

Usage of solar over nuclear as an alternate energy source in support of Green & Sustainable supply chain practices in India

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Abstract: Modernisation and industrialisation has provided materialistic benefits to mankind but in hindsight it has adversely impacted the environment. The major impacts have been on depletion of natural non-renewable sources, pollution in various forms and growing hazardous waste, which have eventually become a serious point of concern. As the whole world is eventually facing the threat of climate change, it is pertinent that some concrete & constructive steps are taken to neutralise or minimise these impacts. Over a few decades, there have been tangible initiatives being taken at global level, wherein, many countries across the globe have become sensitive to sustainability and have come together to set varieties of targets that have been put forth to control the negative side of industrialisation. Eventually it has been understood that we all will have to stand united for sustainability of our environment. Industrial expansion is driven by demand which in turn comes from innovation and availability of cost effective products. The demand from the end user finally drives the complete value stream of a product from cradle to grave. The management of this value stream is called supply chain management. The sustainability efforts to make the supply chain minimise environmental impacts is called the Greening of Supply Chain management (GSCM). We know that energy is a key ingredient in operationalisation of the supply chains and its inconsiderate use has a major impact on the environment. Energy is derived from both non-renewable as well as renewable resources and all have varying impacts on the environment. Hysterical use of easily available fossil fuels, which are non-renewable sources, is depleting the reserves and also because of their related heavy emission issues, are impacting the environment. The cautious use of energy and use of the right source is a big contributor in Greening of the Supply chain & long term sustainability. This paper looks at GSCM evolution, the role of energy in sustainability, introduces the various sources of energy & the related challenges. The special impetus in paper is given on nuclear as well as solar energy to highlights the specific benefits and downsides. It is derived that Solar energy made from Solar power, which is in abundance in India, is an alternate long term sustainable source.

Keywords: Green SCM, Sustainable, Solar, Nuclear, Environment

1. Introduction

In pre globalisation era consumers had limited options and so were not demanding. The focus on quality and delivery time was limited and the industry operated as a sellers' market. The major change in consumer behaviours came in 1970s - 1980's which could primarily be linked to revolution of information technology, through the development of personal computers and disk operating systems. With more information in hand and better global connectivity, the consumers became very demanding on variety, features and technology. This meant need of delivering better and quality products at faster paces. This change in consumer behaviours grossly forced the companies to look at how they operated, to put special impetus on expansion for scale and to work on cost reductions to meet market expectations. On one side industrialisation and technological advancement has done wonders for the consumers but on hind sight has brought a lot of challenges for the environment. The vast expansion in manufacturing has put a lot of load on resources like land, water, energy, raw material requirements etc. Over last century, the mass production has led to enhanced wastage, rejection and by products which are left out for disposal into soil, water or air. Further for ease of availability and lower cost, the demand for non-renewable resources and non-eco-friendly options have been higher.

1.1. Sustainability and Green Supply Chain Management

Need of better collaboration and leveraging evolved new concept in operations which by 1990s became very popular and was tagged as Supply Chain management and since then has been one of the main areas of interest.

As per Gunasekaran (2015) [1] supply chain collaboration is a relationship between supply chain partners which are developed over a period of time to achieve lower cost, higher quality, and greater product innovation, reduce risks and enhance market value.

However, with heavy industrialisation, the impact on environment enhanced to level of concern thus bringing global focus on sustainability. This demanded for a look out on identifying the root causes, finding alternate methods, seeking commitments at country level and taking steps towards controlling the pollution and side effects. This primarily got orchestrated through initiatives like 1992 Earth Summit in Rio on sustainability development,

Signing of Kyoto protocol in 1997 and then its implementation in 2005. These have been amplified later in this research paper.

The efforts towards sustainability influenced the supply chain management heavily as the customer sentiment, govt regulations, social pressures and stakeholders' expectations demanded so. The collective efforts in looking at all supply chain elements from the lens of greening and sustainability gave birth to new and modern concept called Green Supply Chain Management (GSCM).

