Flexibilization of conventional Power Plants – The Indian Experience

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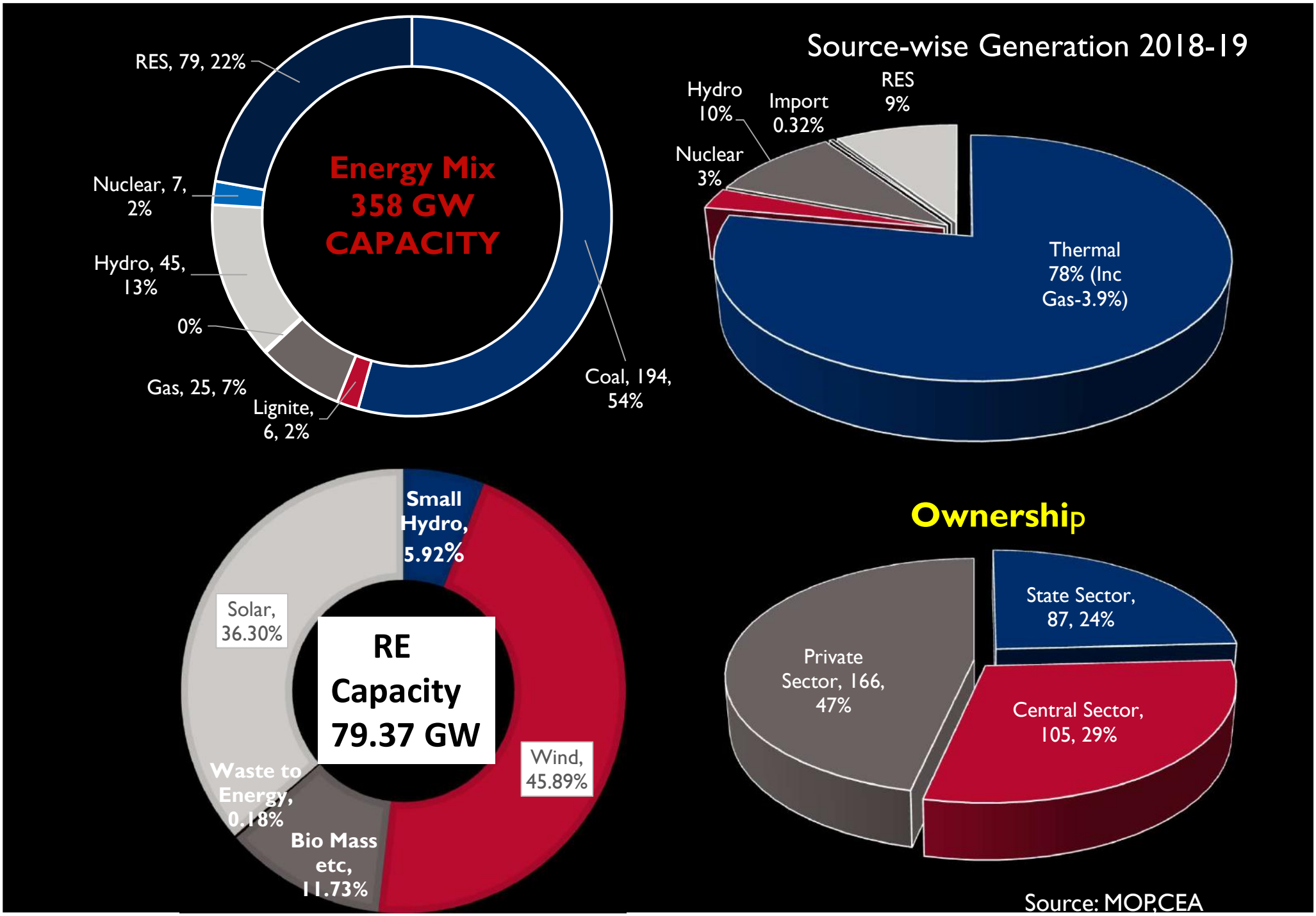
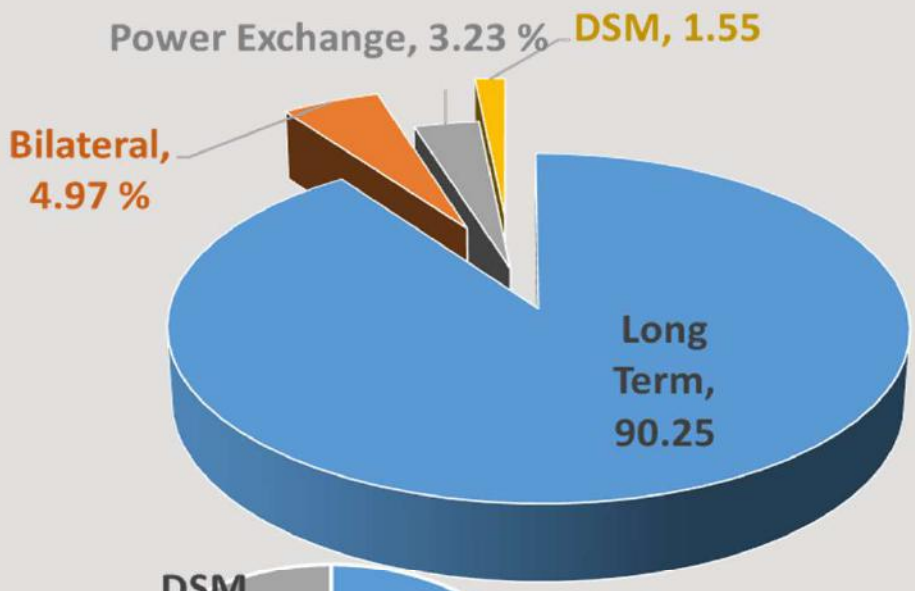
Outline

