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Let noble thoughts come to us from all sides
Rig Veda

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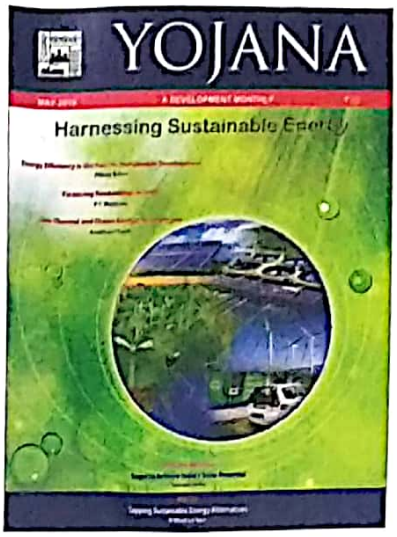
YOJANA

Meeting Future Energy Needs



Sustainable and renewable energy sources are a crucial strategic national resource. Creating environment friendly development programmes is one of the most challenging tasks for most modern governments. Harnessing sustainable energy resources becomes important while planning for energy programmes. And hence, meeting the nation's energy requirements is high on the agenda of any government. Renewable energy sources contribute to a nation's sustainable growth trajectory, in addition to protecting the environment, promoting investment and conserving ecology.

India, like most other countries, has a very high dependence on fossilized fuels for its energy requirements. The other major energy source is coal. It is generally accepted that fossilized fuels are liable to be exhausted as they are not replenishable. And, thermal plants are highly polluting. At the same time, the need for energy is increasing at an alarming rate. Whether it is industrial energy, household energy or vehicular energy, the demand is more than the capacity. Hence the need of the hour is increased energy supply, which is replenishable and at the same time does not damage the environment.

India's Intended Nationally Determined Contributions centre around promotion of clean energy, especially renewable energy; enhancement of energy efficiency; safe, smart and sustainable green transportation network; abatement of pollution and India's efforts to enhance carbon sink through creation of forest and tree cover. Solar energy, bio-gas, geo-thermal energy and ocean energy are some clean energy sources that may help mitigate the ill-effects of environmental pollution. While energy harnessed from oceans is still in a nascent stage in India, geo-thermal energy seems a more viable renewable energy technology that has the potential to provide clean energy for both electric power production and direct heat applications.

Bio-gas as an energy source can be a boon to rural India. Bio-gas energy can not only ease the energy situation in rural areas but also ensure waste recovery – both agriculture waste and dairy waste.

Other more well-known energy sources, like solar and wind energy are in use in some parts of the country. But financing renewable sources is a major issue . Financial assistance in the form of low-interest rate, long-term loan guarantees are some available means of addressing the high capital costs of creating renewable energy sources. Institutional finance is also one way of solving this problem.

As on date, India is heavily dependent on imported oil and gas as well as coal to meet its energy requirements. But concerted efforts are on, at the same time, to harness renewable energy sources and so that India is able to honour its commitments as per the Paris Accord on Climate Change.

Energy Efficiency is the Key for Sustainable Development

Abhay Bakre

In India the electrification of households has taken place on a massive scale and demand for energy has increased. One of the key reasons for this has been the growing population. Another, is the enormous increase in energy intensive economic activities. As the conventional sources of energy are reducing and the renewable sources are under developing phase, improving energy efficiency at all levels of the energy spectrum is the cost-effective and quick solution to address this problem.

There is a direct relation between energy, environment and sustainable development. A country seeking sustainable development ideally must utilize only those energy resources which have minimal environmental impact. Some of the concerns regarding the limitations imposed on sustainable development by environmental emissions and their negative impacts can in part be overcome through increased energy efficiency. The government, through Nationally Determined Contributions has aimed to reduce emission intensity of GDP to 33-35 per cent below what it was in 2005 by 2030. However, to

Consumer appliances are one of the important areas of energy consumption. Daily household electronic appliances like AC, Microwave, Washing Machine etc., are included in this sector. A lot of initiatives are being taken to reduce the energy consumption and to enhance the technology for energy efficiency in consumer durable sector.

The author is Director General, Bureau of Energy Efficiency.

achieve this target, there is a need for a concerted move to ensure increased energy efficiency especially in 3 sectors-

- Industrial sector
- Real estate
- Consumer appliance

Industrial Sector

Industrial sector continues to be the highest energy consuming domain where energy conservation would play a vital role. There is also huge potential for energy conservation and technology enhancement for efficiency in key intensive industries. With an aim of energy efficiency improvement, Bureau of Energy Efficiency (BEE) is implementing Perform, Achieve and Trade (PAT) scheme under the National Mission for Enhanced Energy Efficiency (NMEEE).

Perform Achieve and Trade (PAT)

It is a regulatory instrument to reduce specific energy consumption in energy intensive industries, with an associated market based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded. PAT cycle- I had 478 DC's covering total 8 sectors including Aluminum, Cement, Chlor-Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power Plant, Textile, which were mandated to reduce their specific energy consumption (SEC) i.e. energy used per unit of production. Overall, the SEC reduction targets envisaged to secure an energy saving of 6.686 million tonne of oil equivalent (mtoe). The implementation of PAT in designated industries has led to energy saving of 8.67 MTOE in year 2015 which is about 1.25 per cent of total primary energy supply to the country in the "first cycle". This energy saving also translates into mitigating about 31 million tonne of CO_2 emission.

The energy savings of the Designated Consumers (DCs) of PAT Cycle-I have been converted to tradable Energy Saving Certificates (ESCerts). About 38.25 lakh ESCerts had been issued to 306 designated consumers while 110 Designated Consumers have to purchase about 14.25 lakh for their compliance. The total volume of ESCerts traded by 2018 was about 12.98 lakhs resulting into a business of about INR 100 crores.

The "second cycle" of PAT was notified in March, 2016 covering 621 DCs from 11 sectors which include eight existing sectors and three new sectors, viz. Railways, Refineries and DISCOMs. PAT in its second cycle seeks to achieve an overall energy consumption target of 8.869 MTOE. Since PAT scheme is currently based on a rolling cycle i.e. inclusion of new sectors/designated consumers every year, the "third cycle" of PAT was notified in March 2017 and it seeks to achieve an overall energy consumption reduction of 1.06 MTOE for which SEC reduction targets have been assigned to 116 DCs from six energy intensive sectors. Targets for the "fourth cycle" of PAT have been notified in March 2018 under which 109 DCs have been notified from existing sectors and two new sectors i.e. Petrochemical and Commercial Buildings (Hotels) with an overall SEC reduction target of 0.6998 million tonne of oil equivalent. At present total 956 designated consumers belonging to 13 energy intensive sectors are under PAT cycles-II, III, IV and V undergoing implementation of energy efficiency projects to achieve the assigned targets.

Real Estate Sector

The Bureau of Energy Efficiency (BEE) envisages a phased approach for developing an energy conservation code for the residential sector. The idea is to create a simple and implementable code focusing on building envelope which can be integrated with the existing building codes and bye-laws.

The design of the building envelope will have a direct impact on:

- Heat conduction through the roof, opaque wall and glazed windows
- Solar radiation gains through glazed windows
- Natural ventilation
- Day-lighting

The real estate sector consumes over 30 per cent of the total electricity consumption in India annually and is second only to the industrial sector as the largest emitter of greenhouse gases; of which around 75 per cent is used in residential spaces.

The building envelope thus will impact both the thermal comfort as well as electricity used for space conditioning. In this context, BEE has two programs (1) Eco Samhita, Energy Conservation Building Code for Residential Buildings, and (2) Labelling for Energy Efficient Homes.

Eco Samhita (Energy Conservation Building Code for Residential Buildings)

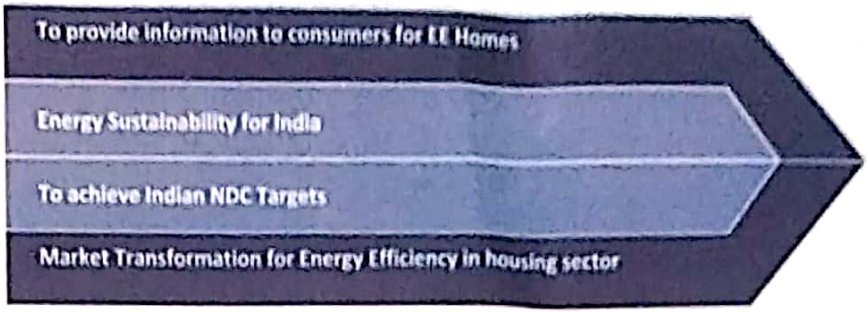
The Eco-Niwas Samhita (Part I: Building Envelope) aims to set minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climate) as well as for ensuring adequate natural ventilation and daylighting. The code is applicable to all residential use building projects built on plot area $\geq 500\ m^2$. The code has been developed with special consideration for its adoption by the Urban Local Bodies (ULBs) into building bylaws. This strategy enables most of the new urban housing stock to be brought into the net for capturing the opportunities and the benefits of energy efficiency in residential buildings.

The Part I – Building Envelope Design is the first component of the Eco-Niwas Samhita, Building Code for Residential Buildings. Its early and immediate introduction was aimed at improving the construction and design of new residential building stock, as it is being built currently and in the near future, to significantly curtail the anticipated energy demand for comfort cooling in times to come. This critical investment in envelope construction and design made today will reap the benefits of reduced GHG emissions for the entire lifetime of the buildings.

The code is designed in a simple-to-apply format, requiring only arithmetic tabulation based on the architectural design drawings of the residential buildings. This will be usable by architects as well as engineers and will not require any specialized skills or simulation software. This also enables the Code to be readily adopted in the building bylaws and regulatory instruments such as Environmental Clearance for Large Projects.

Labelling Programme for Energy-Efficient Homes

To enable consumers to compare building performances from a sustainable energy point of view, a comprehensive labelling scheme is important. Energy labels help consumers to make efficient decisions through the provision of direct, reliable and cost less information. The objective of proposed labelling programme is mentioned below:



This is expected to save substantial energy through improving energy efficiency to houses nationwide. The estimated energy saving potential through proposed labelling program is around 388 BU by the year 2030.

In conjunction with this, the programme also brings up various ancillary benefits:

- It shall act as an embryo to stimulate the larger energy-efficient materials and technologies market. To seek the energy efficiency label, customers shall demand energy efficient building materials which in turn, would give enough impetus to suppliers to produce the same.
- After the implementation of the labelling mechanism, the housing value chain would encourage an additional set of professionals to expedite the complete process of residential label granting. This way, the labelling regime shall also be a stimulant for the Indian job market.
- It will also motivate material manufacturers to invest in energy-efficient material manufacturing in India.
- Labelling mechanism shall cause a reduction in energy bills. This will empower individuals with a greater disposable income that can be consumed at other avenues, saved for future contingencies or invested for cash-generating asset creation for overall economic growth.
- It helps the nation in working towards the fulfilment of Global Sustainable Development Goals 7 of the United Nations Affordable and Clean Energy.

Consumer Appliances

Consumer appliances are one of the important areas of energy consumption. Daily household electronic appliances like AC, Microwave, Washing Machine etc. are included in this sector. A lot of initiatives are being taken to reduce the energy consumption and to enhance the technology for energy efficiency in consumer durable sector.

Bureau of Energy Efficiency (BEE) has been promoting energy conservation through optimum temperature settings for Air Conditioners. According to the study of BEE, one degree increase in the AC temperature setting results in saving of 6 per cent of electricity consumed. 24-26 degree Celsius default setting has been recommended by BEE for energy savings and also to reduce greenhouse gas emission.

Measures to promote advancement of technology and energy efficiency in Microwave Ovens which is becoming a popular household gadget, are also being taken. Savings of over 3.0 Billion units of electricity are estimated at consumer-end through adoption of Star Rated Microwave Ovens and Washing Machines by 2030. This would be equivalent to Green House Gases (GHG) reduction of 2.4 Million-ton of CO_2 by the year 2030 through these recent initiatives. ❑

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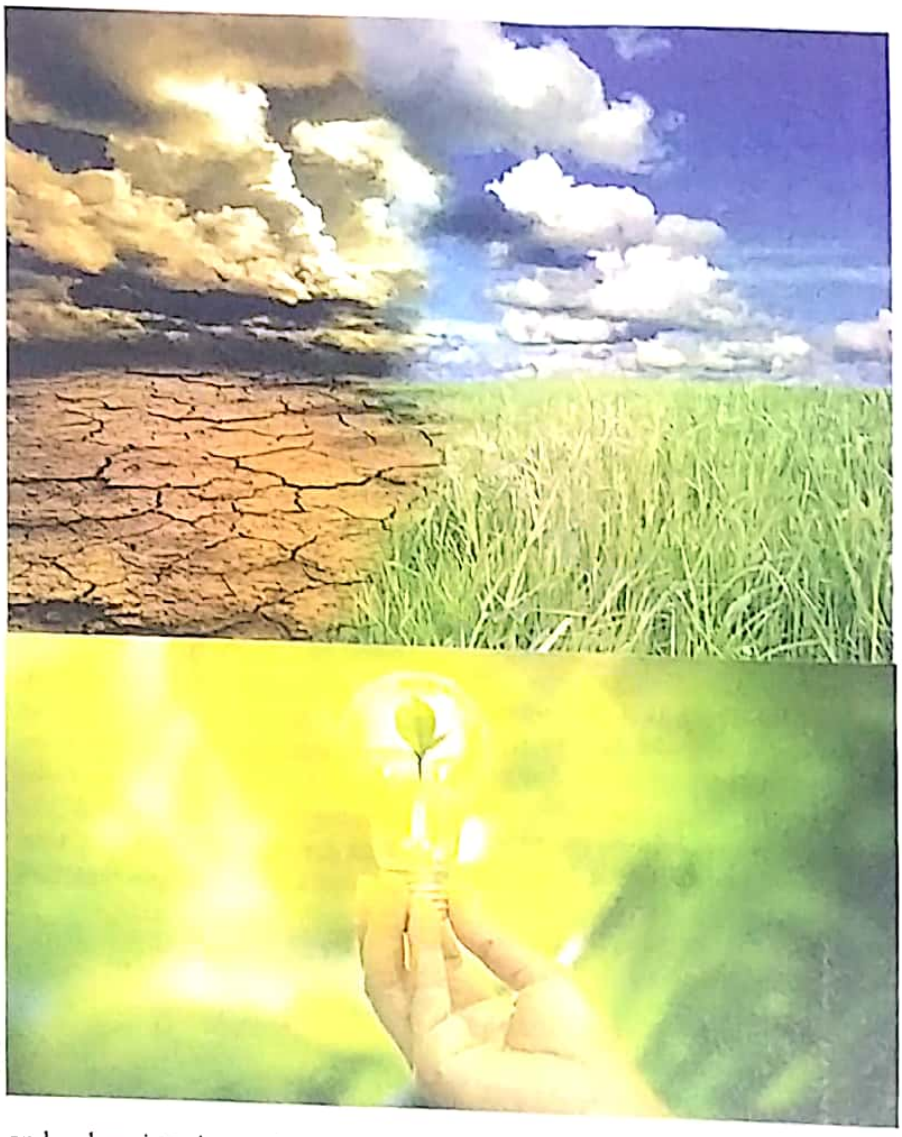
Tapping Sustainable Energy Alternatives

N Bhadran Nair

What is sustainable development? Sustainable development is "development that meets the needs of the present without compromising the ability of future generations," which otherwise means "economic development that is conducted without depletion of natural resources."

