Future Challenges in Indian Power Sector including the Remedial Actions

Apoorva Anand
Assistant Director
Central Electricity Authority

Ammi Toppo
Director
Central Electricity Authority

J. Bandyopadhyay
Chief Engineer
Central Electricity Authority

Abstract : The Indian Power Sector is set to face several challenges in imminent future. This shall call for revolutionary changes in the way the power sector functions today. First challenge originates from Government of India 's ambitious target of 175 GW Capacity Achievement from Renewable Energy Sources by 2022 and integration, thereof, into the national grid. This shall necessitate radical changes in the way traditional generators and grid operate. Low PLF of the Thermal Plants, requirement of flexible operation of the Thermal plants, ensuring availability of adequate balancing capacity, meeting steep ramping requirements, forecasting of RES generation with acceptable degree of accuracy etc. are some of the challenges the Indian Power Sector has to overcome. This is further complicated by the acute shortage of gas for the Gas based plants, very slow development of hydro sector including pump storage plants etc. Again, over the last few years, the rate of capacity addition particularly from coal based sources has outpaced the rate of growth of demand. As a result, the pool of unutilized capacity is expanding rapidly. The situation may further get compounded due to likely under-utilisation / non-utilisation of around 50,000 MW of coal-based capacity which are at different stages of construction and may materialize between 2017-22. Requirement of no additional coal based capacity in imminent future may deal a severe blow to the large manufacturing base for Thermal Power Plant's equipment. Implementation of the new environmental norms including retirements of units and phasing thereof, is another issue which also poses serious challenges to the entire power sector. Other significant problems may arise in the large scale disposal of energy storage devices like batteries which shall be employed on a wide scale in solar roof tops installation and Electric vehicles.

This paper highlights the challenges likely to be faced by the power sector in the imminent future and the urgent steps needed to overcome the challenges.

INTRODUCTION

Since the decision of Government of India to have Installed capacity of 175 GW of RES, whole of the power sector has shifted its focus and is aligning itself to achieve the target set by the Government. Simultaneously, everyone is trying to figure out the future scenario and other events which may unfold due to this radical shift in Indian Power sector. The need to the hour is to assess the challenges which need to be dealt with and threats which may derail our plans to achieve the target within the ambit of sound principles incorporated in Electricity Act,2003.

LARGE SCALE INTEGRATION OF RENEWABLE SOURCES

Government of India has set an ambitious target of capacity achievement of 175 GW from Renewable Energy sources by March 2022. As of 31.03.2017, the Installed capacity of RES (excluding Hydro) stands at 57,260.23 MW [1]. The goal of achieving more than three times of present installed capacity of RES over a period of 5 years till 2022 is going to be a very challenging task for India.

As per the Draft National Electricity Plan, the fund requirement for the achievement of RES capacity of 175 GW is estimated to be around 6,48,050 crores [2]. To meet this requirement, Government may provide some of the funding as Grant to few projects going to be developed by States/PSUs but this might be just like a drop in the ocean of fund requirement. Primarily, the main sources available for debt funding are scheduled commercial banks, financial institutions like PFC, REC, LIC but with the mounting burden of NPAs and fiscal bail out of Discoms, banks and financial institutions may find it hard to fund such a huge requirement of debt. Innovative solutions like issuing green bonds, climate bonds etc. by projects for their capital requirements may be explored. Other sources which may

fund these projects are loans from World bank, Asian Development Bank, EXIM bank etc.

Apart from capital requirement, the challenge lies in drawing interest of developers/investors in this sector. The market price of solar power has been reducing drastically over the last few years (Rs10.95-12.76 per kWh in 2010-11). In the latest competitive bidding carried out for Bhadla Solar Park 3, the price being quoted was as low as Rs 2.44 per kWh [3]. Several players are in the fray of solar capacity installation and consequentially the profit margins and ROC (Return on Capital) have fallen considerably. This ongoing trend of fierce competition may create uncertainty over the long term sustainability of these projects as project developers are also faced with risks like nonpayment of dues for power purchased by DISCOMs and refusal of utilities to off-take power. States are also deferring their power procurement plans from RES projects in order to benefit from this trend of decreasing prices. Against the capacity addition target of 12 GW in 2017 from solar, only 6 GW solar capacity has been commissioned in 2017.

