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Turbidity currents

1. Introduction

1.1 General

India's water resources become increasingly strained, as the population of India continues to expand. Discharge of untreated sewage is the single most important cause for pollution of surface and groundwater in India. Heavy pollution from open sewers is common place in urban areas and arsenic contamination of groundwater continues to threaten the health and well-being of local communities. India is defined as a 'water stressed' country and innovative methods to provide cost-effective water treatment to communities are a crucial requirement if growing populations are to be sustainable. Sewage are to be removed by applying different sewage treatments. A natural river continually picks up waste products from and drops them on its bed throughout its course. Knowledge of sediment transport can be applied extensively in civil engineering such as to plan how to control the flow of water in culverts, over spillways, below pipelines and around bridge piers and abutments, excess of which can damage the environment and failure of foundation of the structures. Moreover, when suspended load of sediment is substantial due to human activities, it can cause environmental hazards including filling up of the channels by siltation. Sediment transport is the movement of organic and inorganic particles by water. In general, the greater the flow is, the more sediment will be conveyed. Water flow can be strong enough to suspend particles in the water column as they move downstream, or simply push them along the bottom of a waterway. Transported sediment may include mineral matter, chemicals and pollutants, and organic material. The total load includes all particles moving as bed load, suspended load, and wash load.

Turbidity, as an optical property of water, is one of the more difficult parameters to measure. Turbidity is caused by particles and coloured material in water. Total suspended solids (TSS) are the main cause of turbidity. Turbidity currents are most typically underwater currents of usually rapidly moving, sediment-laden water moving down a slope. Turbidity currents can also occur in other fluids besides water. In the most typical case of oceanic turbidity currents, sediment laden waters situated over sloping ground flow down-hill because they have a higher density than the adjacent waters. The driving force behind a turbidity current is gravity acting on the high density of the sediments temporarily suspended within a fluid. As such currents flow, they often have a "snow-balling-effect", as they stir up the ground over which they flow, and gather even more sedimentary particles in their current. Their passage leaves the ground scoured and eroded. Once a turbidity current reaches the calmer waters of the flatter area, the particles borne by the current settle out of the water column. The sedimentary deposit of a turbidity current is called a turbidite. When sediment transport removes material from a streambed or bank, the erosion process is called scour. Scour can occur anywhere where there is water flow and erodible material. Local scour is an engineering term for the isolated removal of sediment at one location, such as the base of underwater structures, including bridge piers and abutments. This localized erosion can cause structural failure, as bridges and overwater constructions rely on the bed sediment to support them.

1.2 Scope of this work

The objective of the present work is to understand the hydrodynamics of turbidity currents over plane beds based on velocity and concentration distributions. The sewage can be removed by offset jets.

2. Turbidity currents

2.1 General

Turbidity currents are density currents that are generated due to the density difference of suspended sediments and water in a mixture. In turbidity currents, suspended sediment makes the density of the mixture greater than the density of the ambient water and provides the driving force; the sediment laden flow must generate enough turbulence to hold the sediment in suspension. They can be observed in the

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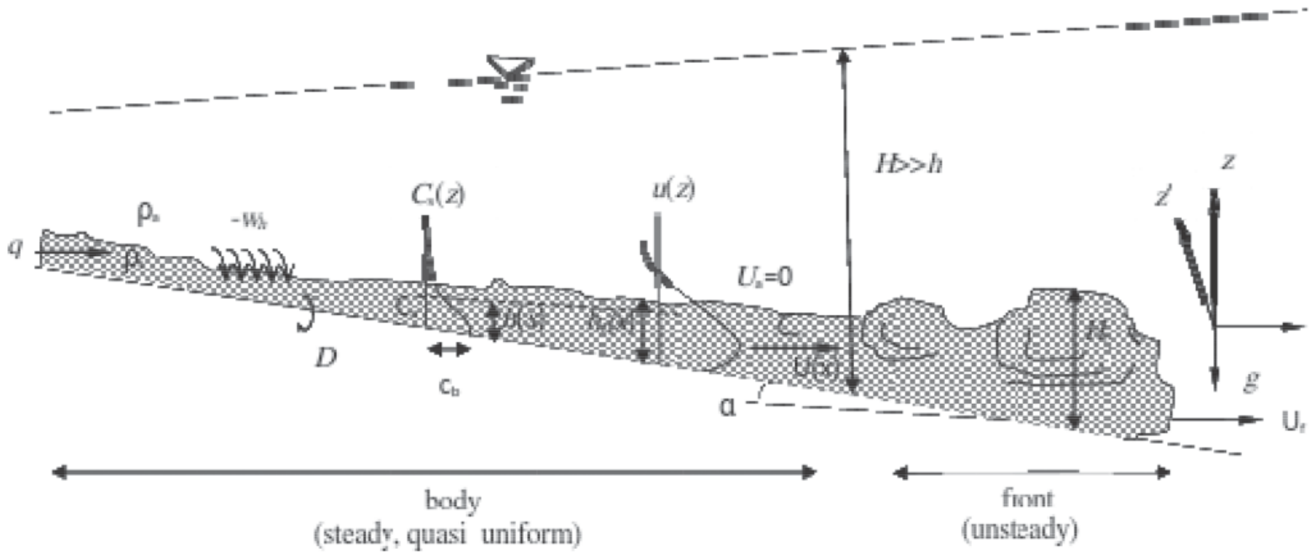

Fig.1 Definition sketch of turbidity current

flows entering large bodies of water containing high concentration of suspended sediments. These are sediment-laden gravity currents that exchange sediment with the bed by erosion or deposition as the flow travels over the down slope. Turbidity currents derive this driving force from the sediment in suspension. They experience a resisting shear force on the bed and entrain water from above. Two types of turbidity currents can be distinguished: Low velocity, low density and high velocity, high density. High velocity, high density turbidity currents often carry suspended materials introduced near the shore to the deep sea.

Turbidity currents can be originated by various processes. Discharges of large amounts of sediments, e.g., mine tailings, underwater landslides caused by earthquakes, and re-suspension of suspended materials by waves during storms are three possibilities. Turbidity currents can be eroding or depositing, accelerating or decelerating, depending on the combination of initial conditions, bed slope, and size of sediment particles. A turbidity current with deposition and erosion is a flow in three components: clear ambient water, turbid water and sediment (bed material).The turbidity current entrains clear water into the flow and simultaneously either deposits suspended sediment on the channel bed, or entrains bed material into the flow. Actually turbidity current entrains and deposits at the same time, but there is a net flux either to the bed (depositing current) or from the bed (entraining current). Turbidity currents are self-generated currents. The flow will vanish when all suspended materials are deposited on the bottom, and grow when sediments are entrained from the bed.

Turbidity current is made up of a front or head advancing into the ambient fluid, being followed by the body. The driving force for the front (unsteady flow) is the pressure gradient which is due to the density difference between the front and the ambient fluid. The driving force for body (steady flow) is the gravitational force of the heavier fluid. A schematic diagram of turbidity current is shown in Fig.1.

2.2 Review of literature

The characteristics and behaviour of turbidity currents was studied by many investigators and some of them are reviewed below.

