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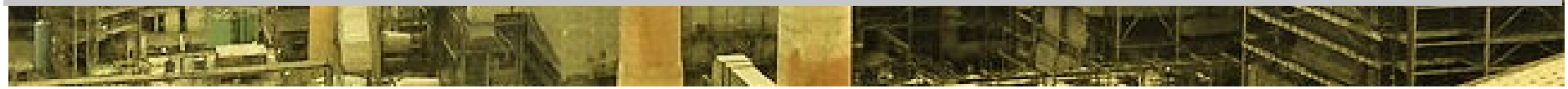
# Flexibilization of conventional Power Plants – The Indian Experience

**Greening the Grid (GTG)**
**Renewable Integration and Sustainable Energy (RISE)**
A Partnership between USAID/India and Government of India



# Outline

- **The Indian Electricity Landscape**
- **Rapid Transition in the Indian power sector**
- **Emerging Scenario & Need for Flexibility**
- **Barriers of Flexibilization**
- **International Experience and Indian Pathway – preparing for flexing of coal units**
- **Benchmarking**
- **Cycling Costs**
- **Summary**

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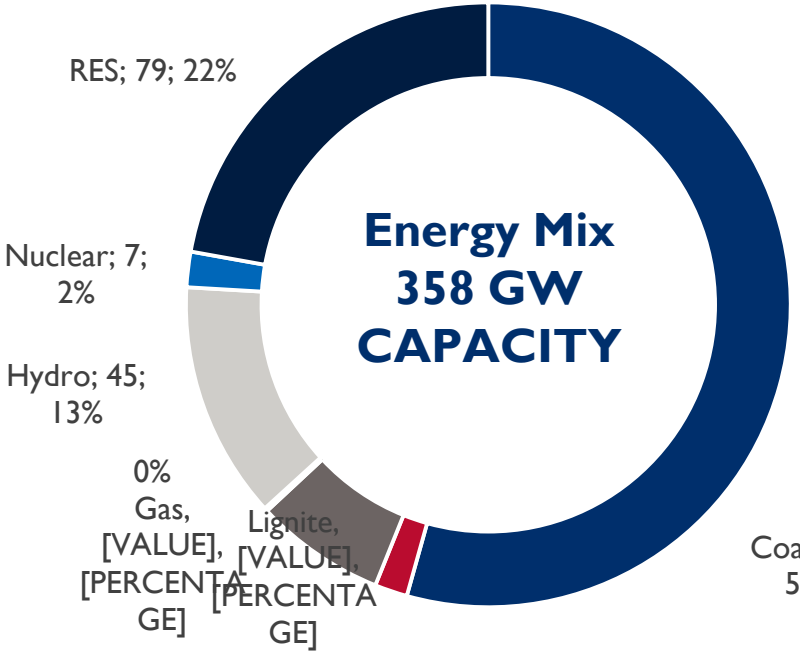
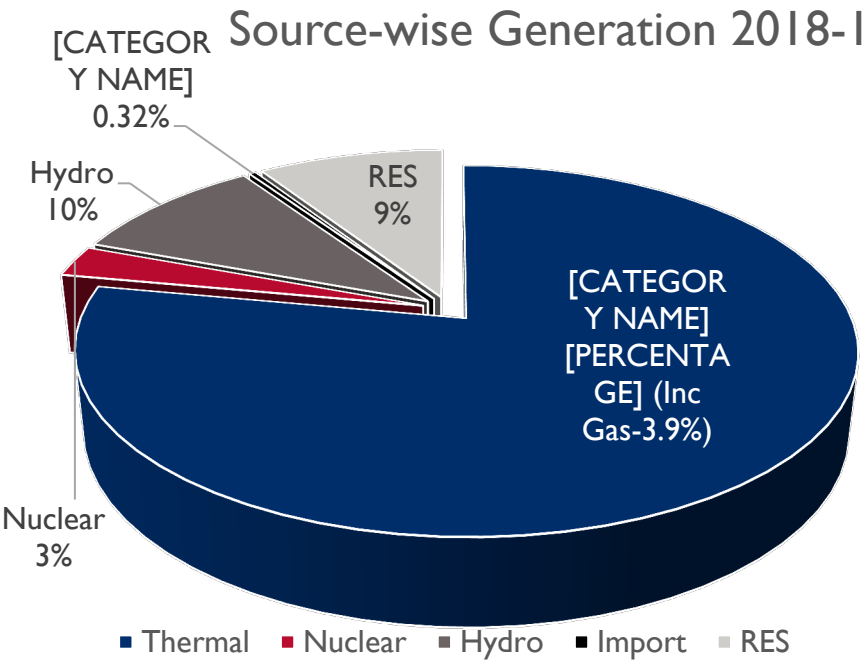
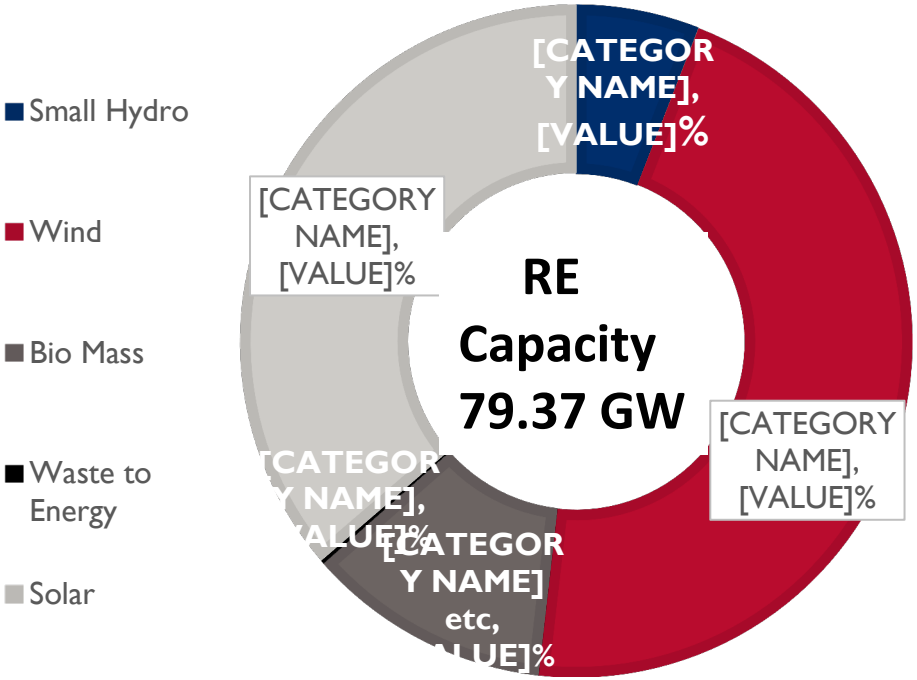
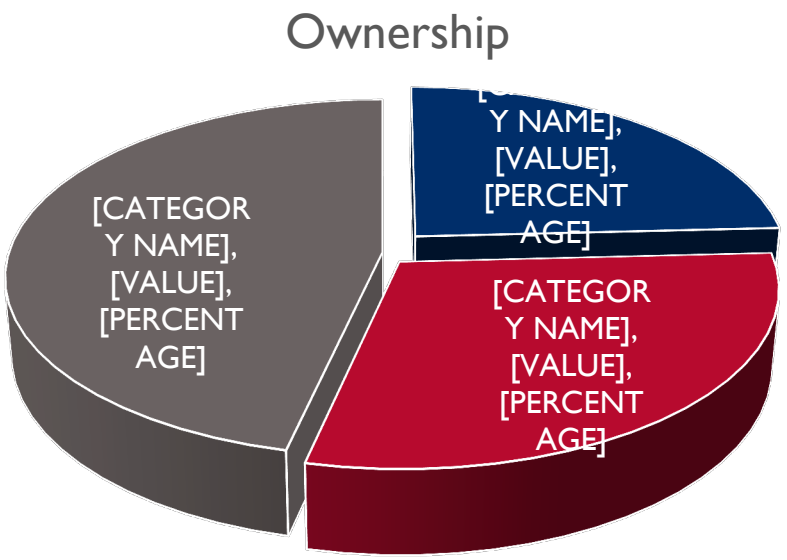
# The Indian Electricity  Sector landscape