As per Srivastava (2017) [2], the concept of 'Green Supply Chain' has come up which is integrating environment consideration into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the concluding product to the consumers as well as end of life management of the product after its useful life.

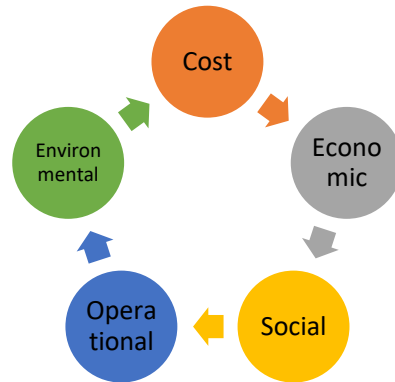


Figure 1 Five Performance Measures of GSCM towards sustainability

1.2. Energy options & role in Supply Chain

Looking at all resources contributing into complete supply chain, it is seen that energy plays a vital role as is needed in all legs whether for running machines, lighting & powering assembly lines & office buildings, process related to heating and cooling, transportation or air conditioning of buildings etc.

The energy though is a key resource in running of industry but is seen as a substantial contributor in generating harmful wastes and thus impacting the environment. Sustainability cannot be focussed without focussing on energy consumption, looking at sources of energy and ensuring that we drive towards more efficient form of energy which can fulfil our requirements with minimal impact on environment. We also need to look at renewable options to lessen the load on depleting non-renewable resources.

The main source of energy in non-renewable are natural gas, coal, lignite, mineral oil and nuclear wherein in renewable the sources are Hydro, Solar, Wind (Onshore as well as offshore) and biomass.

So, if we need to make Green Supply Chain management (GSCM) effective and successful, special focus has to be given on Energy sources options and by paving a sustainable energy road map for future.

2. Literature review

Jayaram J et al, 2014 (3) has beautifully created a model to link customer actions with Government policies and various company's strategies on sustainability. Delphi approach as well as Grounded theory approach is used for identifying the managerial practices in supply chain management which are sustainable. The framework can be used as an audit tool to benchmark practices of a company against the best in the class across various elements which may include green design, reverse supply chains and product recovery. The framework can be used to track overall progress also.

Kudroli K et al, 2014 (4) has used a qualitative exploratory study on challenges around green SCM by looking at past and present secondary sources based researches. The research paper has observed an overall increase in the interest in the industry towards environmental issues. The paper has highlighted as how an India enterprise can improve on organisational performance by using the GSCM practices thus extending its contribution to India's emerging economy. The paper has highlighted the key themes related to GSCM as reverse logistics, greening product design, greening material management and manufacturing process and greening distribution and marketing. The paper finally links the GSCM global practices with Indian perspective.

Garg D et al, 2014 (5) looks at the performance measures of GSCM and rank them by looking at their contribution towards sustainability. The paper looks at both positive contributors as well as negative aspects around implementation of GSCM. An Analytical Hierarchy process (AHP) has been used for analysis. Nineteen performance measures over 5 perspectives have been adequately mapped. The five perspectives being social, economic, environmental, operational and cost. The proposed framework can help the practicing managers to make the right decision on GSCM measures in their organisation. The same model can be used to efficiently evolve their sustainability practices in the manufacturing organisation.

Mohanty. G.P et al. 2014 (6) has carried out an empirical study on management practices around green supply chain management.in the micro, small and medium enterprises also known as MSME's in India. It is observed that there is a lot of external pressure on MSME on deployment of sustainability practices as they get involved in various to the extent as participants as suppliers, distributors or in capacity of business partners. It is established that adoption of GSCM are fully mediated by external pressures along with internal pressures. Six important factors have been identified have been identified inbound and out bound greening, technological greening, reverse logistics greening, ecological and compliance greening. It was concluded that GSCM is to make more efficient use of all resources.