The government has taken several steps for attracting investment by providing fiscal incentives and subsidies like Viability Gap Funding from National Clean Energy fund(NCEF), Accelerated Depreciation etc. The Government has also created a Payment Security Fund to ensure visibility of cash flows for solar developers through Solar Energy Corporation of India against defaults by State distribution companies. Government has also formulated National Tariff Policy 2016 mandating solar RPOs to increase to 8% by 2022 for state utilities. Despite all these measures, it had been claimed by Solar and wind project developers that their investments were in jeopardy, owing to delays in signing of PPAs, delays in payments on commissioned plants, and forced reduction/shutdown of their power plants. Thus lack of enforcement of RPOs by state regulators and poor financial health and credit worthiness of the DISCOMs pose a serious threat for the development of RES capacity in India. Although, Government of India remains committed to create a lower-risk investment atmosphere for this sector but facilitating this huge capital investment still remains a challenge in years to follow and requires a holistic approach in cooperation with states to deal with it.

The challenge also entails integration of additional RES Generation capacity of around 118 GW into the national grid over the next five years. This will require strengthening of our transmission and sub-transmission networks, which also require capital infusion. Multi-faceted planning of grid integration of the renewable energy capacity considering all associated factors and contingencies would only lead to the achievement of targets. Suitable inter-state and intra state transmission corridors need to be laid for evacuation of power from RE rich states to the load centers. In this regard, it is appreciable that Green Energy corridor project is already under implementation and PGCIL is executing the inter-state projects and state transmission utilities executing intra state projects. Another problem lies in the gross mismatch of the gestation periods of RES Generation and transmission capacities. The typical gestation period of laying down a transmission line varies from 3-4 years but the gestation period of installation of RE based generator is typically around 12-18 months. This may lead to a situation of bottlenecking of power or RE plant being forced to back down. Developers need to be assured of the evacuation and sale of power from their project. Therefore, transmission projects need to be planned well in advance to cater to the generation from RE sources.

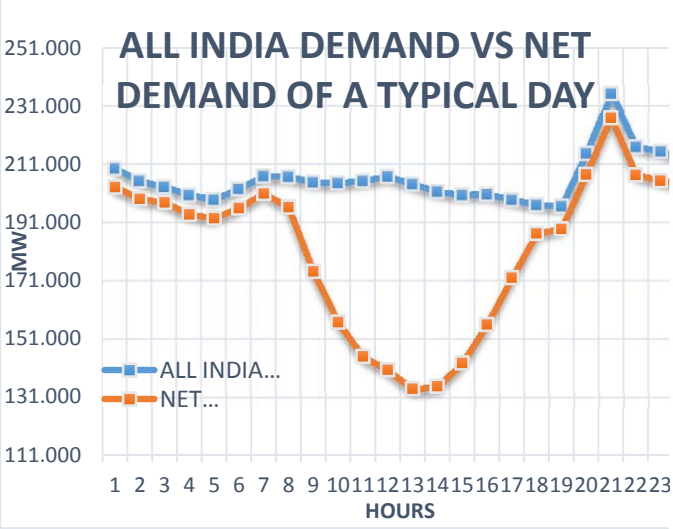
It is also envisaged that capacity of 40 GW from solar rooftops would be available by 2022. The achievement of this target requires distribution and sub-transmission levels to be strengthened. State utilities have introduced the concept of Net metering for the promotion of solar roof tops but solar roof tops installation is still not gaining enough traction.