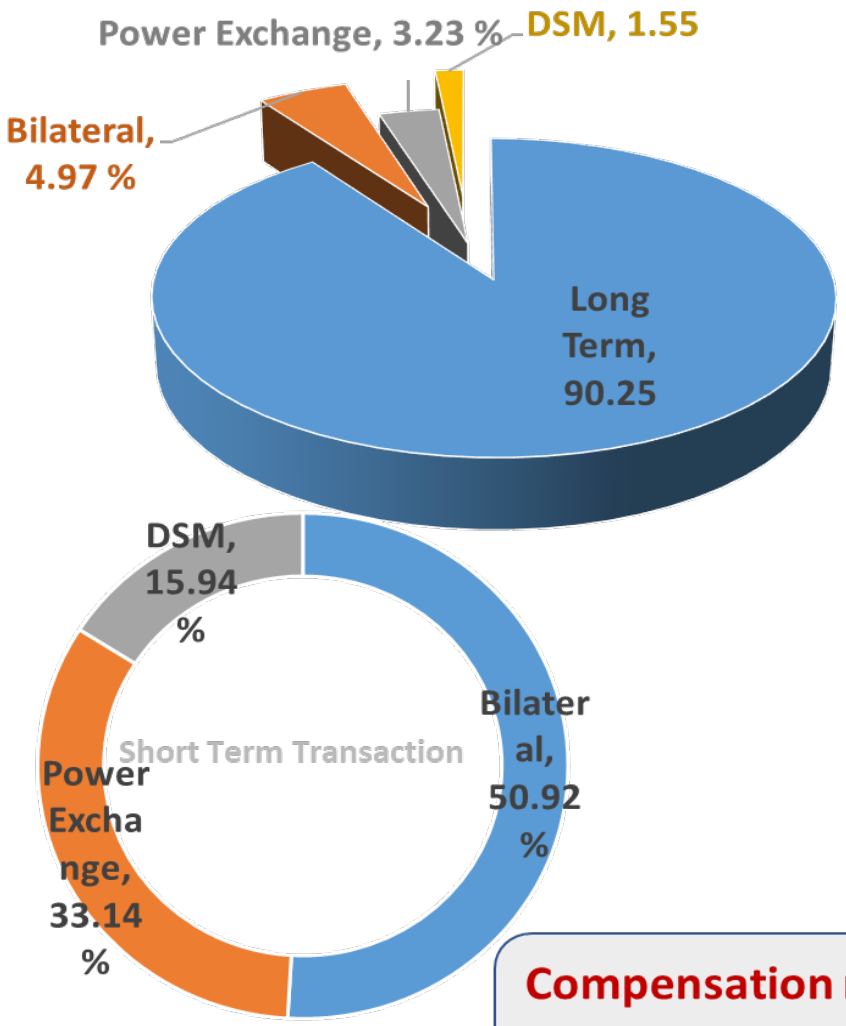

Energy Mix
358 GW
CAPACITY
RES; 79; 22%
Nuclear; 7; 2%
Hydro; 45; 13%
0% Gas, [VALUE], [PERCENTAGE]
Lignite, [VALUE], [PERCENTAGE]
Coal; 194; 54%


