that is abundant and ecofriendly in nature. The study explores various renewable energy power generation resources and their utilities; but certain benefits make solar photovoltaic power generation lead over other renewable energy sources. The significant advantages of solar photovoltaic power generations are affordability, easy installation, noise-free, low-maintenance, etc. Although, yielding optimal energy and fixing the power quality issues are the real challenges in solar power generation. Literature exhibits the execution of traditional and modified techniques to fix power management and quality issues. Those techniques need a supplementary proposed strategy for performance enhancement. The study finds the design constrain in Wireless Sensor Network (WSN) while powered by batteries and their limited lifetime need definite improvement in terms of performance and efficiency.

Keywords: solar power generation, solar harvesting system, renewable energy, wireless sensor network (WSN).

INTRODUCTION

Currently, from fossil fuels all countries cover their energy needs such as coal and natural gas, and carbon emission is increasing as well, and countries increases the energy consumption (Elum ZA and Momodu AS 2017). In this opinion, for sustainable development, the increasing energy need from renewable resources such geothermal, solar, wind, bio-mass and biofuels will assist to preserve the pollution of the sources at the lowest level (Taner Guney 2019). Amid renewable energy resources, solar energy has collected wide attention because it is supportable, free and non-polluting (Ozge Ayvazogluyuksel and Ummuhan Başaran Filik 2018). The Renewable Energy (RE) systems have a main portion to play in overpowering the limitations over the depletion of the global warming and the traditional fossil fuel resources (Masoud Sharafi and Tarek ELMekkawy 2014). From burning fossil fuels, the moderation of global warming made by emissions has revolved into a serious problem in many portions of the world (Alex Coram and Donald W. Katzner 2018). The energy provision can also be partly or totally realized by several form of environmental energy harvesting whose energy sources contain solar, wind, vibration and radio-frequency (RF) signals (Michal Prauzek *et al*. 2018). The design of WSNs is the main problem that the sensor node battery energy is restricted and gets consumed within a minor period of time depending on the duty cycle of the use (Himanshu Sharma *et al*. 2019). Now, (a) solar photovoltaic and (b) solar thermal are the two main methods of solar energy. Solar energy is a large, clean and freely accessible source of energy (Vishal Bhalla and Himanshu Tyagi 2017). The solar PV device works by directly converting the solar energy to the electrical energy. But for electronic devices, it is hard to supply supportable power by these energy storage units which need to be occasionally charged or replaced. To solve this issue, the self-powered system has been newly exploited to harvest environmental energy and convert it into sustainable electricity (Weixing Song *et al*. 2019). Maximum power point tracker (MPPT) is usually employed in conjunction with the power converter (dc-dc converter and/or inverter) to optimize the use of large arrays of PV modules. This algorithm generates the output voltage reference to touch the MPP by altering duty cycle of the DC-DC converter. The most generally used algorithm is Perturb and Observe (P&O) method; it shows simplicity of usage and easy implementation (Afef Badis *et al*. 2016).

LITERATURE REVIEW

Review on Non-Renewable Energy

Year/author/reference	Techniques	Remarks
In 2020, Zhihong Tang *et al*. [11]	Improved Weather Research and Forecasting Chemistry (WRF-Chem)	**Problem Identification:** • The Haiyang Nuclear Power Plant (HYNPP) was put into commercial operation at the end of 2018, and the nuclear accident has caused great concern about the environment. **Summary:** • The improved WRF-Chem model and NCEP's FNL meteorological data were used to estimate the radiological impact of a severe accident assumed by China's Haiyang nuclear power plant on the surrounding area.
In 2019, Reza Mahmoudi [12]	"multivariate data analysis techniques", "game theory", "Shannon entropy" and "the technique for order of preference by similarity to ideal solution	**Problem Identification:** • Inefficient performance of thermal power plants may end up in serious economic and environmental problems for example CO2 emission. **Summary:** • Several integrated approaches based on Multivariate Data Analysis (MDA), DEA and game theory have been used to overcome this classic shortcoming of DEA models. Then proposed approaches are applied to evaluate the performance of Iranian TPPs.
In 2019, M.A. Kurgankina *et al*. [13]	coal-water slurries containing petrochemicals (CWSP)	**Problem Identification:** • Recover the large and growing amount of coal processing wastes (filter cakes) accumulated by millions of tons a year; • Recover waste industrial oils (used motor oils, industrial oils, oil sludge, etc.), which are also produced at high rates; **Summary:** • To modify the fuel supply systems for a TPP switching from solid, liquid, and gas fuel to high-potential CWSP fuels.
In 2015, Carla Regina Gomes and Jose Antonio Carlos Canedo Medeiros [14]	radial basis functions, the RBF neural network	**Problem Identification:** • An application of neural networks with Gaussian radial basis functions to the problem of identification of three design basis nuclear accidents postulated for a PWR nuclear power plant. **Summary:** • On the occurrence of a transient or of an accident on the nuclear power plant, even the most experienced operators can be confronted with conflicting indications due to the interactions between the various components of the plant systems; since a disturbance of a system can cause disturbances on another plant system, thus the operator may not be able to distinguish what is cause and what is the effect.