Akiyama and Stefan (1985) derived various equations that govern the movement of two-dimensional gradually varied turbidity currents in reservoirs and over beaches and solved numerically. The model included and quantified all mechanisms which control accelerating and decelerating turbidity currents. The model consisted of depth-integrated equations for conservation of mass and volume, momentum equations and an empirical relationship for water entrainment and sediment entrainment. The equations were numerically solved by a Runga-Kutta method. The flow of turbidity current was found to be dependent on three factors: initial conditions, the size of the suspended sediment particles and the channel slope. The model explained clearly the differences as well as the similarities between subsurface gravity currents with and without sediment erosion and deposition. Parker et al. (1986) presented a general concept of the equations of motion of turbidity currents, their closure, and their solution for the continuous, spatially developing case in submarine canyons. Special attention is drawn on the possibility of self-acceleration, or ignition, by means of the incorporation of bed sediment into the current. Two models are presented. The first of these is the three-equation model, which can be considered as a generalization of the model of Ellison and Turner (1959) for simple, conservative density currents to the case of eroding and depositing turbidity currents. The self-acceleration predicted by the three-equation model was so strong that the energy constraint failed to be satisfied. The problem was rectified by the formulation of a four-equation model, in which an explicit accounting was made of the mean energy of the turbulence. Sediment entrainment from the bed was linked to the level of turbulence in the four-equation model. Parker et al. (1987) conducted various experiments to determine the behaviour of turbidity currents laden with non-cohesive silt (silica flour) moving down a slope the bed of which was covered with similar silt. The motion of the head was not studied; measurements were concentrated on the continuous part of the current that was essentially constant in time but developing in space. Only supercritical currents were studied. The currents were free to erode sediment from and deposit sediment on the bed. Experimental data were used to establish approximate similarity laws for the velocity and concentration distribution, and to evaluate several shape factors that enter in the vertically-integrated equations of motion. Stacey and Bowen (1988) developed a simple numerical model that successfully simulated observations of small-scale, laboratory, density currents flowing down inclines of constant slope. The model results suggested that laboratory determinations of the bulk Richardson number have been biased by molecular processes but that determinations of the entrainment coefficient are probably applicable to large scale currents, and even to turbidity currents in which the gravitational driving force is provided by suspended sediment. The entrainment coefficient as a function of bottom slope is accurately simulated by the model down to slopes as small as 0.5 degree. Its value depends primarily on the stability of the current above the velocity maximum, which is not a function of the drag coefficient. Garcia (1993) conducted laboratory experiments to study the behaviour of turbidity currents in the proximity of a slope transition. Saline currents and sediment laden currents (which included two grades of silica and two grades of glass beads) were generated and the hydraulic jumps showed similar characteristics. During experiments, several velocity profiles were measured and plotted which showed a distribution resembling that of a wall jet. Altinakar et al. (1996) presented a series of experiments with turbidity currents using two different types of sediments and those experiments were supplemented by saline gravity currents. The sediments used were fine, K-13 (d_s = 0.047 mm) and the coarse, K-06 (d_s = 0.026 mm) sediments of specific gravity 2.65.The velocity distributions for all runs were evaluated and plotted. The turbidity current can be divided into two regions: wall region (turbulence is created by bottom shear and sediment entrainment) and jet region (turbulence is created by free shear zone and water entrainment). The height, h where the velocity is maximum, $u = U_m$ separates these regions. The velocity distribution in the wall region is expressed by logarithmic relation Eq. 1 or an empirical power relation Eq.2 which when plotted gives an experimental value of n = 1/6. The distribution in the jet region is represented by a near-Gaussian relation given by Eq.3. If the exponent is taken to be constant, m = 2, a curve fitted to the whole data set yields, $\alpha_c = 1.412 \pm 0.065$.

$$\frac{u(z)}{U_m} = \frac{1}{k}\ln z + c \quad \text{... (1)}$$

$$\frac{u(z)}{U_m} = \left(\frac{z}{h_m}\right)^n \quad \text{... (2)}$$

$$\frac{u(z)}{U_m} = \exp\left[-\alpha_c\left(\frac{z-h_m}{h-h_m}\right)\right] \quad \text{... (3)}$$

where, h and U are the height and velocity of the current.

Lee and Yu (1997) studied the hydraulic characteristics of the turbidity current in a reservoir by a series of experiments. Kaolin was used as the suspended material. The plunge points were found to be unstable initially. As the experiment went on, it moved downstream from the incipient plunge location and finally reached a stable location. The thickness of the turbidity current was found to increase while the layer-averaged velocity and concentration decrease in the longitudinal direction, the layer-averaged velocity has the smallest variation rates. Equations for the dimensionless velocity and concentration profiles were obtained. A layer with approximately constant concentration, named denser layer, was observed in the study. Sequeiros et al. (2010) presented results of a set of 74 experiments that focus on the characteristics of velocity and fractional excess density profiles of saline density and turbidity currents flowing over a mobile bed of loose granular particles. The parameters that were varied during the experiments included flow discharge, fractional excess density, bed material, and bottom slope. The profiles were plotted and analysed. Experimental data were used to establish similarity relations for vertical profiles of velocity and fractional excess density, and to evaluate shape factors used in the depth-averaged equations of motion for different flow and bed conditions.

2.3 Velocity distribution

The velocity distribution in turbidity current in a fully developed state is almost similar to that in submerged plane wall jet. A submerged plane wall jet is described as a jet of fluid that impinges tangentially (or at an angle) on a solid wall surrounded by the same fluid (stationary or moving) progressing along the wall (Dey et al., 2010). For a turbidity current, on one side (in the inner layer), the current is confined to the bed, while on the other side (in the outer layer), it is bounded by the stationary ambient fluid (Fig.1). The boundary conditions for the velocity distribution in turbidity current are such that the velocity vanishes at the bed and at the interface between the turbidity current and the ambient fluid. Thus, the velocity distribution attains a maximum (peak velocity) at the extremity of the inner layer, that is, the junction of the inner and outer layers of the current. Below the maximum velocity level (in the inner layer), the flow is characterized by a boundary layer flow, while above the maximum velocity level (in the outer layer), the flow is structurally similar to a free jet. Therefore, the turbidity currents are composed of an inner shear layer influenced by the bed and an outer layer of the self-similar type of a shear flow (Parker et al., 1987; Stacey and Bowen, 1988; Altinakar et al., 1996).

The datasets in the form of non-dimensional stream-wise distance z/δ over non-dimensional velocity $u(z)/U_m$ are plotted and a comparison is made with the plots of Altinakar et al. (1996), Garcia (1993) and Sequeiros et al. (2010). The inner layer and outer layer of jet refer to the zones below and above the point of occurrence of maximum velocity U_m, called the jet velocity. Precisely, the jet layer ($\eta > \eta_0$) extends up to the inflection point (that is, the point of change of sign of slope (d^2u/dz^2) of a u-distribution. Below the jet layer, there exists a wall region layer ($\eta < \eta_0$). The jet layer thickness δ is important from the view point of scaling the vertical distance z (Dey et al. 2010). η_0 refers to the ratio of z_0 (the distance from the bed where the maximum velocity occurs) to jet layer thickness δ and η refers to the ratio of z (any distance above the point of occurrence of maximum velocity) to the jet layer thickness δ.