Source-wise Generation 2018-19
[CATEGORY NAME] 0.32%
Hydro 10%
RES 9%
[CATEGORY NAME] [PERCENTAGE] (Inc Gas-3.9%)
Nuclear 3%
Thermal
Nuclear
Hydro
Import
RES


RE
Capacity
79.37 GW
[CATEGORY NAME], [VALUE]%
[CATEGORY NAME], [VALUE]%
[CATEGORY NAME], [VALUE]%
[CATEGORY NAME] etc, [VALUE]%
Small Hydro
Wind
Bio Mass
Waste to Energy
Solar


Ownership
[CATEGORY NAME], [VALUE], [PERCENTAGE]
[CATEGORY NAME], [VALUE], [PERCENTAGE]
[CATEGORY NAME], [VALUE], [PERCENTAGE]

## Volume of Electricity Transaction-May,2019




### The Indian Power Market

- Mostly Long term physical contracts and on a day-ahead basis PPAs with two part tariff based on capacity charges and Variable Costs
- **DSM**(Deviation settlement Mechanism) and **Anciallary Services** (RRAS) to address intra-day energy requirement as well as system imbalances
- **AGC** introduced in few coal stations
- **SCED**
- Flexibility in generation and scheduling

**Compensation mechanism** for part load operation which partly compensates the generators for the extra cost incurred on account of efficiency deterioration and extra oil consumption.

# Rapid Transition in the Indian Power Sector

| | Today | Target |
|---|---|---|
| Installed capacity | ~358 GW | ~ 948 GW by 2032 |
| Generation (in BUs) | ~1294 BUs | ~1436 BUs by FY 20 |
| Peak Load Demand | ~183 GW | ~229 GW (by FY 20) |
| Per capita consumption | ~ 1149 kWh | ~ 3026 kWh …(World average) |
| Renewable capacity | ~79 GW | 175+ GW (by 2022) |
| AT & C Losses | ~18.22 % | 15% by FY 19 |

*Source: MOP, CEA*

1. Government's focus on attaining affordable "24x7 Power for All" by 2019.
2. Energy Sector growing at a CAGR of ~7%-8%.
3. Big push to Renewable Energy- to grow from ~79 GW presently to 175GW by 2022.

Although coal will remain the mainstay of energy security in India, there will be a fundamental change in the business model of coal based stations.

Preparation and management of Flexible Operation of Fossil based plants will be a critical factor for survival in the Changed Business Environment and will need Realignment of Strategies .

# Emerging Scenario & Need for Flexibility

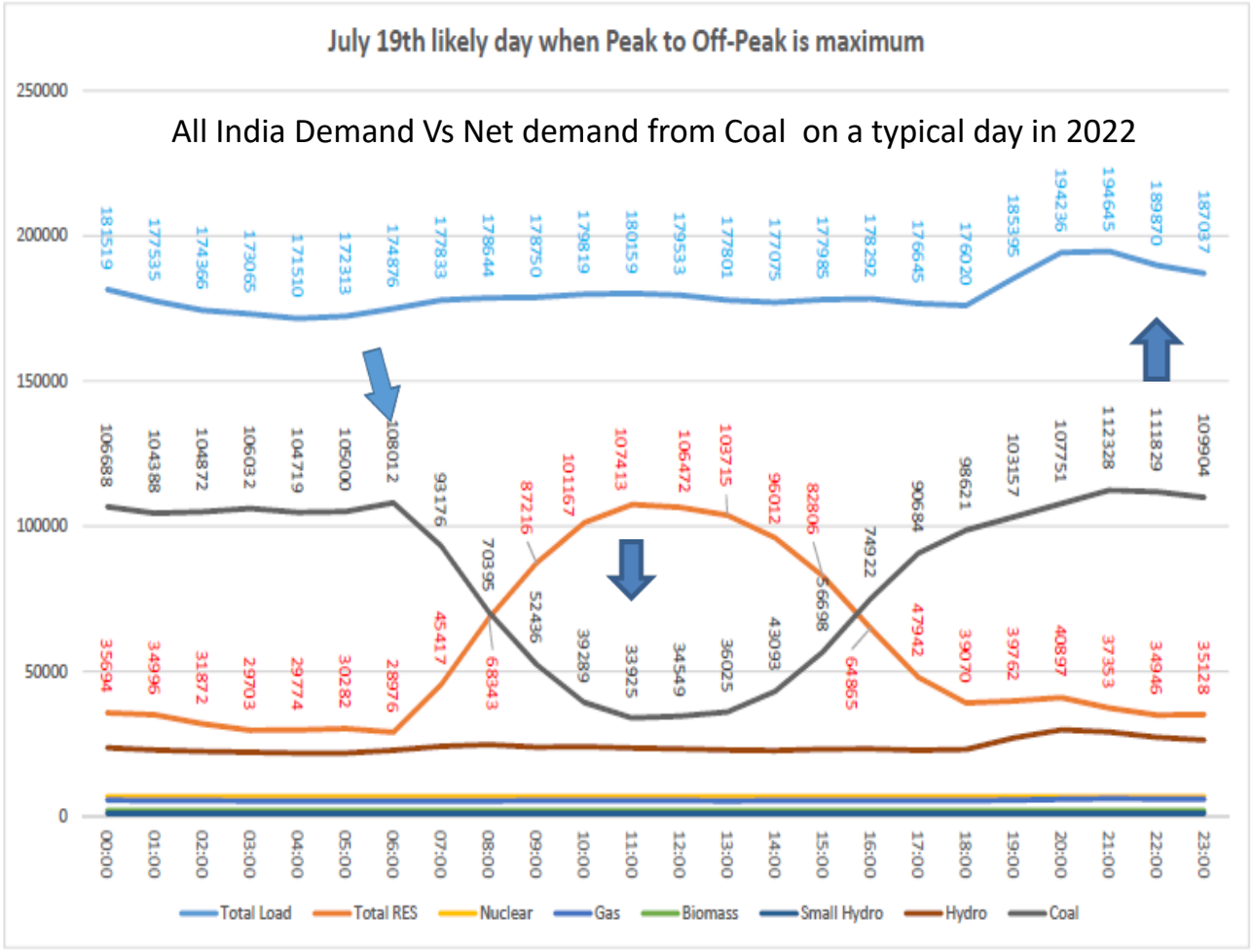
As per NREL study on Grid Modeling for India (2016), for a 2022 scenario, technical minimum of 70% for coal-based plants would result in RE curtailment of about 3.7%. The curtailment reduces to 0.76% for a tech. min. of 40%