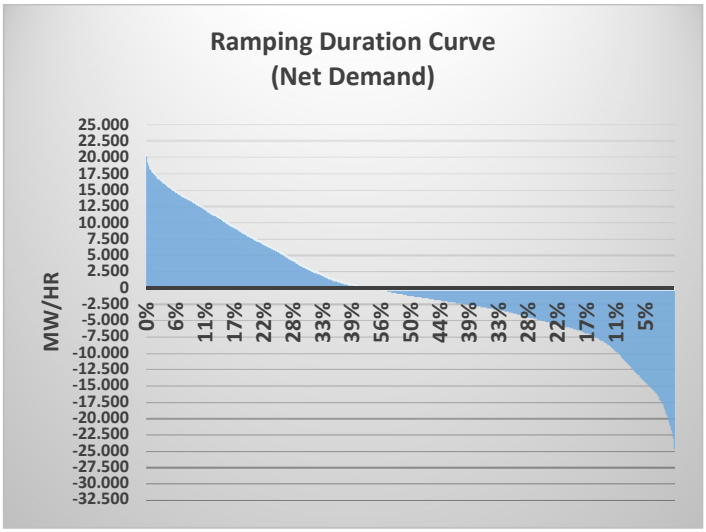
Integrity, security and reliability of the grid has to be ensured with the Grid integration of Variable RE sources. Uncertainty and variability of RES Generation poses a great challenge to achieve this. Greater flexibility in the operation of conventional power plants will be essential to deal with this challenge. Ancillary services operation will also be required for maintaining grid stability due to intermittency and variability associated with RE generation. A comprehensive set of regulations relating to net metering, time differentiated tariffs for end consumer, ancillary services may be formulated soon to deal with the challenges lying ahead.

BALANCING THE GRID

The Renewable Energy Generation has two aspects i.e. Variability and Uncertainty associated with it. The generation from solar is highly variable during the day. Generally, it gets maximum during the noon and gradually reduces till zero in the evening when the load on the grid is maximum. The variability of Wind energy can be significant over the seasons. Due to this, the net demand curve is very steep during the evening and to balance the

grid, flexible generation that can ramp up quickly is required. The load duration curve for the year 2021-22 for the total demand and net demand (subtracting renewable generation from the load) has been studied, and it was observed that the demand to be met by the conventional generation varies between 158 GW to 225 GW in case of zero renewable, whereas in the net demand (with 175 GW of renewable) the conventional generation varies between 71 GW to 125 GW. The ramping requirement for the year 2021-22 has been studied for 8760 hours, and it was found that ramping requirement of 7500 MW/hour is required for only 5% of time for zero renewable capacity whereas with 175 GW of renewable capacity this requirement rises to 21% of the time. It has also been observed that the difference in daily off-peak and peak ratio in case of zero renewable is in the range of 0.02 to 0.05 whereas in case of 175 GW of renewable it is between 0.05 to 0.15. The generation from 160 GW of wind and solar which is of variable in nature will displace conventional generation, leading to less frequent dispatch and fewer generating hours. The typical net load curve (duck shaped curve) and ramping duration curve as given in Draft NEP has been given as below.





To cater to the Huge peaking requirement, gas power plants and hydro power plants especially pumped storage type hydro plants will be required. Other storage technologies like large capacity batteries which are in nascent stages of development can also contribute in meeting the peaks. Economic viability of all such balancing technologies will need to be assessed so that the electricity is within the reach of every consumer at affordable rates.

Gas based plants can be quite productive during evening to meet the balancing power and ramping requirement. However, the domestic gas production has been almost constant over the years. There has been unavailability of sufficient domestic gas for running gas power plants of around 24 GW. The average gas supplied to the gas based power plants during the year 2015-16 was only 28.26 MMSCMD. The Gas Power plants can run on imported RLNG but the prices of energy become high enough to be able to get the despatch as per the merit order despatch. As per Draft NEP, it is estimated that around 53.56 MMSCMD[2] gas would be required for gas based power stations to meet the balancing and peaking requirement of the grid. Therefore, suitable tariff mechanisms need to be designed to encourage power plants to operate in such a manner as to fulfil the peaking requirement.

Also, the availability of hydro power for ramping requirement is limited by the Irrigational requirements, failure of monsoon etc. The gestation period of a Hydro Power Plant is generally 7-8 years. Focusing on Hydro Power from now will start to yield result 2027 onwards. The Hydro capacity which is already under construction is mired

with different issues hampering its growth like Land acquisition issues, Environment and Forest issues, Rehabilitation & Resettlement, Natural Calamities, Law & order problem & Local issues, Contractual problems, Geological uncertainties, Difficult Terrain & Poor Accessibility, Funds constraints, Force Majeure Risk, Inter-state issues etc.