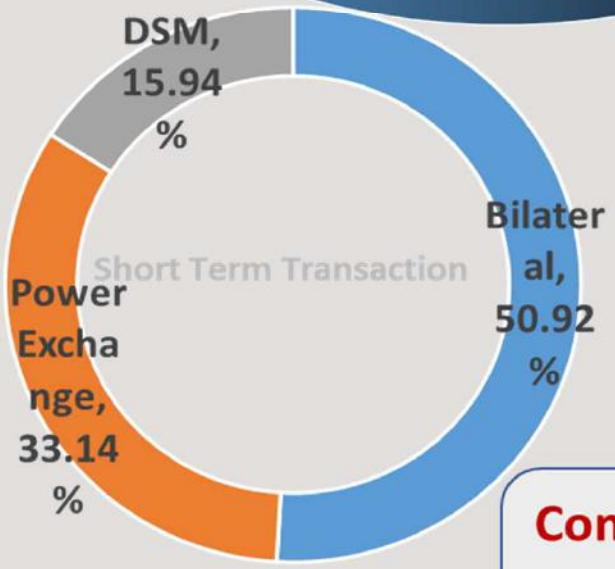
- The Indian Electricity Landscape
- Rapid Transition in the Indian power sector
- Emerging Scenario & Need for Flexibility
- Barriers of Flexibilization
- International Experience and Indian Pathway – preparing for flexing of coal units
- Beyond Pilot studies
- Cycling Costs
- Summary

The Indian Electricity Sector landscape


Energy Mix
358 GW
CAPACITY
RES, 79, 22%
Nuclear, 7, 2%
Hydro, 45, 13%
0%
Gas, 25, 7%
Lignite, 6, 2%
Coal, 194, 54%
Source-wise Generation 2018-19
Hydro 10%
Import 0.32%
RES 9%
Nuclear 3%
Thermal 78% (Inc Gas-3.9%)
RE Capacity 79.37 GW
Small Hydro, 5.92%
Solar, 36.30%
Wind, 45.89%
Waste to Energy, 0.18%
Bio Mass etc, 11.73%
Ownership
State Sector, 87, 24%
Private Sector, 166, 47%
Central Sector, 105, 29%
Source: MOP,CEA

