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Alternate energy: Strategy to address energy security in emerging India

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Abstract

The increase of energy demand is one of the matters of concern for upholding energy security in emerging India. The major challenges include the trade-off between economic growth, environmental impacts, and national security. As the nation is largely dependent on fossil fuel imports to meet its energy demand for industries and domestic use, the sustainability of alternate energy become a vital link to future development. It is evident that any sudden energy crisis due to geopolitical turmoil can derail the industrial growth and devastate the economic progress. The rapid technological developments in alternate energies like wind and solar energy have made them competitive with conventional energy sources. Nuclear power with latest technology will play an important role for sustainable source of energy supply to effectively bridge the increasing energy demand gap. India, blessed with abundance of alternate energies like solar and wind has made strategic initiatives for development and awareness during the past few decades and the benefits are now significant especially in decentralized villages and semi-urban areas. It is the high-time for the government agencies, industries, customers and other stakeholders to mull over the alternate energy as one of the main future strategies for energy security of the country. This paper discusses the techno-economic aspects of abundant alternate energies particularly wind and solar.

Introduction

Most of the commercial energy demand in India is met largely by imported fossil fuels. In 2013, India was the 4th biggest consumer and net importer of crude and petroleum products in the world. As the country is essentially dependent on energy import, any shortfall due to unforeseen geopolitical situation may cause acute energy scarcities which will consecutively impede the industrial growth and economic progress. In order to achieve energy independence, the dependency on imported oil has to be reduced by developing alternate energy sources. The average per capita consumption of energy in India is still much lower than that of developed countries. However, the same is expected to rise sharply due to high economic growth and scope for rapid industrialization. The sustainable renewable energy can be a vital link in industrialization and development of nation. In the near-term, total fossil energy demand will likely increase even faster because of steady industrial and economic growth. Apart from augmenting the energy supply, renewable resources will help India in mitigating the climate change. The competitiveness of alternate energy source is further enhanced due to rise in oil price and the added yields from carbon emission reduction credits under clean development management. The alternate energy technologies will create of sustainable energy sources for independence from politically sensitive fossil fuel imports and also reduce hazardous greenhouse gas emissions. The fluctuation of oil price due to increased geo-political turmoil demands a transparent integrated energy policy for accelerated growth of domestic energy resources.

Current Scenario: Technology & Economics

India has seen an annual growth rate of about 22 per cent for renewable energy in the last decade. The production from non-conventional sources in India during 2013-14 is about 53.22 billion units. The major contributors are wind and solar with 31.26 billion units and 3.35 billion units respectively. Alternate energy also payback to investment in the form of carbon credit for clean development mechanism. Wind and

solar power don't produce waste and so no investment for waste management is needed during the life-cycle in such power facilities.

Wind energy: Wind energy is a clean alternative energy source as compared to conventional fuel and has the advantage of being harnessed in rural and remote areas. In order to tap the potential of wind energy sources, the scientific wind mapping has been done extensively. At present, there are 154 wind monitoring stations under various wind mapping projects. In India, winds are influenced by the strong south-west summer monsoon, which starts in May-June, the weaker north-east winter monsoon, which starts in October and during the period march to August, the winds get stronger over the whole Indian peninsula except the eastern coast. Wind speeds during November to March are comparatively weak, though higher winds are available in the Tamil Nadu coastline. Wind turbines are mounted on tower to capture the most energy with less turbulent wind. Wind turbine converts kinetic energy from the wind into electrical power. The combination of lift force (which pulls the blades toward it) and drag force (which acts against front side of blades) causes the rotor to spin like a propeller and spins the generator to make electricity. Wind turbines can be used as stand-alone applications, or connected to a utility power grid or even combined with a hybrid system. Wind farms, the arrays of large turbines are becoming significant source of renewable energy as part of a strategy to reduce dependency on fossil fuels.

The economics of wind energy is more encouraging than many other alternate energy sources. Unlike solar, the wind energy is available continuously and cost of power generation is cheaper at site. The wind power has emerged as a highly commercially viable and competitive energy source due to increased R&D activities and intrinsic strengths like non-polluting & sustainability. The generation cost of wind energy is mainly determined by the parameters like investment cost (production, transportation and erection cost), land-cost, operation and maintenance cost, average wind speed, hub height and financial parameters like interest rate and etc. With new technology innovation and economies of scale production, the wind turbines (which influence the major investment cost) are becoming cheaper and more powerful. Thus, the cost of wind power generation per kWh shows a decreasing trend with time.