Review on Renewable Energy

Biomass Energy

Year/author/reference	Techniques	Remarks
In 2019, Y K Dalimunthe *et al*. [15]	Biomass energy	**Pros** • Biomass energy is produced from fuels made from plant and animal waste. • It is a domestic resource and can reduce our present state of overreliance on fuel imports. **Cons** • The impact that has occurred from the imbalance between oil production and current consumption is one of them is the rise in oil prices fluctuate. **Summary:** • To determine the impact of renewable energy socialization, especially biomass for residents in Tambora Flat, West Jakarta.
In 2016, Dragoljub Dakic *et al*. [16]	Biomass energy	**Pros** • The efficiency (energy efficiency) should be acceptable for EU market, above 80%, • The devices should be as simple as possible, which means as chep as possible, in the sense of investment, as well as operational costs. **Cons** • The comparison is given only for differences in investment costs. • If the facility would be used for industrial purposes (for drying, cooling or processing of agricultural products), then the investment will be higher for the price of a bale storage building. **Summary:** • A public-private partnership in building thermal plants utilizing agricultural biomass can help reviving Serbian villages. • It is shown how building thermal plants fueled by baled biomass from neighboring fields can reduce investment and operational costs of such a plant.

Tidal Energy

Year/author/reference	Techniques	Remarks
In 2018, Roslynna Rosli and Eric Dimla [17]	Tidal energy	**Pros** • The reduction in carbon dioxide and greenhouse gases would be further improved as tidal energy produces virtually no emissions. • Secondly, the enhancement of energy security where tidal energy generators provide a more reliably consistent output compared to those of other renewable energy such as wind power. **Cons** • It should be close to land • Environmental Impact Assessment. **Summary:** • Tidal energy is a predictable and reliable source of energy where the exploitable capacity is potentially huge, dispersed in different locations globally. • Identifying the tidal velocity and mean kinetic energy flux is one of the first aspects of resource assessment when identifying a potential site.
In 2016, Xia Hainan *et al.* [18]	Tidal energy	**Pros** • High sea streams energy density • Power characteristics performance assessment plays an important role in improving the generation ability and availability of tidal energy converters. **Cons** • Damaging effects, for both migratory sea species and seabed, due to existing underwater cables and anchorages. **Summary:** • Tidal flow direction is known to affect the power performance of tidal energy converters, yet correction method to the projected capture area of tidal energy converters remains limited. • A reliable method to analysis the power characteristics performance of fixed and floating horizontal axis tidal energy converters.

Wind Energy

Year/author/reference	Techniques	Remarks
In 2020, Abdolrahim Rezaeiha *et al*. [19]	wind energy	**Pros** • low noise • low manufacturing costs • low installation and maintenance costs • Less visual disturbance and low shadow flickering. **Cons** • less efficient, • less economically viable and • within the urban environment mean wind speed is generally lower **Summary:** • A simple framework is presented to provide a preliminary assessment of the urban wind energy potential for large spatial scales, such as multiple cities, a region or a whole country.
In 2018, Abdul R. Beig and S.M. Muyeen [20]	wind energy	**Pros** • It reduces the time of wind turbine turning to the wind direction. • It increases an opportunity for effective electricity generating. **Cons** • Larger wind turbine installations can be very expensive and costly to surrounding wildlife during the initial commissioning process. • Noise pollution may be problem if wind turbines are installed in the densely populated areas. **Summary:** • The wind turbine generating electricity also turns based on wind direction (90o) for electricity generating. • The determination of wind direction of the wind turbine by using standard deviation of direction signal from wind measuring equipment on the wind turbine.