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

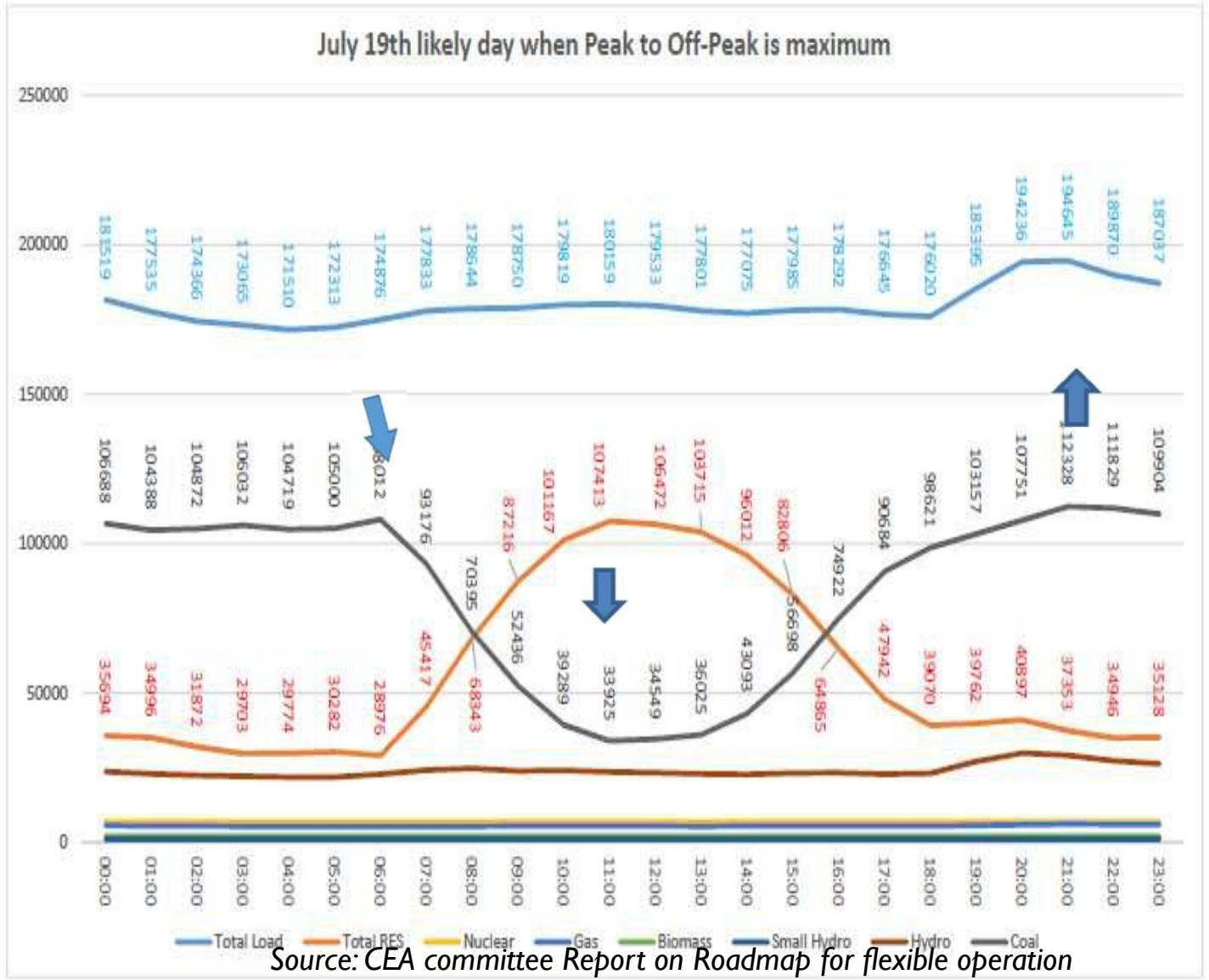
Grid Evolution,
Baseload ➡ Cycling

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

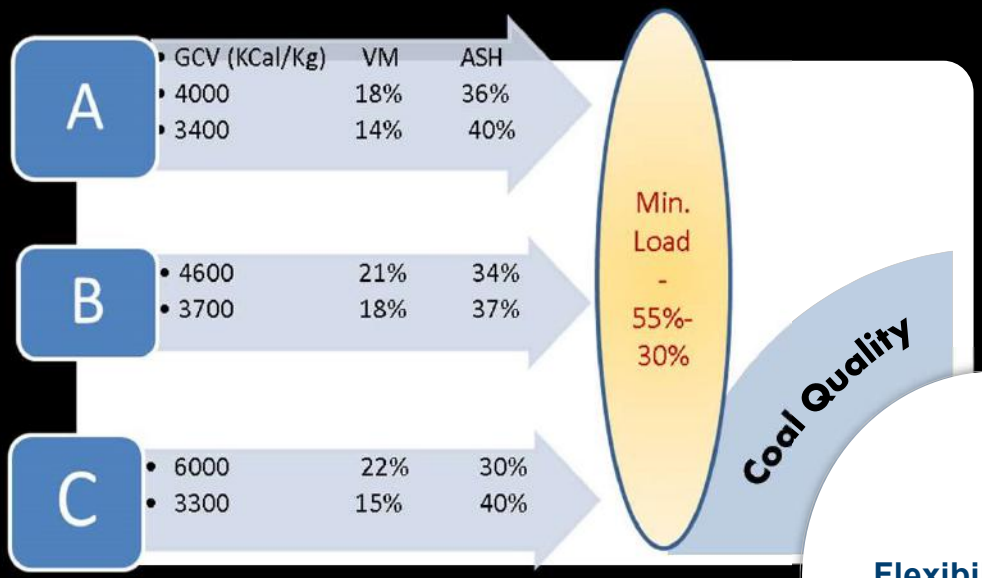
The successful integration of 175 GW RE will depend on the flexibilisation of fossil plant. Favourable policy and market regulation will be the key drivers for success.

All India Demand Vs Net demand from Coal on a typical day in 2022



Source: CEA committee Report on Roadmap for flexible operation

Barriers to Flexiblization



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

Limited participation