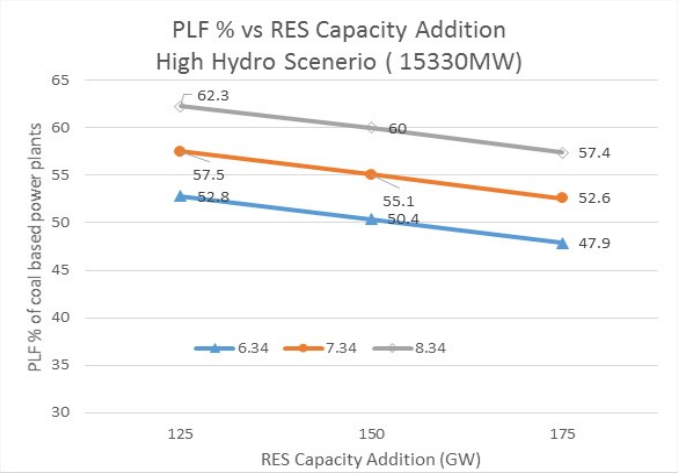
Analyzing all factors, it appears that it is going to be an arduous task for the grid operator to meet demand requirement along with maintaining grid security & reliability. Balancing the national grid is going to be a great challenge for all stakeholders in the power sector. Thermal Power plants would have to carry out retrofitting to increase their ability to ramp up significantly.

Adding to the variability issue of generation, uncertainty is also associated with the energy generated from RES. For example, there may be a sudden cloud cover or fall in wind velocity which may affect considerably the planned load flows with in the network. Advance and precise forecasting of wind and solar can help reduce the uncertainty of variable renewable generation and helps system operators to plan for extreme contingencies in which renewable generation is unusually high or low. Although, there has been significant improvement in the development of forecasting techniques for renewable energy but still there is a long way to go before we are able to predict available generation more precisely. Demand side management measures encourages the customers to maximize the use of RE while the availability of energy is high and prices of energy are low. The integration of renewable generation into the grid requires changes in the existing network to allow bi-directional flow of energy i.e. from generator to users and vise-a versa. To have effective demand response, smart grid technologies involving smart meters, communication and other methods may be utilized. For reliability and stability of the grid, interconnection of grid at Regional and National level is also to be improved.

LOW PLF of THERMAL POWER PLANTS

Although the CUF of RES based power plants is low compared to conventional power plants but the energy generated by 175 GW of RES would be around 274 BUs in 2022 as given in the draft NEP which will be around 17.5% of the total energy required in 2021-22[2].

This would lead to a significant reduction in the PLF of Thermal power plants. Hydro plants by and large would not be affected because they could be used effectively during the time of peaking requirement. It is expected that PLF of thermal power plants may fall to the level of around 48-50 % in 2022. This can be attributed to several factors apart from renewable capacity addition.