Bose. P.D et al. 2013 (7) has done a study of India's most valuable companies on their corporate sustainability Initiatives. Total top Indian 100 companies have been analysed which were spread over 15 sectors. 24 variables over 3 sections were applied on analysis of all companies. The analysis is divided into three parts Core Business practices, Operations and Organisation & Management. It is found that there is a strong focus on corporate governance Only about 25% had published reports like global reporting Initiatives. The study has highlighted two areas of improvement for companies. First, less than twenty percent only of the companies disclosed sustainability information related to supply chain issues which if done more can help enhance efficiency by working with suppliers and vendors.

Sarkis J, 2011 (8) has carried out his study on GSCM boundaries and flow perspective. Boundaries and Flows framework has been used to show relationship of green supply chain aspects with other environmental management philosophies and practices. The GSCM aspects are looked at both upstream as well as downstream where in the key elements of Industrial environmental practices are Environmental Management Systems, Industrial ecology & symbiosis, design for environment, life cycle management and Producer responsibility. Finally, potential areas for investigation that focus on general relationships between boundaries, flows & industrial practices to GSCM. The boundaries identified are Political, proximal, economic, organisational, informational, legal, cultural, technological & temporal.

Kumar, R.S. et al. 2010 (9) This research paper focuses on economic performance & innovations which are influenced by subcontracting by Trans National Corporations. 33 SMEs in automobile industry have been analysed in the paper. The assistance as provided by TNC are through assistance in areas like product related assistance, Marketing, financial guidance, production and purchase processes and Human resources. It was observed that t relationship between SMCs and TNC is more limited to purchase- supplier which involved basic requirements e.g. product specifications, feedback on performance of product, providing advance intimation on orders, preferential pricing and payments. The relationships were found weak in production processes, marketing, human resource and financial support. It was found that higher the linkage between the two higher is the performance of SME and its innovations.

Oza. H.S et al. 2015 (10) has looked at the relationship of GSCM practices with economic performance in certain companies from Gujrat (India) which were having ISO 14001 certifications. Five areas were identified for analysing their effect on economic performance. The five elements being green purchasing, green packaging, green design, green manufacturing & green recovery. Principal component analysis was used in grouping the questions. There was positive relationship found between Green supply chain management practices and economic performance.

Kumar. S, et al, 2012. (11) This paper looks at if green supply chain is a requirement for profitability or not.

Rao P et al, 2005 (12) This paper also looks as how competitiveness and economic performance is influenced by green supply chain

3. Objectives of research

This research paper's objective is to link the importance of green supply chain management with importance of energy which is one of the key resource in complete manufacturing value stream. Various energy resources need to be looked at with identification of their side effects. Having basic understanding that fossil fuels are limited and need a long term alternate, we need to check our options. On an initial information exploration, nuclear & solar energy came as not fully exploited eco-friendly options though nuclear energy is perceived as high risk option. Hence, while looking at all energy options, it is important to gather information on nuclear energy risk perspective and special impetus need to be given to check if Solar is alternate sustainable energy for India's future.

4. Research questions

- In pursuit of sustainability by top manufacturing Indian companies (flag bearers), is there focus on energy in their GSCM & sustainability initiatives?
- Gather knowledge on what are the various energy sources, trends and their side effects with reference to India?
- What are the advantages and challenges associated with usage of nuclear and Solar energy and to see if Solar is the right alternate source of energy to support Green Supply Chain practices deployment?

5. Research methodology

Exploratory & qualitative research methodology has been used to gather relevant information. Literature review of articles has been carried out. Further government websites, published papers and information on world wide web have been aptly referred. The relevant questions, probable solutions and suggestions thus have been evolved. Since this is a conceptual paper hence hypothesis building and testing has not been carried out.