India, which became a sovereign nation, had to develop its agricultural resources and national infrastructure to meet sustenance of approximately 330 million people and take the country on a development trajectory. Until the 1970s, sustainable development had never attracted the imagination of the global community. At the 1972 UN Conference in Stockholm, the world body raised concerns for preserving and enhancing the environment and its biodiversity to ensure human rights for a healthy and productive world. The developing countries, including India, argued that their priority was development, whereas the developed countries made a case to bring environmental protection and conservation in the forefront of global agenda.



According to World Health Organisation, climate change affects the social and environmental determinants of health – clean air, safe drinking water, food security and shelter. Between 2030 and 2050, climate change is expected to cause approximately 2,50,000 additional deaths every year from malnutrition, diseases like malaria, diarrhoea and heat stress. Its cost to health is estimated to be between 2-4 billion US dollars a year by 2030.

Ancient Indians had practised to live in harmony with nature – worship of nature and its creations has its roots in this doctrine. However, over the ages, we have plundered our natural resources, with scant regards to its sustainability. We forgot the dictum of our forefathers that the present generation is only a custodian of the natural resources

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and has the responsibility to pass it on without depleting it, to our future generations.

As India raced to catch up with the developed world, it was caught in a vortex to bring development and energy security for self-sufficiency. At the same time, it could seamlessly join the environment bandwagon, as protection of nature was in our national DNA.

India has joined hands to 'fight against' global warming and climate change and brought in responsible changes in its development doctrine and energy generation and usage to bring down its contribution to global warming. In fact, today, India is at the forefront of global campaign against these phenomena.

India's energy requirement is being met primarily from conventional sources, like coal and oil. But with worldwide concern over the impact of fossil fuel on climate and global warming, India decided to tap alternatives that contribute less carbon emissions to the atmosphere.

Globally, there is a realisation on the need to move fast to find solutions to arrest climate change, which would trigger more intense storms, dangerous heat waves, more frequent and longer-lasting droughts and rising seas. It also has a direct effect on food production, livelihood, health and environment.

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Since climate change is the defining issue of the present times, the world body has taken the initiative to reduce emissions of greenhouse gases through better transport, food and energy-use to bring in improved health, particularly reduced air pollution.

India is a signatory to the landmark Paris Agreement on Climate Change, which has brought all nations to a common cause to undertake efforts to combat climate change through Nationally Determined Contributions (NDCs) and to strengthen these efforts in the years ahead.

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Emissions in India were estimated to have grown by 6.3 per cent in 2018, pushed by strong annual economic growth of around 8 per cent, according to recent projections by the Global Carbon Project. India was among the four major emitters in 2017 (7 per cent) along with China (27 per cent), the US (15 per cent) and the European Union (10 per cent). The rest of the world contributed 41 per cent.

Coal is still the mainstay of Indian economy. Though global coal use is lower than its historical high, it is expected to grow in India, driven by growth in energy consumption. Its GDP and industrial production would continue to drive electricity demand and the expected electricity generation.

India has now embarked on a mission to bring down the share of fossil fuel in its energy basket, by tapping non-conventional sources. India being the founding nation of International Solar Alliance, has the leverage to switch over to cleaner energies and clean-up its smog-choked cities.

The National Solar Mission promotes ecologically sustainable growth, while addressing the country's energy security challenge and contribute to global effort to meet climate change.

India has set an ambitious renewable capacity expansion programme, with a projected growth of achieving 40 per cent of its total power generation from non-fossil fuel sources by 2030, to meet NDC target. The target would place India among the world leaders in renewable energy use.

If India develops its alternative and sustainable sources of energy, the country does not require crude imports. It has the alternative sources in abundance as crude substitution, according to scientists involved in energy research.

Crude import is a key factor in India's current account deficit (CAD), which currently is 49 billion dollars or 1.9 per cent of the Gross Domestic Product (GDP). The increasing CAD is a cause of concern for the country and if it crosses the threshold of 3 per cent of the GDP, it would badly affect the economic stability.

Besides, India's import is hugely affected by the geopolitical situation, like the threat of sanctions by the United States on imports from Iran, the second biggest supplier of crude to India.

Another technology that has been unveiled by Indian scientists is for conversion of sewage into biofuels. A sewage treatment plant (STP) launched in Delhi would convert 10 lakh litres of sewage into three tonnes of biofuel per day.

India has a huge potential for producing liquid and gaseous fuels from biomass. A strategy for gradual reduction of import dependency has been initiatied, as the country would continue to remain vulnerable to international situations. The strategy targets to reduce import dependency by 10 per cent by 2022.

Besides biofuels, India has the potential to generate green energy from Solar, Wind, Geothermal, Ocean Thermal Energy, which are all non-carbon options and can help reduce carbon imports by demand substitution. Also hybrids are expected to emerge in the energy sector like Wind-Solar and Wind-Solar-Biofuels.

Road transport sector accounts for 6.7 per cent of India's Gross Domestic Product (GDP). Currently, diesel alone meets an estimated 72 per cent of transportation fuel demand followed by petrol at 23 per cent and balance by other fuels such as CNG, LPG etc. for which the demand has been steadily rising.

Another major source of environmental pollution is nuclear power generation. Nuclear plants create 50 per cent more thermal pollution than fossil fuel plants. The challenge India faces now is to improve energy access to modern energy at affordable price in a sustainable and responsible manner without sacrificing economic growth and social development to meet the aspirations of its burgeoning population.

The domestic crude oil production is able to meet only less than one fifth of the demand, while the rest is met from imported crude. India's energy security will remain vulnerable until alternative fuels to substitute/ supplement petro-based fuels are developed based on indigenously produced renewable feedstock.

Though non-conventional sources of energy are not entirely without impact on environment, in comparison, it is the better option, being the lesser evil. Fossil fuels—coal, oil, and natural gas—do substantially more harm than renewable energy sources by most measures, including air and water pollution, damage to public health, wildlife and habitat loss, water use, land use and global warming emissions.

The extraction and utilization of coal have created a massive impact on environment with far reaching consequences. Nearly 65 per cent of India's electricity is generated from thermal power, for which the feedstock is invariably coal mined in India. Power generation through the Boiler-Turbine route results in atmospheric pollution due to the release of particulate matter, carbon dioxide, sulphur and nitrous oxides.

The other major energy source is oil. Oil pollution is an inescapable fact of life in the 21st century, when the teeming millions depend on oil for various modes of transport. The process of extraction of oil, transportation and storage of oil cause enormous loss to the natural and human environment. India has set a target to phase out petrol and diesel driven vehicles by 2030.

Indian automotive sector is among the fastest growing industries in the world. By 2020, it is expected, the annual demand for passenger vehicles, commercial vehicles and two wheelers in the country will be 46.7 million, turning India into the third largest vehicle market in the world.

As per International Energy Agency (IEA) estimates, globally, transportation sector accounts for 30 per cent of worldwide energy consumption and is the second largest source of carbon dioxide emission contributing to 20 per cent of greenhouse gas. India's National Mission for Electric Mobility seeks to mitigate the adverse impact of economic development, by completely switching over to electric vehicles by 2030.

Another major source of environmental pollution is nuclear power generation. Nuclear plants create 50 per cent more thermal pollution than fossil fuel plants.

The challenge India faces now is to improve energy access to modern energy at affordable price in a sustainable and responsible manner without sacrificing economic growth and social development to meet the aspirations of its burgeoning population. ❑

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Financing Renewables in India

P C Maithani

For India, the success of the renewable energy sector will be crucial to meet its Nationally Determined Contribution (NDC) under the Paris Agreement and its transition towards a sustainable future. In its NDCs, India has committed to reducing its greenhouse gas emissions intensity by 33 to 35 per cent below 2005 levels, and to achieving 40 per cent of its installed electric power capacity from non-fossil sources by 2030. Simultaneously, India has set an ambitious domestic target of 175 GW of renewable energy by 2022. The National Electricity Plan 2018 reaffirms further expansion to 275 GW by 2027. Undoubtedly, this is significant departure from business as usual and would entail a new paradigm with support mechanisms, facilitative policies and access to new technologies and investment.

As part of national efforts, India has embarked on an intensive renewable energy programme that covers a basket of applications, including grid power, off-grid power, modern cooking energy, thermal application in industry and many more. Over the period, renewable energy has emerged as a true multi-benefit system, combining ecological necessities with domestic priorities and economic opportunities. It addresses the complex challenges of energy security, energy access, growing energy demand and domestic job creation. With 77 GW renewable energy capacity on ground and 54 GW at different stages of fruition, India is well on the way to realise the ambitious target of 175 GW by 2022. The policy landscape for renewable energy deployment is ever evolving in response to felt needs. The renewable energy projects are mostly being implemented in the private sector. The steps taken by the government to support the renewable energy sector include: fiscal and promotional incentives, such as capital subsidy, guidelines for transparent competitive bidding process, waiver of Inter State Transmission System (ISTS) charges and losses, viability gap funding (VGF), standards for deployment of renewables systems and devices and permitting Foreign Direct Investment up to 100 per cent under the automatic route. By the year 2022, the renewable power share in the overall electric installed capacity is expected to reach 37 per cent. If large hydro is included, the share of non-fossil fuel electric installed capacity in the electricity mix would be around 48 per cent.

Over the period India has become a favourable investment destination for renewables. A variety of investors finance renewable energy projects in India, including institutions, banks and registered companies. Institutional investors are either state-owned, private or bilateral and multilateral

Over the period, renewable energy has emerged as a true multi-benefit system, combining ecological necessities with domestic priorities and economic opportunities. It addresses the complex challenges of energy security, energy access, growing energy demand and domestic job creation. With 77 GW renewable energy capacity on ground and 54 GW at different stages of fruition, India is well on the way to realise the ambitious target of 175 GW by 2022.

The author is Adviser, Ministry of New and Renewable Energy.

institutions. Among banks, both private sector and public sector banks are involved. In addition to registered companies, venture capital and private equity investors contribute to equity investments. Development Banks, like Indian Renewable Energy Development Agency (IREDA), continue to represent a key source of funds for renewables, particularly in project finance. The very liberal foreign investment policy allows foreign investors to enter into joint ventures with an Indian partner for financial and/or technical collaboration and for setting up of renewable energy-based power generation projects. The Indian renewable energy sector received approximately US $3.2 billion in the form of Foreign Direct Investment (FDI) in recent years. A study report from CEEW, New Delhi has estimated that the percentage of FDI in renewables has almost doubled from its average value of 1.7 per cent since 2000 to 3 per cent in the year 2017-18 and this trend is expected to sustain given the ambitious Indian renewables target. There exist other provisions such as priority sector lending status for renewable energy for loans up to a limit of Rs 150 million to borrowers for solar, biomass, wind and micro-hydel power generation and also for renewable energy based public utilities like street lighting systems and remote village electrification.

Broad estimates suggest that additional investment in renewable plants for upto the year 2022 (without transmission lines) would be about US $ 80 billion at today's prices (prices are declining; so actual would be less). Further an investment of around US$ 250 billion would be required for the period 2023-2030. Thus, on annualized basis, investment opportunity for over US$ 30 billion per year is expected to come up for the next decade and beyond.

Generally, grants and concessional finance both play a role in stimulating renewable energy investment, although their share is miniscule in total finance space in India. At present, concessional finance is mainly for strengthening transmission and distribution networks and solar roof top sectors. KfW, Germany's concessional line of credit for Green Energy Corridor Project; World Bank, Asian Development Bank and New Development Bank for the solar roof top projects; and European Investment Bank (EIB) for financing renewables are on-going examples. As such, India's financing landscape is largely represented through mixture of equity and non-recourse debt as private sector dominates in renewable energy financing.

Notwithstanding, Venture Capital (VC) and Private Equity (PE) investments are also growing, albeit slowly. From the year 2017 onwards some of the wind companies have been successful in raising funds to expand their operations. Greenko Energy, an independent power producer based in Hyderabad, have raised US $155 million in PE expansion capital from GIC, the sovereign wealth fund of Singapore and the Abu Dhabi Investment Authority. In addition, Hero Future Energies, an independent power producer company has raised US $125 million in PE expansion capital from the International Finance Corporation (IFC) and the IFC Global Infrastructure Fund. Another company, Clean Max Enviro Energy Solutions, have secured US $109 million from Warburg Pincus to fund its solar roof top operations. These apart, IREDA have raised US $300 million through the issuance of Green Masala Bonds.

The National Solar Mission has provisioned PSM for ensuring payment to the developers in case the distribution company falters in payment. Putting in place a well-structured PSM helps in lowering the off-takers risk and increasing investment attractiveness.

The finance landscape for the energy sector is undergoing significant changes. With renewables, in many situations out competing other energy technologies, the financial markets have started repositioning themselves for a fundamental shift towards renewable energy finance. Financial assistance in the form of low-interest rate, long-term loans and loan guarantees are globally accepted means to address the high up-front capital costs of renewables. In this context, arranging institutional finance for increased renewables deployment would require concerted efforts. Gearing up the banking sector, exploring international funding, and developing a suitable mechanism for risk mitigation or sharing by addressing both technical and financial bottlenecks is a challenge. The major areas for action are detailed herein under.

First, pension or sovereign funds are potent sources for patient capital for renewables. Top 400 Global funds manage assets of around US $ 75 trillion. Green bond issuance has surpassed US $120 billion. Even a small portion of proceeds from these funds could easily meet the investment required for renewables over a decade, assuring a constant and low risk yield that simultaneously makes our planet green. In 2014, the Securities and Exchange Board of India (SEBI) introduced Infrastructure Investment Trusts (InvITs). The feedback from industry suggests that due to the current limitation of 49 per cent cap on leverage, InvITs are unable to offer adequate returns in comparison to alternative investment avenues with similar assets.

Second, reducing cost of the foreign debt by reducing the currency hedging cost has potential to mobilize foreign capital and spur investment by reducing the cost of the capital. This would reduce the delivered cost of renewables and make them more competitive. An analysis by the Climate Policy Initiative suggests that the expected cost of providing a 10-year currency hedge through a Foreign Exchange hedging facility would be around 3.5 percentage points per year that would be broadly 50 per cent below the market rate.

Third, robust Payment Security Mechanism (PSM) will also contribute to de-risking the investment. Successive studies have confirmed that one of the most important risks to the Indian

renewable energy sector is the counterparty credit risk, associated with the risk of state-owned utilities delaying or defaulting on their contractual payments to power producers. The timeliness and reliability of payments for power purchase by state distribution companies remains a persistent risk for investments. The National Solar Mission has provisioned PSM for ensuring payment to the developers in case the distribution company falters in payment. Putting in place a well-structured PSM helps in lowering the off-takers risk and increasing investment attractiveness.

As an illustrative example, tariffs discovered in the Rewa solar park projects is largely attributed to the availability of concessional funds and the availability of payment security mechanisms to protect developer's interests. For the Rewa project, four layers of payment security ensure that, in the case of any delay or even natural calamities that may lead to a transmission disruption, payment to developers is still guaranteed. The first tier of the security mechanism is a letter of credit provided by off-takers, DMRC, and MPPMCL, that equals a one-month bill for the energy generated by developers. The second tier is a payment security fund operated by Rewa Ultra Mega Solar Limited (RUMS). It consists of three months of payment assurances in case the off-takers delay or make a payment error. This three-month payment guarantee comes on top of the one-month line of credit provided by offtakers. The third tier is the state guarantee that if there are payment delays by off-takers, then the state will step in to pay the difference or the pending amount to the developers. The state government is also providing the fourth tier of payment security by agreeing to bear the cost in cases where a transmission outage lasts beyond 50 hours. These provisions are now widely referred to as a model for de-risking Off-takers risk.