In the near-boundary zone (that is, within the inner layer of the jet) ($\eta < \eta_0$), the $1/m$-th power law is assumed which is found to fit well for the datasets.

$$\frac{u(z)}{U_m} = \frac{1}{m}\left(\frac{\eta}{\eta_0}\right)^{\frac{1}{m}}\left(1 + m - \frac{\eta}{\eta_0}\right) \quad \text{... (4)}$$

In the jet region, $\eta > \eta_0$, boundary effects come into account and the following relation given by (Dey et al. 2010) holds well.

$$\frac{u(z)}{U_m} = \sec h^2(\eta - \eta_0)\left[1 + \alpha \tanh(\eta - \eta_0)\right] \quad \text{... (5)}$$

where α is an additional term mainly due to submergence.

The values of m and α are calculated for all velocity profiles of experimental data and averaged. The values that gives better degree of accuracy is m = 1/2 and α = –1.036 obtained by using η_0 = 0.25 and δ = 1, which are contradictory to the results obtained by Altinakar et al., (1996), i.e., m = 1/6 and α = 1.4. Moreover, whether the value of m obtained is accurate or not has also been tested by power law in a different form and third-order polynomial law as,

$$\frac{u(z)}{U_m} = \zeta^{\frac{1}{m}} \quad \text{... (6)}$$

$$\frac{u(z)}{U_m} = 1.5\zeta - 0.5\zeta^3 \quad \text{... (7)}$$

The distance at which inflection point occurs can be obtained by equating Eq.5 to zero,

$$\sec h^2(\eta - \eta_0)\,[1 + \alpha \tan h(\eta - \eta_0)] \quad \text{... (8)}$$

Putting the values of α and $\eta_0 \eta_0$,

$$1 - 1.036 \tan h(\eta - 0.25) = 0$$

$$\eta = \eta_{max} = 2.2676 \quad \text{... (9)}$$

The dimensionless discharge is calculated as below

$$q = \int_{0}^{\eta_0} \frac{u(z)}{U_m} d\eta + \int_{0}^{\eta_{max}} \frac{u(z)}{U_m} d\eta \quad \text{... (10)}$$

$$= \int_{0}^{\eta_0}\left[\frac{1}{m}\left(\frac{\eta}{\eta_0}\right)^{\frac{1}{m}}\left(1 + m - \frac{\eta}{\eta_0}\right)\right] d\eta + \int_{\eta_0}^{\eta_{max}} [\sec h^2(\eta - \eta_0)\{1 + \alpha \tanh(\eta - \eta_0)\}] d\eta$$

Solving, we get

$$q = 0.67 \quad \text{... (11)}$$

Fig.2 displays the computed velocity distributions obtained from Eqs.4 and 5. The experimental data plots of turbidity and salinity currents obtained from Parker et al. (1987), García (1993, 1994), Altinakar et al. (1996), Sequeiros et al. (2010) are overlapped on the computed curves in Fig.2 for comparison.

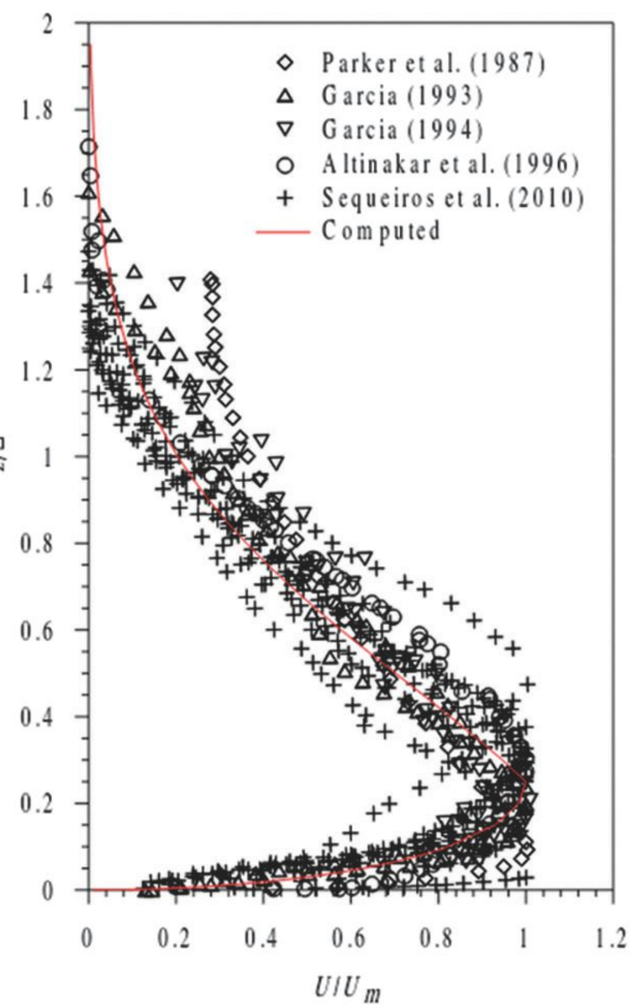

Fig.2 Computed dimensionless velocity profiles

2.4 Concentration distribution

The turbidity current can be considered as a self-generated current in which sediment particles are suspended by the turbulence. The transport of suspended sediment particles in turbulent flow takes place due to the advection and diffusion processes in the ambient fluid.

The concentration distribution is given:

In the near boundary zone ($\eta < \eta_0$), by a Rousean relation as

$$\frac{c}{C_0} = \exp\left(-w_s \int_{\eta_0}^{\eta} \frac{d\eta}{\xi_s}\right) \qquad \text{... (12)}$$

where C_0 is the reference concentration at a distance of η_0 = 0.25 from the bed where the velocity is maximum, w_s is the settling velocity of the particles and ξ_s is the diffusivity of sediment particle given as a function of η as

$$\xi_s = \beta \kappa u_* \eta \left(1 - \frac{\eta}{\eta_0}\right)^{m} \qquad \text{... (13)}$$

where k is the von Kármán constant, u^* is the bed shear velocity, a coefficient $\beta = 1$ (Rouse,1937) and m is a coefficient taken as 0.9.

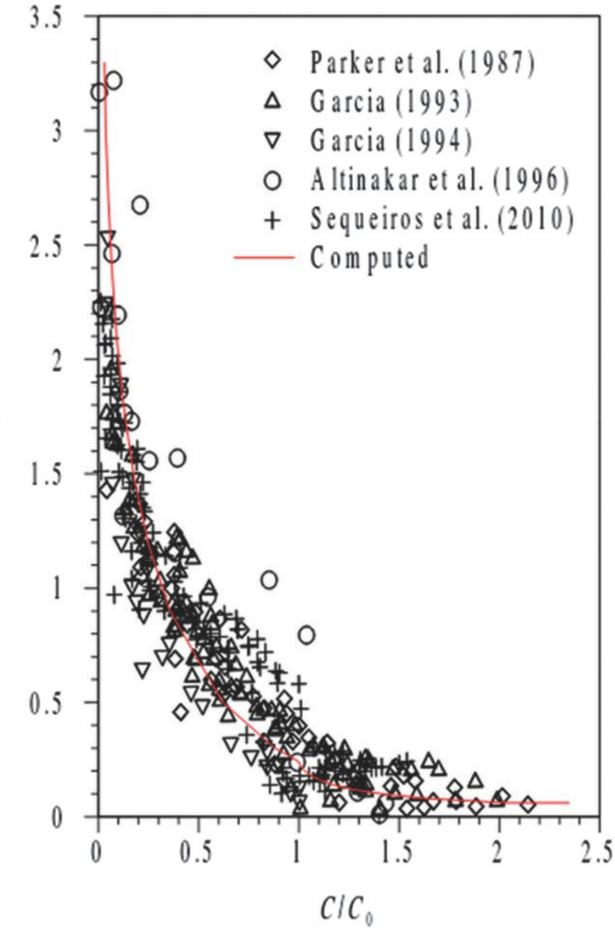

Fig.3 Computed dimensionless concentration profiles

Integrating Eq.12 by inserting Eq.13, the following expression is obtained:

$$\frac{c}{C_0} = e^{-\zeta \int \eta \left(1-\frac{\eta}{\eta_0}\right)^{m} d\eta} \qquad \text{... (14)}$$

$\zeta = w_s/\beta ku^*$ which is called the Rouse number.