Geothermal Energy

Year/author/reference	Techniques	Remarks
In 2020, Abdul Ghani Olabi *et al.* [21]	Geothermal energy	**Pros** • Low energy consumption • Lower cost of electricity • Low capital cost **Cons** • More complex • Control problems • Connection troubles • **Summary:** • The use of renewable energy sources helps in reducing pollution and gas emissions associated with traditional fossil based fuels. • There are several other factors such as soil properties, ambient conditions, drilling cost, materials, equipment and cycle conditions.
In 2019, Austin Anderson and Behnaz Rezaie [22]	Geothermal energy	**Pros** • Lower land requirement • Reliability • Water scarcity • CO2 Sequestration. **Cons** • Lower efficiency • Higher initial investment • Risk of geological changes **Summary:** • Geothermal energy provides a renewable energy source that has potential to supply reasonable amounts of electricity, heating, and cooling. • The environmental impact and economic viability of the technology are mapped as well.

Solar Power Generation

Year/author/reference	Techniques	Remarks
In 2020, Shiva Gorjian *et al*. [23]	Solar energy	**Pros** • They are compact and therefore can be easily installed on roofs • They provide acceptable outputs even under poor weather conditions. • Sustainable facilities. **Cons** • PV cells heat up during energy conversion and due to solar irradiation. This reduces their efficiency, requiring efficient cooling solutions • Maintenance concerns, especially cleaning PV panels, require water, which is already scarce in arid zones. • Efficiencies and energy output are low and are highly dependent on many external factors, making the system unreliable. **Summary:** • Solar PV systems can be employed to either supply electricity or both heat and electricity (through the use of PVT systems) to supply the energy demands of various agricultural activities.
In 2020, Swamy *et al*. [24]	Solar energy	**Pros** • Non-destructive • Portable • Safety. **Cons** • Power quality and management issue **Summary:** • The growing demand for energy is unsustainable without serious contribution from the various renewable energy sources currently available, including photovoltaics. • Photovoltaic energy generation is clean, reliable and relatively easy, and fast to manufacture and install.
In 2018, Himanshu Sharma *et al*. [25]	wireless sensor networks	**Pros** • The efficiency of the solar energy harvester circuit shows a very significant role, • Almost any localization **Cons** • If the efficiency of solar energy harvester system is poor, then the battery will not get recharge properly and hence the wireless sensor network lifetime will decrease. • Even partial shading affects the power generation. **Summary:** • By utilizing ambient solar photovoltaic energy an efficient solar energy harvesting solution to the limited battery energy problem of WSN nodes. • The research focus is to increase the overall harvesting system efficiency, which further depends upon solar panel efficiency, PWM efficiency, and MPPT efficiency.

PROBLEM IDENTIFICATION AND SCOPE OF RESEARCH

Increasing power demand, global warming, air pollution and depletion of fossil fuels turns the global researcher to think about alternate and resolving sources of power generation. Based on that, renewable energy is the alternate and appropriate source of energy that conserve environment. It is obvious from the study that limitations in bio-energy, tidal, geo-thermal and wind power generation like in appropriate foe large production, expensive capital cost, required high maintenance, threat to wildlife urges considering solar energy harvesting system. It is obvious from the literature review solar energy plays a vital role in energy harvesting having various advantages over other form of renewable energy generation affordability, low maintenance, noise free, abundant in resource that urges considering. However, power quality issues and power management are the actual crucial issues to sort out.

RESEARCH OBJECTIVE

- The objective of the study is to exhibit the merits and demerits renewable energy power generation over Non-renewable energy power generation.
- The study determined the role and importance of solar energy harvesting over other form of renewable energy generation system.