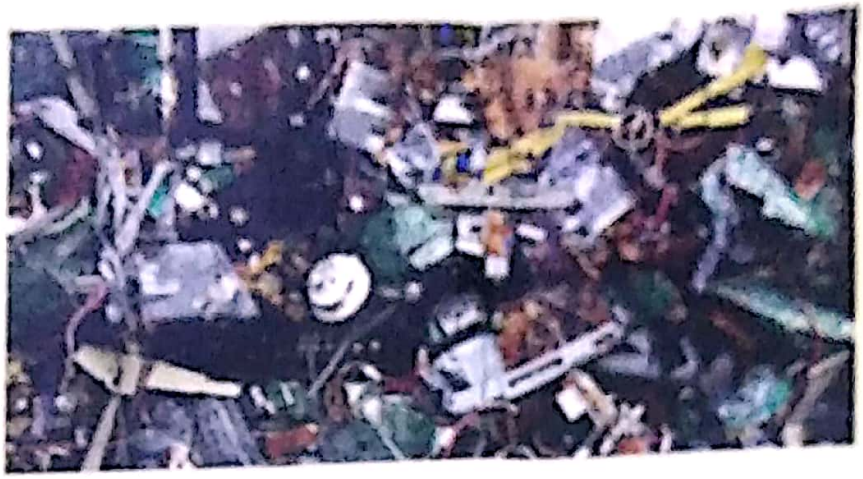
Fourth, absence of dedicated ecosystem that looks at the financing needs of the renewables in most of the bilateral and multilateral financing institutions. In furtherance to the policy of building financial frameworks for sustainable energy sectors, the banks may consider to earmark a certain percentage of their loan portfolio for renewables. This will be a critical factor for unlocking significantly scaled-up investment in renewables.

Given right instruments put in place, there is no dearth of funds for renewables investment. India has put in place several progressive policies, both at the federal and state level. However, financing challenges are bound to continue given the ambitious targets and requirement of patient capital. India has rightly been exploring a combination of short and long-term policy solutions. New ways of financing renewables, including through credit and risk guarantees, innovative currency hedging facilities, government bonds etc. would help in attracting additional capital, lowering the cost of debt, and also ensuring that India achieves its renewable energy targets.

(E-mail-pcmaithani@nic.in)

DO YOU KNOW?

E-waste Management



Digitalisation and the electronics industry is the world's largest and fastest growing manufacturing industry. Availability of electronics goods in the market has increased temptation of consumers to replace their household electronic items with newer models for various reasons. The net effect is a higher rate of obsolescence, which is leading to growing piles of e-waste.

Electronic waste (e-waste) comprises waste electronics/electrical goods that are not fit for their originally intended use or have reached their end of life. This may include items such as mobile phones, computers, monitors, calculators, CDs, printers, scanners, copiers, battery cells, Radio, TVs, medical apparatus and electronic components besides white goods such as refrigerators and air-conditioners.

These gadgets and equipment contain hazardous constituents, although e-waste itself is not harmful. E-waste contains valuable materials such as copper, silver, gold and platinum which could be processed for their recovery when such wastes are dismantled and processed, since it is only at this stage that they pose hazard to health and environment.

Electronics and electrical equipment seem efficient and environmentally-friendly, but there are hidden dangers associated with them once these become e-waste. The harmful materials contained in electronic products, and replacing outdated units due to technological updation pose a real danger to human health if electronic products are not properly processed prior to disposal.

Heavy metals such as lead, barium and cadmium contained in some electronic and electrical gadgets can be very harmful to health if they enter the water system. These materials can cause damage to the human nervous and respiratory systems.

India is among the world's largest consumers of mobile phones. With more than 1.5 million tonnes of e-waste generated annually, most consumers are still unaware of how to dispose of their e-waste. Recycling of e-waste was almost entirely left to the informal sector, which does not have adequate means to handle either the increasing quantities or certain processes, leading to intolerable risk for human health and the environment.

The law on e-waste management was first passed in 2011. It was based on Extended Producer Responsibility (EPR), which put the onus on the producer for the management of the final stages of the life of its product, in an eco-friendly way, by creating certain norms in tandem with State Pollution Control Boards. It has been made mandatory for leading multinational companies to set up electronics manufacturing facilities and R&D centres for hardware and software. E-waste (Management) Rules, 2016, enacted since October 1, 2017, had further strengthened the existing rules. The present rule has strengthened the Extended Producer Responsibility (EPR), which is the global best practice to ensure the take-back of the end-of-life products. A new arrangement entitled, 'Producer Responsibility Organisation' (PRO) has been introduced to strengthen EPR further. PRO, a professional organisation, would be authorised or financed collectively or individually by producers, to share the responsibility for collection and channelisation of e-waste.

Further, Central Pollution Control Board (CPCB) shall conduct random sampling of electrical and electronic equipment placed on the market to monitor and verify the compliance of law on Restriction of Hazardous Substances (RoHS) and the cost for sample and testing shall be borne by the producer. The random sampling shall be as per the guidelines of CPCB. If the product does not comply with RoHS provisions, the producers shall take corrective measures to bring the product into compliance, and withdraw or recall the product from the market, within a reasonable period as per the guidelines of CPCB.

SPECIAL ARTICLE

Steps to Achieve India's Solar Potential

Sumant Sinha

The needs of India's burgeoning population are rising. However, the status quo of resources might not be adequate to fulfill the growing demands of a fast paced economy. Take for example the power sector.

Country's per capita consumption of electricity stands at a meagre 1,100 kWh/year which is much lower compared to other large economies like the US and China. Demand for power is set to rise further with increasing rates of urbanization and industrial growth. Plugging this demand supply gap by augmenting capacity in the power sector is a key priority for the policy makers.

Unfortunately, our traditional sources of energy generation are already nearing their saturation levels. India must also honour its global commitments on curbing greenhouse gas emissions, as per the Paris

The author is the Chairman and Managing Director of ReNew Power.

Agreement, implying we need to move away from a fossil fuel driven growth path. Clearly, we need to look at alternate solutions so we can address our energy security in a sustainable fashion, with a progressive reduction in carbon levels. Evidence from several developed countries points towards renewable energy adoption as the only way forward. Clearly, India needs to adopt this route in its growth journey. The country has a huge potential for harnessing renewable energy, especially solar, since almost the entire country is blessed with abundant sunlight throughout the year.

The Indian Government has set the renewables capacity target at 175 GW, to be achieved by the year 2022, with the highest percentage, 100 GW, to be contributed by solar power. The Government has accorded prime focus to this sector, with several initiatives and incentives to attract more players and ramp up capacity. As a result, in the past years, we have already added 28 GW solar capacity while the compound annual growth rate has reached as high as 55 per cent. Launch of the International Solar Alliance, was also a significant step to strengthen the sector. By setting up solar parks, providing viability gap funding support and introducing schemes like KUSUM (aiming to harness solar power for agriculture) and SRISTI (catalyzing adoption of rooftop solar solutions), the Government has shown its keenness to fast track growth of solar industry. However, there is room for more strategic interventions to fully realise India's solar potential and plenty of groundwork is needed to help us move closer to the ambitious target of 100 GW solar power capacity by 2022. Here are five areas that need more attention and focus, to take the Indian solar power industry to the next level.

India must also honour its global commitments on curbing greenhouse gas emissions, as per the Paris Agreement, implying we need to move away from a fossil fuel driven growth path. Clearly, we need to look at alternate solutions so we can address our energy security in a sustainable fashion, with a progressive reduction in carbon levels. Evidence from several developed countries points towards renewable energy adoption as the only way forward.

1) Technology

While solar is becoming an important contributor to energy needs in India, there is still a huge gap to be filled. Rooftop solar solutions, for example, can add large capacities but certainly need a push from respective state governments. Newer advancements in the field like floating solar (solar panels mounted on structures that float on water bodies), and BIPV (wherein the conventional materials used for facades and roofs of buildings are replaced by photovoltaics systems) can play a vital role in increasing capacity. Considering the huge potential in the sector, both the government and private entities must emphasise and support R&D and adoption of latest technology and innovations in this area. This will not only help shape the future course but also yield benefits in the form of reduced costs – in turn facilitating adoption.

2) Policy Push

Thanks to technology evolution and government policy, solar power tariffs have decreased over the past few years making solar energy more accessible to the common man. However, tariff margins discovered in reverse auctions have been pushed lower in recent years leading to a squeeze in profit margins. Considering that tariffs are now significantly lower than other sources of energy, we need to move towards healthier tariffs to help private players work with sustainable business models, and attract a higher capital inflow. This will eventually lead to augmented supply and further lowering of prices for the common people. Respective state governments should also accentuate the rate of solar power generation with regular capacity addition.

3) Discom Health

Despite the government's initiatives to reinvigorate power distributing companies, the health of state discoms has not improved much over the years. These distribution companies form a crucial link in the cycle of energy generation and have an impact on the overall process. Hence, maintaining

Rooftop solar solutions, for example, can add large capacities but certainly need a push from respective state governments. Newer advancements in the field, like floating solar (solar panels mounted on structures that float on water bodies) and BIPV (wherein the conventional materials used for facades and roofs of buildings are replaced by photovoltaics systems) can play a vital role in increasing capacity. Considering the huge potential in the sector, both the government and private entities must emphasise and support R&D and adoption of latest technology and innovations in this area.

discoms in good shape forms an extremely important link on the road to 2022. The healthier the distribution companies, the more power they can purchase and supply. Steps should be taken to strengthen the discoms such that they are able to support higher tariffs, honour RPOs and settle power providers' dues on time.

The government should also bring in policies to operationalise ancillary and capacity markets to extract the total value of renewable energy technologies.

4) Financial Reforms

Reforms in banking systems will go a long way in assisting the renewable energy sector. As of now, sectoral categorisation of banks sees renewables as part of the power sector, due to which, for most banks, the loan limit is majorly consumed by thermal plants and only a small fraction of the fund remains available for the renewables sector. Reality is that the renewables sector has clocked exponential growth and contributed handsome revenues to the exchequer. Considering the above, renewables should be categorised as a separate sector. This will help widen access to funds and simplify the process of loan procurement for companies. The government can also consider according priority sector status to renewables, given its strategic importance. Deeper and diverse bond markets will help in securing affordable finance for clean energy projects in the future. The government should continue its mission of cleansing the banking system and help them regularise bad loans while also reviewing lending norms so they are less stringent. A healthy banking system will be able to provide more funds at a competitive cost to propel the renewables sector.

5) Enabling Ease of Doing Business

The government's pursuit of reforms has created a more conducive environment for investments in India, reflected in our steady rise in Ease of Doing Business rankings over the past couple of years. However, faster processing of approvals for project implementation across the value chain, especially conversion approvals of land in different states would be of great help to the renewables sector. It has been seen that lack of proper power evacuation infrastructure has resulted in investor disinterest in the past. Considering this, the government should work on building more robust transmission systems. This will not only increase investor faith in the overall process but will also ensure no MW loss/leakage during power distribution.

Achieving the ambitious target of 100 GW solar power capacity by 2022 needs a collaborative effort from all the stakeholders, including the central and state governments' financers, discoms and private players. The government has a key role to play — not only by providing the required policy support but also acting as a central coordinator- guiding and synchronising efforts from various stakeholders, to catalyze the solar industry's growth. ❑

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Geo-Thermal and Ocean Energy Technologies

Anubhav Uppal

Keeping in view the commitment for a healthy planet and as per India's Nationally Determined Contributions made in the Paris Accord on Climate Change, India has made a pledge that by 2030, 40 per cent of installed power generation capacity shall be based on clean energy sources. Accordingly, an ambitious target has been set of installing 175 GW of renewable energy capacity by 2022. This includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power. As on date, around 77 GW of renewable energy capacity has been installed in the country with major share coming from solar and wind power technologies. The possibility of venturing into new emerging renewable energy technologies, such as Floating Solar, Offshore wind, solar wind hybrid, energy storage, etc is also being explored. However, renewable energy technologies such as geo-thermal and ocean energy still remain at a nascent stage in India.

Ocean Energy

Oceans occupy more than 70 per cent of earth's surface and are an inexhaustible source of renewable energy. Ocean energy is the energy harnessed from ocean waves, tidal range (rise and fall) & tidal streams, temperature gradients and salinity gradients. Only few commercial ocean energy power plants have been commissioned till date. Around 536 MW of installed ocean energy capacity is in operation at the end of 2016, with major share of two large scale tidal barrage plants i.e. the 254 MW Sihwa plant in the South Korea (completed in 2011) and the 240 MW La Rance tidal power station in France (completed in 1966). Apart from tidal barrage plants which use established tidal turbine technology, other ocean energy technologies are still largely in pre-commercial development stages.

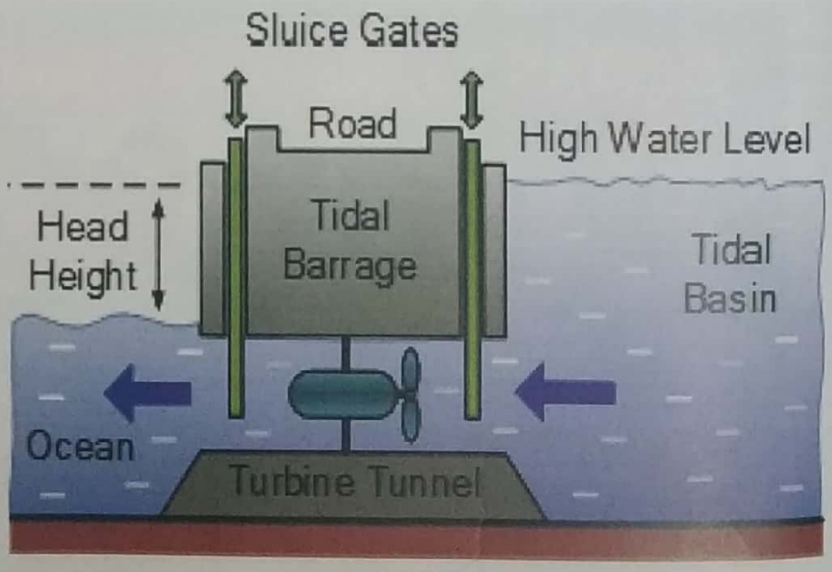
World Scenario

Leading countries in Ocean Energy technology are UK, USA, Sweden, Canada, France, South Korea. Examples of few large scale Tidal (Barrage) Plants are 254 MW at South Korea (2011), 240 MW at France (1966), 20 MW at Canada, etc. Ocean Technology, such as Tidal (Current), Wave, Ocean Thermal Energy Conversion (OTEC) are still at pre R&D stage/Kilo Watt level.

Geothermal Energy has experienced modest growth worldwide in recent times as compared to other Renewable Energy sources especially wind or solar due to its site specific nature, risk/uncertainty involved with resource exploration and high capital cost.

Indian Scenario

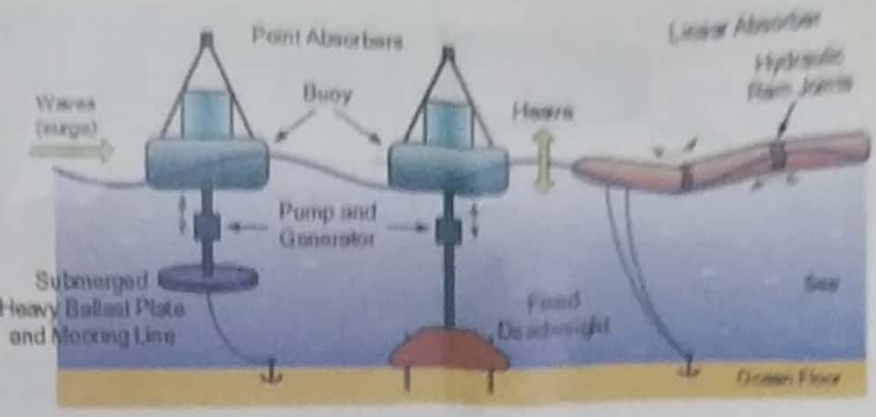
As per study conducted by IIT Madras, Theoretical Potential for tidal Energy in India is 12500 MW, Promising locations are Gulf of Khambhat & Gulf of Kutch (GJ), Sunderbans (WB), Western Ghats (MH), etc. Theoretical Potential for Wave Energy in India is 41,000 MW, Promising locations are



Tidal Energy

The author is Scientist B, Ministry of New & Renewable Energy, Government of India.