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 < 5%) Largely under Long Term Contract arrangements(PPA),which have limited flexibility.

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

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

Key Interventions across India

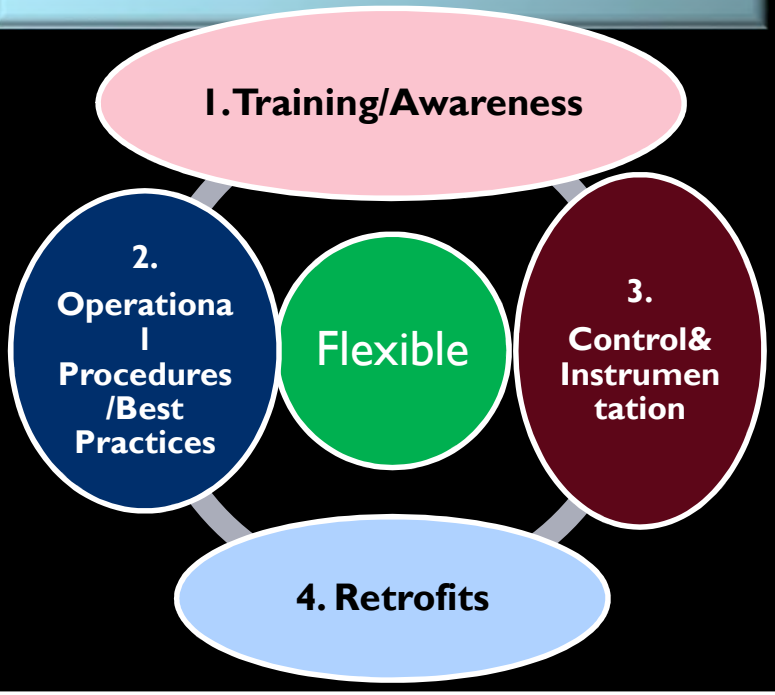
- **Task force on Flexibilization with IGEF support**(CEA,NTPC,EEC,POSOCO,VGB,MOP)
  - ➢ **Studies carried out at two units of NTPC**
- **Committee on Flexibilization under CEA roadmap for preparation of units for flexibilization**
- **Studies by OEM(SIEMENS,GE,BHEL)**
- **USAID's GTG carried out techno-commercial 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**