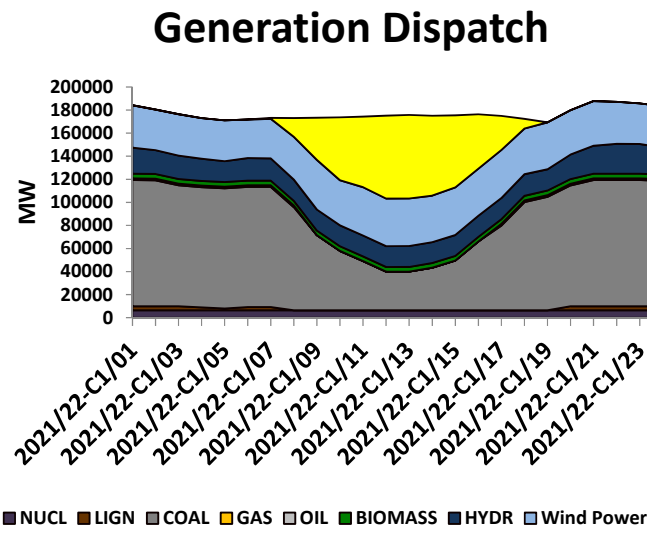


During the 12th plan, it has been witnessed that the rate of capacity addition has outpaced the rate of growth of demand. The capacity addition of 99,209 MW [1] taken place during the 12th plan has exceeded the target of 88537 MW from conventional sources. This overachievement against the target is mainly due to excess capacity addition in thermal. During 12th Plan the Thermal capacity addition target was fixed at 72,340 MW but the capacity addition achieved was 91730.45 MW. The energy demand and peak demand have grown at the rate of 4.04% and 4.18% CAGR [6] during the 12th plan respectively while the Installed capacity has grown at the rate of 10.3% CAGR during the 12th plan.

Since, as per Electricity Act 2003, Generation has been mostly delicensed and Decision of setting up of Power Plants lies with the individual discretion of the developers/investors. This has led to excessive generation capacity to meet the demand. As per Draft NEP, more than 50,000 MW of thermal capacity is already under different stages of construction which is likely to yield benefit by 2022. The additional capacity which is going to be commissioned may compound the problems for Thermal Power Plants and may remain under-utilized significantly.

Further, in India, the peak demand time does not coincide with RE Generation. This leads to requirement of sufficient capacity from other sources to meet the peak demand. Therefore, peaking requirement leads to installation of costly Thermal capacities to meet the peak demand.

All these factors are responsible for the cumulative effect of decreasing PLF in the coming years. The next challenge lying ahead for thermal capacities will be to operate flexibly to accommodate the variability and uncertainty associated with RE Generation. Plant flexibility can take many forms, including the ability to start up and shut down over short periods, run at a low minimum load, rapidly change generation output, and offer ancillary services to support system reliability. By march 2022 the coal and lignite based capacity will be around 248 GW which may be 48% of the total installed capacity and these capacities need to be flexible to accommodate the RE generation [2]. As per Draft NEP, ramping up requirement in the grid will be more than 12,500 MW/Hr for 10% of the duration within a year. To achieve this, retrofitting based on latest technology is needed to be carried out in several units which will entail capex also. Thermal capacity will be required to back down considerably during the time of peak generation from Solar capacities. In fact, during a typical day in Monsoon season, the hourly despatch from Coal based capacity could drop to about 30,000 MW during the time of peak solar generation and would ramp up to around 1,10,000 MW within 6 hours. It may lead to a scenario where two shift operation of thermal power plants could become a norm. The cost of Coal based generation may also increase due to surge in operation and maintenance costs.



To promote flexibility in the operation of Coal based power plants and compensate them for the loss or capex to be incurred by them, suitable fiscal incentives need to be provided if grid security is to be ensured. New Tariff regulations need to be formulated by CERC/SERCs in keeping with requirement of the times ahead.

UNDERUTILIZED MANUFACTURING CAPACITY

As per the Draft National electricity plan prepared by CEA, no coal based generation capacity addition is required in the next five years in the normal retirement scenario.

Additionally, no coal based generation capacity is required for the period 2022-27 as the existing and under construction capacity of 50500 MW will be able to cater the required energy and peak demand.

One of the primary reasons for this has been the lack of Energy Demand in the coming years. The rate of growth of energy demand has been moderated due to government focus on energy efficiency and in reduction of technical and commercial losses etc. Several initiatives in this regard have already been taken.

As the Energy Generation sector was delicensed in Electricity Act 2003, it drew a huge interest from investors. India had a staggering energy deficit of 10.6 % during 2011-12 and analyzing the power situation, it was realized that India needed a huge capacity addition [6].

For huge capacity addition, it was prudent to have Indigenous manufacturing base as to ensure lifetime support for services and spares, maintenance problem solving and customization for trouble free operation of these units in the Indian conditions.

Also, with the advent of units of large capacities with higher efficiency, it was foreseen that future capacity addition should comprise of these larger capacities especially super critical units. Government also tried to facilitate the investment in indigenous manufacturing capacity for manufacture of super-critical units.