Western Coast of Maharashtra, Goa, Karnataka, Kerala, Kanyakumari, Southern tip of India, etc. However, resource survey at target locations i.e. Western Ghats, Eastern Ghats, etc. may be undertaken to assess/ validate actual potential. These technologies are more suitable for off grid electricity generation in remote coastal areas/mangroves/ islands where Tariff is very high @ Rs 25/Kwh for diesel based captive power generation. Major bottlenecks for deployment are high upfront cost i.e. Rs 60 Crore for 1.125 MW wave energy plant at A&N islands and Rs 2000 Crore for 8 MW plant by Indian Navy, high tariff @ Rs 15.69/ KWh with 50 per cent grant for A&N wave energy plant.



Wave Energy Converters

Technology

a) Tidal Energy

The tidal cycle occurs every 12 hours due to the gravitational pull of the moon. The difference in water level from low tide and high tide is potential energy that can be harnessed. Similar to hydropower generated from dams, tidal water is captured in a barrage across an estuary during high tide and forced through a turbine during low tide. The capital cost for tidal energy power plants is very high due to high civil construction that results in high power tariff. In order to harness power from the tidal energy, the height of high tide must be at least five meters (16 feet) greater than low tide.

b) Wave Energy

Wave energy is generated by the movement of a device either floating on the surface of the ocean or moored to the ocean floor by the force generated by the ocean waves. Many different techniques for converting wave energy to electric power have been developed. Wave conversion devices floats on the surface have joints hinged together that moves with the waves. The kinetic energy pumps fluid through turbines and generates electric power. Moored wave energy conversion devices use pressure fluctuations produced in long tubes from the waves moving up and down. This wave motion drives a turbine.

c) Current Energy

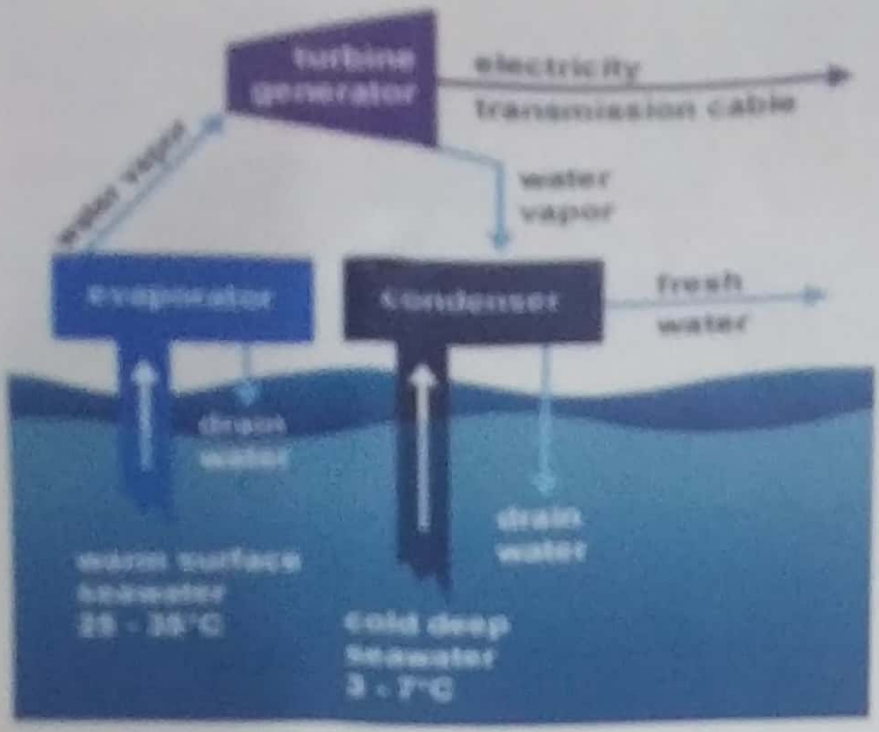
Ocean current is ocean water moving in one direction. This ocean current is also known as the Gulf Stream. Kinetic energy can be captured from the Gulf Stream and other tidal currents with submerged turbines that are very similar in appearance to miniature wind turbines. Similar to wind turbines, the movement of the marine current moves the rotor blades to generate electric power.

Ocean current turbine

d) Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion, or OTEC, uses ocean temperature differences from the surface to depths lower than 1,000 meters, to harness energy. A temperature difference of even 20°C can yield energy efficiently. Research focuses are on two types of OTEC technologies to extract thermal energy and convert it to electric power: closed cycle and open cycle.

In the closed cycle method, a working fluid, such as ammonia, is pumped through a heat exchanger and vaporized. This vaporized steam runs a turbine. The cold water found



Ocean Thermal Energy Converter

at the depths of the ocean condenses the vapor back to a fluid where it returns to the heat exchanger. In the open cycle system, the warm surface water is pressurized in a vacuum chamber and converted to steam to run the turbine. The steam is then condensed using cold ocean water from lower depths.

Future Road Map

Most Ocean Technologies are still at Pre R&D/commercialization stage worldwide. Therefore, technologies need validation from leading research institutes before demonstration. It is necessary to plan to develop Demonstration projects initially for each ocean energy technology at feasible sites before going for commercial plants to also to undertake resource assessment with support from leading countries in ocean energy expert.

Geothermal Energy

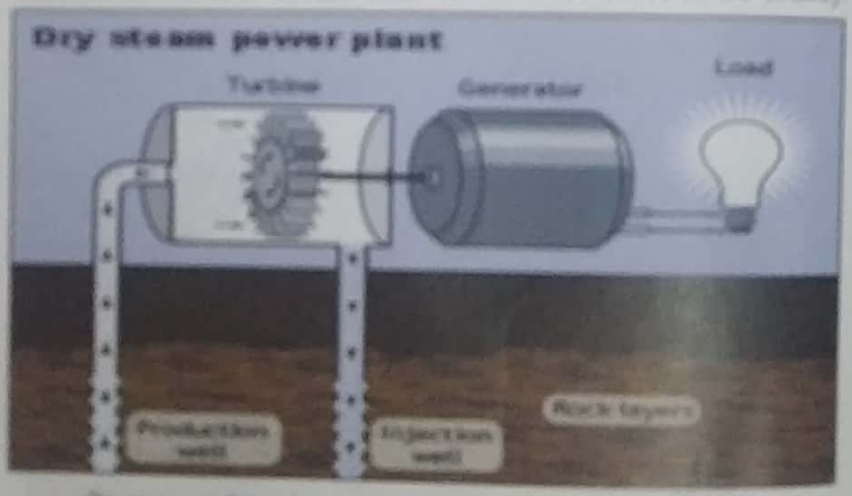
Geothermal Energy is a mature renewable energy technology that has a potential to provide clean and reliable energy for power generation and direct heating/cooling. Geothermal Energy can be utilized for both electric power production and direct heat applications including Ground Source Heat Pump (GSHP) for space or district heating, generating hot water for domestic/industrial use, running cold storages and greenhouse, horticulture, etc. However, Geothermal Energy has experienced modest growth worldwide in recent times as compared to other RE sources especially wind or solar due to its site specific nature, risk/uncertainty involved with resource exploration and high capital cost.

World Scenario

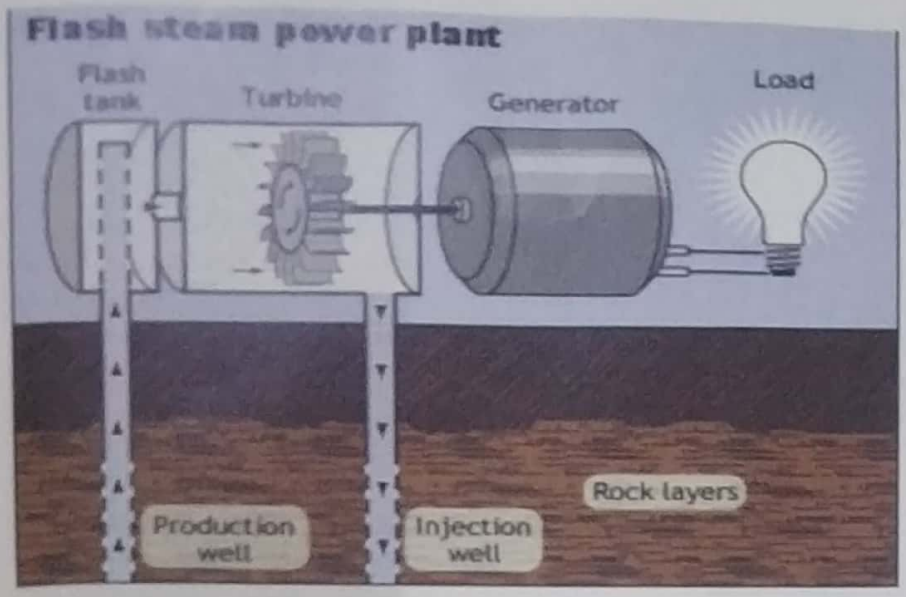
Total Installed Capacity for Geothermal Power is around 13.5 GW. Leading countries in geothermal power generation capacity are USA (3600 MW), Philippines (1900 MW), Indonesia (1600 MW), New Zealand (1000 MW), Mexico (900 MW), Italy (800 MW), Turkey (800 MW), Iceland (700 MW), Kenya (600 MW) & Japan (500 MW). Total installed capacity for geothermal direct heat utilization for heating/cooling (excluding heat pumps) is around 23 GWth. Leading countries in geothermal direct heat use are China (6.1 GWth), Turkey (2.9 GWth), Japan (2.1 GWth), Iceland (2.0 GWth) & Italy (1.4 GWth). Total installed capacity for Ground Source Heat Pump (GSHP) is around 50.3 GWth with leading markets as USA, China & Europe (France, Germany, Italy & Sweden).

Indian Scenario

India is still at nascent stage of geothermal energy utilization with no geothermal power plant set up in the country so far due to high upfront cost of Rs 30 Cr/MW & indicative Tariff in range of Rs 10 per KWh, site specific deployment, lack of load center and power evacuation facility nearby, high risk involved in exploration, etc. Geological Survey of India (GSI) with CSIR - National Geophysical Research Institute (NGRI) carried out preliminary resource assessment for the exploration and utilization of geothermal resources in 1970s & 1980s in the country



Dry steam geothermal power plant (Source: US Department of Energy)



Flash steam geothermal power plant (Source: US Department of Energy)

As per preliminary investigations undertaken by the GSI, there are around 300 geothermal hot springs in India. Most of these geothermal hot springs are in medium potential (100 C to 200 C) and low potential (<100 C) zones. The promising geothermal sites for electric power generation are Puga Valley & Chummathang in Jammu & Kashmir, Cambay in Gujarat, Tattapani in Chattisgarh, Khammam in Telangana & Ratnagiri in Maharasthra. The promising geothermal sites for direct heat use applications are Rajgir in Bihar, Manikaran in Himachal Pradesh, Surajkund in Jharkhand, , Tapoban in Uttarakhand & Sohana region in Haryana.

Technology

Power Generation: Hot water and steam from deep underground can be piped up through underground wells and used to generate electricity in a power plant. There are three types of geothermal power plants:

i) **Dry Steam Plants** which use geothermal steam directly. Dry steam power plants use very hot (>235 °C) steam from the geothermal reservoir. The steam goes directly through a pipe to a turbine to spin a generator that produces electricity.

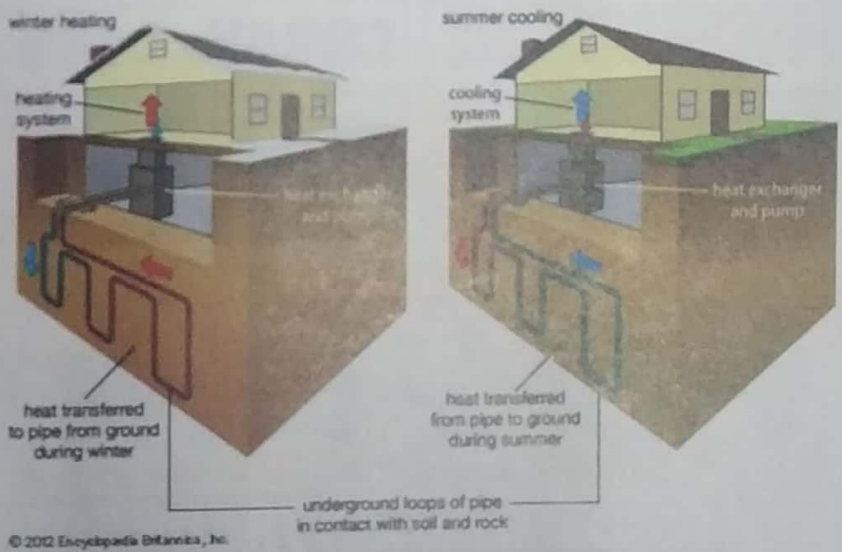
ii) **Flash Steam Plants** which use high pressure hot water to produce steam. Flash steam power plants use hot water (>182 °C) from the geothermal reservoir. When the water is pumped to the generator, it is released from the pressure of the deep reservoir. The sudden drop in pressure causes some of the water to vaporize to steam, which spins a turbine to generate electricity. Hot water not flashed into steam is returned to the geothermal reservoir through injection wells.

iii) **Binary Cycle Plants** which use moderate-temperature water (107 to 182 °C) from the geothermal reservoir. In binary systems, hot geothermal fluids are passed through one side of a heat exchanger to heat a working fluid in a separate adjacent pipe. The working fluid, usually an organic compound with a low boiling point such as Iso-butane or Iso-pentane, is vaporized and passed through a turbine to generate electricity.