**Grid Evolution,**
**Baseload ➡ Cycling**

**Impacts of Plant Cycling on Damage Rates and the ultimate Costs of providing power**

**Critical risks of process safety, increased costs, higher probability of equipment failure and reduction in unit life associated with cycling will need effective management**

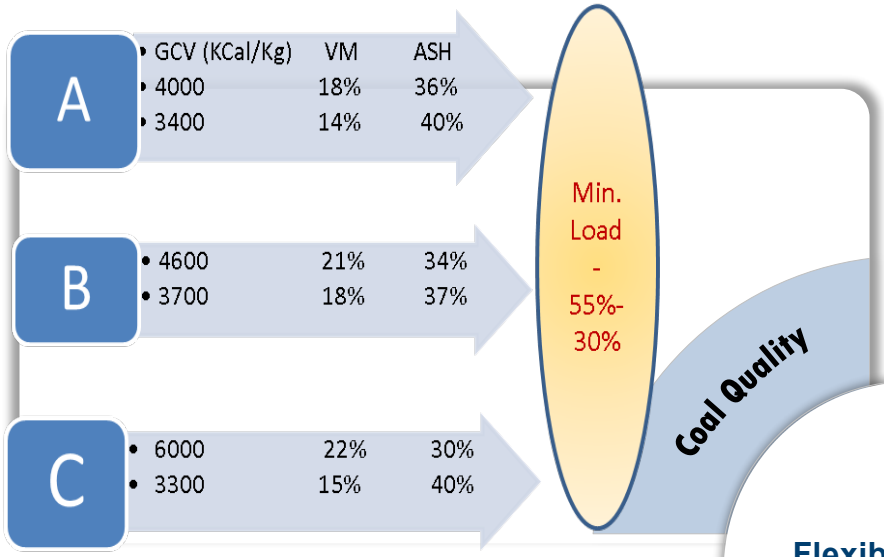
**The successful integration of 175 GW RE will depend on the flexibilisation of fossil plant. Favourable policy and market regulation will be the key drivers for success.**




*Source: CEA committee Report on Roadmap for flexible operation*

# Barriers to Flexiblization

**Varying Coal Quality posed a major challenge to flexibilisation**




- Most of the state Utilities yet to reduce minimum load levels
  - **Geographical Concentration of Renewable**
  - Transmission constraints
  - Curtailment of RE

Limited participatio

**Flexibilisation for Integration of 175 GW RE**

## Culture /Mindset

Operating Expertise to be created
**Simulators** for flexible operation
New Analytical Tools required
Increased Digitilisation

Culture/Capacity building & Investment

One time investment for making units flex ready.
Country-wide cost estimated at **14,000 crores for 82** GW capacity.

Policy support Regulatory Framework

In India ,Market participation is limited. (Net Traded Energy is <

Largely under Long Term Contract arrangements(PPA),which have limited flexibility.

**Incentivization** through regulation or market needed.
**Grid codes..AGC,Anciliary services**

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# International Experience and Indian Pathway – preparing for flexing of coal units

# Key Interventions across India

- **Task force on Flexibilization with IGEF support**(CEA,NTPC,EEC,POSOCO,VGB,MOP)
  - **Studies carried out at two units of NTPC**
- **Committee on Flexibilization under CEA roadmap for preparation of units for flexibilization**
- **Studies by OEM(SIEMENS,GE,BHEL)**
- **USAID's GTG carried out techno-commercial studies at four units (NTPC & GSECL**
- **GTG studies provided the first set of cost of cycling data for the Indian context.**
- **Various test runs carried at NTPC's – Mouda and GSECL out under GTG-RISE Initiative.**

## Impact

- **Increased Awareness /Capacity Building**
- **Assessment of capabilities.**
- **Test Run Demonstration of 40% Minimum Load**
- **Assessment of future levels of increased flexible operations.**
- **Assessment of technical issues and potential solutions for specific generation unit types associated with different specific flexible operations modes.**
- **Data generated for Cost of Cycling –Required for regulatory interventions**