As a result of the efforts made by the Government over the last decade for creating indigenous manufacturing capacity, large capital investment in the manufacturing sector took place and several joint ventures by the International manufacturers were set up in India.

As per Draft NEP, India has adequate Indigenous manufacturing capacity for Supercritical equipment consisting of 22,700 MW per year for Boiler and 24,500 MW per year for Turbine- Generator. Manufacturing capacity for hydro turbines, Gas turbines/Combined cycle and nuclear stations also exists in the country.

Apart from Main plant equipment manufacturing base, several companies have heavily invested in the businesses

associated to Power plant construction like Balance of plant systems such as Coal Handling Plant, Ash Handling Plant, Water Treatment / DM Plant, Cooling Towers, CW System, Chimney, electrical systems and switchyard. These systems are considered crucial for timely implementation of Projects.

Overall, huge amount of capital has been invested in the sector on the anticipation of getting decent Returns on Capital. But, the situation is changing at a rapid pace and several manufacturers have started reporting lack of sufficient orders. The capacity utilization factor for several manufacturing utilities have been quite low.

Moreover, the emerging scenario also does not augur well for these manufacturing utilities. Presently, Government of India has started giving more emphasis to Renewable Energy Sources and their capacity development. Government of India has set an ambitious target of capacity achievement of 175 GW from RES by 2022. It is expected that such focus on development of RES may continue beyond 2022 as India has to comply with its INDC (Intended Nationally Determined Contribution) commitment. In addition, the demand projections carried out in 19th Electric Power Survey have been significantly lower than the projections carried out in 18th EPS. These factors do not encourage the infusion of fresh capital in the establishment of new Thermal power plants.

Consequentially, the orders for the manufacturing utilities of Thermal power plants are getting dried up. This may render the manufacturing capacity and associated capital unutilized and which may end up being added to the list of Non-Performing Assets of the Banks. Requirement of no additional coal based capacity in imminent future may deal a severe blow to the large manufacturing base for Thermal Power Plant's equipment.

IMPLEMENTATION OF ENVIRONMENT NORMS AND PHASING OF RETIREMENT

India has submitted its INDC targets at UNFCCC in which it has committed to reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level [8]. Correspondingly, stringent emission standards have been contemplated for thermal plants and strict compliance of emission norms would be necessary to reduce emission intensity. This has necessitated the installation of Flue Gas Desulphurization(FGD) systems to reduce the emissions significantly.

The new environmental regulations had been aimed at installation of this technology latest by December 2017. Notification in this regard had been issued by Government in 2015 only. But several plants have not made any progress to comply with the order. Installation of FGD technology by plants entails large capital expenditure of about 0.5 Crore per Megawatt. There is no regulation being framed for the increase in the tariff of energy due to the cost incurred on FGD systems installation. It is estimated that cost of energy from emissions compliant coal power plants would increase to 3890 Rupees per MWh[11]. Therefore, Thermal power stations have been deferring this capital expenditure as they would be rendered uncompetitive due to additional incurred cost of generation. To install FGDs for such a large coal based capacity about 160 GW the Technology & Technical challenges under Indian conditions are given below:

- Space and Layout to be finalized on case to case basis. There are two types of FGD system - Limestone and Sea Water based FGD system. Space is required for FGD system equipment's and for the storage of limestone and gypsum a by-product. As per the report on land requirement for Thermal Power Plant by CEA, space varying from 7 acres for 2x500 MW units to 27 acres for 6x660 MW units is required for limestone based FGD system. However, the space required for the sea water based FGD system is 4 acres for a 3x 700 MW station using imported coal.
- The Auxiliary Power Consumption shall increase for FGD operation by 1.0-1.5% affecting the plant efficiency.
- Additional Water requirement
- Lime stone source to be identified - As per an estimate, 120 Tons/MW of limestone is required for FGDs. The requirement of limestone may further increase with new coal based capacity addition. The sourcing of such a huge quantum of limestone and disposal of the gypsum by-product of FGDs is a major concern.