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



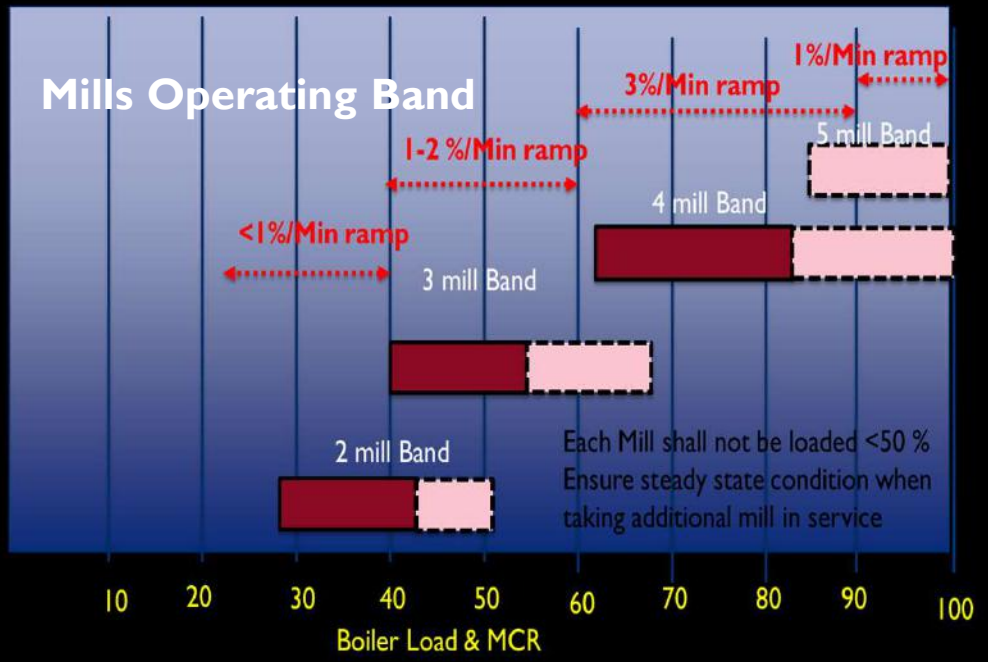
- The biggest obstacle to achieving Unit Flexibility is the Culture.
  - The entire organization needs to be invested in meeting the new market demands and keeping the coal units viable.
- **Flexible operation is a difficult mode of operation** and even the most conservative approach will **increase 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.

How to proceed beyond Pilot Studies?????

Key Learnings of Pilot Studies/Test Runs suggest the following…….

What Generators need to do?

