Flexibilization of Conventional Power Plants – The Indian Experience

Anjan Kumar Sinha
Renewable Integration and Sustainable Energy Initiative Under Greening the Grid (GTG-RISE)[1],
New Delhi, India.

Abstract — **As per India's commitments of COP 21, the target of adding over 175 GW of renewable by 2022 has gained a momentum towards the trend of fundamental change of electricity markets, with renewable prices as a key driver of this change. Utilities like NTPC has already started to face difficulties in coping up with this trend with a hit in the bottom line. In India, a largely hard coal-based generation, with limited storage hydro and gas supplied, most of the cost-effective balancing resources has to be provided by coal generators. Flexibilization of coal-based plants with the low grades Indian coal will need investments in retrofits procedural changes in practices besides capacity building of the entire generating staff.**

This paper comprehensively outlines the cost-effective ways of achieving coal power plant flexibility with proper incentivization in the present regulated environment of India. It is based on a wealth of actual case studies, pilot studies and data (studies by VGB under IGEF, Intertek under USAID, GTG, CEA and NTPC), which provides a reference source for the technical capabilities of power plants and the costs of providing actual flexibility. It also discusses the technical options and of operational procedural modifications and retrofits to existing power plants for enhancing system flexibility. The Indian context Unit-wise categorization of the coal plants have been done with the metrics of age, variable costs, heat rate, coal quality, unit size and design. This categorization would help the generators and the policy makers in planning for future flexibilization resources.

In fact, every IPP must identify the value that additional flexibility can add to its plants and plan the necessary intervention. Flexibility comes at a cost and benefits vary by plant, so it is important to ensure that the benefits outweigh the costs before focusing attention on possible technical and expensive upgrades. The planned capacity must be adequate overcoming the flexibilization deficit for all modes of flexibilization required in 2022 and beyond. The paper is aimed at policy makers and regulators who need to understand power plant flexibility in order to enhance system planning and upgrade policy, market and regulatory frameworks. It is important to understand that economic rules will drive the adaptation of technical measures by plant operators and give access to low cost resources needed for balancing. Even, access to the latent flexibility in the system will need unlocking through market rules. Proper incentivization rules will help to accelerate investment, innovation and the use of smart, efficient, resilient and environmentally sound technologies, which is crucial for ensuring electricity security in modern power systems. Incentivization can be best achieved in the market mechanism where the true value of flexibilization gets discovered, but India needs to move gradually from the present regulated environment to real time market.

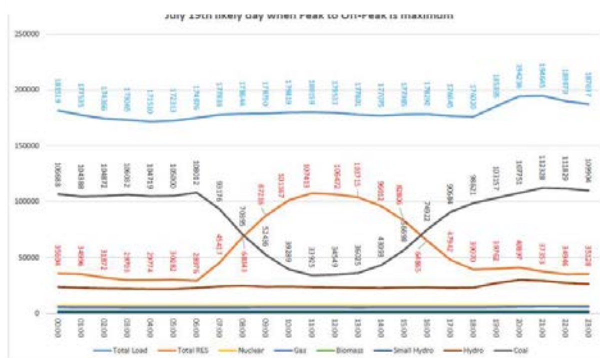
Keywords — Flexibilization, Coal generation, retrofits, cost recovery.

I. INTRODUUCTION - EMERGING SCENARIO AND NEED FOR FLEXIBILITY

Like, many power systems around the world, Indian Power system is poised for undergoing a period of rapid change. India has set a target of 175 GW of renewable energy (RE) capacity addition by 2022. While RE achieved grid parity, in India, the share of installed capacity of renewable energy out of the overall capacity, has increased more than doubled in the last couple of years.