6. Impetus on Energy in GSCM initiatives of top 10 manufacturing companies in India

Sharma. D., 2021 (13) have done a study to look at contribution towards sustainability by 10 top manufacturing companies in India. The study has been deep dived to identify focus on energy sources by these companies in GSCM practices to support sustainability. The findings are given below,

- ITC - We could see that 40.9% of ITC energy is coming from renewable sources and 25% emission reduction has been achieved through logistics optimisation. Energy conservation measures have helped ITC in avoiding 9,747 tonnes of GHG emissions.
- Nestle's Energy utilization (GJ / Ton) has reduced by 49% from 2004 to 2019, Water use (m^3 / Ton) has reduced by 54% from 2004 to 2019 and CO₂ (Tons eq. /Ton) has reduced by 58% from 2004 to 2019. The company continue to focus on reducing the energy consumption and make investments in renewable energy footprint. This has contributed to the reduction of carbon footprint at the manufacturing facilities. Some of the company's contributions are like 540 million Litres of water replenished in FY2018-19, 33 million Units of electricity consumed in FY2018-19 from renewable sources, 14 million Kilograms of carbon emissions reduced in FY2018-19 from previous year, water replenishment brought to 98% in FY19 with a target of 100% by Fy2020, 54.78% electricity from renewable sources (36% from wind and 18% from Solar),
- L&T offer green technology solutions to their clients, work continuously on energy intensity reduction and shrinking the carbon footprint. Most of the campuses are water positive and many harness green energy. Some interesting facts shared in integrated report covering sustainability are a) 90500 MT of co₂ emissions at the factories avoided, b) 9.3% of total energy consumed is renewable energy, c)
- Wipro has been able to achieve a 40% of energy footprint from renewable energy sources.
- Sun Pharma, the company recognised that that being energy efficiency and reducing energy consumptions not only helps improves environment but also gives economic benefits. Through greener investments the company is committed to generate more green energy and reduce the dependence on fossil fuels. This has been demonstrated by the investment in area of wind energy and testimony is in FY 19 through generation of 2.05 Million kWh of clean energy
- Ultra tech Company's captive renewable capacity stands at 66.23 MW. It generated 35 million units of electricity from renewable sources during the year. It is a signatory of the EP100 and committed to double its energy productivity over the next 25 years. The company has set a target to reduce its CO₂ intensity by 25% by FY21, as compared to FY06.

7. Role of Energy in sustainability & Energy Sources

In the literature review, we have looked at importance of sustainability and Green Supply Chain management. It is important and as discussed earlier that we focus on one key ingredient in supply chain which is energy. As we

know, any conventional industry will look at the energy resources which are easy to get and are cost effective. The environmental impacts by virtue of emission or depletion of non-renewable resources have been ignored in past. Until we raise the awareness on the long term loss and also identify and develop cost effective and manageable alternates, the ignorance may continue. The major source of energy has been burning of fossil fuels. The fossil fuels take more than 1000 year to be built wherein at the rate they are being used, may get depleted in 100-200 years (17) This is a matter of concern as we may not be leaving the scarce resources left for future generations.

It is thus pertinent that we not only understand the importance of sustainability, green supply chain management but put special focus on the role of energy, look at its source selection and promote the right energy sources for future. More from India perspective, it is important to look at Solar energy as an option as Sun rays are abundant in the country and are uniformly distributed. This research paper is thus focussing on the said areas.

7.1. Traditional sources, alternate sources of energy

Traditionally, the source of power generation were fossil fuels like coal, lignite, petroleum, gas etc. Fossil fuel deposits on the earth are finite and since these sources have now reached at the verge of extinction, hence the world turned to discover alternative sources of energy, thus the scientists discovered hydroelectric, wind (both onshore as well as offshore), bio-gas, tidal, geo-thermal, hot spring water as the power production sources. Not to forget the two key new resources being Solar energy and nuclear energy.

In India 53.7% of energy is derived out of coal with second place taken by hydro with 13.6% contribution. Wind comes at third place with 10.2% contribution. The next position is that of Solar which is at 9.5%. It is surprising to see that India being a tropical country, having blessed with abundant sunlight in not exploiting this source to its full extent. The nuclear power engagement had started with a big bang but big plans got stalled because of Japan disaster in 2011. It is elaborated in later pages.