# Initiative under GTG-RISE,USAID

Pilot supports technical interventions and operational changes at NTPC's Ramagundam (200 MW unit), Jhajjar (500 MW unit) and GSECL Ukai TPS (200MW & 500 MW unit)

### Stage 1: Techno Economic Assessment & Roadmap

- Technical due diligence and detailed feasibility assessment
- Establishing reliable costs of flexibilisation – capex as well as opex

### Stage 2: Regulatory Pathway and Fleet Level Strategies

- Assistance in framing Regulatory Mechanisms for Flexibility
- Assistance in building fleet level strategies for NTPC / GSECL

### Stage 3: Pilot Implementation

- Technical Assistance in pilot / fleet level implementation to NTPC
- Leverage private partnerships and contribution in investments

### Stage 4: Scale up

- Assist in fleet-wide implementation and national scale up
- Capacity building of operators – Procedures and Operational Toolkits

**2017**

- Pilot Conceptualization
- On Boarding of Technical Assistance (TA) Firm
- Stakeholder Discussions & Data Collection
- TA Implementation Plan

**2018**

- Technical Assessment reports completed for NTPC and GSECL units
- Executive Exchanges to US
- Knowledge Dissemination Workshops

**2019**

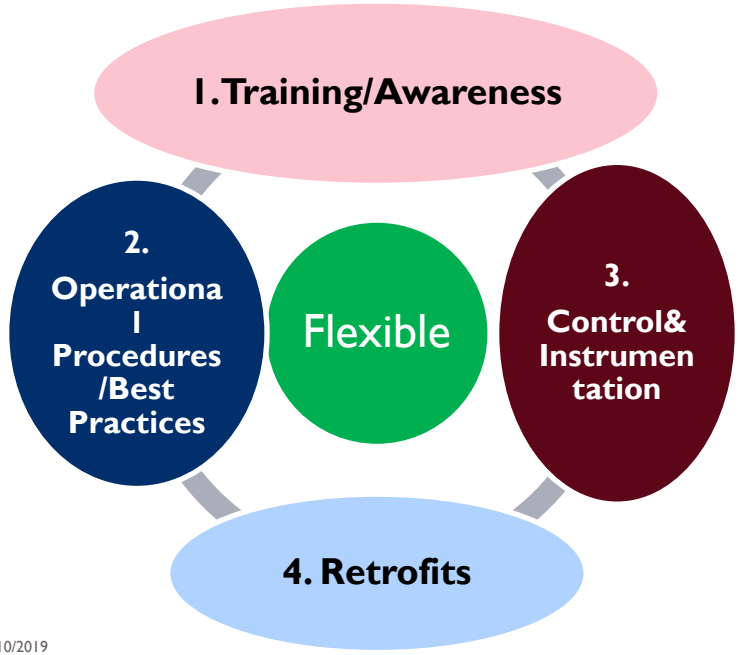
- Regulatory Frameworks for flexibilization to CERC & GERC
- Pilot Test Runs & Fleet Wide Strategies
- Changes to Operating Procedures
- Executive Exchanges & Knowledge Dissemination Workshops

**2020**

- Facilitate fleet-wide adoption and National scale up
- Knowledge Dissemination Workshops

# Harsh Realities of Cyclic Operation

- Flexing with lack of **awareness**, can be disastrous
- Well known that cycling causes damage and when equipment degrades, performance degrades.
- Damage not immediate but accumulated and not easy to quantify
- By the time symptoms of damage is visible it may have become very costly to Correct




- The biggest obstacle to achieving Unit Flexibility is the Culture.
  - The entire organization needs to be invested in meeting the new market demands and keeping the coal units viable.
- **Flexible operation is a difficult mode of operation** and even the most conservative approach will increase plant O&M costs along with per MW variable costs
- However those plants that can operate flexibly to meet market conditions while minimizing the financial impact of operating in this environment, **will continue to be dispatched**, at least for the near future.
- Operations for Flexible Operations requires a **holistic perspective of the entire plant** to avoid unintended consequences.
- Revisiting the operational procedures, Training of O&M manpower can enhance flexibilization
- Plant operators need to be **trained for an in-depth knowledge** of every plant system, with broad understanding of combustion, heat transfer, plant control methodology, damage mechanisms such as creep and FAC, steam turbine operating limits, and emissions equipment.