These changes will drive a structural shift in power systems planning and operations. Moreover, they will have intrinsic implications for ensuring energy security, reliability and ensuring cost effective delivery of electricity. Hence, they require a coordinated and proactive response by policy makers and relevant stakeholders. Based on the inputs from pilot studies, case studies and real time data, this report provides a comprehensive overview of how power plants

Figure 1: July 19th likely day when Peak to Off-Peak is maximum (24 hours load/demand pattern)



[1] This paper is made possible by the support of the American People through the United States Agency for International Development (USAID). The contents of this paper are the sole responsibility of the author and does not necessarily reflect the views of USAID or the United States Government. This paper was prepared under Contract Number AID-OAA-I-13-00018/AID-386-TO-17-00001.

can contribute to making power systems more flexible, while enhancing electricity security.

Various studies (CEA,GTG,GE and NTPC) suggest that with renewable penetration of 175 GW there would be a daily net load swings of >80GW by 2022 **(Figure-1**). This creates an urgent need to lay out clear roadmap to address large renewable integration in a very short time. Moreover, In Indian, the major part of the variability and uncertainty will have to be managed by Coal based plants , due to limited balancing resources from gas and hydro.

Managing this transition to 2022 and beyond will require innovative approaches across the entire power system, spanning both institutional reforms and technical adaptations. This may include a need for governments to change policy, market and regulatory frameworks. It may also require enhanced power system planning and operation. This approach paper focuses specifically on incentivization required for making coal-based stations flexible and ensuring their proactive participation.

II. CASE STUDIES/PILOT STUDIES IN THE INDIAN COAL PLANTFOR ASSESSMENT OF FLEXIBILITY

Over the past three (3) years a number of successful pilot case studies and test runs have been conducted in Indian coal based plants. NTPC has been at the forefront on this aspect taking up the studies at its various coal based units. The inputs from these studies and pilot test runs including real time data provides a comprehensive overview of managing the power plants in low load situations and thereby contributing in making the power system more flexible while enhancing electricity security.

Each of these pilots/case studies covered some or the other following broad objectives. It is interesting to mention that all of the following objectives feature as key aspects of USAID GTG-RISE Pilots on Coal based Flexible Power Operations at NTPC and GSECL.

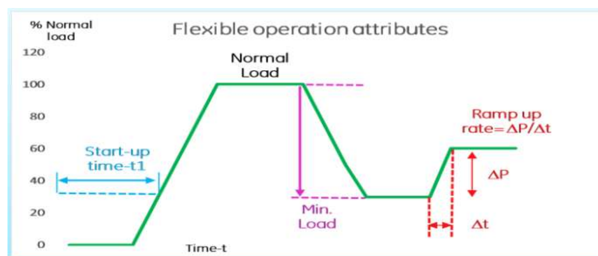
- Stable low load operation with reduced minimum load (<=40% of MCR) without oil support.
- Increased Ramp rates (3% or more)
- Optimization of start-up through automation/digitalization (reduction of start-up time and oil consumption)
- Efficient operation during cycling operations/sustained part load operation
- Minimum Impact on environment (NOx and CO reduction)
- Safety of man and machine
- Reliable operation and reducing the impact of cycling on equipment life
- Identifying the costs of cycling including the initial capital investments required and O&M expenses and methods of reducing the costs
- Study and recommend the changes require in the power plants in respect to the above
- To support in building a business case with associated commercial compensation mechanisms for flexibility for discussions with Ministry of power (MOP),CEA and CERC.
- To provide insights to CERC on compensation for generation units to act as flexible units.
- Modification of operational and maintenance practices for flexibilization
- Learning and Capacity Building

III. BENCHMARKING AND FLEXIBILZATION METRICS

Based on the wealth of case studies and pilots successfully done with international cooperation, the need for defining the matrix of flexibilization and benchmarking the same in context to the Indian scenario was felt .The Central Electricity Authority (Central policy making agency of the government of India) has dealt with the issue of defining the metrics in its report, *"A Roadmap for Flexible Operation of Thermal, Gas and Hydro Power Stations to Facilitate Integration of Renewable Generation".* It is based on the various countrywide studies and data from generating stations.

Minimum Load: The minimum load is the lowest possible net load a generating unit can deliver under stable operating conditions. It is measured as a percentage of the nominal load.