Sl. No.	Raw material	Production in MW	Percentage
	Coal	199,594.5 MW	53.7%
	Lignite	6,360 MW	1.7%
	Gas	24,991.51 MW	6.7%
	Diesel	509.71 MW	0.1%
	Nuclear	6,780 MW	1.8%
	Large Hydro	45,699.22 MW	12.3%
	Small Hydro	4,712.17 MW	1.3%
	Wind Power	37,940.95 MW	10.2%
	Solar Power	35,303.3 MW	9.5%
	Biomass	10,085.49 MW	2.7%
	Total Energy	3, 71,976.85 MW	100%

Table 1 Electricity Sector in India (1)

7.2. Disadvantages from power generation sectors

All energy sources have their own advantages as well as disadvantages. They have been contributing to India's requirement based on their availability, government policies, cost of generation etc.

The broad comparison on various power generation sources on their environment impact are nicely depicted in below chart.







Comparing the Environmental Impacts of Power Generation						
	Biomass 	Coal 	Nuclear 	Natural Gas 	Solar 	Wind 
Planning and Cost Risk	Moderate	High	High	Moderate	Low	Low
Climate Change Impact	Moderate	High	Low	High	Low	Low
Air Pollution Impact	Moderate	High	Low	Moderate	Low	Low
Land Impact	Moderate	High	High	Moderate	Moderate	Moderate
Water Impact	Moderate	High	High	High	Low	Low
Other Impacts (Noise / Visual Impacts)	Moderate	Moderate	High	Moderate	Low	Moderate

Table 2 Comparing the Environmental Impacts of Power Generation (15b)

Nuclear and Solar energy sources from initial study need special attention so all related observations are collated in subsequent sections. The impacts of other energy sources on sustainability have been looked for and collated as below.

7.2.1. *Coal* - Leaves harmful by-products upon combustion which contribute to global warming. Contribute heavily in carbon emissions. Mining of coal destroys habitat leading to displacement of people and makes land nearby mines as unsafe for human habitation. Exhausts from coal fired plant includes carbon monoxide, mercury, selenium and arsenic. These substances can cause harmful acid rains

7.2.2. *Lignite* - Exposure to lignite enhances the risks of chronic bronchitis, heart attacks, lung cancer and heart insufficiency (16)

7.2.3. *Gas* - Gas needs extraction from sources which sit deep in earth. The wells have to be dug and then the gas which is extracted has to be transported through pipelines. The drilling requires construction and thus disturbs the land sites which in turn have an effect on the established ecosystem through erosion and extending effects on migration patterns of fragmenting wildlife. Hazardous chemicals are used in drilling the wellbore. (17). The water table gets effected and can cause water pollution which can pose hazard to neighbouring communities and the walls are fractured using pressurised water. This contaminated water disposal can also cause water pollution. Further methane, being a key ingredient of gas, is found in higher proportions along with other hazardous air pollutants in the vicinities where drilling or excavations of gas are carried out. These are really hazardous elements for health.

7.2.4.

7.2.5. *Diesel* – Diesel generators produce substantial amount of greenhouse gases and harmful air pollutants including black carbon (BC), carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxide, hydrocarbons (HC), and particulate matter (PM). (18)

7.2.6.