Solar energy: Solar power systems can only use direct beam radiation and need to be positioned in regions with high direct solar radiation. The feasibility solar energy system at any location depends on meteorological data on sunlight conditions for that region. It also depends on the summer highs & winter lows and variable local weather conditions. Solar thermal technology use solar energy to generate heat energy and is used in residential and manufacturing applications. A basic system consists of a solar thermal collectors and circulation fluid and pump. Whereas, in solar PV system, typical silicon based solar photovoltaic cells are grouped together into a solar module which converts the sunlight into electricity directly. Technological development has opened up a huge new market for solar power as vast numbers of people in remote areas don't have access to grid electricity. In reality, people have to pay more for lighting due to inefficient kerosene lamps. Although solar power usually costs more than electricity from conventional power plants, but it makes economic sense as the cost of lighting is half in comparison to kerosene. Also, the declining cost of LED-based lighting, storage batteries, and solar panels have made it possible for millions of households to switch from crude kerosene lamps to cleaner and safer electric lighting. A low cost and lightweight polymer solar cell was invented to substitute the costly silicon made PV cells, but the conversion efficiency of polymer cell was less than the silicon cells. Recently, another innovative polymer solar cell developed by researchers at the University of California which has higher energy conversion ratio and is compatible with large-area printing techniques. A modified process for printing polymer solar cells could further reduce the cost of making the plastic photovoltaic. Large-scale solar installations presently use either central inverter or a sequence of inverters for power conversion. The system output is diminished if any panel gets damaged or shaded from the sun. M/s Array Power, California has invented a new Sequence Inverter technology, designed for commercial-scale solar installations that can be integrated during module production. These inverters reduce the number of critical components, decrease the productions costs and increase in overall reliability. A new technology for converting scraped car batteries which are major cause of lead pollution into solar cells (Perovskite compound) has been developed with efficiency comparable to conventional solar cells. The initial demonstrations have been conducted at MIT, USA. The recycle production of such solar cells from junk batteries will not only benefit in increase of renewable energy, but also to reduce toxic stockpiles of lead causing environmental hazard. Researchers in Michigan State University have developed new

transparent solar panels which exploit the techniques of absorbing specific non-visible wavelengths that can be extensively used from buildings to cell phones or on any object with a clear surface.

From economic point of view, the tapping of solar energy is still considered as expensive due to high initial investments, difficulties to integrate with grid due to intermittent nature, storage problem, conversion efficiency, component price sensitivity, limitations in power evacuation & transmission and lack of public awareness etc. Solar power also suffers in those areas which remain often cloudy and sunlight is available only for a small part of the year. Besides, solar power installations require large area. Gujarat came up with an innovative way to put PV arrays up on canals and waterways to reduce space. The solar power generation system has intrinsic advantages like free & abundant, inexhaustible and free from geo-political risks. As the international consensus on climatic change has been growing towards a clean energy system, the solar power turns out to be a major choice as an affordable and feasible global energy source in the sun belts. Although, the cost of solar energy is significantly higher in comparison to conventional fuels used for generating electricity, the declining trend of solar energy cost due to innovation of thin-film technology, mass production of solar panels and improved conversion efficiencies, automatic trackers for panel orientation will make it on par with conventional energy. Also, utility rebates and government tax incentives, consideration of cost for carbon emissions will formulate a level playing field for solar energy.

Nuclear energy: Nuclear power can be a crucial alternative energy source to make India as energy self-reliant nation. As India was barred from trade in nuclear plant & materials due to its weapons program and issues related to Nuclear Non-Proliferation Treaty till 2009. The development of civil nuclear energy was also slowed down during this period. However, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium due to the trade bans and lack of indigenous uranium. The 123 agreement on civil nuclear cooperation between India & the USA has made possible for setting up large capacity nuclear power reactors with foreign collaboration. The government had approved sites at Chhaya Mithi Virdi in Gujarat and Kovvada in Andhra Pradesh for setting up six reactors at each site in cooperation with the USA. A collaborative effort has already been started by Nuclear Power Corporation of India Limited (NPCIL) with General Electric Hitachi Nuclear Energy International (GEH) & Westinghouse Electric Company (WEC) of the USA for the same. A preliminary contract has been signed in September, 2013 between NPCIL and WEC for technical feasibility studies.