- Even though, the controlling techniques in solar power harvesting having glorious in its performance, still the results are inadequate to yield the optimal performance.
- Subsequently, the research unveils the power quality issues are to be sort out by incorporating appropriate methodology in associate with traditional approach for performance enhancement.
- The research exemplifies the design constraints and batteries limited lifetime of the solar energy harvesting system for WSN.

WORKING PRINCIPLE

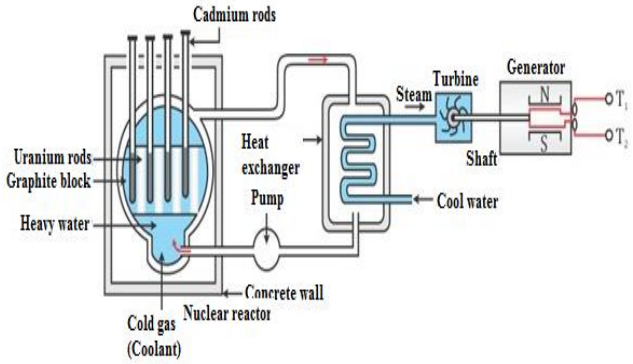

Figure-1. Working principle of nuclear power plant.

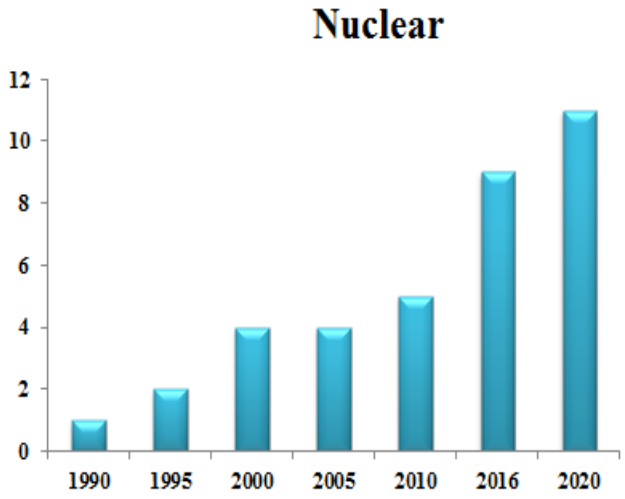

Figure-2. Primary energy consumption (Nuclear) of India from 1990 to 2020.

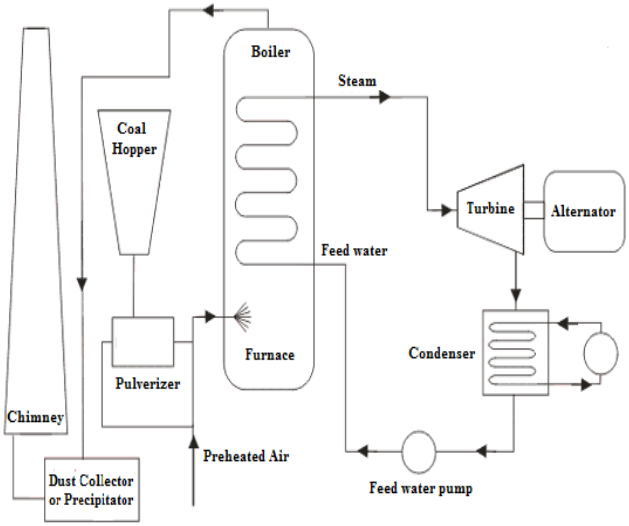

Figure-3. Working principle of thermal power plant.

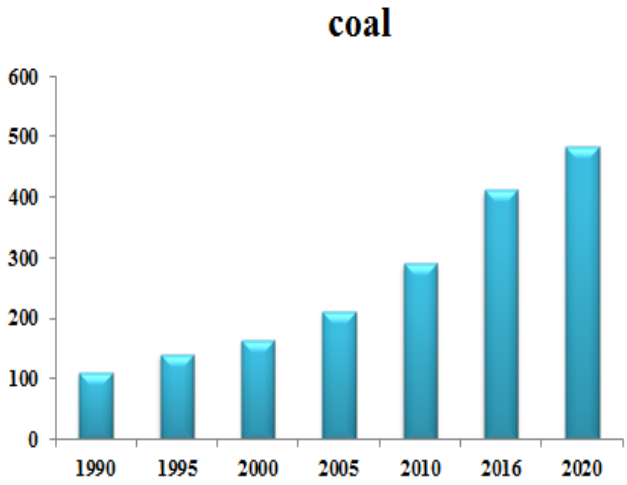

Figure-4. Primary energy consumption (coal) of India from 1990 to 2020.