- **Operational Procedures modification- can achieve up to 80% of the flexibility**
- **Combustion optimisation**
- **Upgradation of C&I systems**
- **Fleetwide Approach**
- **Capacity Building –Simulators,Train the Trainer Programme to create Indian Experts**



System Operators

AGC would be a mode of operationalising the balancing power

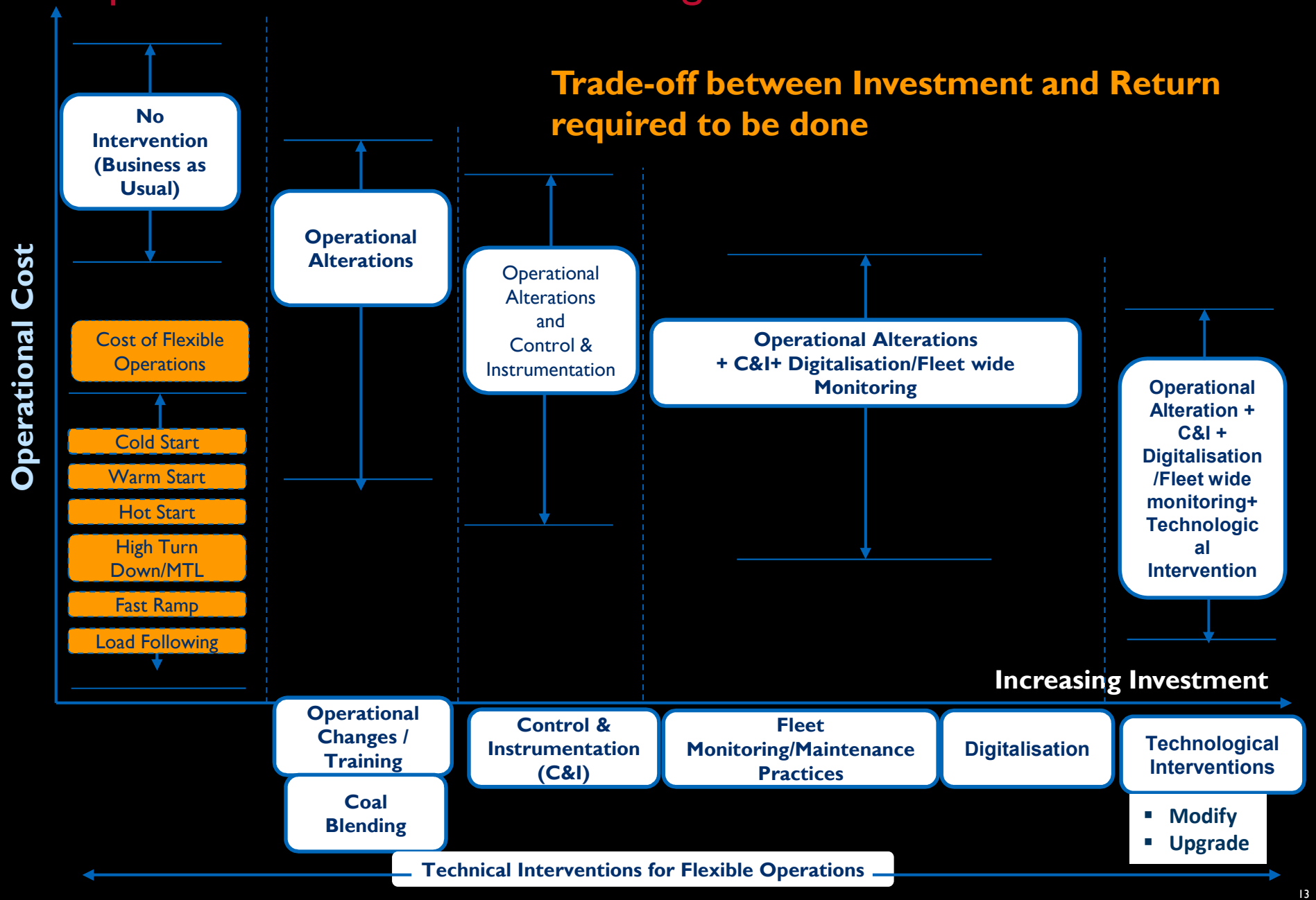
The nation-wide expansion of AGC requires a clear understanding and defining the value based flexibilization metrics ,understanding the extra pain and effort required to deliver the same when required.