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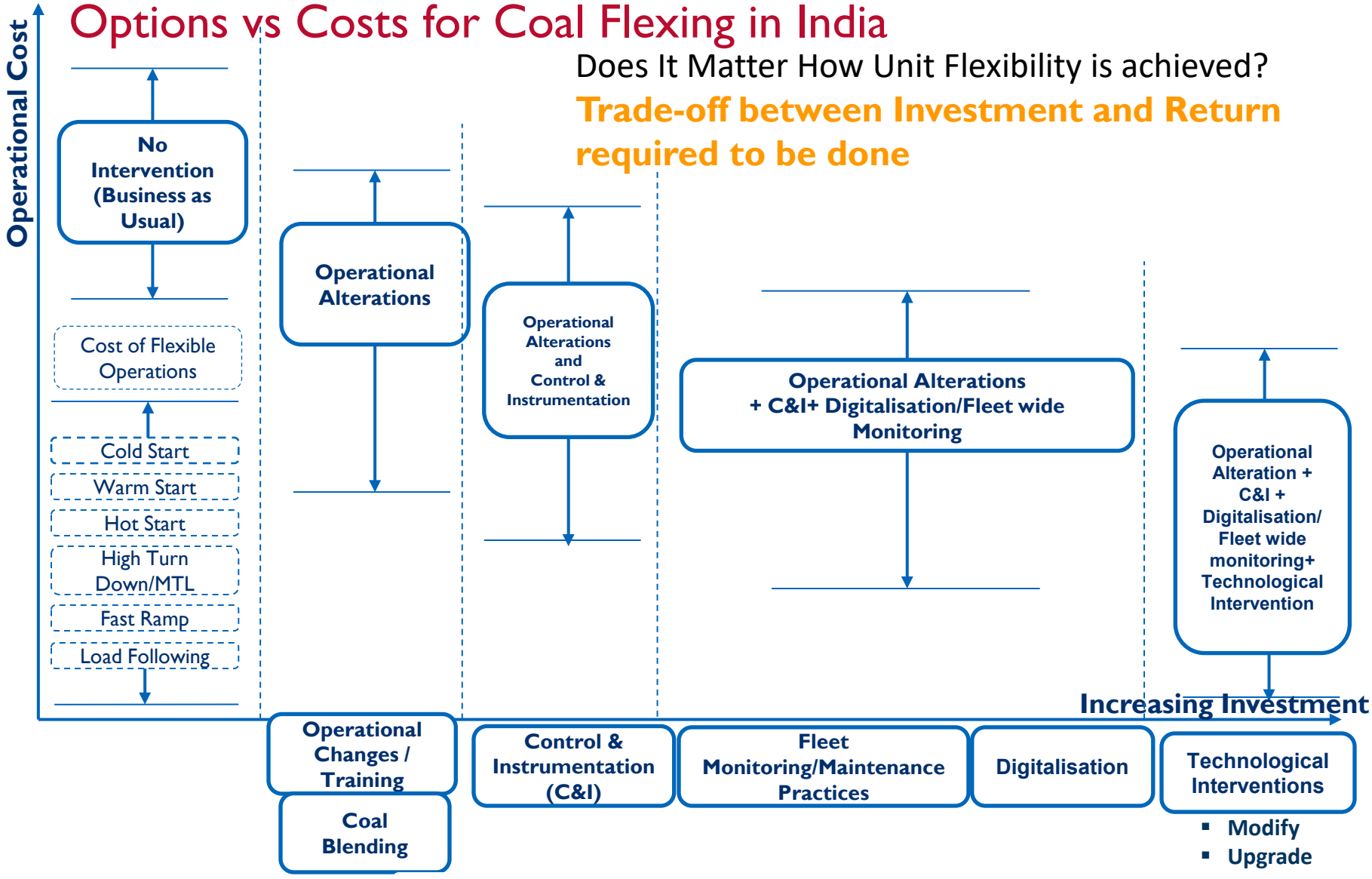
# Options vs Costs for Coal Flexing in India

Does It Matter How Unit Flexibility is achieved?

**Trade-off between Investment and Return required to be done**



# Flexible Future: Need for Benchmarking

**Defining**
- Defining from different perspectives

→ Min Load; Ramp Rate; Start-up time; Reserves

**Measuring**
- Metrics
- Quantifying

→ Cost components- EHS,EFOR, EOH,Reliability

**Operational -isation**
- Sources, options
- Preparedness for Coal based plants

→ Merit order based on?
- Variable Cost
- Heat Rate
- Emissions

**Compensation/ Incentivisation**
- Regulatory framework
- Market structure and mechanisms

→ Mechanisms for operationalization Ancillary service, DSM, AGC,real time

**Market Alignment of Metrics**

**Choosing which units to flex?**
**Will be based on technical capability and market mechanisms**

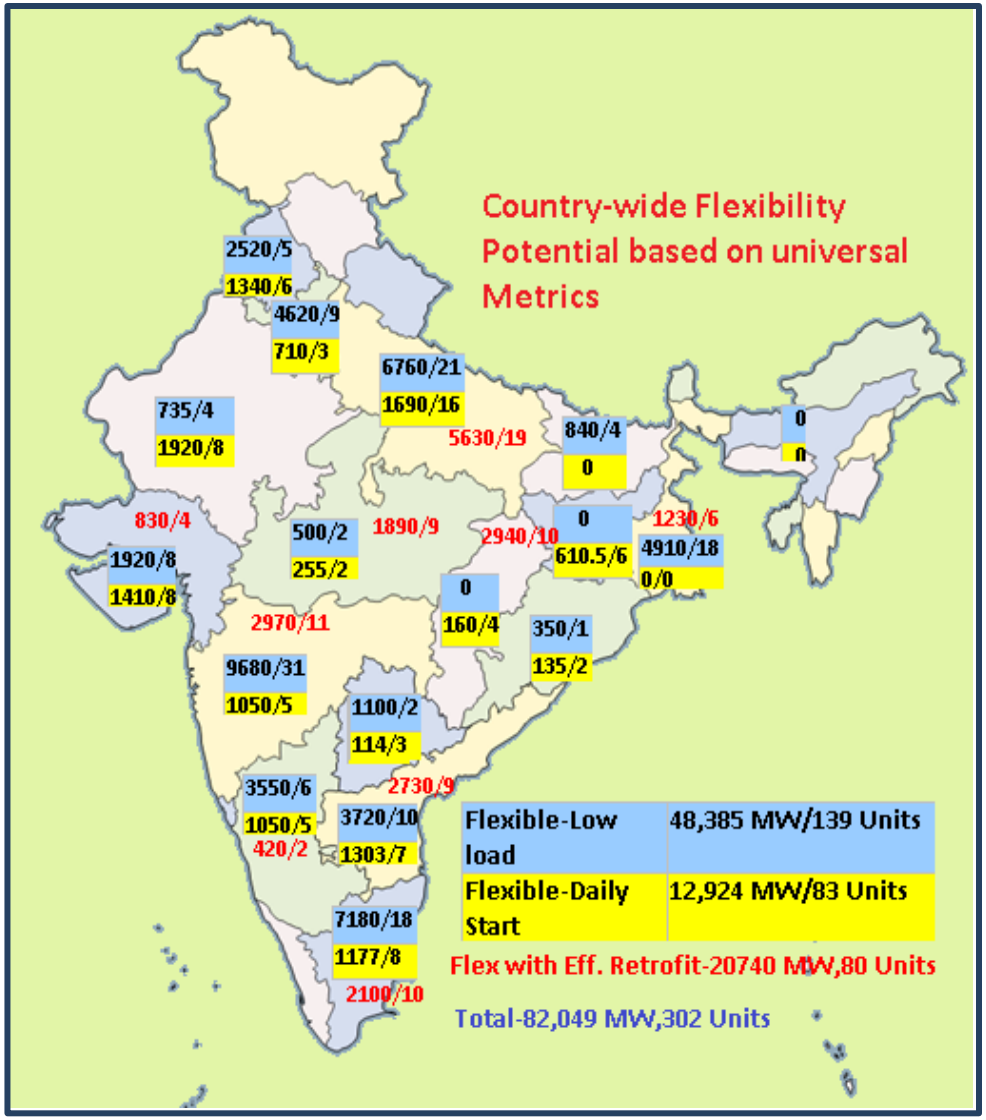
**Units to operate based on the value it can provide to the system**