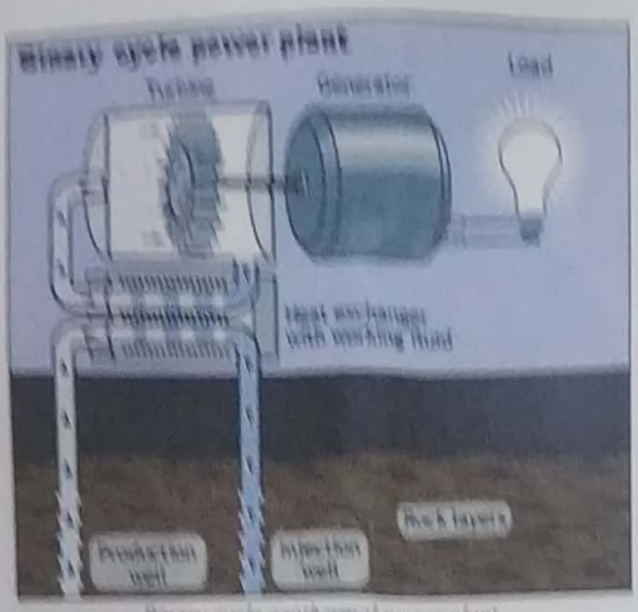
Other thermal applications: Apart from geothermal power generation, this renewable source can be utilized directly for thermal applications through these technologies:-

i) **Space/District Heating**: In areas where hot springs or geothermal reservoirs are near the Earth's surface, hot water can be piped in directly to heat homes or office buildings. Geothermal water is pumped through a heat exchanger, which transfers the heat from the water into the building's heating system. The used water is injected back down a well into the reservoir to be reheated and used again.

ii) **Geothermal Heat Pump/ Ground Source Heat Pumps**: A few feet under the ground, the soil or water remain a constant



Geothermal Heat Pump (Source: Encyclopaedia Britannica)



Binary cycle geothermal power plant
(Source: US Department of Energy)

50 to 60 degrees Fahrenheit (10-15 degrees Celsius) year-round. In this method, geothermal heat pumps use a system of buried pipes linked to a heat exchanger and ductwork into buildings. In winter the relatively warm earth transfers heat into the buildings and in summer the buildings transfer heat to the ground or uses some of it to heat water. These heat pumps function as both air-conditioning and heating systems. Fluid circulates through a series of pipes under the ground or beneath the water of a pond or lake and into a building. An electric compressor and heat exchanger pull the heat from the pipes and send it via a duct system throughout the building. In the summer the process is reversed. The pipes draw heat away from the house and carry it to the ground or water outside, where it is absorbed.

Future Roadmap

Industry led, applied R&D proposals to harness geothermal energy under Research, Design, Development & Demonstration (RDD&D) policy are necessary for this renewable energy source to become operational. Plans should be made to develop Demonstration projects initially each for geothermal electricity production & direct heat use applications. PSUs may undertake resource assessment with support from leading countries as geothermal expert. Projects for space cooling and industrial process heating using GSHP technology may be supported through subsidy, preferential tariff from power companies as technology is energy/water efficient. ❑

(E-mail: anubhav.mnre@gov.in)

Biogas–A Story Untold

Richa Mishra

Read in school that solid wastes can be converted into gas to produce energy and that electricity can be generated by burning sold waste found in the landfills. Wonder how?

India generates about 1,45,128 tonne of waste daily (or around 53 million tonne annually) and on an average 46 per cent of it is processed daily, according to the Ministry of New and Renewable Energy (MNRE).

For a country like India that is heavily dependent on expensive imported oil and gas imports as well as coal for meeting its energy requirements, it definitely makes more sense to look at alternative resources. And this is where the Waste to Energy programme propagated to recover energy in the form of Biogas/ BioCNG/ Power from urban, industrial and agricultural wastes gains importance. Besides, it also promotes off-grid connectivity.

While a programme of this kind requires government support, the challenge is to ensure that various Ministries work in synergy. Another, challenge for Waste to Energy management is, how various schemes can become revenue generator for small players.

But, there is a hitch here – shifting social dynamics.

"Maintaining cattle is becoming difficult for an individual. Therefore, individual biogas plants are seeing a decline. However, scope for larger private plants is growing with more private diaries coming into business. So, the effort should be to promote larger projects," said an official.

About 184 Waste to Energy plants based on urban, industrial and agricultural wastes have been set up in private sector with an aggregate capacity of 315.24 MWeq. However, there are still many challenges remaining to promote this programme as it also means undoing a social mindset.

For a country like India that is heavily dependent on expensive imported oil and gas imports as well as coal for meeting its energy requirements, it definitely makes more sense to look at alternative resources. And this is where the Waste to Energy programme propagated to recover energy in the form of Biogas/ BioCNG/ Power from urban, industrial and agricultural wastes gains importance. Besides, it also promotes off-grid connectivity.

It also needs to be ensured that Waste to Energy plants themselves do not violate any environmental norms particularly for municipal solid wastes. Marketing of the concept is another uphill task which requires governmental involvement as well as financial support is needed in setting up a plant, which is not cheap.

The author is Associate Editor/Bureau Chief Delhi, The Hindu - Business Line.

Biogas can be used for transport fuel. In fact, oil refining and marketing companies have got into action to make it a reality. What is Compressed Biogas (CBG) and how does it work? According to experts, it has the potential to boost availability of more affordable transport fuels, better use of agricultural residue, and cattle dung, as well as to provide an additional revenue source to farmers.

Called Sustainable Alternative Towards Affordable Transportation (SATAT), it is expected to benefit vehicle-users as well as farmers and entrepreneurs. Besides, CBG will also help bring down dependency on crude oil and gas imports. The potential for CBG production from various sources in India is estimated at about 62 million tonnes annually.

CBG can be produced from various bio-mass/waste sources, including agricultural residue, sugarcane press mud, distillery spent wash, cattle dung and sewage treatment plant waste. The other waste streams, like rotten potatoes from cold storages, rotten vegetables, dairy plants, chicken/ poultry litter, food waste, horticulture waste, forestry residues and treated organic waste from industrial effluent treatment plants (ETPs) can be used to generate biogas.

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In fact, CBG is similar to the commercially available natural gas in its composition and energy potential and can be used as an alternative, renewable automotive fuel. Given the abundance of biomass in the country, CBG has the potential to replace CNG in automotive, industrial and commercial uses in the coming years, as Pradhan had said. Industry experts say that if the country exploits this, no surprises then that gas imports will come down to zero one day.

There are multiple benefits of converting agricultural residue and cattle dung into CBG on a commercial scale:

- Responsible waste management, reduction in carbon emissions and pollution
- Additional revenue source for farmers
- Boost to entrepreneurship, rural economy and employment
- Support to national commitments in achieving climate change goals
- Reduction in import of natural gas and crude oil
- Buffer against crude oil/gas price fluctuations

But, a lot depends on pricing as India is a price sensitive market. The Working Group on Biofuels is in the process of finalising a pan-India pricing model for CBG. Besides, according to the proposal, the entrepreneurs would be able to separately market the other by-products from these plants, including bio-manure, carbon-dioxide, etc. to enhance returns on investment.

While solar and wind did develop a glam quotient, they can only be intermittent to coal or other fossil fuel. What can actually work in favour of India is biogas. Yes, there are challenges like CBG quality and marketing.

Biogas cannot succeed without governmental support as it is still at a very nascent stage here. But once it takes off, the government can play the role of a facilitator and allow private sector to run the business. ❑

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Driving a Green Transition for the Environment

Venkatesh Dwivedi

With global penetration growing at close to 75 per cent[1] per year, electric mobility is the definitive game-changer for the transport sector the world over. India has its own vision for electric mobility: as a member of the eight-country Clean Energy Ministerial,[2] a high-level forum to promote clean energy policies and programmes, India aims to achieve a 30 per cent electric vehicle penetration by 2030. This goal is inspired not only by the promise of curtailing its crude oil dependence, but also for environmental sustainability.

Going electric for the environment

A fossil-fuel powered mobility ecosystem is environmentally unsustainable, due to a variety of reasons. Foremost are the greenhouse gas (GHG) emissions in the form of tail-pipe exhaust. Internal combustion engines (ICEs) are among the leading sources of air pollution across the world,[3] and India regularly features in the list of countries which have the world's highest[4] rates of vehicular emissions, and correspondingly, air pollution[5]-related deaths.

According to the National Green Tribunal (NGT), vehicular emission is one of the major sources of India's urban pollution. By 2030, India is anticipated to have an estimated 400 million customers[5] in need of mobility. For one of the largest auto markets in the world, fossil-fuel-led mobility will imperil environmental sustainability.

On the whole, electric vehicles offer environmental benefits. They have zero tail-pipe emissions, simply because they do not use an internal combustion engine (ICE). According to

The increasing public consciousness on the adverse health effects of air pollution combined with robust policy framework for EVs has translated to the emergence of a fast-growing private sector ecosystem. India's e-mobility sector is also taking cues, insights and knowledge from global counterparts and adapting best practices to an Indian context.

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a NITI Aayog report, India can reduce 64 per cent of the energy demand for road transport and 37 per cent of carbon emissions by 2030, by pursuing a shared, electric and connected mobility future.

What about emissions from an electric mobility future?

Naysayers may argue that EVs are simply transferring the burden of fossil fuel, if instead of petrol and diesel, the source of electric power generation is coal. Coal-based thermal power generation today meets 70 per cent[6] of India's power needs. Coal is also the bane of India's energy value chain from an environmental point of view, along with pushing out airborne emissions of poisonous chemicals like carbon dioxide, combustion of coal for thermal generation also releases sulphur dioxide, nitrogen oxide and mercury, all poisonous particulate matters, into the air. According to a study published in the journal *Nature Sustainability*[9] in February, India's coal-fired power plants are the most dangerous when it comes to their health impact.

Could more electric mobility-linked demand simply trigger more coal-based energy demand?

First, let's look at the math.[8] A single kilowatt of energy can give an EV a range of 10 kilometres. If coal is used for generation, this translates to 1 kg of CO_2. In comparison, a litre of petrol or diesel can provide a range of 10 km for city driving- and generate 2.3 to 2.7 kg of CO_2 per km in emissions.

Similarly, research in Europe[9] has shown that even powered by the most carbon-intensive electricity, EVs still have lower GHG emission than a conventional, internal combustion engine powered vehicle. Secondly, EVs convert[10] about 59 per cent–62 per cent of the grid energy to power at the wheels. In comparison, ICE vehicles convert maybe a fifth of petrol's energy to drive power. It is instantly clear that even with coal-powered generation powering them, EVs are still going to be more efficient (with regard to emission) than when powered by conventional fuels. Further, when calculating emissions from a purely energy generation point of view - renewable vs. conventional - calculations do not include the considerable energy required to extract, refine and manufacture petrol or diesel. In sum, in every way possible, conventional energy, whether derived from coal or petrol/diesel, is always going to be more inefficient than electricity generation for EV use.

Secondly, India is fast shaping its transition to a renewable-led energy future. The nation is very much on track to meet, and possibly outperform its target of 100 GW of solar energy capacity (as part of a larger 175 GW renewable target) by 2022, according to Central Electricity Authority (CEA) data. A robust target gave a clarion call to industry and policy to synergise. The result: India is today the world's second most attractive market for renewable energy equipment in the world.

Simultaneously, to ensure that solar, and other renewable forms of energy are not hurt by their biggest drawback – intermittency – there are a few plans in the offing. While India's renewable players had proved their mettle in generational capacity, one of the biggest challenges here have been transmission constraints.

The recent national Mission on Transformative Mobility and Battery Storage,[12] which encourages setting up large-scale, export-competitive integrated batteries and cell-manufacturing giga-plants in India through a Phased Manufacturing Programme (PMP). The mission's focus on production localization can bring down the battery storage costs. Considering that battery costs are a significant cost to overall EV costs, this step can make EVs affordable, making them attractive.

Investment in battery technology is also important from an environmental point of view. Enabling the storage of highly variable, season and time-

of-day dependent energy sources like solar and wind, battery technology presents a powerful pathway out of coal dependence. Solar-powered public charging stations are also being rolled out by discoms like BHEL and across India, delivering 100 per cent zero-emissions based electricity to electric vehicles. Establishing strong linkages between renewable energy and electric mobility, these initiatives are ensuring that at the last-mile, EV-owners can access sustainably generated energy with ease and affordability.

How is India enabling the electric transition?

Strategies like demand and supply side-incentives; promotion of R&D in battery technology and management systems; promotion of charging infrastructures are some measures required to bring about the mobility transition This transition is anticipated to provide a thrust to investments in the EV eco-system. While the Indian EV story has been in making for almost two decades, now it seems to be acquiring significant momentum in both its mobility and overall sustainable energy transition. The increasing public consciousness on the adverse health effects of air pollution combined with robust policy framework for EVs has translated to the emergence of a fast-growing private sector ecosystem. India's e-mobility sector is also taking cues, insights, and knowledge from global counterparts, and adapting best practices to an Indian context. Considering both its environmental and economic benefits, the goal of 30 per cent fleet electrification will necessitate even more collaboration among OEMs and related service providers across automobile, technology, energy, and allied fields.

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India's Conundrum: Aligning Emission Mitigation with Development

Ritu Mathur, Garima Vats, Swapnil Shekhar

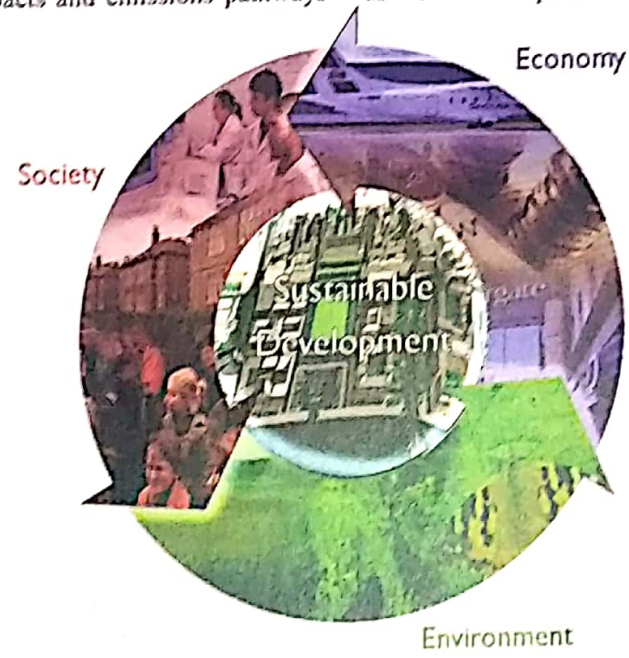
With a per capita GDP of $1965 (vis-à-vis a world average of $10363), India's HDI is 0.64, placing it at a rank of 130 among 189 countries.[1] Despite being one of the fastest growing economies of the world, nearly 12 per cent of the households still do not have access to basic services like clean water[2] and 55 per cent of the households live in mud or semi-concrete houses.[3] Even in 2011/12, around 52 per cent households used firewood for cooking. India's per capita electricity consumption was about a fourth of the global average while its per capita energy consumption was around one-fifth of the global average in 2015/16,[4] reflecting a combination of the prevailing energy access and affordability issues. Accordingly, India still needs to significantly improve its development infrastructure towards achieving higher levels of well-being for its population.

Historically, the developed countries accounted for the larger part of the global emissions as they industrialised and developed their infrastructure earlier. In recent years, as economic growth picked up in the non-OECD countries, the share of OECD and non OECD emissions has reversed, and was 37.2 per cent and 62.8 per cent in 2017 as compared to 61 per cent and 39 per cent respectively in 1960. India and China accounted for 55 per cent of non- OECD emissions, with China contributing to 44 per cent and India accounting for 11 per cent in 2017.[5]

India's GHG emissions (excluding land use change and forestry) increased by nearly 115 per cent between 1994 and 2014, the energy sector contributing to the majority of GHG emissions which went up from 61.3 per cent in 1994 to 70.7 per cent in 2010,[6] and 76.6 per cent in 2014. The per capita GHG emissions between 1994 and 2014 went up by 56.4 per cent, from 1.3 to 2.0 tonnes of CO_2e per capita[7] which is still less than half of the current global average.[8]

The recent IPCC Special Report on impacts and emissions pathways of 1.5°C clearly states that the speed and scale with which transitions will need to occur are not the same as would be required for 2°C world.

The key elements of India's current transition story need to relate with enhancing efficiency in the energy system to dampen the growth in future energy requirements and to simultaneously transition towards cleaner energy forms, wherever feasible, to reduce the ensuing emissions. Accordingly, we are now witnessing the era of the transition to new renewables like solar and wind energy.