Government of India has been contemplating retirement of old, inefficient units due to non-compliance of the new environmental norms. However, this endeavor is being opposed by several states and utilities as retirement of any project will affect several of its stakeholders severely.

In order to fulfil social obligations several states have been shouldering the legacy of running quite old units of Thermal plants which are inefficient and do not have sufficient space for installation of FGD systems.

Additionally, several critical issues may arise due to sudden retirement of such units. The man power employed in such projects would be rendered jobless and it would be a

challenge to employ or provide social security benefits to those people. Shutting down the project may also face local agitation as the project provides for sustaining the local economy.

It further needs to be decided whether the inefficient units would be replaced by the efficient ones or the project would be totally scrapped. The disposal of the scrap which might be generated in the process also poses serious concerns.

Another prominent challenge which might be faced would be regarding the Grid Stability. It has been estimated that around 34,000 MW capacity shall be retired in the coming years. It must be ensured that Phasing out of units over the coming years is carried out in a manner which causes minimal disturbance to the Grid. It needs to be taken care of that sufficient new capacity is commissioned before the units are retired.

Retirement at a large scale will also affect the Power procurement plans of the states. States would need additional capital if they decide to replace the old units with the new and efficient units and would further burden the finances of the state. Any further tweaking up of emission norms in the future might worsen the situation and jeopardize the operation of several Thermal power plants.

Eventually, carrying out the retirement of around 34,000 MW capacity might prove to be a bitter pill to swallow both for the State and Central Governments.

LARGE SCALE DISPOSAL OF ENERGY STORAGE DEVICES

Large scale penetration of Renewable sources of Energy in Indian Power system will necessitate installation of Large Energy Storage Devices, primarily batteries to compensate for the variability of RES generation and meeting the balancing requirement of the Grid.

In India, Lead Acid batteries are used on a wide scale for automobile and non-automobile purposes. Other types of batteries used in India are Nickel metal hydride, Nickel Cadmium Battery, Lithium ion battery etc.

Handling and recycling of batteries in India is governed by Batteries (Management and Handling) Rules, 2001 issued by Ministry of Environment and Forests that require lead battery manufacturers to collect a minimum of 90 % of the batteries sold by them [12]. But the compliance of these rules is in dire straits as only a small percentage of the total batteries sold are being collected back by battery manufacturers.

The lead recycling industry is in nascent stage in India and is struggling hard to achieve economies of scale despite rampant use of lead acid batteries. The present state of system is inadequate to collect sufficient quantities of used lead batteries through formal sector channels. In fact, cheap and polluting technologies are thriving in the current scenario through small operators.

Backyard smelting of used lead acid batteries is rampant in the country. Such improper handling and recycling of lead jeopardize the health of the workers and is an environmental hazard. It is therefore essential to ensure that secondary production of lead is done in environmentally sound manner in the facilities registered by Central or State Pollution Control Boards.

With increasing penetration of Electric Vehicles and solar roof tops installations, battery use would be more widespread in the coming years. This would mandate formulations of strict laws for recycling of batteries and incentivizing the customers to surrender the used battery to the collection centers of the company. Recycling facilities of ample capacity is needed to be set up for carrying out the recycling of the batteries.

Presently, Lithium ion batteries are gaining attention from battery manufacturers due to its longer life, higher capacity and ease in handling. But Li ion battery recycling process is more complicated than lead acid or Ni-Metal hydride battery. In fact, an economically viable technology for Li ion battery recycling is still under development.

The used Li-ion batteries may end up in the wrong recycling streams due to lack of awareness and regulations about their disposal. There has been few cases of minor explosions and fires being reported in the garbage containing Li-ion batteries.

Therefore, suitable methodologies need to be devised for segregating and recycling Li-ion Batteries from rest of the garbage. Also, it is the need of the hour to formulate regulations for disposal/recycling of different kinds of batteries based on economically and environmentally sound principles. Labelling of battery components by means of bar codes, RFID chips etc. can be quite useful to segregate different kinds of batteries and providing incentives for good recycling practices and penalties for the bad ones can be a way forward in this regard.

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