7.2.7. *Bio-mass* - The burning of biomass can release pollution more than that of fossil fuels. The plants are not able to sequester these pollutants the way carbon dioxide emissions are handled. If these pollutants are not handled carefully, health and environmental issues may emerge. (1)

7.2.8. *Hydro-electric* - Hydropower plants hinder the free flow of water as it requires to hold water by creating reservoirs. The properties of water vary from water which goes into the reservoirs as compared to what is released. All said this effects the flora and fauna, which has an impact on migratory birds, fish and animals as their life cycles get effected. Hydropower plants require heavy construction in the beginning, needs continuous maintenance and operations and in last need dismantling. These lead to Greenhouse gas emission throughout the various phases of the power plant life cycle. The construction is supported by heavy transportation of materials

and equipment which also contributes heavily in air pollution. The construction also effects the land parcel and leads to erosion and rise in dust level and loosening of top soil. (20)

7.2.9. *Wind* - Wind energy is not constant or predictable. Wind farms need large area to operate which could be in thousands of acres. The initial investment required for wind mills installations are very huge. The wind mills are tall and have very big blades which are prone to effect the flying birds. Wind turbines need a minimum of 7 mph so they can only be put at locations like coastlines or mountain ridges which can provide that those type of wind speeds. The rotation of blades which are at high speed not only effect the birds but create a lot of noise pollution as well. The noise created by wind mills is a concern & vibrations of turning blades sometimes interfere with TV and cell phone signal strengths. The construction related to wind farms establishment and wind mill installations can affect the local ecosystem and have an effect on the local species, so these need to be handled diligently. (21)

8. Advent of Nuclear and Solar Energy

The credit for nuclear energy success in India goes to great Indian nuclear physicist Mr Homi J Bhabha who is proudly also known as father of Indian nuclear programmes. He discovered that nuclear fission process by using two elements Uranium and Thorium could generate nuclear power resulting into heat in turbines which in turn produces electricity. For this purpose, though a huge power house has to be maintained.

Thorium was seeming to be available in abundance in coast of south India to an extent that they are largest reserves in the world. Thorium has number of superior characteristics but lags behind Uranium as it does not have any fissile content. The Thorium need to be converted to Uranium 233 before it can be used in nuclear reactor. (8) The challenge on nuclear energy generations was initially seen in Uranium availability which later got resolved as huge deposits of the material could be found in Tuminalapalla belt and Tumulapalli village. In fact, the reserves were estimated as big enough which placed India in top 20 countries in the world. (23)

India's first nuclear plant was established in 1969 in Boisar in Maharashtra named as Tarapur Atomic Power Plant. Gradually more plant came into existence under Nuclear Power Corporation of India (NPCIL). Today NPCIL has 7 plants across India with 22 reactors. The approx. output is 6780 MWe which is circa 1.3% of India's total electricity demand.

With the rise of wonderful nuclear science technology and the sufficient availability of raw materials for its production, India stood at the top rank in the Nuclear power production and having potential to meet the National requirement of energy. So looking at the potential of nuclear energy and the fear of population explosion, India made an aspiring plan of increasing the output multi fold and to take the output to 63GWe by 2032.

Unfortunately, there had been accidents in the area of Nuclear energy generation. The top 2 as declared by International Atomic Energy (IAEA) at scale of 7 were Chernobyl in then's Soviet Union and Fukushima in Japan. Chernobyl incidence happened in April 1986 as core of a reactor opened up sending plumes of radioactive material into the atmosphere at Chernobyl nuclear power plant near Pripyat a Ukrainian city, once part of Soviet Union. Certain no of people died of acute radiation sickness and 100 of thousands are said to be severely impacted. Fukushima incident happened in March 2011 (24). This happened because of Tohoku earthquake of 9 magnitude resulting into Tsunami and led to 3 nuclear reactors meltdown and multiple hydrogen explosion at the Fukushima plant. The nuclear accident did not directly kill anyone but it is said that overall incidence led to 1600 stress related deaths. 156000 people had to be displaced. Huge discharge of radioactive isotopes took place from reactors into the sea. the contaminated water of the sea which was used in cooling the towers will take time up to the year 2022 to cool. The nuclear plant thus displaced people, effected their health destroyed the nature, but also poisoned the Pacific Sea by the radioactive radiation, the effect of which is still being felt. Overall all the nuclear plants were badly damaged and had to be written off.