In the jet region, $\eta > \eta_0$, by a Rousean relation:

$$\frac{c}{C_0} = \exp\left(-\zeta \frac{\eta - \eta_0}{\eta_{\max}}\right)^{\lambda_c} \qquad \text{... (15)}$$

$$\varepsilon_s = \beta \kappa u_* \frac{1}{\lambda_c} (\eta - \eta_0) \left(\frac{\eta_{\max}}{\eta - \eta_0}\right)^{\lambda_c} \qquad \text{... (16)}$$

where, $\lambda_c = 0.2$ and $\zeta = 1$.

Fig.3 presents the computed concentration distributions obtained from Eq.14. The experimental data of Parker et al. (1987), García (1993, 1994), Altinakar et al. (1996), and Sequeiros et al. (2010) for gravity currents are shown in Fig.3 for comparison.

2.5 Conclusion

The equations for velocity and concentration distributions for the near boundary and jet region are separately computed and compared to the results of previous investigators. The dimensionless profiles of velocity and of concentration are shown in Figs.2 and 3. The modified equations give best fit compared to the other.

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Notes and News

State Energy Efficiency Index 2019 releases

The Union Minister of State (Independent Charge) for Power and New & Renewable Energy, Mr. R.K. Singh recently released 'State Energy Efficiency Index 2019', which tracks the progress of energy efficiency (EE) initiatives in 36 states and union territories based on 97 significant indicators. The index was released on the occasion of RPM (Review, Planning and Monitoring) meeting held on 09-10 Jan 2020 at New Delhi.

The index is developed by Bureau of Energy Efficiency (BEE) in association with Alliance for an Energy Efficient Economy (AEEE). It will help states contribute towards national goals on energy security and climate action by helping drive EE policies and programme implementation at the state and local level, tracking progress in managing the states' and India's energy footprint and institutionalising the data capture and monitoring of EE activities by states.

The first such index, the "State Energy Efficiency Preparedness Index 2018", was launched on August 1, 2018. Taking forward the State Energy Efficiency Preparedness Index 2018, the State Energy Efficiency Index 2019 incorporates qualitative, quantitative and outcome-based indicators to assess energy efficiency initiatives, programmes and outcomes in five distinct sectors – buildings, industry, municipalities, transport, agriculture, and DISCOMs. New indicators for this year include adoption of Energy Conservation Building Code (ECBC) 2017, energy efficiency in MSME clusters, etc.

The required data was collected from the concerned state departments such as DISCOMs, urban development departments and other departments with the help of State Designated Agencies (SDAs). This year, a total of 36 states and union territories have been assessed based on their efforts and achievements in policy and regulation, financing mechanisms, institutional capacity, adoption of energy efficiency measures and energy savings achieved.

For rational comparison, states/UTs are grouped into four groups based on aggregated Total Primary Energy Supply (TPES) required to meet the state's actual energy demand (electricity, coal, oil, gas, etc.) across sectors. TPES grouping shall help states compare performance and share best practices within their peer group. Under four categories based on TPES, Haryana, Kerala, Karnataka, Maharashta, Himachal Pradesh, Uttarakhand, Puducherry and Chandigarh have been evaluated as progressive states/UTs in the State Energy Efficiency Index 2019.

Key takeaways for the states

The State EE Index 2019 shows that majority of the initiatives taken by states are related to policies and regulations. Most of the first-generation energy efficiency policies prepared by BEE under programmes on Standards and Labelling (S&L), ECBC, Perform Achieve and Trade (PAT), etc. are understood by states and as the next steps they should focus on ensuring greater compliance to achieve savings. Based on the analysis of responses submitted by states this year, a three-point agenda is suggested for consideration by state agencies:

1. Proactive role by states in policy formulation and implementation to shift the focus from "policies in place" to "policies successfully implemented".
2. Strengthening the mechanism for data capture, management and public availability of data: For this year's index, SDAs proactively contacted various state departments to gather data. However, SDAs should further enhance their engagement with state departments and private sector to enable a robust mechanism for energy data management system.
3. Enhancing the credibility of EE schemes: Ensuring the integrity of programmes that have direct or indirect linkages with common consumers is significant to energy efficiency market transformation. The states must demonstrate an approach which includes enforcement and compliance checks as well as independent monitoring and verification of savings, which is integral to all EE policies and programmes.

Renewable energy sector makes rapid strides in 2019 – year end review

As a part of Nationally Determined Contributions as per the Paris Accord on Climate Change, India has made a pledge that by 2030, 40% of our installed power generation capacity shall be from non-fossil fuel sources and also by 2030, reduce emission intensity of GDP by 33-35% from 2005 level.

Economic growth, increasing prosperity, a growing rate of urbanisation and rising per capita energy consumption has increased the energy demand of the country.

Keeping in view the above and the country's commitment for a healthy planet with less carbon intensive economy, we decided in 2015 that 175 GW of renewable energy capacity will be installed by the year 2022. This includes 100 GW from solar, 60 GW from wind, 10 GW from biomass and 5 GW from small hydropower. The substantial higher capacity target will ensure greater energy security, improved energy access and enhanced employment opportunities. With the accomplishment of these ambitious targets, India will become one of the largest green energy producers in the world, surpassing several developed countries.

The Prime Minister in his address to Climate Action Summit stated that "India's renewable energy capacity would be increased much beyond 175 GW, and later till 450 GW". In line with the objective of expanding renewable energy sector, several important initiatives were taken during year 2019.

Renewable energy capacity is rising rapidly and the status of projects as on 17.12.19 is given below:

Sector	Installed capacity (GW)	Under implementation (GW)	Tendered (GW)	Total installed/ pipeline (GW)
Solar power	32.53	25.05	25.78	83.36
Wind power	37.28	9.64	2.20	49.12
Bio energy	9.94	0.00	0.00	9.94
Small hydro	4.65	0.55	0.00	5.20
Wind solar hybrid	0	1.44	0.00	1.44
Round the clock (RTC) power	0	0.00	1.60	1.60
Total	84.40	36.68	29.58	150.66

Major initiatives undertaken during the year 2019

1. Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM)

In a major initiative towards making *Annadata* also *Urjadata* PM-KUSUM scheme was approved on 8th March 2019 and implementation guidelines were issued on 22.7.2019. The state-wise allocation of capacities for the first year was made on 13.8.2019. The scheme covers grid-connected RE power plants (0.5 – 2 MW)/solar water pumps/grid connected agriculture pumps and has following three components:

Component A: Installation of 10,000 MW of decentralized ground mounted grid connected renewable energy power plants by farmers of 500 kW to 2 MW capacity within 5 km distance from sub-station primarily on barren/uncultivable land. The DISCOMs will purchase power at pre-fixed tariff for which they will get PBI of Rs.0.40 per unit up to Rs. 33 lakh per MW in a span of five years.