Regulators

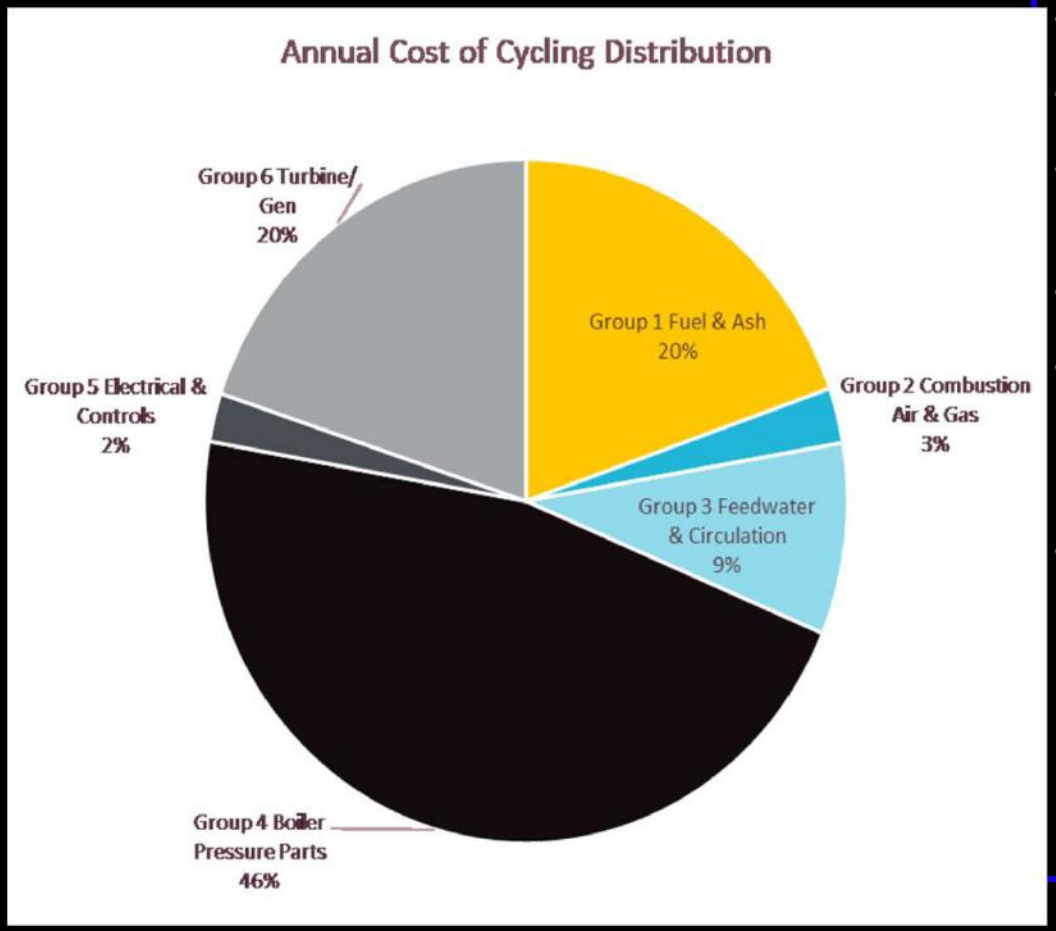
There is an immediate requirement for mechanisms to remunerate the generators providing flexibility

New Ancillary /Market based products for balancing power

Options vs Costs for Coal Flexing in India



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.