Figure 2: Flexible operation attributes



Start-up: The start-up time is defined as the period from starting plant operation until reaching minimum load. The start-up time of different generation technologies varies greatly. The other factors influencing the start-up time are, down time (period when the power plant is out of operation) & the cooling rate.

Flexibility-related improvements to coal plant startup typically occur through reductions in four key areas: (1) startup time, (2) startup fuel cost, (3) startup emissions, and (4) startup variation.

Startup Time

A typical small or large subcritical coal unit can take several hours for a start up. With a time-based classification, the shutdown/ startup event is classified by the number of hours the unit has been off-load prior to the startup.

For medium sized units a commonly used time classification is:

- < 8 hours off-load = hot start
- 8 to 48 hours off-load = warm start

- 48 hours off load = cold start.

In most cases, for large units these time values will be higher. Traditionally, the turbine casing temperature drop from a hot to ambient condition is used to determine the start types. Unfortunately, these time-based and high-pressure steam turbine casing metal temperature-based start-up classifications do not adequately classify the start-up type with respect to the boiler's thick-section pressure parts or other boiler components, which generally cool down much faster than the high-pressure steam turbine casing. A hot or warm start on the turbine might be a cold start on the boiler. In general, a cold start is more damaging than a warm or hot start due to the excessive temperature differentials on the components.

It should also be noted that the cooling behaviour of the boiler and drum/other thick walled components can vary widely, depending on the shutdown procedure and how the procedure affects the preservation of drum pressure and furnace gas temperature, and the circulation of fluid into the drum either from the feedwater/economizer or throughout the waterwall circuits.

Ramp rate:

The ramp rate describes how fast a power plant can change its net power during operation. Mathematically, it can be described as a change in net power, ΔP, per change in time, Δt. Normally the ramp rate is specified in MW per minute (MW/min), or in the percentage of nominal load per minute (% P/min). In general, ramp rates greatly depend on the generation technology.

There are several different aspects which are important to consider when characterizing ramp rates. Coal units can have ramp rates of 1%/min to 3%/min depending on size and control technology at the operator's disposal.
Several factors impact ramp rates on steam units, including the fuel quality variation, which can have a significant impact on ramping capability. The typical Indian coal quality variation directly corresponds to temperature variations, thus making load (MW) change more difficult. The control of boiler parameters is more challenging with ramping, often resulting in increasing variability of waterwall outlet temperatures. Further, the ramping can elevate combustion dynamics which induces hardware damaging pressure pulses. All of this needs to be managed properly to ensure reliable operation. The rapid increase/decrease of firing temperature can further add stress to the hardware during ramping events. Control systems allow operators to vary fuel to air ratio and control rate of change of energy, some hardware replacement with advanced controls can improve ramp rates.

IV. Impact on Cost to Generators due to Flexible Operation

Cycling costs, some of which are often latent and not clearly recognized by operators and marketers. Most small and, especially, large coal units were designed for baseload operation and hence, incur significant costs on cyclic operation. Thermal differential stresses from cycling result in early life failures compared to base load operation

Operation and Maintenance Cost

Increased Maintenance is required along with more frequent component replacements due to increased life consumption and damage due to cycling.

Reliability Impacts-Equivalent Forced Outage Rate [EFOR]

Load Following and Ramping Costs

Increasing ramp rates during load following can be expensive for normal operations. (not a linear relationship).

Start Cost Impacts

Cycling start costs have a very large spread or variation and unique to every start-up type (Cold, Warm and hot).

Start-up Fuel Input and Other Start Costs

Start cost inputs that include water, chemicals, additives and auxiliary power.

Heat Rate Impacts

Cycling's effect on heat rate is the greatest for small coal units.

Environmental Impacts

Comparison of the value of power system flexibility measures is an important step for informed decision making.

It is important for the plant owners to know the true cost of generation while operating on flexible mode before they decide to operate on non-base load modes. The technical minimum operation (55%) as mandated by CERC in India may not have the same effect in terms of input cost for generation and damage penalty for every station. Units can have varying economic consequences. So every coal plant asset owner must be aware of his techno-economic minimum.