Component B: Installation of 17.50 lakh standalone solar powered agriculture pumps for which Government of India will provide financial support up to 30% of the cost of solar pump and the states to also provide at least 30% of the cost of solar pump, balance cost to be shared by the beneficiary farmer. (For NE and hilly states/UTs the central support would be up to 50% of the cost of solar pump.

Component C: Solarisation of 10 lakh existing grid-connected agriculture pumps for which Government of India will provide financial support up to 30% of the cost of solarisation and the states to also provide at least 30% of the cost of solarisation, balance cost is to be shared by the beneficiary farmer. (For NE and hilly states/UTs the central support would be up to 50% of the cost of solarisation.

Targets: Setting up of 25,750 MW additional solar capacity by 2022.

Implementing framework: Scheme will be implemented by agencies designated by the states for the three components in the respective states as per implementation guidelines issued by MNRE. The centralised tendering envisaged for Component-B. Centralised tendering for 1.75 lakh solar pumps Component-B completed by EESL (Energy Efficiency Services Ltd.) and the states started implementations of Component-B. For Components-A and C the states have to initiate process as per guidelines.

2. Standard bidding guidelines

The Ministry has issued guidelines for tariff based competitive bidding process for procurement of power from grid connected solar and wind power projects with an objective to provide a framework for procurement of solar and wind power through a transparent process of bidding including standardisation of the process and defining of roles and responsibilities of various stakeholders.

In order to strengthen the contractual provision in the contract (power purchase agreement) between the solar power generators and the procurers, and to facilitate setting up of solar power projects, the government, vide notification dated 22.10.2019 from the Ministry of New & Renewable Energy, has made following major amendments to the guidelines for tariff based competitive bidding process for procurement of power from grid connected solar PV power projects:

(i) Solar power generators have been allowed to submit documents/lease agreement to establish possession/ right to use 100% of the required land in the name of the solar power generator for a period not less than the complete term of the PPA, on or before the scheduled commissioning date (SCD).

(ii) Clear and elaborate provisions for time extension and compensation to affected party in the event of natural and non-natural force majeure events with specific provisions regarding termination due to natural and non-natural force majeure events have been included.

(iii) Quantum of compensation for back-down has been increased from 50 % to 100% with provision for recognition of only written instructions of back-down and payment of back-down compensation.

(iv) Corresponding time extension in date for achievement of financial closure and scheduled commissioning date, in case there is a delay in adoption of tariff by the concerned Electricity Regulatory Commission beyond a period of 60 days from the filing of such application.

Similar relaxations were also made for wind power bidding guidelines.

3. Development of ultra mega renewable energy power parks (UMREPPs)

The Ministry has undertaken a scheme to develop ultra mega renewable energy power parks (UMREPPs) under the existing Solar Park Scheme. The objective of the UMREPP is to provide land upfront to the project developer and facilitate transmission infrastructure for developing renewable energy based UMPPs with solar/wind/hybrid and also with storage system, if required.

The implementing agency of the UMREPPs may be a special purpose vehicle (SPV) in the form of a joint venture company (JVC) to be set up between central public sector undertaking (CPSU) and any state public sector undertakings (SPSU) or state utility or agency of the state government or a SPV fully owned by any CPSU or a SPV fully owned by any state PSU/state utility/agency of the state government.

NTPC, SECI, NHPC, THDC, NEEPCO, SJVNL, DVC, NLC and PFC have proposed to set up UMREPPs of around 42,000 MW in various states.

4. Grid-connected rooftop solar (RTS) programme

Phase II of the grid connected rooftop solar programme was approved with a target for achieving cumulative capacity of 40,000 MW from rooftop solar (RTS) projects by the year 2022 in February 2019. In the Phase-II programme, central financial assistance (CFA) for the residential sector has been restructured. Important features of the Phase-II of RTS are as under:

- Power distributing companies (DISCOMs) will be the implementing agencies
- Subsidy/CFA will be available for the residential sector only
- CFA under residential category will be provided for 4000 MW capacity and the same will be provided on the basis of benchmark cost or tender cost, whichever is lower.
- For RTS systems up to 3 kW, CFA is 40%; for capacity above 3 kW and up to 10 kW, CFA is 40% for first 3 kW and 20% for balance quantity; for capacity above 10 kW, CFA is 40% for first 3 kW and 20% for next 7 kW. No subsidy beyond 10 kW capacity.
- For group housing societies/residential welfare associations (GHS/RWA), CFA will be limited to 20% for RTS plants for supply of power to common facilities; however, the capacity eligible for CFA for GHS/RWA will be limited to 10 kW per house with maximum total capacity up to 500 kWp.
- Residential consumers/group housing societies/ residential welfare associations have to pay only balance amount after deducting the CFA to the empanelled vendor for installation of the RTS project
- For availing the benefit of CFA, indigenously manufactured PV modules and cells are to be used.
- Performance based incentives will be provided to DISCOMs based on RTS capacity achieved in a financial year (i.e. 1st April to 31st March every year till the duration of the scheme) over and above the base capacity i.e. cumulative capacity achieved at the end of previous financial year.

5. Solar PV manufacturing

The government producer scheme for setting up of solar PV power plants using domestically manufactured SPV cells and modules.

The government have approved a scheme [CPSU scheme Phase-II (government producer scheme)] for setting up of solar PV power plants by government producers [central public sector undertakings (CPSUs)/state public sector undertakings (SPSUs)/government organisations, etc.], as per extant guidelines, in a World Trade Organization (WTO) compliant manner, using domestically manufactured solar PV cells and modules to encourage ‘Make in India’ in solar PV manufacturing sector.

Solar PV manufacturing linked PPAs for solar power plant

Tenders for setting up of solar PV manufacturing capacities in India linked with assured offtake in the form of PPAs for solar power plant has been finalized. SECI has already concluded a bid for one such tender under which 2-3 GW of solar PV cells and modules manufacturing capacity linked with 8-12 GW of solar PV power plants capacity is likely to come up.

6. Wind-solar hybrid

The main objective of the National Wind-Solar Hybrid Policy is to provide a framework for promotion of large grid connected wind-solar PV hybrid system for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land. The wind-solar PV hybrid systems will help in reducing the variability in renewable power generation and achieving better grid stability. The policy also aims to encourage new technologies, methods and way outs involving combined operation of wind and solar PV plants. So far, SECI has awarded 1440 MW capacity of wind solar hybrid projects after e-reverse auction. In addition, Hero Future Energies has commissioned wind solar hybrid project by adding 28.8 MW of solar project to an existing 50 MW wind project (total 78.8 MW hybrid project) in Raichur district, Karnataka.