At present, total capacity of nuclear power plants in operation in Gujarat, Karnataka, Maharashtra, Rajasthan, Tamil Nadu & Uttar Pradesh are 440 MW, 880 MW, 1400 MW, 1180 MW, 440 MW, 440 MW respectively. In addition, the unit-1 of the Russian-designed Voda-Voda-Energo Reactor (VVER) at Kudankulam nuclear power plant has reached full capacity on 7th Jun, 2014. This is the first nuclear power plant in the country to touch 1,000MW of power generation. The power produced from this unit will be shared amongst Tamil Nadu, Karnataka and Puducherry. Three nuclear power projects are under construction at Kakrapar (Gujarat), Rawatbhata (Rajasthan) and Kalpakkam (Tamil Nadu) with capacities of 1400MW, 1400MW and 500MW respectively. In the 12th Five Year Plan, new indigenous projects are planned at the locations: Gorakhpur (Haryana), Chutka (Madhya Pradesh), Mahi Banswara (Rajasthan), Kaiga (Karnataka), Kalpakkam (Tamil Nadu) with capacities of 1400MW, 1400MW, 1400MW, 1400MW, 1000MW respectively. Also new reactors with foreign cooperation are planned at locations kudankulam (Tamil Nadu), Jaitapur (Maharashtra), Kovvada (Andhra Pradesh), ChhayaMithiVirdi (Gujarat) with capacities of 2000MW, 3300MW, 3000MW, and 2200MW respectively.

Shortage of nuclear fuel: The country has 20 nuclear power reactors under operation with installed generating capacity of 4780 MWe. As per separation plan, only 10 reactors are currently placed under International Atomic Energy Agency (IAEA) safeguards and are eligible for imported fuel. Additionally, two more reactors, set up with the international cooperation with Russian Federation, at Kudankulam (Tamil Nadu) are also under IAEA safeguard. The other 10 nuclear power reactors located in Karnataka, Uttar Pradesh, Tamil Nadu and Maharashtra continue to use uranium sourced within the country. Due to mismatch in demand & supply of domestic uranium, the total power generated by these reactors is usually lower than their installed capacity of 2,840 MWe. So far, 211473 tonne of U_3O_8 equivalent to 179329 tonne of uranium has been established by Atomic Minerals Directorate for Exploration and Research (AMD). After signing of the Civil Nuclear Cooperation Agreement with the USA, the Department

of Atomic Energy has been importing uranium ore to supply fuel for nuclear reactors under IAEA Safeguards in the country as per the separation plan. The contractual agreements were entered into with M/s. AREVA, France, M/s. JSC TVEL Corporation, Russia, M/s. NAC Kazatomprom, Kazakhstan and M/s NMMC, Uzbekistan. Also, it has been planned to enter into long term agreements with foreign suppliers for delivery of uranium to ensure uninterrupted supply.

Strategic Initiatives

The short-term and long-term strategic goals with a comprehensive energy policy need to be framed jointly by government agencies, academic institutions, social scientists for development of sustainable alternate energy resources. The energy policy needs to shift the focus from conventional energy to alternate energy resources, increase in R&D activities, transfer and application of energy efficient technologies and practices. In India, the distribution of electricity to all consumers falls under the purview of the respective state governments. The central government assists the efforts of the states through its schemes like R-APDRP (Restructured Accelerated Power Development and Reforms Progrmme) for up-gradation and strengthening of electrical infrastructure to achieve the target of one of the dream projects "POWER FOR ALL BY 2022". Recently, the World Bank has also submitted a report titled "More Power to India: The Challenge of Distribution" to the Government of India, which highlights the improvement necessary in the distribution system. Effective utilization of renewable energy sources like solar and wind can contribute significantly to accomplish such ambitious plans.