V. Flexibility at the Power Plant Level

Power plants can provide different modes of flexibility. However, depending on cost structure (fixed costs vs variable costs), fuel type and plant design, power plants show large differences in their flexibility performance. Global experience shows that many, if not all plants can operate flexibly, across different timescales.

Before the transition of existing thermal power plants toward more flexible modes of operation it is important to decide the remuneration for the plant to take a decision.

A comprehensive approach is needed to increase the flexibility of a power plant, starting with raising awareness of plant flexibility across all relevant stakeholders. Understanding current capabilities, executing test runs and improving digitilisation capabilities are general priorities.

Power plants will be required to be modified/retrofitted to enhance their flexibility. This includes measures to reduce the time needed to start and stop the plant, lower the minimum operation level of plants and increase the speed at which plants can change their output.

Global experience shows that substantial flexibility has been achieved with moderate investments and operational changes. This has further been corroborated through the studies under IGEF (special Task Force) at NTPC stations.

VI. Power Plants Categorization

Traditionally, power system planners across the globe have found it useful to classify demand for electricity into three categories: baseload, intermediate, and peak load.

- *Baseload Plants/High merit order plants in the Indian regulated market*
- *Intermediate load/Mid merit order plants in the Indian regulated market*
- *Peak load Plants/Low merit order plants in the Indian regulated market*

VII. Cost Structure Versus Flexibility

From an economic perspective, plants to meet the baseload are cost-optimal in terms of variable costs due to lower fuel costs and due to their location at pit heads. For peaking plants, it is just the opposite; high fuel costs are not a problem, as long as fixed costs are comparatively low. Ironically, in India, the peaking coal plants are comparatively newer plants and have higher fixed costs and as many of them are located far off from coal source, the variable costs are higher. Moreover, most of the newer plants are supercritical plants and if tun at lower loads lose their advantage in terms of higher efficiency.

VIII. Assessment of Flexibility Potential:

Surveying the country wide existing fleet's present ability to operate flexibly is an important step in determining the inventory of power plant flexibility potential and subsequently determining the measures that would be required in the future. This step involves collecting data on various power plant flexibility parameters e.g. stable turn down, ramp rates, start-up times, part-load efficiencies, the operation and maintenance costs associated with various modes of operation, and the remaining useful lifetime of the plant.

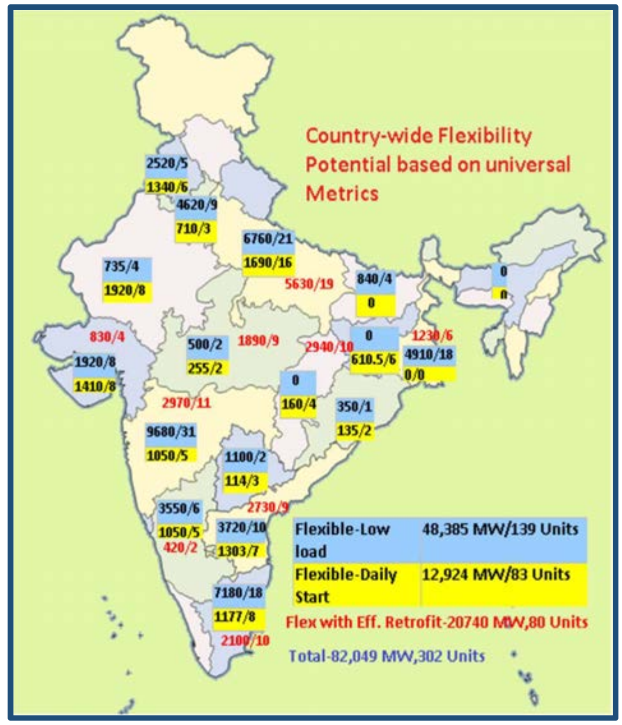
The data on various power plant flexibility parameters for all the stations in India was collected by CEA and preliminary assessments were carried out.