- Ramping
- Start-up Time
- Off line capabilities
- Spinning Reserves capability
- Primary reserves capability
- Minimum stable generation
- Automatic voltage regulation (MVAr)

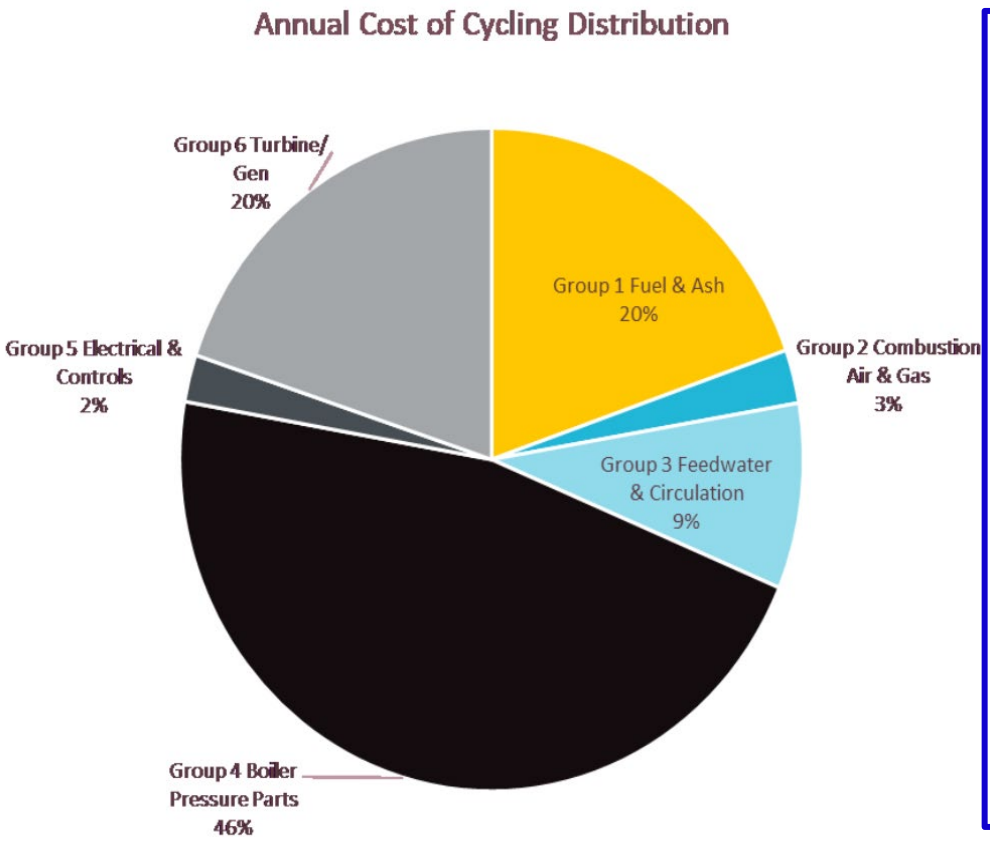
**Need to define new flexing products.**

# Categorisation of Units

| Category | Metrics |
|---|---|
| **Base Load** 140GW/299Units | ECR<< State M.O.<br>GCV < 2800,VM<15%<br>Supercr. (except 14 Units) |
| **Flexible-Low Load** | ECR=> State M.O.(>Rs.2.5/KWH)<br>GCV >2800,VM > 15% |
| **Flex with Efficiency Retrofit** | Units>25 Years<br>Unit size-200 and above<br>HR> 2500 |
| **Flexible Daily Start** | ECR>> State M.O.<br>(unlikely to get schedule in 2022)<br>HR>2500, |
| **Retire/replace** | >25Years<br>HR>2600<br>Unit sizes<200 MW |



# Understanding the Total Costs distribution




- Systematic records of all components
- Optimise maintenance expenditure
- Overhauling duration, timing and scope-Greater OH frequency in later years of life and cycling
- Failure statistics
- **Failure faults-independent of operation**
  - Due to construction, design, operating errors etc.
- **Predictable faults and dependent on service time**
  - Wear and tear of ageing component
  - Corrosion, erosion and distortion
  - Creep and fatigue damage
  - Cycling

**Predictive Tools: Estimated weekly damages, EFOR,Life management actions**

It is necessary to tailor the overhauling and maintenance intervals for the particular unit on the basis of data available.The analysis of component-wise cost data is important

Metrics of equivalent operating hours, EHS is helpful.