The Wind power programme in India was started towards the end of the 6th Five year plan, in 1983-84. The Wind Resources Assessment Programme has been implemented through the state nodal agencies and Field Research Unit of Indian Institute of Tropical Meteorology (IITM-FRU) and Center for Wind Energy Technology (C-WET). As on 31st Mar, 2014, with installed capacity of 21,141.36 MW, India ranked 5th in the World after China, US, Germany and Spain in terms of wind power installed capacity. The wind sector alone comprises 68 per cent of the total renewable energy produced in the country. Indian Wind Energy Association has estimated that with the existing level of technology, the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 102 GW. The Jawaharlal Nehru National Solar Mission (JNNSM) was launched on the 11th Jan, 2010 by the Prime Minister. The mission has a ambitious target of deploying 20,000 MW of grid connected solar power by 2022 through long term policies which include aggressive research & development and indigenous production of critical raw materials, components and products. Tapping of solar energy in the country is 2647 MW as on 31.05.2014 which is very less as compared to the available potential of 30-50 MW/sq. km. The average annual received sunshine in the country is 3,000 (over eight hours per day). The annual growth registered in solar energy production during the last three years: 27.61 % in 2011-12, 63.68 % in 2012-13 and 56.04% in 2013-14.

Government endeavour & achievement: The government has taken several measures to spread awareness for solar and wind energy systems. These include publication of book, magazine, organizing workshop & seminar etc. Global Wind Day has been celebrating since, 2007 to create awareness and achievements in wind energy sectors. Ministry of New and Renewable Energy (MNRE) is implementing Remote Village Electrification (RVE) Programme to provide financial assistance using renewable energy sources including solar energy in remote areas villages where electricity grid extension is not found feasible by the state governments.

The planned install capacity during 12th plan period was initially fixed at 18,500 MW. However, the new government has decided for capacity addition with ambitious wind energy generation of 10,000 MW every year to reduce dependence on imported fuels. In view of that, MNRE, manufacturers of wind turbine (IWTMA) and other stakeholders will jointly study the grid availability in six states for additional installation of wind power annually. The existing manufacturing capacity of wind turbines in India is 9500 MW with provision of further expansion. Also, India can attract more investments in wind sector by resolving issues like power evacuation and purchase obligations with the state utilities. C-WET has initiated a pilot project for off-shore wind power generation in collaboration with ONGC and the European Union Consortium.

The Ministry is providing financial incentives for the installation of both off-grid and grid connected solar power plants through various schemes. These include preferential tariff, generation based incentives, accelerated depreciation, concessional/zero excise and customs duties etc. MNRE is also implementing off-grid and decentralized solar applications scheme under JNNSM for installation of solar power plants in various parts of the country. Ministry of Power is implementing Decentralized Distributed Generation (DDG) scheme for both conventional and renewable energy sources for villages where electrification of grid connectivity is not feasible. Both under the DDG scheme and RVE programme, the government provides 90% subsidy of the project cost. Under the DDG scheme, the balance 10% projects cost can be arranged by the implementing agency or from any financial institutions and for RVE projects the balance 10% can be financed from the state governments. Under off-grid and decentralized solar applications scheme, the Ministry provides 30% capital subsidy for installation of solar water heaters in general category States and 60% capital subsidy in special category states (North Eastern States, Sikkim, Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Lakshadweep and Andaman and Nicobar Islands). For installation of solar photovoltaic lighting systems, 30% capital subsidy (Max Rs.135/- per watt peak) is granted depending upon capacity and configuration. Government has also approved 48 cities to develop as of "Solar City" for reduction of minimum 10% of projected demand in conventional energy within five years by exploiting additional renewable energy sources and energy efficiency measures.

The schemes under RVE programme for cost effective solar power lighting solutions for rural population have significant impact on kerosene subsidy bill and lighting up about 47 percent of the country population will depend on such fund availability. Under the off-grid and decentralized solar applications scheme, MNRE provides 30% capital subsidy for installation of solar power plants and 90% for government organizations of special category states. The government has launched a scheme to encourage installation of solar water heaters by setting targets in phased manner. The phase-I of the Mission has been completed and achievement is 100%. The cumulative target for phase-II (2013-17) & phase-III (2017-22) are set as 15 Millions sq.M and 20 Millions sq.M respectively. The government has proposed a programme for installation of one lakh solar pumps for irrigation and drinking water purposes across the country. A total number of 11626 solar pumps have already been installed in the country till 31/03/2014 and a total of 14788.45 lakh rupees have been sanctioned for solar pumps under "Off grid and Decentralized Solar Applications'' scheme in 12 states. The government is encouraging installation of solar street lights under off-grid and decentralized solar applications scheme with 30% capital subsidy. The Ministry provides 90% capital subsidy for government organizations for installation of solar street lights in special category states. A total of 274679 solar street-lights have been installed in various locations of the country. Grid connected solar power plants of 2596 MW aggregate capacity has been commissioned during the last three years across the country. The capacity of plants commissioned under central schemes & states initiatives is 896 MW in 2011-12, 754 MW in 2012-13 and 946 MW in 2013-14. A goal for exploitation of grid connected solar power capacity of 20,000 MW by 2022 in three phases has been set under the National Solar Mission (NSM) with capacities of 1000 MW in phase-I (till 2013), 9000 MW in phase-II (2013-17), and 10000 MW in phase-III (2017-22). As per MNRE, an total capacity of 1686 MW of grid connected solar power plants was commissioned at the end of NSM phase-I, and a further capacity of 1000 MW has been added during NSM phase-II till 30.06.2014.