NTPC ltd has carried out assessment of the flexibility potential at few of its stations, followed by **test runs** to ascertain the future flexibility levels that can be reached with interventions. The requirement of CAPEX for various levels of flexibility has also been published in the Task Force report (Task force under Ministry of power).

IX. Choosing Thermal Generation Sources for Different Flexible Needs Based on Techno-Economic Criteria

All India Unit level Data was collected, w.r.t. size, make of main components, age, coal quality, past PLF, location, design, variable cost with respective state merit order etc. Based on the data, the analysis of technical capability data of the All India hard coal fleet was done to establish the capacities that can be made available for different modes of flexing as follows:

Figure 3: Inventory of units identified across various locations for different modes of flexible operation



From the above table we infer that 82050 MW of flexible capacity can be made available and necessary interventions needs to be planned accordingly. In addition, the "base load category operate on flexible mode to a limited if required with minor interventions.

Inefficient Units (HR>2550, which can run on flexible operation with efficiency retrofits, else the cost of flexibilisation will be very high.

Flexible-Daily Start- small Units (210 and below with HR>2550Kcal/KWH) and units will be likely be very low in the merit order (at the end of the merit stack) in 2022.

Flexible-Low load-Units which will be scheduled partly in 2022.Mostly 200 MW and above

Supercritical units have been categorized in the "base load" category. But ,some of the non-pit head super critical will find it difficult to be scheduled because of the high Variable cost.

X. Strategies for Making the Existing Plants More Flexible

A number of different investments and operational and policy changes can be made to increase flexibility in modern systems, which in turn can lead to cleaner, more secure, more resilient and more affordable power systems.

However, there is **no one-size fits-all approach** to make existing power plants flexible. Based on global experience and studies carried out in Indian power plants, a diversity of strategies are available to make existing power plants more flexible. Every unit is unique in terms of age, make, historical operation, fuel type and design and will need a specific solution. The retrofit solution will have to be decided after a thorough cost-benefit analysis after conducting a test run.

Various Test runs were carried out at stations of NTPC Ltd, GSECL, Sagardighi(WBSEB) with participation of OEMs/OEDs and International experts to decide on the strategy for cost effective ways of flexibilization. These strategies include:

- Changes to operational practices for existing plants. Substantially high capital investments are not necessarily required to operate power plants more flexibly. Changes to certain plant operational practices often enabled by improved data collection and real-time monitoring (as being done in NTPC Antariksh) can be used to unlock latent flexibility at existing plants. As per VGB report of pilot studies carried out at NTPC Dadri and Simhadri, no investment is required for 50-55 % minimum load operation and can be achieved with modifications in operational practices alone. Test runs and assessment by EPRI has shown the existence of large flexibilization potential which can be unlocked by modifying operational practices alone. The only constraint is coal quality. However, flexible operation at higher ramp rates and frequent startup will incur significant O&M costs due to increased life consumption of components.
- Operation of HP/LP bypass periodically for fast load reduction.
- Flexibility retrofit investments for existing plants. Depending on the plant technology, a range of retrofit options are available to improve various flexibility parameters of power plants (e.g. ramp rates, start-up times, minimum economic or technical generation levels). As per studies carried out in NTPC stations and test run carried out at NTPC Dadri by VGB and Siemens capability of 40% minimum load has been demonstrated and can be sustained with minimum retrofits like Control and instrumentation,boiler condition monitoring and combustion optomiser, coal analysers etc.Earlier,for fast ramp up , a cost-effective retrofit of condenser throttling was done at NTPC Dadri Unit6 and its effectiveness in providing fast primary response has been proven beyond doubt.
- Efficiency retrofits for very old and inefficient plants. These old plants can be run for a very limited duration**. It can be an effective low-cost solution.**

The startup operational flexibility retrofits target reductions in startup time and corresponding startup variability, along with reduced emissions. As per Pilot studies by VGB in NTPC Stations ,some of the retrofits can reduce startup times by 50%. These retrofits also improve shutdown on units,reducing the shutdown related damages. Improved controls provide the maximum benefit and can sometimes improve startup/shutdown times by 100%.