Component-wise maintenance decisions can be taken on the importance,redundancy,safety etc.

# Typical Flexing Costs

Flexing Costs

**CAPEX**

**One-time cost required for preparing units for Flexing**

**OPEX**

**O&M costs**

Increased Forced Outages.

Life consumption costs

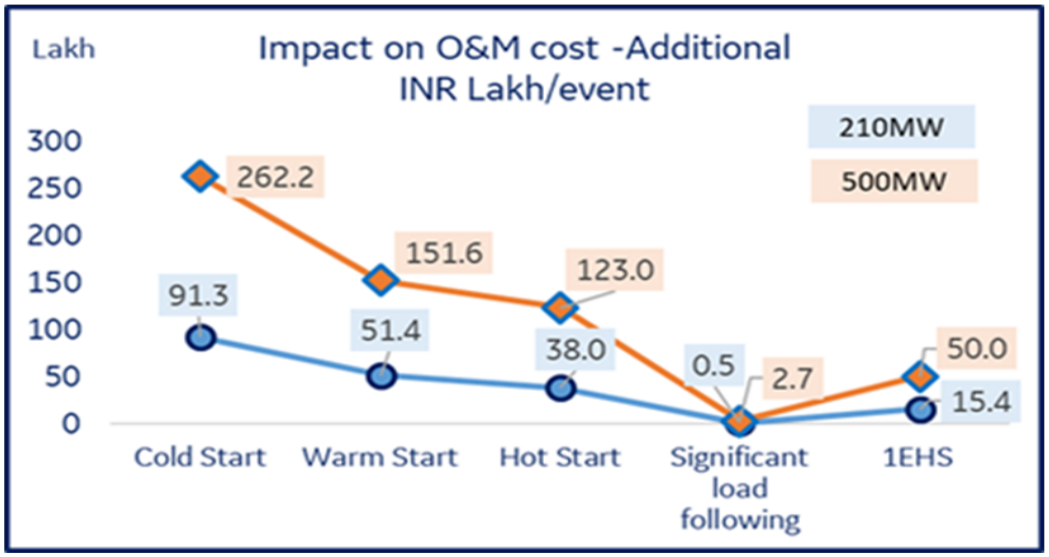
Load Following Costs (signi
Increased Ramp Rates

**ECR costs**

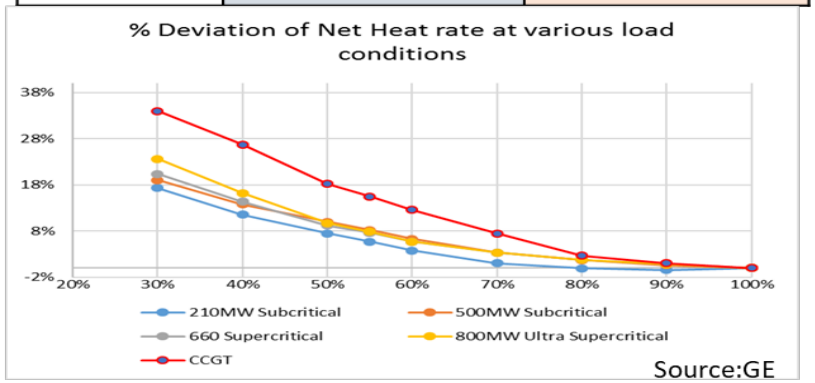
Start-up Cost (Aux. Power + Chemicals + Water + life consumption)

Start-up Oil

Heat Rate effects due to Power Plant Cycling




| | 500 MW UNIT Oil cons. in Kl | 200/210 MW Oil cons.in Kl |
|---|---|---|
| COLD | 90 | 50 |
| WARM | 50 | 30 |
| HOT | 30 | 20 |




Source: GTG-RISE/Intertek

# In Summary . . .

- **Flexible operation is a difficult mode of operation** and even the most conservative approach will increase plant O&M costs along with per MW variable costs
- However those plants that can operate flexibly to meet market conditions while minimizing the financial impact of operating in this environment, will continue to be dispatched, at least for the foreseeable future.
- Operations for Flexible Operations requires a holistic perspective of the entire plant be maintained to avoid unintended consequences.
- **Revisiting the operational procedures**, Training of O&M manpower can enhance flexibilization
- Plant operators need to be trained for **an in-depth knowledge of every plant system**, with broad understanding of combustion, heat transfer, plant control methodology, damage mechanisms such as creep and FAC, steam turbine operating limits, and emissions equipment.
- **Market and operational rules** would be the key enabler for thermal flexibility
- The **Stakeholders engagement including International cooperation** is critical at every step
- The biggest obstacle to achieving Unit Flexibility is the **Culture**?
  - The entire organization needs to be invested in meeting the emerging demands and keeping the coal units viable.

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