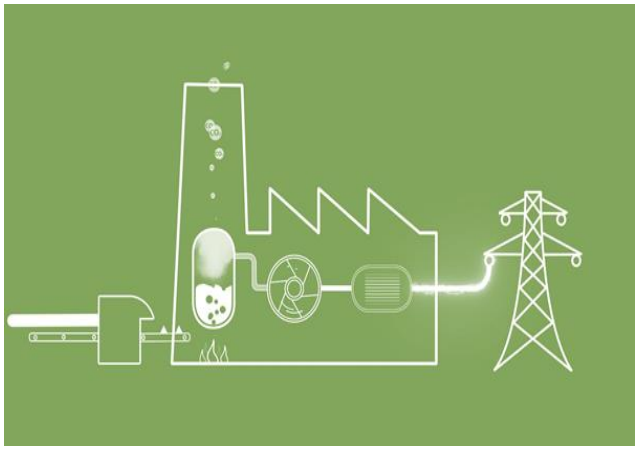

Figure-5. Working principle of biomass energy.

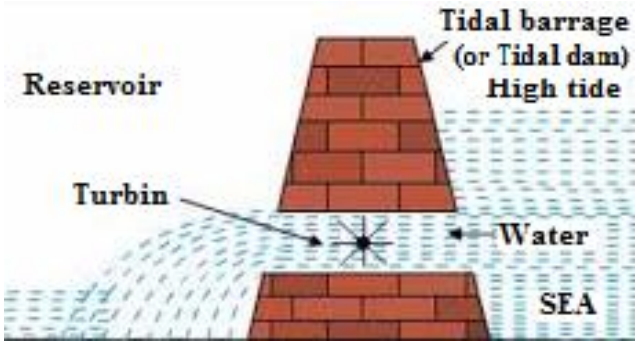

Figure-6. Working principle of tidal energy.

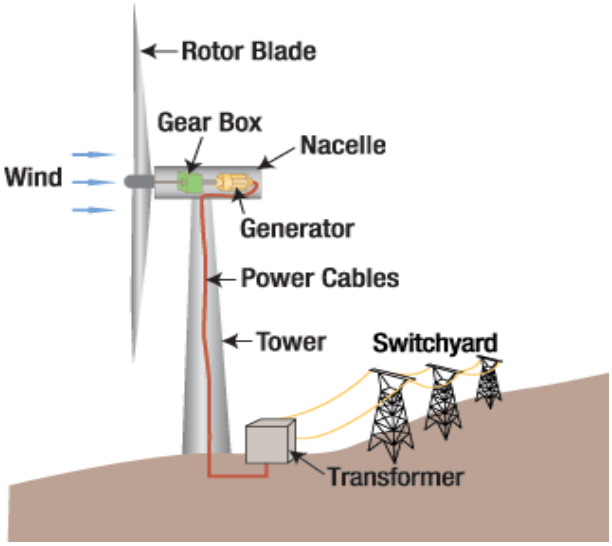

Figure-7. Working principle of wind energy.

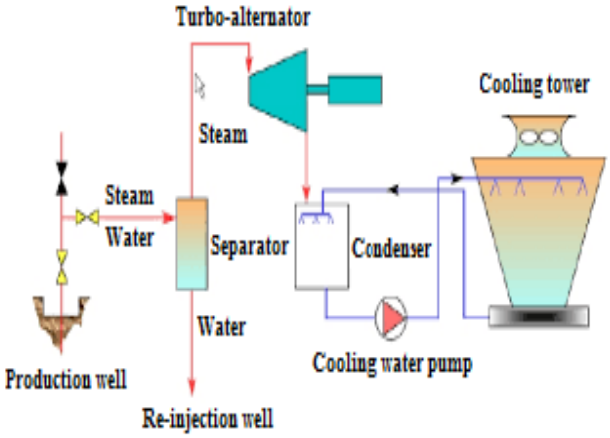

Figure-8. Working principle of geothermal energy.