7. Offshore wind power in India

The National Offshore Wind Energy Policy was notified in October 2015 with an objective to develop the offshore wind energy in the Indian Exclusive Economic Zone (EEZ) along the Indian coastline of 7600 km eight zones are identified each in Gujarat and Tamil Nadu having cumulative offshore wind energy potential of 70 GW. Expression of Interest for first 1 GW offshore wind project was floated in April, 2018. More than 35 participants from in country onshore wind developer/manufacturer as well as international offshore wind developers had participated. The inputs received from the participants have been duly considered in designing the bid documents.

8. Inter-state transmission system (ISTS) Phase-II (66.5 GW REZ)

Potential renewable energy zones (66.5 GW – solar 50 GW and wind 16.5 GW) have been identified in the states of Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Rajasthan and Madhya Pradesh and a comprehensive transmission scheme was evolved integrating these renewable energy zones.

The scheme is being implemented in phases by way of either tariff based competitive bidding (TBCB) or through regulated tariff mechanism (RTM) by PGCIL. The TBCB bids are being carried out by PFC and REC. The allotment of works in TBCB or RTM is done by established committees of transmission constituted by the Ministry of Power.

Of this, Phase-I projects (for evacuation of 12.4 GW) have been bid out, awarded and are under implementation. Phase-II projects (for evacuation of approximately 15 GW) have been allotted by the Ministry of Power in October/November 2019 and the bids have been issued by PGCIL/PFC. The Phase-III (approximately 39 GW) projects are under approval of the National Committee on Transmission.

9. Payment comfort

Opening of LCs by all DISCOMs/distribution licensees for all producers.

The Ministry of Power has issued an order regarding opening and maintaining of adequate letter of credit (LC) as payment security mechanism (PSM) under Power Purchase Agreements (PPAs) by distribution licensees (DISCOMs).

Further, the Ministry of Power has instructed Power System Operation Corporation Ltd. (POSOCO) that according to the procedure for scheduling of power to distribution company, power will be scheduled for dispatch only after a written intimation is given to the appropriate load despatch centre (LDC) i.e. NLDC/RLDC/SLDC that letter of credit (LC) for the desired quantum of power with regard to the generating stations has been opened.

Term loans to DISCOMs for clearing outstanding payments of RE generators.

The Ministry has requested PFC/REC/IREDA to extend short term loan to DISCOMs for the purpose of making payments to renewable energy generators.

10. Energy storage

SECI have floated two tenders which include battery storage systems:

1. 1200 MW tender with requirement of supplying power during evening/morning (six hours) peak, with battery storage system.
2. 400 MW round the clock renewable, this will also come with battery storage system.

11. Second Assembly of the International Solar Alliance (ISA)

The Ministry hosted the second assembly of International Solar Alliance (ISA) on 30th and 31st October 2019 New Delhi. On 30th October 2019, coordination and consultation meetings on different aspects of ISA programmes and initiatives were held.

The Assembly met on 31st October 2019 and was presided by Mr. R.K. Singh, Union Minister and ex-Officio President of ISA. Delegations from 78 countries participated in the Assembly including 29 ministerial delegations of which 25 are from ISA member countries, two from signatory countries, and two from prospective member countries. The Assembly deliberated upon ISA's activities and new proposals for accelerating development and deployment of solar energy in ISA member countries and approved Rules and Procedure of the Assembly, Manual of Regulations of ISA, and Work Programme and Budget for the year 2020.

13. Dispute resolution mechanism

During the period MNRE set up a dispute resolution mechanism for wind/solar projects to consider the unforeseen disputes between solar/wind power developers and SECI/NTPC, beyond contractual agreement. This mechanism will help in smooth implementation of solar/wind energy projects in India, by expeditiously resolving, unforeseen disputes that may arise beyond the scope of contractual agreements.

14. Off-grid solar PV applications programme Phase III

The government is implementing Phase-3 of the off-grid solar PV applications programme for solar street lights, solar study lamps and solar power packs. Based on the demand for solar street lights and solar study lamps sanction has been issued to states; EESL has completed centralised tendering for solar street lights and solar study lamps.

Provision has been made for financial support up to 90% of the benchmark cost of the system for NE states, hilly states/

UTs and island UTs; up to 30% of the benchmark cost of the system for other states. Solar study lamps for students will be provided in NE states and LWE affected areas with 85% financial support from the central government.

Targets: 118 MW of off-grid solar power systems during 2018-20

Implementing framework: Projects will be implemented by state nodal agencies in their respective states. Centralised tendering will be done for solar streetlights and solar study lamps.

15. Atal Jyoti Yojana (AJAY) Phase-II

Applications covered: Solar street lights.

Financial support: 75% of the cost by MNRE and balance 25% through MPLAD.

Targets: A total of 3,04,500 solar street lights (SSLs) will be installed in the following states/regions:

i. States of Uttar Pradesh, Bihar, Jharkhand, Odisha and Assam, which were covered in Phase-I of the Scheme as there is additional demand in these states.
ii. Hilly states/UTs of Jammu & Kashmir, Himachal Pradesh and Uttarakhand.
iii. North Eastern states including Sikkim.
iv. Islands of Andaman & Nicobar and Lakshadweep.
v. Parliamentary constituencies covering 48 aspired districts of states other than those covered in (i) to (iii) above.

Year end review of the Department of Atomic Energy

The major policies and programmes by the Department of Atomic Energy (DAE) during the year 2019 are given below:

Nuclear power programme

- Kaiga atomic power station (KGS-1) has set the world record of 962 days of continuous operation.
- Tarapur atomic power station units (TAPS 1 &2), connected to the grid in April and May 1969, have completed 50 years of safe operation. TAPS - 1&2 are currently the oldest operating power reactors in the world, producing reliable power at about two rupees per unit.
- At present there are 22 reactors with installed capacity of 6780 MWe operating above 80% plant load factor in the country.
- Six pressurised heavy water reactors (PHWRs) of 700 MWe capacity each are at different stages of construction which would add 4200 MWe.
- Four VVER reactors (KKNPP-3 to 6), each with 1000 MWe capacity are under construction.

Nuclear Fuel Complex (NFC), has completed supply of 37 element fuel bundles to Kakarapar atomic power plant (KAPP3), first 700MWe PHWR, towards initial core requirement by establishing fabrication facility for 37 element fuel bundle manufacture.

- Many of our research facilities, including synchrotron, cyclotron, Dhruva, fast breeder test reactor (FBTR) etc. continued to achieve the highest ever performance. FBTR was operated at 30 MWe, a major milestone in its history, and its turbo generator was synchronized to the grid, delivering an electrical output of 6.1 MWe.

Indus synchrotrons (Indus-I and II) a national facility at RRCAT continued its operation in the three shifts, round the clock mode and 20 beam lines have been made available to users from all over the country. Nearly 1,000 user experiments have been carried out till November 2019.

- RRCAT has developed two medical devices viz.
  (i) ‘TuBerculoScope’, a low cost, compact and portable optical device for rapid detection of TB, and
  (ii) An ‘OncoDiagnoscope’, which is a low cost Raman probe, for in situ spectroscopic measurements of biological tissues. This is a compact and portable system for the non-invasive detection of (pre)cancerous lesions in oral cavities. This device was successfully deployed at six cancer screening camps by doctors of AIIMS, Jodhpur.
- IREL has also successfully developed a flow sheet and produced 99% pure hafnium oxide from NFC raffinate. These are value added products.