Some of the common policy and regulatory obstacles like land acquisition and resettlement, obtaining environment and forest clearances have delayed major projects in energy sector. The Ministry of Environment has eased the Green Rules through notifications in Aug, 2014, for mining, roads, power and irrigation projects and other industrial sectors. It has relaxed a few regulations related to environment, forest and tribal rights. Review of the powers to the National Green Tribunal is under consideration within the Ministry of Environment and the Prime Minister's Office. Recently, the government has announced a few urgent measures to achieve the planned target for renewable energy production.

- Provision of Renewable Purchase Obligation (RPO) for solar power in the National Tariff Policy.
- Grant of subsidy on off-grid applications and Generation Based Incentive (GBI), facility for bundled power & Viability Gap Funding (VGF) for grid connected solar power projects.
- Setting up ultra mega solar power projects & solar parks, 1MW solar parks on the banks of canals and solar power driven agricultural pump sets for energizing.

- Concession on import duty/excise duty exemption, accelerated depreciation and tax holiday for setting up of solar power plants.

Public sectors initiatives: The public sector undertakings in India have been contributing substantially in economic and social development for the nation since inception. A MoU between Ministry of New & Renewable Energy and Ministry of Petroleum & Natural Gas (MoPNG) has been signed to improve energy security along with clean energy development through investments in large solar, wind and other renewable energy projects by developing two special purpose vehicles (SPV). The SPVs will be formed with participation from PSUs under MoPNG and under MNRE which are ONGCL, IOCL, OIL, GAIL, BPCL & HPCL and EIL (Engineers India Ltd), SECI (Solar Energy Corporation of India) & IREDA (Indian Renewable Energy Development Agency). In an initiative of Ministry of Heavy Industries and Public Industries, Ministry of New & Renewable Energy and Ministry of Power, BHEL, SECI, Sambhar Salts Limited, Power Grid Corporation, Sutlej Jalvidyut Nigam Limited and Rajasthan Electronics & Instruments Limited have signed a MoU in Jan, 2014 for setting up of a ultra mega solar power project with total capacity of 4,000 MW at Sambhar in Rajasthan on BOO basis. OIL had installed a 54MW wind farm and another 13.6 MW in Rajasthan which were effectively connected to the state electricity grid. OIL has set up two 100 kW solar power plants in Rajasthan and Assam. Additionally, OIL has also taken up a 5 MW solar power plant in Rajasthan. ONGC has set up the ONGC Energy Centre (OEC) for research in alternate energy sources to develop affordable clean energy solutions for commercialization and is currently working on performance of solar thermal dish-stirling engine system in the Solar Energy Centre at Gurgaon. ONGC is to set up a solar power plant of 1 MW to cater power to its office and colony in Rajahmundry. IOCL has installed a 5 MW solar power project in Rajasthan and a 21 MW wind power project in Gujarat and another 48.3 MW wind power project is under implementation in Andhra Pradesh.

IOCL has set up a JV company with NPCIL to put up a 1400MW nuclear power plants at in Rajasthan with Pressurized Heavy Water Based Reactor (PHWR) technology and is expected to be completed by 2017. NPCIL has signed joint venture agreement with National Thermal Power Corporation Limited, National Aluminium Company Limited, to set up a JVC for nuclear power project to harness and develop nuclear energy for generating electricity on a commercial basis. ONGC is exploring investment opportunities in the nuclear power generation sector in association with the NPCIL. Also, ONGC has undertaken a comprehensive program for exploration for uranium in the sedimentary basins of India.