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The world would require rapid and far reaching transitions at the global as well as national levels.[9] Therefore it is clear that while rapid and inclusive development is clearly an overriding priority for the country on one hand, the global responsibility and pressure on India to grow sustainably is also significant as the urgency to address climate change issues is assuming increasing importance globally.

What makes India's current energy transition unique?

Energy transition is by no means a new concept for India – the country has had a history of transitioning to different energy choices based on the stage of the country's development and main national priorities. In the initial years of national planning following India's independence, the primary focus was on socio-economic development and energy policies focused on supply adequacy and infrastructure development. In the years that followed, the energy sector witnessed a gradual transition away from traditional use of biomass to modern energy forms like coal and petroleum products. The 5-Year Plans shifted their focus from issues of energy access in the 1970s, to that of national energy security in the 1980s and modernization of energy infrastructure in the 1990s.[10] During these years, the energy sector witnessed a transition towards higher levels of electrification and an increase in the share of thermal power generation (especially coal based) as compared to hydro power, as energy supply saw rapid increase. Increasingly, the understanding of energy security also evolved to include aspects of access, affordability and efficiency rather than being seen in a narrow sense of only national self-sufficiency. India's Eleventh (2007-2012) and Twelfth Plan (2012-17) presented the broad vision and aspiration of a 'faster, sustainable, and more inclusive growth'[11] and priority to environmental sustainability was also explicitly mentioned.

The key elements of India's current transition story need to relate with enhancing efficiency in the energy system to dampen the growth in future energy requirements and to simultaneously transition towards cleaner energy forms, wherever feasible, to reduce the ensuing emissions. Accordingly, we are now witnessing the era of the transition to new renewables like solar and wind energy.

The role of energy efficiency as a key element of India's sustainable development path can be easily understood since whatever energy reduction is achieved, it directly contributes to lowering the pressure on energy and infrastructure supply of a rapidly growing economy and in turn contributes to reducing the energy or emissions intensity of the country.

Given the global urgency to tackle climate change, following the Paris Agreement in 2015, India had set out its Nationally Determined Contribution (NDC) targets for 2030, which broadly have three main targets, viz:[12]

1. Reducing the emissions intensity of its GDP by 33 per cent-35 per cent from 2005 levels.

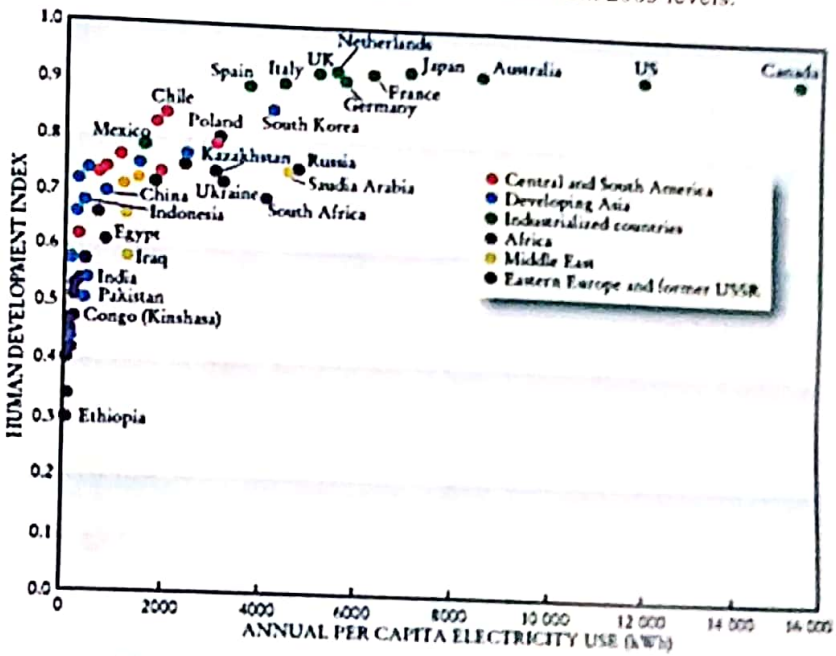


Figure 1: Human Development Index (HDI) of countries plotted against their per capita electricity use in kWh;
Source: Human Development Report 2018, World Bank 2019

2. Achieving 40 per cent cumulative electric power installed capacity based on non-fossil energy sources, contingent on international transfer of technology and low cost finance.
3. Creating an additional carbon sink of 2.5- 3.0 billion tonnes of CO_2 equivalent through additional forest and tree cover.

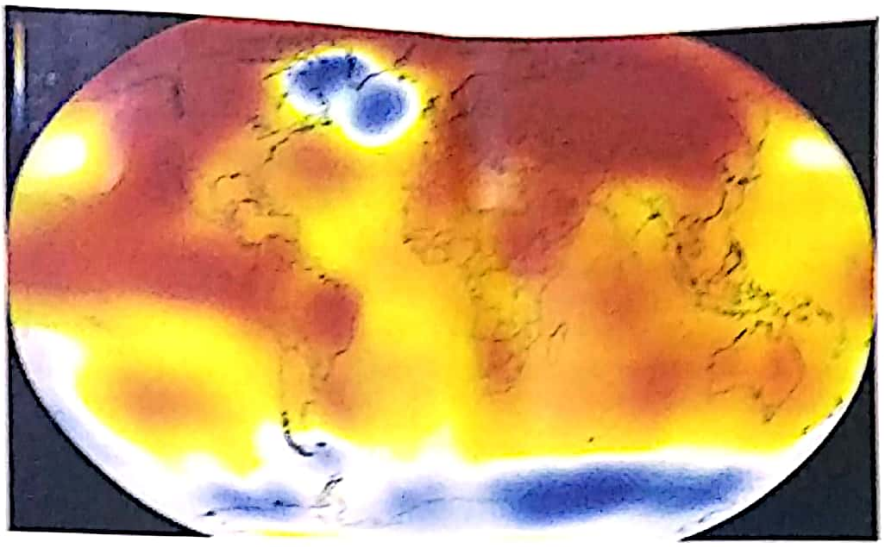
Out of the three main NDC targets, the first two relate with the energy sector which not only indicates the importance but also the crucial role that this sector needs to play in achieving India's emission reduction.

Despite its low historic emissions, India is today at a juncture where it is faced with tremendous pressure to increase its economic growth and provide for improved access to energy and services whilst attempting to simultaneously minimise GHG emissions. Most countries have in the past undertaken a decoupling of emissions from their growth trajectory at a time when the requirement for rapid growth and industrialization was already over. Also, no other country has been able to achieve an HDI of 0.9 or more without a per capita electricity consumption of at least 4000 kWh per annum[5] (Figure 1).

This places India in a unique position where the need to think about the transitions in the coming years needs to be more innovative and holistic in nature, so as to simultaneously and synergistically align development objectives with environmental sustainability.

India's energy sector choices for low carbon development

Based on analysis of several energy sector scenarios developed by TERI as part of a study,[6] the three most relevant areas that could contribute to energy sector decarbonisation include energy efficiency improvements, power sector decarbonisation through renewables like solar and wind, and increased electrification of end-uses as the power sector gets increasingly decarbonised.



The role of energy efficiency as a key element of India's sustainable development path can be easily understood since whatever energy reduction is achieved, it directly contributes to lowering the pressure on energy and infrastructure supply of a rapidly growing economy and in turn contributes to reducing the energy or emissions intensity of the country.

A recent assessment indicates that an energy reduction of at least 12 per cent could be achieved by 2041 by efficiency improvements alone across energy demand sectors. The maximum scope for energy efficiency rests in the industrial sector [specifically iron & steel, and micro, small and medium enterprises (MSMEs)], followed by transport sector (through shift of mobility from road to rail and vehicular efficiency improvement), commercial sector (specifically shops and malls) and residential sector (space conditioning and lighting).[7]

Moving towards renewables such as solar power is a "win-win" option for India given the abundance of sunshine in the country and the rapid development of solar technologies that has resulted in a rapid plummeting down of renewable based electricity costs in recent times. Today, the cost of renewables (especially solar) has decreased rapidly, making it fairly competitive with fossil based generation. It is expected that renewable electricity (with storage) would attain large scale commercial viability by 2030, thereby overcoming the intermittency challenges (for wind and solar power).

Moreover, it is clear that as the electricity sector gets increasingly decarbonised, it could augur well for India to move towards electrification of end-uses such as cooking and mobility. Leapfrogging to electric cook-stoves judiciously in some cases could bring in greater benefits in terms of moving to a low carbon path rather than first making a transition towards LPG/ PNG as part of the effort to move to cleaner modern fuels. Similarly, if the country could make a quick move to electric vehicles directly

Employment considerations are critical considering the changes in both fuel and technological choices that India may witness in the coming years. While the new technologies, like renewables, may promise employment generation, there might be job losses in other sectors, like the coal sector. In India, employment at Coal India, the world's largest coal producer, has fallen by around 36 per cent, from 511,000 workers in 2002/03 to 326,000 in 2015/16.

rather than making a transition first to fuels such as CNG and locking the country into potentially infructuous infrastructure in the longer term, we could also simultaneously address the issue of local air pollution in cities. However, the shift to electric vehicles is contingent not only on improvements in battery technology, but also on systematic overhaul of the infrastructure to meet the charging requirements etc.

Similarly, while the issue of intermittency of renewables has been addressed globally by natural gas playing a role in balancing power, India could maximize the utilization of its existing fleet of coal based plants in the short term to support the transition to renewables in the power sector. Even though gas is a relatively cleaner fossil fuel as compared to coal, recent analysis suggests that it may be prudent to leapfrog directly to renewables from coal in the power sector, rather than locking into gas based infrastructure at this stage.

Two key aspects need to be carefully deliberated whilst evaluating the scope for enhancing the pace and scale of India's mitigation pathways.

Firstly, with regard to economically viable technological choices, several options do exist and are gainfully being exploited already in the country. Several policies and measures are geared towards enabling the uptake of these preferred options. These energy options (especially those based on renewable resources like solar and wind) or even efficient appliances can in the long term, bring in significant economic benefits to the consumers at the individual level, and to the economy at large. However, they often entail high upfront capital costs for setting up the associated infrastructure. Therefore, the financial requirements of these alternatives need to be carefully considered especially if they need to be adopted at larger scales. A recent estimate suggested that the country would need around $4.5 trillion by 2040 to meet its developmental aspirations alone.[16]

While technological choices and solutions exist for India's energy transition, there also exist several challenges that would need to be addressed via suitable policies and measures, keeping India's socio-economic context in mind. Adoption of some efficiency measures may require behavioural changes apart from purely technological solutions, and therefore necessitate ways to motivate consumers to shift to such options through innovative business models and strategies. The adoption of renewables at larger scales would also need to be complemented with grid improvements to handle higher share of intermittent/variable power.

In light of this, it is important that the country does not compromise on development related spending while proceeding towards a low carbon pathway. Alternative and additional sources of finance should be tapped to ensure that both objectives can be pursued synergistically.

Secondly, recent analysis indicates that while moving to higher levels of emission reduction viz. towards a 2°C world, may be feasible with the existing state of technologies, faster and deeper mitigation towards levels that may help achieve a 1.5°C world may prove to be difficult unless technologies such as battery storage become economically viable at scale. Similarly, accelerating the pace of electrification of vehicles could prove to be detrimental unless the power generation sector is already highly decarbonised.

Further, while technological choices and solutions exist for India's energy transition, there also exist several challenges that would need to be addressed via suitable policies and measures, keeping India's socio-economic context in mind. Adoption of some efficiency measures may require behavioural changes apart from purely technological solutions, and therefore necessitate ways to motivate consumers to shift to such options through innovative business models and strategies. The adoption of renewables at larger scales would also need to be complemented with grid improvements to handle higher share of intermittent/variable power.

In the industrial sector, the first cycle of the Perform, Achieve and Trade (PAT) scheme directed towards improving energy efficiency in designated units across the eight major industries of India over-achieved its target. However, with the relatively lower hanging fruit being tapped already, it is likely that tapping additional savings may not be as easy to achieve. Perhaps the biggest challenge to adoption of energy efficient technologies in the industry sector comes from the Micro, Small and Medium Enterprises (MSMEs). These being small, un-mechanised and having limited dependence on electricity offer limited avenues of efficiency improvement. They also lack capital and motivation to shift to better processes and technologies because unlike the big industries, they lack the advantage of scale.

In other cases, such as in the transport sector, there may still be technological gaps in terms of availability of economically viable alternatives. While solutions have emerged at the pilot scale to find substitutes for Aviation Turbine Fuel (ATF) used in the aviation sector, and to fuels used in the shipping and heavy road-freight transportation, these solutions are still not readily available for large scale transitions.

There are several examples of innovative ways through which India has adopted switchovers to efficient alternatives. The aggregation of demands to drive down prices of the technological solution is one such example that has been adopted in case of procurement of LED lights,[17] and efficient power-looms equipment to

small and medium units in the Textile industry.[19] However, India needs several such strategies to meet the ambitious target of Paris Agreement of reducing the global temperature rise to well below 2°C.

Linking climate mitigation with sustainable development

For a developing country like India there are several other concerns that need to be handled simultaneously with emission mitigation. The interconnections between climate and some major social determinants, like equality, equity, poverty, health, human security, ethics, and well-being, are well recognised.[18] The three biggest challenges as put forth by the World Economic Forum in a recent article are skill development and employment for the future workforce, socio-economic inclusion of rural India, and a healthy and sustainable future.[20]

Employment considerations are critical considering the changes in both fuel and technological choices that India may witness in the coming years. While the new technologies, like renewables, may promise employment generation, there might be job losses in other sectors, like the coal sector. In India, employment at Coal India, the world's largest coal producer, has fallen by around 36 per cent, from 511,000 workers in 2002/03 to 326,000 in 2015/16.[21]

As we stand at the cusp of an era of rapid technological, socio-economic and geopolitical changes, India could face a significant bifurcation of economic outcomes between those who are able to fully integrate in the emerging economy and those who are not. This divergence could become apparent in future jobs, wages and the changing nature of work.Sectoral changes in both the number and nature of jobs will require concerted efforts towards skill development, re-skilling, or up-skilling of the population employed in these sectors.[22]

Inequality, an important determinant of social sustainability, has also been increasing in India over the last few years. The Gini coefficient of wealth in India was 0.83 in 2017, placing India among the countries with highest inequality levels.[23] Based on recent NSSO consumption surveys, the Gini coefficient indicated a rise in consumption inequality from 0.32 in 1993-94 to 0.38 in 2011-12 in urban areas. Corresponding estimates in rural areas are 0.26 in 1993-94 and 0.29 in 2011-12.[24] Accordingly, India with a growing and young population base, needs to be mindful of creation of employment opportunities and ensuring inclusive growth in planning India's development trajectory.

Further, while the environmental trends at the macro level are seen to be improving, local environmental issues that are directly linked to social welfare, like air pollution and water shortages, seem to be intensifying at localised levels. Therefore, planning in the Indian context additionally needs to be mindful of growing levels of local air pollution, environmental footprint of its current and future activities, as well as sustainability of land and water.

Conclusion

In sum, on the one hand, India's energy transition story needs to address the technology development perspective which calls for enhanced and accelerated efforts to increase the uptake of clean and efficient energy substitutes, processes, and end-use equipment, such that the country does not lock itself into large stocks of inefficient equipment and infrastructure. At the same time, India needs to address the social development perspective wherein it needs to enable a higher standard of living for all her citizens by growing at a relatively higher pace and in a more inclusive way, ensure access to clean and modern energy forms in a reliable and affordable manner for all sections of society, doubling of farm incomes, creation of job opportunities through strengthening of industrial base etc. Connects across linked sectors also require careful investigation of trade-offs to ensure the success of mitigation strategies. India must therefore undertake an integrated and holistic approach to use innovative business models and dynamic decision making to address the multiple challenges at the policy and institutional levels or those posed by socio-cultural and market barriers, in order to successfully convert the challenges into opportunities for inclusive growth.