Mega science projects

Vigyan Samagam, the travelling exhibition a first-of-its-kind in the world showcasing all the Mega science projects on a single platform. This is jointly organised by Department of Atomic Energy (DAE), Department of Science and Technology (DST) and National Council of Science Museum, Ministry of Culture are jointly organising a multi-venue mega-science exhibition, Vigyan Samagam at Mumbai, Bengaluru, Kolkata, and New Delhi. The footfalls, both at Mumbai and Bengaluru, have been very impressive with more than 2.7 lakh visitors at both the cities.

67 ultra-stable power converters built at ECIL, Hyderabad for FAIR accelerator in Germany have been shipped to Germany after factory acceptance clearance from FAIR, Germany.

Civil nuclear cooperation

Progress has been made in India’s bilateral international engagement in civil nuclear cooperation with major partners.

Russia:

- Discussions are underway with ROSATOM for building 6×1200 MWe nuclear power plant at a new site.

France:

- Negotiations are in advanced stage for implementation of the Jaitapur project (6×1650 MWe).

U.S.A:

- Discussions are underway with Westinghouse for building 6×1100 MWe nuclear power plant in Kovvada (A.P.)

(vi) Progress in procurement of uranium from major global suppliers:

As part of Government's efforts towards operationalisation of India's international civil nuclear cooperation, significant outcomes have been achieved in fuel supply arrangements with major global suppliers viz, Canada, Kazakhstan and Australia.

Human resource development

Since its inception in 2008, last year, Homi Bhabha National Institute (HBNI), a deemed to be University of the Department, crossed the prestigious milestone of awarding 1000 Ph.D degrees and 1000 M.Tech degrees. Till March 31, 2018.

- HBNI awarded 1132 Ph.D degrees and 1060 M.Tech degrees. Today, a large number of the practicing oncologists in the country have been associated with HBNI academic programs. Based on its NAAC accreditation, HBNI was chosen by UGC as one of the Deemed-to-be Universities to be given enhanced autonomy.
- Global Centre for Nuclear Energy Partnership (GCNEP) has started operating in its newly developed campus near Bahadurgarh from April 2017. The centre has conducted more than 18 International training programmes, technical meetings, workshops, etc., on topical areas. Since signing of MoU between GCNEP and Bangladesh Atomic Energy Commission, 10 experts from DAE have been deputed for consultancy work for Rooppur nuclear power plant, Bangladesh varying from a few weeks to less than 3 months.

Cabinet approves MoU between India and Saudi Arabia for cooperation in the field of renewable energy

The Union Cabinet chaired by the Prime Minister was apprised of a Memorandum of Understanding between the Ministry of New and Renewable Energy of the Government of India and the Ministry of Energy of the Kingdom of Saudi Arabia for cooperation in the field of Renewable Energy. This was signed on 29th October, 2019 in Riyadh.

Objectives

The MoU aims at setting up a framework for cooperation between the two parties in the field of renewable energy in the following areas:

1. Upgrading the level of technologies and their applications in the field of renewable energy.
2. Contributing to the field of renewable energy to raise its efficiency in the national energy combination in the Kingdom of Saudi Arabia.
3. Developing the renewable energy projects in solar, wind, biogas, geothermal and other fields of renewable energy.
4. Development and localization of value chain in the field of renewable energy.
5. Developing and boosting uses of solar energy small applications for buildings, homes and others.

Electrification in rural sreas

All the inhabited census villages stand electrified as on 28.04.2018. Further, all the states reported electrification of all households, as on 31.03.2019, except few households in LWE affected Bastar region of Chhattisgarh.

Electricity is a concurrent subject and as such providing electricity connection to households falls under the purview of state governments/power utility. All the states/UTs have entered into memorandum of understanding (MoU) with the Government of India for providing 24×7 power supply to all households, industrial and commercial consumers from April, 2019 and adequate supply of power to agricultural consumers as per State policy. The Government of India supplement the efforts of the states through its various schemes including Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), Integrated Power Development Scheme (IPDS), Pradhan Mantri Sahaj Bijli Har Ghar Yojana- Saubhagya and Ujjwal Discom Assurance Yojana (UDAY).

Substantial progress has been made under DDUGJY and Saubhagya schemes towards creation of electricity infrastructure and providing electricity connections to households. Under these schemes, funds are released for sanctioned projects in installments based on the reported utilisation of amount in the previous instalment(s) and fulfilment of stipulated conditionality's. So far Rs.45,174.89 crores have been released under various projects of DDUGJY and states have reported 69% overall progress.

As reported by the states, all the inhabited un-electrified census villages stand electrified on 28.04.2018 across the country.

Further, to achieve universal household electrification by providing last mile connectivity and electricity connections to all households in rural and all poor households in urban areas across the country Government of India launched Pradhan Mantri Sahaj Bijli Har Ghar Yojana – "Saubhagya" in October, 2017. All the states reported electrification of all households on Saubhagya portal, as on 31.03.2019, except few households in the LWE affected Bastar region of Chhattisgarh. Since launch of the scheme, 2.628 crores households were electrified up to 31.03.2019 across the country.

IEA launches first in-depth review of India's energy policies

In partnership with NITI Aayog, International Energy Agency (IEA) released the first in-depth review of India's energy policies.

The report highlights the achievements of India's energy policies and provides recommendations to support the government's goals of promoting well-functioning energy markets and boosting deployment of renewables.

IEA regularly conducts in-depth reviews of energy policies for its member and association countries. This is the first review carried out for India, which has been an IEA-association country since March 2017.

Introducing the report, NITI Aayog Special Secretary Mr. RP Gupta welcomed and commended the hard work of the IEA. He said, 'As India builds on the remarkable growth and development of its energy sector, this in-depth review will help the government in meeting its energy objectives by setting out a range of recommendations in each energy policy area.'

NITI Aayog CEO Amitabh Kant, who had brought up the idea with IEA to conduct the review, said: 'With clear goals in place, the country is making great strides towards affordable, secure and cleaner energy for all its citizens. India is working hard to move towards its aspirations of transforming the energy sector.'

'IEA has the privilege of enjoying a close relationship with India. This first in-depth review of the country's energy policies illustrates the value of our growing collaboration,' said the Executive Director of IEA, Dr Birol.

'The energy choices that India makes will be critical for Indian citizens as well as the future of the planet. This was demonstrated at IEA's 2019 ministerial meeting, which mandated the Agency to start consultations with India for a strategic partnership that could serve as a path to eventual membership, a game-changer for international energy governance.'

The IEA report congratulates the Indian government on its outstanding achievements in extending citizens' access to electricity, affordable efficient lighting and clean cooking in record time through historic schemes like SAUBHAGYA, UJALA and UJJWALA,while pursuing energy market reforms and the swift deployment of renewable technologies. The report highlights the strong growth of renewables in India, which now accounts for almost 23% of the country's total installed capacity. The review also found that energy efficiency improvements in India avoided 15% of additional energy demand, oil and gas imports, and air pollution as well as 300 million tonnes of CO_2 emissions between 2000 and 2018.

India is becoming increasingly influential in global energy trends. The country's demand for energy is set to double by 2040, and its electricity demand may triple, according to the IEA report. Indian oil consumption is expected to grow faster than that of any other major economy. This makes further improving energy security a key priority for India's economy, says the IEA.