Unlocking existing power plant flexibility

Making use of existing generation assets can be cost-effective, but may require regulatory modifications and the introduction of certain economic incentives.

Incentivizing additional power plant flexibility investments

Enhancement of additional flexibility measures can be driven by regulated or market based systems by identifying the value of specific flexibility services and ensuring fair compensation for them.

In market-based power systems this can be achieved by improving energy pricing schemes, close to the moment of delivery (intra-day markets) and during times of scarcity. Implementing a well-designed market mechanism that accurately reward generators for the system level economic value of their flexibility can also incentivise increased flexibility. These remuneration mechanisms may be structured around specific services, such as turn down, ramping during load following or start-up time and could provide additional source of income for power plants that are necessary to the system but unable to maintain business-as usual profitability due to reduced utilisation. This is an opportunity for the distressed Indian IPPs.

Policy approaches for long-term flexibility planning

Even without urgent flexibility deficit, there is a need for immediate Policy actions to accommodate future flexibility needs. This requires technical flexibility assessments in adequacy assessments for different periods, creation of a power system flexibility pool, and modelling of operational flexibility in long-term planning process.

Tentative cost of flexible operation

The costs involved in enabling a thermal power plant for flexible operation may be clubbed under the following heads.

Capital Expenditure (CAPEX)-One Time cost
Operational Expenditure (OPEX)- recurring cost

CAPEX

Capital expenditure required to meet the requirement of flexible operation mainly comes from the capital interventions required at plant level. The number and type of interventions required would vary from plant to plant depending on the age of unit and scope of works.

An estimate of the CAPEX i.e. One-time cost required for preparing units for low minimum load operation has been given by VGB based on studies at NTPC Dadri (210 MW) and Simhadri (500MW). Cost of interventions for below 40 % load will be significantly higher.

Table 1: Estimated CAPEX to enable low minimum load operation

S.No.	Intervention	Rs. Crore per unit
1	For 40 % Technical minimum	3.9 to 7.8
2	Start-up optimization	2.25 to 7.8
3	To manage the consequences of cycling	0.65 to 1.95

Based on OED's Proposal (SIEMENS and GE) for implementation of measures of flexibilisation at NTPC's Dadri and Simhadri. Approximately **20 to 50** Crores based on the interventions required.

NTPC is in the process of carrying out retrofits for 40% minimum load at one unit of Dadri(500MW). Here already, a retrofit of condenser throttling has been carried out by Siemens for providing faster primary response.

OPEX

The report provides a preliminary estimate of the increase in operational expenditure of the thermal power stations due to flexible operation. The increase in operational expenditure due to flexible operation can be clubbed into the following heads. Impact of Flexible Operation on costs:

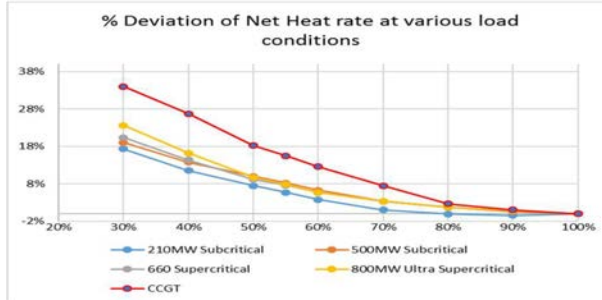
- Cost due to increase in Heat Rate and Auxiliary Power Consumption (APC).
- Cost due to increase in Operation and Maintenance (O&M) due to reduction in life of components.
- Cost due Increased Oil consumption due to frequent start/ stops.

Life consumption, Increase in Equivalent Forced Outage (expressed in terms of increased O&M costs). (Based on the costs on assessment studies at Ramagundam and Jhajjar conducted by M/S Intertek, through USAID-GTG.)