Participation of private sector: To promote the growth of renewable energy sources, several strategies have been formulated and implemented jointly by governments, local institutions, NGOs and private sectors. Although, the manufacturer of solar and wind sectors are by and large dominated by large players, there is a significant presence of small and medium enterprises, particularly in manufacturing of rural energy devices like solar cookers and solar lamps. The government have brought some effective regulation in terms of providing incentives and capital subsidy for small and medium size enterprises for investment in alternative energy. There has been no import duty for import of solar cell during the last three years and the solar power developers are free to procure from foreign and indigenous sources.

The government is promoting wind power projects through private sector investment by providing fiscal incentives, concessional import duty on certain components of wind electric generators, excise duty exemption to manufacturers, tax holiday for 10 years on income generated from wind power projects and etc. Indian Renewable Energy Development Agency (IREDA) and other financial institutions are arranging loans for installation of windmill. Centre for Wind Energy Technology (C-WET), Chennai is providing technical support including wind resource assessment. The MNRE has announced a Generation Based Incentive (GBI). Under GBI, ₹0.50/unit generated from wind power projects is provided to the projects with a ceiling of ₹1.00 Crore per MW.

As on 31.3.2014, out of the total installed generation capacity of 243030 MW, the private sector has contributed 82715 MW. The Government is encouraging privatisation through combined efforts of public and private sectors for the development of power generation from renewable sources so as to meet the increasing demand of electricity and to reduce the emission of greenhouse gases. The Electricity Act, 2003 promotes competition and creates a responsive environment for investment in the electricity industry for public and private sector. Arka Ignou College of Renewable Energy will set up a 15KW solar

power generating panel on a water body near Eco Park in Kolkata by Nov, 2014 under central government funding. This will be the country's first floating solar power generation facility. M/S Solar Town, a Chennai-based startup has been providing power to residential with innovative business model using solar energy systems. Solar Town has so far covered 70 houses to install 100 KW and is targeting 1 MW by March, 2015.

International cooperation: It is worth to mention that, during the 1st half of 2014, Germany has generated 31% of its electricity from renewable energy sources to reduce its dependency on gas import. A huge 17% of this power generation was contributed by solar and wind sectors alone. India recognizes the importance of international collaboration and interchange of technical expertise for exploitation of alternate energy resources. India has undertaken some effective measures like foreign direct investment, acquisition of modern technologies, promotion of import/export of products associated with alternate energy. Recently, Norway has supported an electrification project for solar mini-grid plants covering 28 villages in Madhya Pradesh, Uttar Pradesh, Jharkhand and Jammu & Kashmir. M/S First Solar, a US-based PV module manufacturer has planned to install a 45MW solar power project in Telangana through Indian subsidiary. About 75 million kWh of electricity from this plant would be sold to the local utility at ₹6.49/KWh for a period of 20 years.

Conclusions

Renewable energy sources should also be utilized for benevolent purposes of the underprivileged communities. A lot of poor people in India die annually in diseases like diarrhea etc due to drinking dirty water as they don't have access to potable water. M/S Saurya Enertech, a start-up has developed an innovative solar-powered purifier under United Nations Development Programme (UNDP) which can be effectively used in remote areas where there is no electrification. Student of University at Buffalo, US has developed a low-cost solar lens which can disinfect polluted water from bacteria and pathogens. Such inventions can contribute immensely to various schemes intended for rural health development.

When oil price are low the alternative energy becomes less desired, but when oil price increase, alternate energy like solar power, and wind power become good alternatives to oil and gas. As, India is heavily dependent on fossil fuels, import of crude has compelled India to pay out a huge amount of foreign currency. Any unforeseen import crisis may force the nation to the edge of disaster. As the energy demand has been growing steadily with economic growth rate and even If India maintains an average growth rate of about 6% in the coming years, the existing resources will be under pressure and demand-supply gap both in industrial and domestic sectors may cause acute energy scarcity.

Although, the theme of this paper is essentially limited to solar and wind energies, other alternate resources like biomass, bio-fuels, geo-thermal, small hydro power etc have also enormous potential. The policy makers, industries, customers and other stakeholders should not view alternate energy as a substitute for energy production only, but must vision as a part of strategy in achieving 'sustainable and inclusive growth' to make India Energy Independent.

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