As Indian govt was making exponential plans for expansion of nuclear energy footprint from 6,780 MW to 63 GW by 2032 (25) and from current level to 25% of total power by 2050, there was strong resistance building up in the society and among think tanks. Further, because of the Fukushima tragedy, worldwide agitations and oppositions including India got raised against the technology. In India, looking at these accidents and also linking it to Bhopal tragedy, the opinion was strictly against nuclear energy as that was deemed as a very high risk preposition for the masses. People believed that growth was required but not at the cost of putting life in danger. It was said that electricity should be for the people, it cannot be at the cost of the people.

The Fukushima tragedy reminded Indian of the Bhopal Gas tragedy which hit in 1984 on account of leakage of most poisonous Methyl isocyanate gas from the pesticide plant of the Union Carbide India Ltd., Bhopal (M.P.). This leakage killed 3,787 people instantaneously and about 25,000 in the next years and about 558,125 people injured and 500,000 people were exposed. (26) After the unfortunate tragedy, a nation-wide agitation had started against the Nuclear power technology. In this agitation people from all walks of like joined like fisher men, scientists, retired judges, bureaucrats etc. Admiral Laxminarayan Ramdas, former chief of Naval Staff moved to the Supreme Court assailing the Government's policy on the ground that the impugned Nuclear policy goes against the Fundamental Right to Life guaranteed under Article 21 of the Constitution of India. The Petitioners also challenged the Civil Liability for Nuclear Damage Act, 2010, by capping the financial liability of operators and by making suppliers not liable violates the 'polluter pays' principle and the 'absolute liability' principle which have become recognized as part of the law of the land. The Supreme Court has in the past upheld the "polluter pays" and "absolute liability" principles. (27).

Finally, govt had to bow down and scrap the expansion plans. as a result, the proposed plants like Jaitpur plant in Maharashtra for 9900-MW, Kundamkulam project in Tamil Nadu for the 2000-MW, Haripur plant in Haripur of west Bengal for 6000 MW were stalled as a number of Writ Petitions were also filed in the Supreme Court challenging the justification of installations of such power plants.

So we can say in spite of an option to meet the exponential expanding energy demand in new India, nuclear energy is only continuing catering at a small proportion and cannot be looked at as an alternate to fill in the fossil fuel fed energy void (as and when it comes in).

9. Solar Energy and its connectivity in India

Historically the world has been on gas and fossil fuels till Edison invented the light bulb and later Westinghouse and Tesla brought the concept of AC & DC versions of electric current.

The world has evolved using variety of energy source starting from fossil fuels. As fossil fuels are seen to be highly polluting and are also non-renewable resources thus getting to wards exhaustion hence the scientists have been looking at alternate source of energy. Nuclear energy emerged as a very promising source of energy but because of some of the accidents specially the one in Japan in 2011 has raised serious risk concerns around this mode. This has put the whole exploitation on a side track. If we look at Hydro and wind itself which constitute to 23 % generation in India in spite of all impetus cannot be seen as an alternate to fossil fuels scales. This brings our focus to solar energy which is just contributing 9.1% of India's requirement and not properly exploited, generates interest as being the next big renewable energy alternate.

Solar energy is abundant in nature and latest technology is helping to channelize this solar energy for power generation. It is an awakening fact that in comparison to world consumption of 17.1 TW per year, sun has potential of providing 23000 TW per year. Sunlight comes for free as is a free gift from nature. It can be produced stored and transmitted centrally by state governments in the same way as other conventional power generations are done. The power generation in solar's case is done in DC and has to be converted into AC for long distance transmissions through substations so that they can reach to varied users like houses, colleges, universities, commercial and business establishments etc. The Solar power generation technology is by all means safer and cheaper than any other technology

The first solar power plant was put in Bhadla in Thar Desert on a stretch of 45 sq. km with a target to generate 2255MW to be done in 3 phases. Similarly, 100 MW plant was put in operations in Pokharan and others like 2700 MW plant in Kurnool in Andhra Pradesh and 2700 MW plant in Pavagada in Karnataka.