Cost due to increase in Heat Rate and Auxiliary Power Consumption (APC).

It has been observed that the extent of deterioration in Net Heat Rate depends on the percentage unit loading. The estimates in this report are based on combustion engineering boiler design and GE make turbines of 200/210 MW, 500 MW and 660 MW capacity units.

Figure 4: Percentage of net heat rate at various load conditions



Source: GE

For a typical 200/210 MW unit the increase in tariff due to increase in Net Heat Rate at different loading factors is as below. The base ECR has been assumed to be 200 paisa/kWh based on the average ECR of NTPC stations from April to October 2018.

Figure 5: Increase in tariff due to increase in net heat rate (200/210 MW unit)

		Typical 200/210MW Unit		
Sr. No.	Unit loading %	Increase in NHR (%)	Absolute Paisa/ Kwh	Addl. Paisa/ Kwh
1	90%	NIL	200.0	0
2	80%	0%	199.8	0
3	70%	1.1%	202.1	2.1
4	60%	3.8%	207.5	7.5
5	50%	7.5%	215.0	15.0
6	40%	11.6%	223.2	23.2
7	30%	17.3%	234.6	34.6

Similarly the estimates for 500 MW & 660 MW are given below.

Figure 6: Increase in tariff due to increase in net heat rate (200/210 MW unit)

		Typical 500MW Unit		
Sr. No.	Unit loading %	Increase in NHR (%)	Absolute Paisa/ Kwh	Addl. Paisa/ Kwh
1	90%	1%	201.1	1.1
2	80%	1.7%	203.4	3.4
3	70%	3.3%	206.7	6.7
4	60%	6.3%	212.6	12.6
5	50%	10.0%	220.0	20.0
6	40%	13.8%	227.6	27.6
7	30%	19.0%	238.0	38.0

Figure 7: Increase in tariff due to increase in net heat rate (200/210 MW unit)

		Typical 660 MW Unit		
Sr. No.	Unit loading %	Increase in NHR (%)	Absolute Paisa/ Kwh	Addl. Paisa/ Kwh
1	90%	1%	201.6	1.6
2	80%	1.7%	203.5	3.5
3	70%	3.3%	206.6	6.6
4	60%	5.7%	211.5	11.5
5	50%	9.2%	218.4	18.4
6	40%	14.4%	228.7	28.7
7	30%	20.4%	240.8	40.8

Cost due to Life Consumption reflected in increased O&M cost

Flexible operation leads to a higher rate of deterioration of components. This is observed in increased failure rate and more frequent replacement of components. The impact on reduction in life of components increases with increase in no. of start stops the unit undergoes in a year. As a result, the operation and maintenance cost is significantly higher in units operated on a daily or weekly start-stop basis.

An estimate of the increase in O&M Cost due to reduction in life of components is given below. It is based on study conducted under USAID GTG Rise program by M/s Intertek, USA at Ramagundam and Jhajjar TPS of NTPC. The study was based on the ten-year historical cost data of the units (all the costs are at 2017 levels). The current level costs 28.7 Lakhs/MW for 210 MW unit and 19.22 Lakhs/MW for 500 MW unit is based on the CERC normative O&M cost for year 2016-17. The incremental cost due to each event is expressed as percentage of the normative O&M costs.

Study on increased O&M cost due to life consumption due to cyclic operation of super critical unit have not been carried out. The cost impacts on different operating modes have been detailed below:

The above costs are based on the cycling cost studies of two units of NTPC. It is anticipated that as these costs are based on the past cycling, which has not been very severe, they are expected to rise with increase in cycling and age of units.

Cost of Increased Oil Consumption due to frequent start/ stops.

Start-up of thermal power stations requires secondary fuel support mainly in the form of Oil support (LDO). The quantity of oil consumption depends on the duration of startup. The level of oil consumption for startup has been specified in the CERC IGCC 4th & 5th amendments. During flexible operation, there may be a requirement of increased no. of Cold, Warm or Hot startups as per the balancing requirements. This would lead to an additional cost to the power station. The cost of oil consumption in case of a Cold, Warm & Hot start for a 200 MW & 500 MW unit is given below.