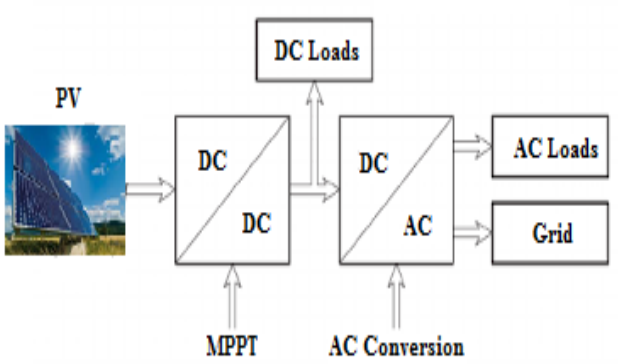

Figure-9. Working principle of solar power generation.

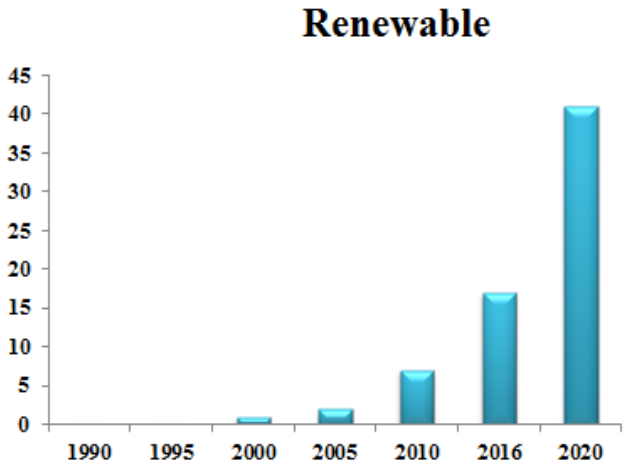

Figure-10. Primary energy consumption (Renewable) of India from 1990 to 2020.

Figure-1 shows the working principle of nuclear power plant and Figure-2 shows the primary energy consumption (nuclear) of India from 1990 to 2020. In Figure-3 the working principle of thermal power plant has been shown and primary energy consumption (coal) of India from 1990 to 2020 demonstrates in Figure-4. Figures 5, 6, 7 and 8 exposed the working principle of Biomass energy, Tidal energy, Wind energy and geothermal energy. In Figure-9, working principle of solar power generation and Figure-10 the primary energy consumption (renewable) of India from 1990 to 2020 has been shown. Renewable energy target like solar, wind and bioenergy exposed for target, installed capacity, under implementation and tendered shown in Figure-12. Figure-13 demonstrate State wise estimated potential of renewable power in India like Uttar Pradesh, Andhra Pradesh, Telangana, Tamil Nadu, Odisha, Maharashtra, Madhya Pradesh, Karnataka, Jammu & Kashmir, Himachal Pradesh, Rajasthan, Gujarat and others.

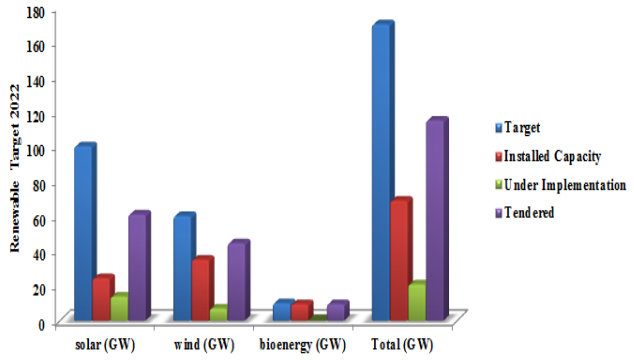

Figure-11. Renewable energy target [26].