Good part about solar energy is that it can be generated at user level also. The user can install solar panels & batteries for storage with ease as there are no stringent govt approvals or clearances solicited. The initial cost of putting solar and basic infrastructure can be easily funded from the cost of main source energy which is paid monthly by the user. One better part of user level solar energy generation is that as solar energy is produced in DC form and now a days major electronic / electric consumptions are in DC so one can stay away from intermediate conversion from DC to AC and then again AC to DC. This has huge potential on cost savings as transformers etc. will not be needed.

Sinha, S. et al (2020) (28) has shared that solar energy can also be used in disaster management. There is an innovation called Rapid rolls which are rolls of solar panels and can be transported to disaster hit areas for

immediate relief rather than taking generators. The Rapid Roll solar panels produce an average 11 kW of power, associated with batteries that can store 24 kW/h. That is about a day's worth of energy for a family.

The solar power farms though need land coverage which cannot be shared with agriculture. The land coverage with solar panels can lead to loss of habitat to the extent of coverage. Large solar farms can create "heat islands" where the surface temperature of an area is much warmer than the rest of the environment.

Initial cost is high as you need to invest in solar panels, batteries, space for installation, installation cost etc. Need space for installation of panels as you need horizontal surface and cannot use vertical height much.

Efficiency of solar system drops during cloudy and rainy days. Though on positive note we say that half the world is always getting sun rays but the other side is that half the world in a day does not get sun rays.

The solar panels can be broken into two broad categories. One being Photovoltaic cells (PV) and the other being Concentrated Solar Power (CSP). Photovoltaic cells are made of semiconductors material which can convert sunlight directly to electricity. On the other hand, concentrated solar power is complementary to PV and uses concentrated collectors also known as solar thermal panels. This system uses reflective devices to concentrate sun's energy to generate electricity. Though PV & CSP have a common objective which is absorbing raw sun energy and to convert it into usable energy.

CSP concentrated plants consumes a lot of water in cooling towers to the extent of 600 to 650 gallons of water per megawatt of electricity generated. Actual water use quantum depends on design & location of solar plant and also on the type of cooling system installed in the project.

On the other side PV cells are basically semiconductors. These are made using various harmful materials in manufacturing process primarily used for cleaning and purification of surfaces. The type of chemicals used in the process are nitric acid, sulphuric acid, trichloroethane and acetone. PV cells can be thin filmed or silicon cells. The thin films ones have a number of toxic material like cadmium telluride, gallium arsenide etc. which could pose public health issues and serious environmental problems. (28)

10. Discussion & Conclusion - Benefits & challenges in use of Solar as a sustainable energy alternate in India

We have discussed the side effects of all the technologies for the generation of power and we have found that there is not a single sector which is free from any side effect. Thus, we have to choose such technology for the purpose of producing current which may be of least side effects, easy to harness energy and cheaper for its consumption and a lasting technology, so that we may not go to search or innovate any other source of power production.

Nuclear energy though has a potential for high level of electricity generation carries very heavy risks of accidents which could be adverse for mankind. From all the discussions, it is clear that in spite of heavy electricity production potential, nuclear energy does not hold solid ground in India as a short to medium term alternate to fossil fuels.

On the other hand, it is seen that Solar energy has no alternative and it has to continue though there are certain adverse effects on humanity, nature, environment, ecology, ocean, ozone layer etc.

It is quite evident that solar energy as is abundant in India seem to be a medium to long term alternate which should be fully exploited and that the development of generating solar power cannot be halted at any rate. The side effects problem, though, has to be addressed by the experts and scientists and let us hope and trust that one day or other the scientists and engineers of the specialized branch shall find out some solution to these problem so that both development of solar power system and sustainable development go hand in hand.

Perhaps keeping in view of these alternatives, the Government of India has innovated the idea of creating solar energy despite the fact that it has certain adverse effects on humanity, agriculture, vegetation, climate, nature and environment.

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