Figure 8: Startup oil consumption cost

Start up oil consumption calculations					
200		Price	45000		INR/KL
		Oil consumption per start (as per CERC)	KL		INR Lakh/event
		Cold	50		22.5
		Warm	30		13.5
		Hot	20		9
500		Price	45000		INR/KL
		Oil consumption per start (as per CERC)	KL		INR Lakh/event
		Cold	90		40.5
		Warm	50		22.5
		Hot	30		13.5

Costs due to a particular mode of operation as per grid requirement.

Additional cost will be incurred by the generator and will be proportional to the percentage of steam flow diverted to the HP/LP bypass.

Increase in Fixed Costs/Unit due to lower PLFs of units providing flexible generation.

As per CERC Tariff orders 2014-19, full fixed costs are recovered on declared capability of 85% or higher. Due to flexible operation there would be loss of availability due to increased maintenance requirements and increased EFOR (equivalent forced outage rates),which will make it difficult for the generator to recover full capacity charges.

XI. Recommendations for Way Forward Policy Options to Incentive Investment in Additional Power Plant Flexibility

It is best to evaluate multiple potential investment options in order to establish a cost-effective flexibility strategy. The investment plan has to be formulated based on the flexibility potential and the actual flexibility requirement (quantum of start-up capacity, minimum load, ramping requirement), and then remuneration mechanisms for the plants may be remunerated appropriately, including market-based mechanisms and other options that are applicable to a regulated structure. Such remuneration measures can be designed to recognise the increasing need for power plant flexibility, and to provide fair compensation for the flexibility services the plants will provide while also taking into account the expected operational behaviour.

Options to unlock investment in power plant flexibility – regulated systems

Allowing for cost recovery for retrofit investments in regulated power plants

If a proposed retrofit project for a regulated power plant is considered cost-effective and appropriate for the system, regulators can consider allowing retrofit costs to be passed through to beneficiaries after due diligence. Ideally, such regulatory decisions are informed by cost-benefit analyses conducted with production cost modelling techniques that evaluate multiple flexibility measures. In the Indian context, the cost-benefit analysis has to be done on the present PPA tariff structure and for the future market-based transition.

It is important to note that all plants do not need to be flexible and therefore do not need to be flexibilised. Any additional investment must be allowed to be recovered only after ensuring that the flexibility has been achieved. Additionally, with the Indian coal actions will be needed on coal blending facilities and procurement of high grade coals.

Revisiting of operating procedures

As per global experience, significant flexibilization has been achieved with modifications to operating procedure alone. Any additional intervention, investment should be done only after ensuring that the full potential from modification of operating procedures has been tapped.

Capacity Building:

A lot of flexibilization can be achieved with change in mind set from top management to operators. The process has to start with unlearning and relearning from the best practices and the mistakes from across the globe. Simulator training is an important component of the capacity building. Capacity building initiatives have been taken by IGEF and USAID.

XII. CONCLUSION:

Thus, the flexibility in existing power plants can be enhanced through regulatory interventions and economic incentives that are not capital-intensive to encourage more flexible power plant operation.

Preparing for flexible operation needs moderate to high investment, depending on the unit's vintage, make, design, type of coal fed etc. Even changes in operational procedure will require expenditure by the utilities for changes in controls, interventions of OEM/OEDs, experts and training of staff.

Policy options that remunerate power plants with greater operating flexibility can provide fair compensation for the provision of flexibility services. The remuneration schemes will depend on the context of the market (in Indian it is mainly regulated market).

The starting point should be by expanding the present compensation mechanism (which compensates the generators only partially for the flexibility services) to include all the costs incurred due to flexibilization. The value of load flexibility is unique as per the requirement viz turndown, ramping, load following or start up. Providing utilities with a financial incentive will enable their proactive participation in pursuing load flexibility.

Further, more Ancillary services products are needed to be devised and introduced.

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