IEA welcomes Indian government policies designed to conduct large-scale renewable energy auctions, open up coal mining to private companies, and promote access to oil and gas markets for foreign investors. The report offers a wide range of recommendations for reforms in support of India's goal of promoting open and well-functioning energy markets in sectors such as coal, gas and electricity. These include building strong regulators to ensure non-discriminatory access, moving from state allocation to market pricing, and further rationalizing energy subsidies.

In India's renewables-rich states, the share of variable renewables in electricity generation is already above 15%, a level that calls for dedicated policies to ensure they integrate smoothly into the power system. NITI Aayog can play a strong role in working with the states to implement power sector reforms, advance grid integration, improve flexibility and coordinate energy policy decisions.

The review also strongly encourages India to institutionalise energy policy coordination across government with a national energy policy framework.

India's Power and Renewable Energy Minister congratulated IEA and NITI Aayog for the launch of the report: 'India's energy policy is a global story. India has the largest unified power grid that operates in a single frequency. India has moved from scarcity to surplus electricity over the past few years, while implementing the largest and the fastest energy access improvement and energy efficiency programmes in the world.'

Coal Minister Joshi said, 'With the support of Mr. Amitabh Kant and Dr. Rajiv Kumar, India recently launched commercial mining operations. IEA's report will be very helpful for designing our future course of action in the energy sector.'

Petroleum and Natural Gas Minister Dr Pradhan said: 'NITI Aayog has already started preparing a National Energy Strategy, and I would like to propose an annual event where NITI and IEA can bring together global energy stakeholders to have a structured energy dialogue. We look forward to engaging with IEA on oil security and on helping India move towards a natural gas-based economy.' NITI Aayog Vice Chairman Dr Kumar emphasises that India's energy goals cannot be achieved without a strong coordination of policies and targets between Central and state governments, notably on electricity market design and renewable targets, and that a stronger cooperation is therefore needed on these fronts.

The report will help India to design implementation strategies to achieve secure and sustainable energy access for its citizens.

International workshop by BEE on "Energy Efficient Cooling"

As part of "Energy Conservation Week", celebrated from 9th to 14th December 2019, Bureau of Energy Efficiency (BEE), a statuary body under the Ministry of Power, conducted an International Workshop on 12-13th December 2019 on "Energy Efficient Cooling" at Scope Convention Centre, New Delhi. The two-day international workshop was organised in association with International Energy Agency (IEA) under SEAD initiative of Clean Energy Ministerial (CEM).

Commenting on the development and implementation of cooling sector, policies and programmes, Secretary, Ministry of Power, Government of India, Mr. Sanjiv Sahai, said," The rising demand for space cooling in buildings, vehicles and cold chain sector is a challenge to be addressed. There is a need to have effective policies and schemes in this sector for deployment of new efficient technologies. BEE has been implementing initiatives towards promoting energy efficient cooling and has conducted several studies for developing policy framework in new sectors like cold chain."

The workshop served as a platform for global experts, industries, and policy makers to explore opportunities to accelerate deployment of an energy efficient cooling, across different sectors and establishments. Objective of the workshop was to chart out steps towards accelerating the development and deployment of efficient cooling appliances, equipment and systems. It helped to explore policies, technologies, innovation, new approaches and business models across space cooling and cold chains. The event highlighted action plans, international best policy practices, measures to stimulate innovation and deliberations on steps forward. These initiatives and knowledge sharing sessions help in framing best policies and support industry bodies to adopt technologies from across the globe. The workshop was attended by various delegates involving regulatory bodies, policy makers, government officials, PSUs, etc. from across the world. Different sessions were attended by officials and experts from different international bodies related to energy efficient cooling. The thoughtful discussions were very fruitful and acted as platform for the stakeholders to adopt new technologies and policy frameworks for an energy efficient cooling environment. The two-day event also witnessed an exhibition showcasing new and innovative technologies in energy efficient cooling sector. The objective of such initiatives is to reduce energy intensity in the country by optimizing energy demand and reduce emissions of greenhouse gases (GHG) which are responsible for global warming and climate change. India has committed to reduce 33-35% of GHG emission by 2030 as part of document submitted to UNFCCC.

47.86 GW of renewable energy capacity installed in last six years

A total of 47.86 GW of renewable energy capacity has been installed in the country during the last six years i.e. March, 2014 to October, 2019. The initiatives taken by the government to explore new and renewable energy sources in the country inter-alia, include the Permitting Foreign Direct Investment (FDI) up to 100 per cent under the automatic route, waiver of inter state transmission system (ISTS) charges and losses for inter-state sale of solar and wind power for projects to be commissioned up to December, 2022, notification of standard bidding guidelines to enable distribution licensee to procure solar and wind power at competitive rates in cost effective manner, declaration of trajectory for Renewable Purchase Obligation (RPO) up to the year 2022, launching of new schemes, such as, PM-KUSUM, solar rooftop phase II, 12000 MW CPSU scheme Phase II, etc.

The government has set a target of installing 175 GW of renewable energy capacity by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro. All the major programmes/ schemes being implemented by the Ministry have established mechanisms to monitor the implementation of these schemes. The provisions, inter-alia, include:

- Physical verification by state implementing agency.
- Periodic inspection by the officials of Ministry of New and Renewable Energy (MNRE).
- Third party evaluation.

Wind power projects of 12,162.50 MW capacity awarded so far

Wind power projects are built up in the country, including in the state of Rajasthan, on the basis of commercial principles taking into account wind resource, land availability, transmission infrastructure, etc. So far, bids for 15,100 MW of wind power projects have been issued, out of which projects of 12,162.50 MW capacity have been awarded. The cumulative installed capacity of wind power (as on 31.10.2019) in the country is 37,090.03 MW. The details of state-wise installed capacity of wind power are given in Table 1.

Table 1: State-wise wind power installed capacity as on 31.10.2019

State	Cumulative wind power capacity as on 31.10.2019 (MW)
Andhra Pradesh	4092.45
Gujarat	7203.77
Karnataka	4753.40
Kerala	62.50
Madhya Pradesh	2519.89
Maharashtra	4794.13
Rajasthan	4299.72
Tamil Nadu	9231.77
Telangana	128.10
Other States	4.30
Total	37090.03

The government has issued 'Guidelines for Development of Onshore Wind Power Projects' on 22 October 2016 with an objective to facilitate development of wind power projects in an efficient, cost effective and environmentally benign manner taking into account the requirements of project developers, states and national imperatives. The Guidelines have provisions for requirement of site feasibility, type and quality certified wind turbines, micrositing criteria, compliance of grid regulations, real time monitoring, online registry and performance reporting, health and safety provisions, decommissioning plan, etc.

The government has also issued 'Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects', on 8th December, 2017, with an objective to provide a framework for procurement of wind power through a transparent process of bidding including standardization of the process and defining of roles and responsibilities of various stakeholders.

The government is promoting capacity addition of wind power projects through private sector investment by providing various fiscal and financial incentives such as Accelerated Depreciation benefit; concessional custom duty exemption on certain components of wind electric generators. Besides, Generation Based Incentive (GBI) is available for the wind projects commissioned before 31 March 2017. In addition to fiscal and other incentives as stated above, technical support including wind resource assessment and identification of potential sites is being provided through the National Institute of Wind Energy, Chennai.

TURBIDITY CURRENTS

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