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Climate Change: Challenges and Opportunities

Urmi A Goswami

On April 1, the Indian Meteorological Department put out its forecast for the April to June season: the average temperatures in most parts of the country are likely to be 0.5 degree Celsius higher than normal with some areas registering temperature increase of more than 1 degree Celsius. This was no April 1 joke. The mercury has been inching up since, giving credence to the forecast.

The IMD's forecast for last summer of higher than normal summer temperatures and heatwaves, too, was borne out. As a matter of fact, the IMD's data from its observational network finds that in keeping with the rising trend of earth's temperature, annual mean temperature in India between 1901 and 2017 has shown a significant increasing trend (0.66°C per hundred years). Global average temperature is now 1°C above pre-industrial levels.

As in other parts of the world, rising temperatures and warming are not the stuff of the future. And neither are the impacts of a warming planet. India has already been experiencing the impacts of 1°C warming. It was evident in Uttarakhand, Chennai,

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Srinagar, Malin, and more recently in Kerala and north-east India, the heat waves of the past summer and the uneven rainfall across the country with floods affecting some regions and very severe drought conditions facing many parts of the country. With global temperature increase likely to overshoot the "well below 2°C" goal of the 2015 Paris Agreement, the events of the past few years portends a huge and expanding danger.

The warning issued by scientists of the UN climate science body, the Intergovernmental Panel on Climate Change from Busan, South Korea in October last year of the immediate and grave consequences of continuing to emit greenhouse gases at current rates was not entirely unexpected for India.

Scientists working on the IPCC special report, Global Warming at 1.5°C, concluded that without a rapid and appreciable reduction in greenhouse gas emissions, the world was on a path to temperature increase of 1.5 degrees Celsius in twelve years that is by 2040. A warming of 1.5°C would mean that large tracts of the existing coasts would be inundated and droughts and floods would intensify exposing billions of people to social and natural dangers. The warning even more dire given that global collective effort as pledged by countries through their national efforts to slow down global warming under the Paris Agreement put the world on a temperature increase trajectory of well over 2°C.

Climate change will require economy-wide transformation. India will need to make dramatic changes across the spectrum-energy, transportation, urban and agriculture systems. It will require investing in human capital, innovation and research and development.

Though no stranger to the adverse impacts of a warming planet, the IPCC special report had a clear message for resource poor and vulnerable countries such as India that it would be among those most adversely affected if warming exceeds 1.5°C.

Sounding the alarm UN Secretary General António Guterres told a gathering at the United Nations headquarters in New York last year: "Climate change is the defining issue of our time, and we are at a defining moment. Climate change is moving faster than we are – and its speed has provoked a sonic boom SOS across our world. If we do not change course by 2020, we risk missing the point where we can avoid runaway climate change, with disastrous consequences for people and all the natural systems that sustain us."

India In A Warming World

As a relatively poor country that is vulnerable to climate change, India will be among those most adversely affected if warming exceeds 1.5°C. It is now clearer than ever before that many of the adverse impacts of climate change are unavoidable. South Asia, particularly India is a hotspot, and will exposed to multiple and overlapping hazards as the planet warms. The impacts even at 1.5 °C warming is considerable-intensified droughts and water stress, heatwaves, habitat degradation, and reduced crop yields.

Rising temperature and the variations in rainfall will impact water supplies. The overall impact of climate change on water resources will manifest as a rise in floods and droughts. The intensity and area affected by floods, river floods due to snowmelt and coastal flooding due to sea level rise-will increase considerably. India's heavily populated 7,500 km long coastline will mean that a sizeable population will be affected by sea-level rise and resulting coastal flooding. Experts say that it could directly affect 50 million people, many of whom are directly dependent on the sea for their livelihood. Cities such as Mumbai and Kolkata too would be under threat.

Acting On Climate Change

India has been stepping up on its efforts to slow down the rate of greenhouse gas emissions and to adapt to impacts that are already being experienced.

In 2008, India launched the National Action Plan on Climate Change. Eight missions—solar energy, energy efficiency, forestry, sustainable habitat, water, agriculture, Himalayan ecosystem, and developing strategic knowledge for climate change—form the core of the multi-pronged, long-term, and integrated strategies for addressing climate change. Besides a national level plan, 32 states and union territories have prepared state level climate action plans. These plans comprising programmes in sectors such as health, industries, disaster management, tourism, and coastal development are focused on reducing greenhouse gas emissions and adapting

TABLE 1: Impact of warming of global temperatures in South Asia/India

	1.5 °C	2 °C
Average temperature increase	2.3 °C	3 °C
Increase in annual highest maximum temperature	1.2 °C	1.7 °C
Increase in frequency of warm extremes	160 per cent	438 per cent
Increase in heat waves in India by 2050	5 times	9 times
Increase in duration of heat waves in India	2 times	3 times
Increase in maximum population exposed to heat wave days	9 times	15 times
Change in average rainfall	No change	Decrease by 3 per cent
Increase in extreme monsoon rainfall	20 per cent	25 per cent
Increase in population exposed to water scarcity	20 million	30 million
Increase in economic damage from river flooding	358 per cent	546 per cent

Source: IPCC SR 1.5 and Carbon Brief

a large developing economy with considerable development deficits and millions still living in poverty grow its economy and sustain that growth while limiting its carbon footprint so as to slow down warming to avoid the more dire impacts of climate change on its people? How does a developing country with limited resources ensure that it can bridge the development gap of its people without endangering their well -being in a climate constrained world while at the same time is able to take advantage of the opportunities of the future?

Material resources and energy are the drivers of economic progress. Growing the economy and bridging the development gap will inevitably require increasing India's consumption of material resources and energy. A recent assessment, Global Resources Outlook 2019, by the International Resource Panel, a United Nations Environment-sponsored science body, reports that the global extraction and processing of material resources—biomass, fossil fuels, metals, and non-metallic minerals—contributes to more than 50 per cent of the greenhouse gas emissions. As a lower-middle income country, India's material footprint is smaller than its high and upper-middle income counterparts. However, it is already experiencing the adverse impacts of a materials-intensive growth model: polluted air, water stress and climate change-induced weather events. Clearly, as India moves ahead urbanising at a rapid pace, building the nearly 70 per cent of its yet unbuilt infrastructure, increasing its manufacturing base, creating jobs in the non-agricultural and mining sectors, it will need to transition to production and consumption systems that are sustainable, produce less waste and use resources and products more efficiently and in a manner that they can be reused, remanufactured, recycled or recovered. It is clear that India cannot afford to adopt the growth models that have underpinned the rise of developed industrialised economies and developing economies such as China.

Climate change is about rising temperatures, shifting precipitation patterns, extreme weather events. It is also much more. It is about changing the way we consume and produce. It is about creating more sustainable economies. And for a country such as India, filling the backlog of development in a climate constrained world poses a real and immediate challenge.

For India to bridge the developmental gap of its people and ensure sustained economic growth, it will have to go beyond the four corners of its international climate change and sustainable development commitments. It will require more than swapping coal power plants for solar panels and wind turbines, and switching from fossil fuel-powered internal combustion vehicles to electric vehicles. Slowing down the rate of growth of emissions is important. Equally important for a developing country such as India is the need to build its ability to withstand the changes that a warming earth necessarily imposes—to augment its resilience capabilities and the ability to convert the challenge of climate change into opportunities.

Climate change will require economy-wide transformation. India will need to make dramatic changes across the spectrum-energy, transportation, urban and agriculture systems. It will require investing in human capital, innovation and research and development. This is the moment for India to invest in re-skilling the 500,000 people who depend directly and indirectly on coal mining as the energy mix changes. It must invest in innovations that minimise the social cost of a climate-induced transformation of the economy.

Reducing material and carbon footprint and energy efficiency of production and consumption systems will require higher levels of research and development. Issues like improving the efficiency and productivity of solar and wind energy capacities so as to truly phase out fossil fuels, developing the support system to change agricultural and cropping systems to alleviate water stress, improve productivity in the face of changing temperature and rainfall patterns. India will need to reconsider its investment decisions so as to build the industries of the future. It requires balancing the needs of the present, the material aspirations of its people with the opportunities of the future.

Climate change is about rising temperatures, shifting precipitation patterns, extreme weather events. It is also much more. It is about changing the way we consume and produce. It is about creating more sustainable economies. And for a country such as India, filling the backlog of development in a climate constrained world poses a real and immediate challenge. However we cannot just grow our way out of this crisis. The path forward must focus on creating wealth that will provide the resilience to deal with the real and physical challenges that a warming earth presents, and to sustain the economic growth that will ensure a better life for all its people. For India, it has to be about creating the capacities to seize the opportunities that the climate crisis presents.

Footnotes

1. Central Electricity Authority, February 2019, All India Installed Capacity of Power Stations
2. Central Electricity Authority, 2018b, *National Electricity Plan (Volume I): Generation*
3. Institute for Energy Economics and Financial Analysis, 2India on track to meet majority of Paris goals
4. Urmi A.Goswami, 2018, India to achieve climate goals before schedule, *The Economic Times* (https://economictimes.indiatimes.com/news/politics-and-nation/india-set-to-increase-share-of-renewables-and-reduce-carbo-dioxide-pollution/articleshow/66924213.cms) ❑

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Forests and Water-Conservation and Sustainable Development

Sumita

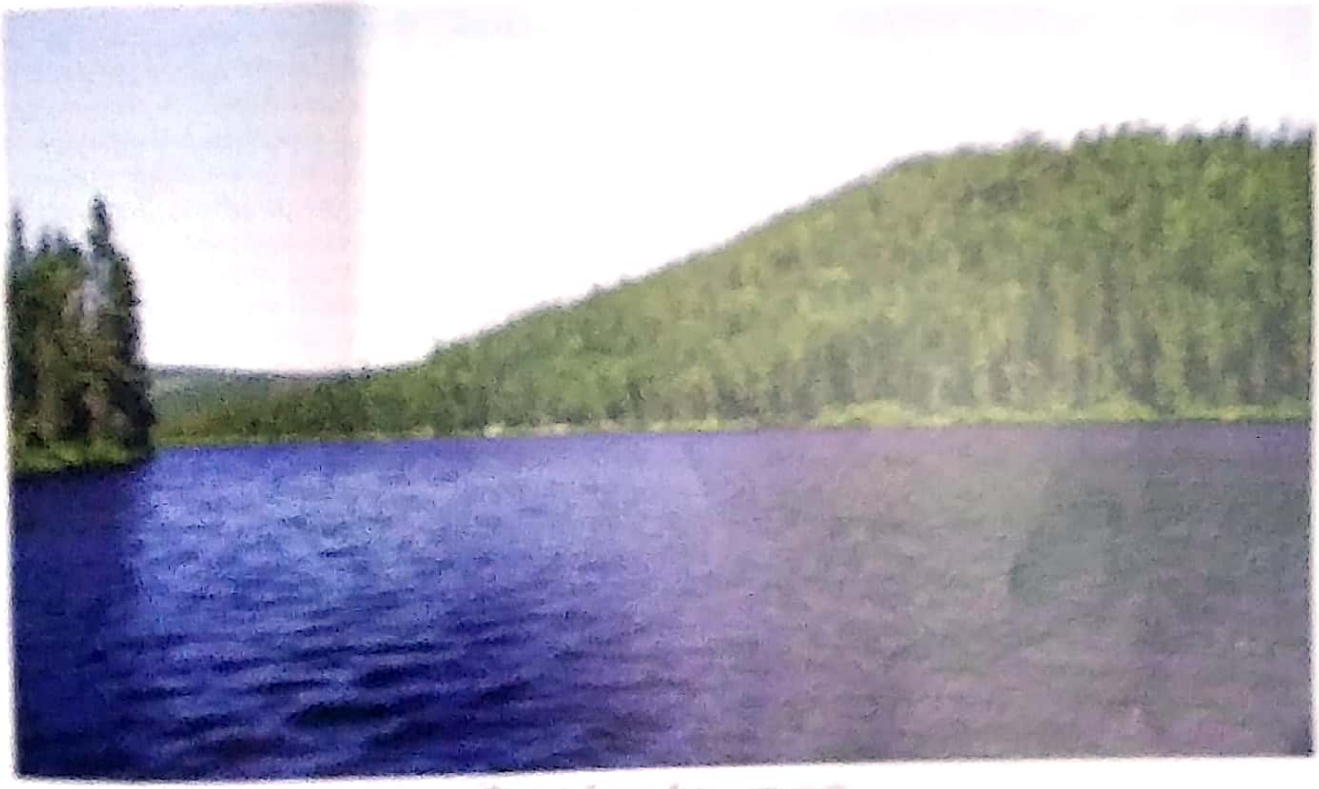

Figure 1 Forests Act...

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Figure 2: Mullaperiyar Water Dam

urbanisation has threatened the forests that nurture the water regime in the ground. Similarly, expansion of road network in higher reaches or upstream areas has caused extensive landslides and erosion and has caused irreparable damage to the perennial water streams. These factors have influenced the ecological functioning of the world's major water bodies and in turn destroyed the various freshwater systems. Consequently, about two billion of world's population is going through water stress which is expected to increase with time. In fact, extent of availability of clean water could prove to be the stepping-stone to development. Issues pertaining to water accessibility, quantity and quality are major global concerns. India is no exception as it is home to one-sixth of the world's total population but has only 4 per cent of the water resources sustaining the economy in terms of agriculture, power and biological productivity. Values of per capita surface water availability have continuously declined and in the near future the country is expected to become 'water stressed'. Water crisis will also lead to health crisis, and women unduly while taking away their considerable time from work, family care and causes loss of economic opportunities.

Forests, Water and People - Interconnections

Forests, water and people are closely interconnected. The availability and quality of water are increasingly threatened by overuse, misuse and ever-increasing pollution levels. It is scientifically recognised that both quantity and quality of water are strongly influenced by forests. The health of forests and its composition has direct impact on water availability as well as quality which shows the importance of the relationship between forests and water. Forested tracts not only constitute catchment of rivers and their tributaries but often they harbour their headwaters. Water, wetlands and forests are constantly interacting to produce healthy and productive ecosystems. Forests absorb rainfall and snow melt and also slow runoff, reduce soil erosion, improve water infiltration rates, recharge aquifers, thus exhibiting 'sponge effect'. At the same time forests growing along the streams filter pollutants from entering the water. Forests therefore undoubtedly play a critical role in the well-being and proper functioning of the hydrological cycle. Since, forests are storehouses of biodiversity, these play an equally important role in global cycling of carbon, oxygen and other gases influencing the earth's atmosphere.

Forest cover is one of the many factors which affect climate at the global as well as regional and also local levels. Forests play a significant role in climate mitigation. Climate change is altering forest's role in regulating water flows and influencing the availability of water resources. Therefore, the relationship between forests and water is a critical issue that requires highest priority attention at all levels.