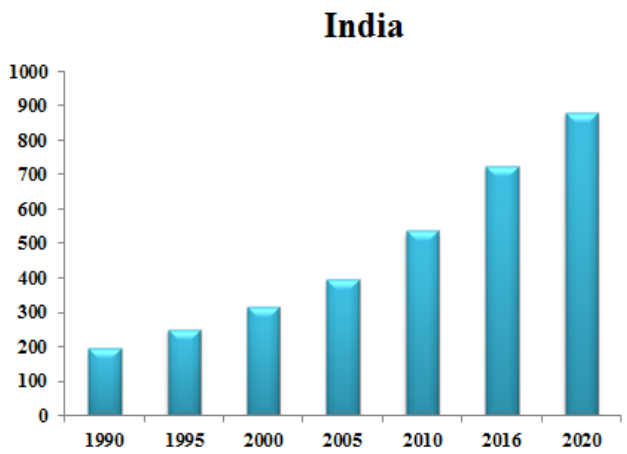

Figure-12. India's primary energy consumption from 1990 to 2020.

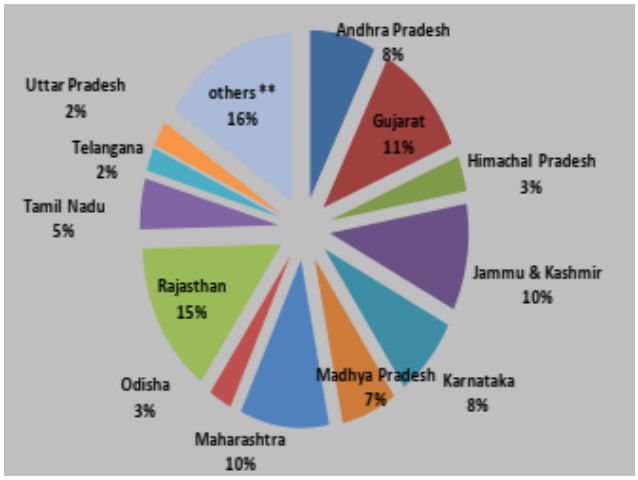

Figure-13. State wise estimated potential of renewable power in India [27].

RESEARCH SUMMARY

The literature review explores limitation of bio-energy, tidal, geo-thermal and wind power generation and the advantages of solar energy harvesting system. As discussed, among other form of renewable energy power generation and renewable energy utilities, solar power generation plays a vital role. The bio-energy form of power generation required bio-waste and produce emission and it is not suitable for large scale. In case of tidal energy power generation, the power generation unit should nearer to land to reduce the transmission loss and cost, the installation cost is high, there may be a chance of damaging effects, for both migratory sea species and seabed, due to existing underwater cables and anchorages. In case of geothermal energy generation, it is complex in process, having controlling problem, high capital cost, changes in geological changes is the significant risk factor. In case of wind power generation, they are expensive although the costs are reducing, threat to wildlife, noisy, create visual pollution. The study also unveils various aspects of solar power harvesting applications, their power quality and management issues. It is obvious from the literature review that the WSN nodes suffer from a major design constraint in that their battery energy is limited and can only work for a few days depending upon the duty cycle of operation. In general, the efficiency of the solar energy harvester circuit plays a vital role. If the ability of the solar energy harvester system is unsatisfactory, then the battery will not get appropriately recharged, and hence the WSN lifetime will reduce. It is mandatory to have an efficient solar energy harvesting solution to the limited battery energy problem of WSN nodes by utilizing ambient solar photovoltaic energy.

CONCLUSIONS

The purpose of the literature review is to cognize the contemporary research in the context of energy harvesting through renewable energy over non-renewable energy power generation. It is evident from the study that solar energy harvesting having major advantages over other form of renewable energy power generation. However, it is essential to sort out certain issues like power management and quality issues. Moreover, the literatures review aid to narrow down research problem from the numerous other solar harvesting issues. Based on that, the study identify WSN nodes suffer from a major design constraint in that their battery energy is limited and can only work for a few days depending upon the duty cycle of operation. In future, the research aim to understand the fundamental of WSN and their design constraints in the battery energy to WSN nodes for a durable network lifetime.

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