Forests–Conservation Values

Since time immemorial, importance of forests to humanity has been well recognized. Forests are seen as source of timber, edible products, fuel wood, medicinal plants and habitat to wildlife. As catchment for rivers, they predominantly affect the volume, quality and timing of water flow as well as rates of soil formation or erosion. Forests have been a source of inspiration and are increasingly used for tourism and recreation. Forests not only provide multiple services but they

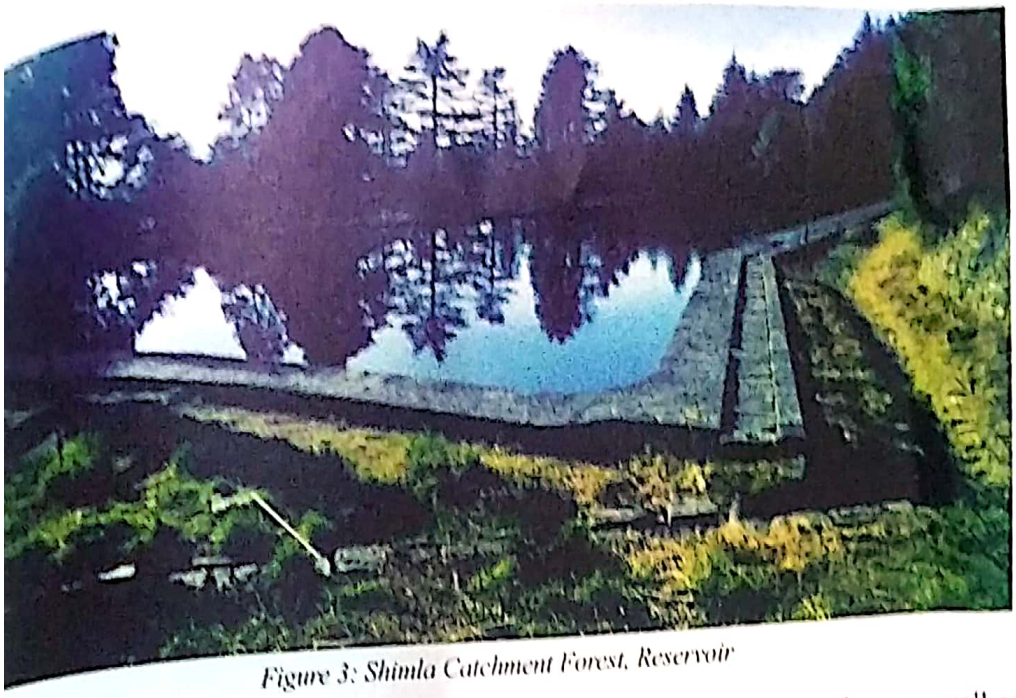

Figure 3: Shimla Catchment Forest, Reservoir

e perceived to have multiple values hich are being recognized by different akeholders. Forested catchments pply a high proportion of water for omestic, agricultural, industrial and cological needs in both upstream and ownstream areas. The health of our aters is the principal measure of how e live on the land. Water management ill not be sustainable unless key cosystem services that influence vailability of water are explicitly onsidered from the landscape ustainability perspective.

Tapping Forest Catchment Potential: A few of the country's pioneer efforts to tap forest catchment potential to augment water supplies o major cities and drier regions are highlighted as below:

- Construction of Mullaperiyar dam on Periyar River in Kerala so as to divert water eastwards to the arid rain shadow region of Madurai under the then Madras Presidency and creating a large lake (26 km²). Forests surrounding the lake and the entire lake area now constitute the Periyar Tiger Reserve (PTR). Diverted water augmented the small flow of Vaigai River and brought notable changes in the thirsty area and ensured sustainable livelihoods by way of agriculture production (Figure 2).
- Protection to high altitude oligotrophic lake, Marsar and diverse forests (500 km²) in the mid slopes constituting the catchment of Dagwan River so as to ensure clean water supply for the city of Srinagar and J&K.
- Similar initiative was taken to provide ensured water supply to Shimla town during the colonial time.

  A small forest patch (10.15 km²) located 8 km east of Shimla constituted an important forested catchment with dense Deodar forests and Oak forests was leased to Shimla Municipal Committee in 1878. Ever since, the water supply to Shimla town is from the catchment forests.

  The forest was declared a Protected Forest and finally notified as Shimla Water Catchment Wildlife Sanctuary (Figure 3).
- Likewise, the water distribution system in Mumbai metropolis is more than 150 years old. Water is brought into the metropolis from various reservoirs. Tansa dam on Tansa River in Thane district was opened in 1892. Before Independence, Tansa was the major source and major water pipelines were laid to supply water to Mumbai. Tansa dam is located within Tansa Sanctuary and forested catchment serves as sponge and continues to provide water recharge even after the withdrawal of monsoon.

Forests Management and Water Conservation

Forests and varied natural water resources (surface water and ground water) are complex and dynamic in nature. In India, there has been a long history of management of forests as well as adequately documented traditional systems of water harvesting and water use, practiced in drylands.

Policy and Legal Framework: Management of Indian forests commenced way back in 1860s with the establishment of forest reserves, law enforcement and initiation of silviculture-based forest working. State Forest Department(s) and trained manpower were created. SFDs are the custodian of forests and wildlife. The Constitution of India-Article 48A provides a clear mandate of the State to protect the environment. Forests and the protection of wildlife fall within the Concurrent List. The Environment (Protection) Act, 1986 is the umbrella legislation for the protection of all aspects of the environment. The issue of pollution and water quality falls primarily under the Water (Prevention and Control of Pollution) Act, 1974. The Indian Forest Act, 1927, and the Forest (Conservation) Act, 1980 are the primary legislations governing forests; while the Wild Life (Protection) Act, 1972 and the Biological Diversity Act, 2002 are significant from the perspective of biodiversity, intellectual property right, and access and benefit sharing.

Paradigm Shift: Newer approaches focus on the ecosystem management,

Figure 4: Tansa Sanctuary and forested catchment

biodiversity, participatory management, sustainable livelihoods, maintenance of ecosystem services and banning green felling ultimately aiming to achieve target of 33 per cent forest cover in the country and also to fulfil the global commitments alongside addressing national priorities and local needs. Presently, about 25 per cent of country's geographical area is covered under diverse forests including 'Trees Outside Forests'. India has established an impressive network of protected areas and presently PAs (Protected Areas) represent nearly 5 per cent area of the country. Prominent country-wide activities carried out under various programmes/ have contributed immensely. Several national level institutions dealing with forestry/ wildlife research, education and training, have been established for capacity building.

Conservation of Water Resources: In the federal scheme of the Indian Constitution, regulation and development of inter-state rivers falls within the legislative competence of the Union Government. States have the legislative competence over water supplies, irrigation and canals, drainage and water storage. States also have the power over issues relating to land and land use. Post-independence the country has realised the priority need for developing water resources, particularly in drier zones for expansion of agriculture and realization of national goals of self sufficiency in food production. A large number of irrigation projects were implemented. As a result, numerous multipurpose dams, reservoirs, canals and ponds came into existence. Water supply was also enhanced tapping ground water resources. There has been a notable growth in number of water sources. India has nearly 2/3rd area under rainfed agriculture and considering limitations on expanding irrigation potential, the country decided to adopt and implement watershed management approach to augment water supply in rainfed areas. Over past decades, country has gained considerable experience in execution of integrated watershed management programmes (IWMP).

Contribution to the Sustainable Development

Past experiences have amply illustrated that forests provide the cleanest and most stable flows of surface water and groundwater recharge among all land uses. Flow amount, quality and timing can be altered by forest management; flows can increase or decrease depending upon post disturbance successional patterns. These findings appropriately indicate linkages between forests and freshwater ecosystems. Both ecosystems significantly contribute towards UN Agenda on Sustainable Development Goals which reflect complex and interrelated nature of social, economic and ecological well-being parameters. In recent past, India has directed its development pathway to meet its priorities of food, water and energy security; economic growth; disaster resilience and poverty alleviation while maintaining the natural capital and adopt transparent and robust governance along democratic lines. SDGs related to water (SDG 6) and land (SDG15) explicitly acknowledge the linkages between forests and water. Further, SDG 6 and SDG 15 have strong interconnections with targets of other SDGs and thus, approaches adopted towards ecosystem management, sustainable forest management, biodiversity conservation, effective and efficient use of water resources would not only contribute to other SDGs but would ensure sustainable overall development and fulfilment of global commitments. ❑

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About Our Books

ASIATIC LION: Reviving the Pride of Gir

Details: This is about the conservation story of reviving the almost extinct lions of Gir.

Author: H. S. Singh

ISBN- 978-81-230-2985-6

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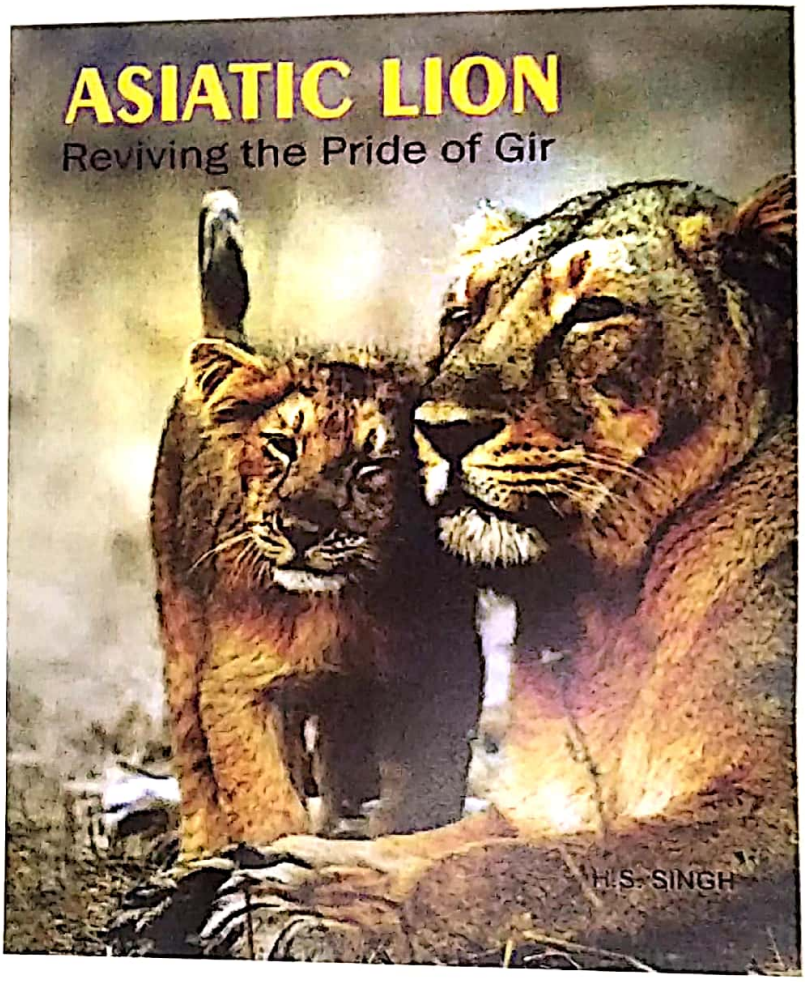
Price- Rs 1250/-



Hailed all over the world as the 'king of the jungle', the lion has always captured the human imagination and fascination in various capacities. *Asiatic Lion - Reviving the Pride of Gir* brings together rare insights, information on flora and fauna, historical records and ancient literature into an interesting account of the history of origin, evolution and escape of the Asiatic lion from extinction in the previous century. One of the most renowned Wildlife Sanctuaries of India, Gir is the only natural habitat of the Asiatic Lion. This informative and engaging read is the result of a lifelong study and unique first-hand experience of Dr. H.S. Singh, former Principal Chief Conservator of Forests, and therefore it brings a perspective that has been long-awaited. The author has also shared interesting observations and pictures from his personal collection, making it an informative and enlightening journey for the readers.

The book, therefore, is an important and valuable resource covering various aspects of the lion's lifecycle, such as social behaviour, breeding ecology, physical attributes, habits and habitats, hunting behaviour, feeding patterns, prey base and predation pattern, along with the ecology of Gir and other animals who share the habitat, like the Chowsingha (the world's only four horned antelope), Sambar (Indian Deer), Striped Hyena, Magar (Marsh Crocodile), Indian Fox, among others. The book encompasses a range of aspects regarding the conservation story of Gir Forests highlighting the labour, compassion and hard work rendered by the forest officials. Conservation efforts undertaken in the Gir forest and for the Asiatic lion during the last five decades has made Gir one of the best managed Protected Areas in the world. However, as discussed in the book by the author, the fate of this majestic animal in the new millennium depends on how human beings respect and treat this majestic feline.

Publications Division of the Ministry of Information and Broadcasting has brought out this book. It is available at Book Gallery, Publications Division, Soochana Bhawan, CGO Complex, New Delhi.

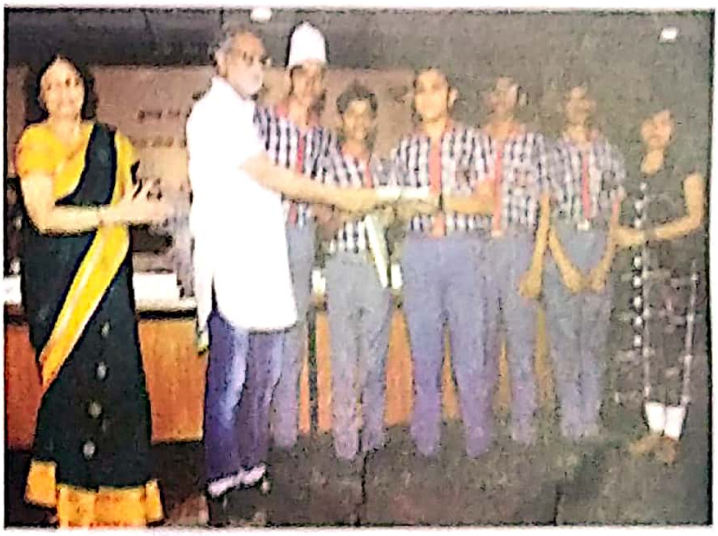
Email at: businesswng@gmail.com to order your copy.

PUBLICATIONS DIVISION COMMEMORATES 100 YEARS OF THE JALLIANWALA BAGH MASSACRE

A special programme titled "Yaad Kar Lena Qurbani" was organised by Publications Division, in collaboration with Indira Gandhi National Centre for the Arts (IGNCA), New Delhi on April 15, 2019 to commemorate 100 years of the Jallianwala Bagh massacre. Professor Chaman Lal, an eminent writer and a specialist in Modern Indian History, Dr. Sachchidanand Joshi, Member Secretary, IGNCA, Director General, Publications Division and Additional Director General, Publications Division were among the dignitaries present.

Speaking on the occasion, Professor Chaman Lal spoke about the brutalities of the massacre and the events that unfolded after it, which led to a united struggle by the people. Dr. Sachchidanand Joshi urged the youth to take inspiration from the freedom fighters and work hard for the progress of the nation.

Students from three schools in Delhi presented various interesting performances on the occasion. Students of Kendriya Vidyalaya, Pragati Vihar performed a skit and read letters of freedom fighters, viz. Bhagat Singh, Chandrashekhar Azad, Subhash Chandra Bose, and others, from the book "Yaad Kar Lena Kabhi: Shaheedon ke Khat" brought out by Publications Division. This book has been translated into other Indian languages, i.e. Malayalam, Tamil, Odiya and Urdu. These translated books were also released on this occasion. Students from Kendriya Vidyalaya, President's Estate and Jawahar Bal Bhawan, Mandi, recited poems from "Zaptshuda Tarsane", published by DPD, which is a collection of poems written by martyrs and freedom fighters which were confiscated by the colonial government.



Continuing the remembrance, Publications Division and IGNCA also organised a book reading and discussion session by eminent authors, Professor Chaman Lal and Ms. Kishwar Desai, on April 16, 2019 at the IGNCA auditorium where they read excerpts from their books, out of which "Shaheed Bhagat Singh: Dastavezon Ke Aaine Me" by Prof. Chaman Lal, is also a DPD publication.

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