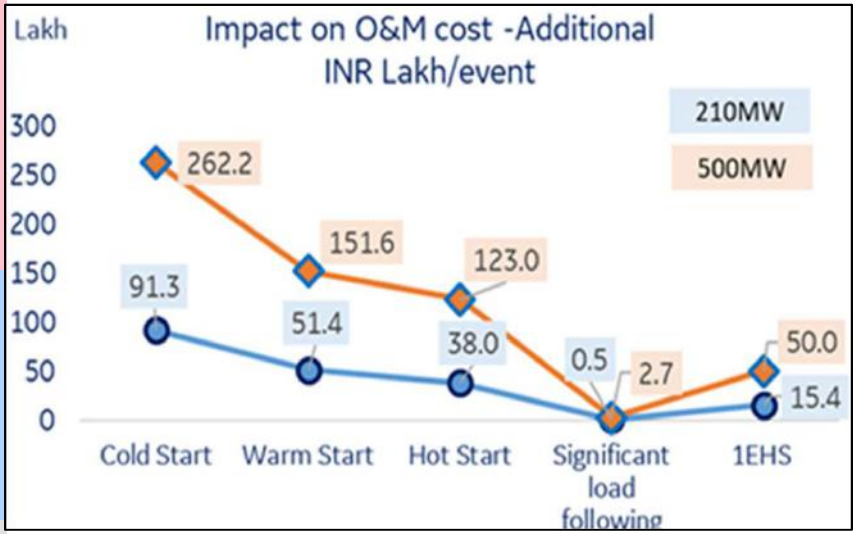
Component-wise maintenance decisions can be taken on the importance, redundancy, safety etc.

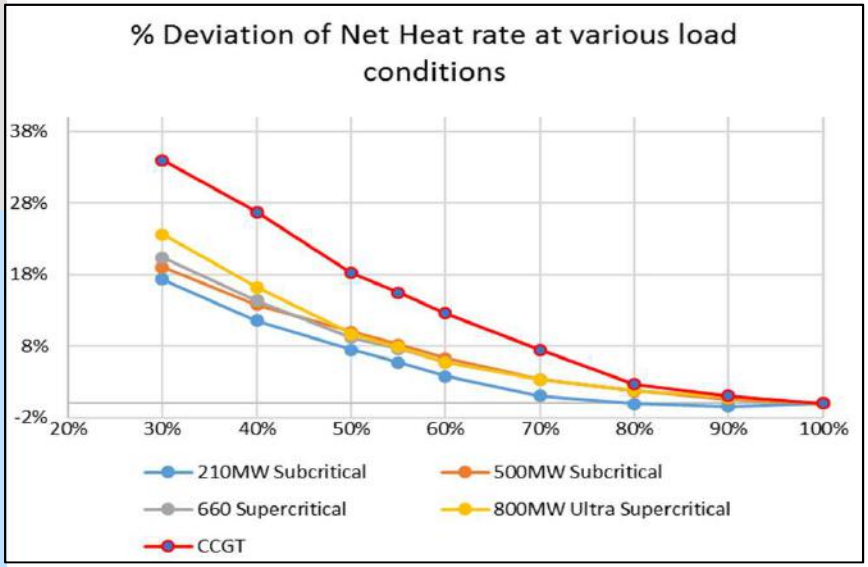
Flexible Operations - Commercial Impact

Typical Costs of Flexible Operations

Cost of Flexible Operations

Factors	Parameters
Energy Charges	• **Start-up cost increases due to increase in** ➢ **Heat Rate** ➢ **APC** ➢ **Oil support**
O&M Cost	• **Increased EFOR** • **Accelerated life consumption due to** ➢ **Start-ups** ➢ **Load Following**
Fixed Cost	• **Accelerated life consumption will have impact over unit availability in ling-term** • **EFOR can impact unit availability in short-term**
Environmental Impact	• **Specific (Kg/MWh) NOx, SOx & CO emissions will be somewhat higher at unit level while flexing** • **Overall emissions would reduce for flexible units due to reduced coal usage.** • **Significant adverse impacts are very unlikely due to installation of emission control devices.**





IMPACT ON TARIFF(FC+ ECR)		ECR-200P/Kwh			
		Typical 200/210MW Unit			
		Due to HR	Add. O&M*	Start up oil	Total Impact(FC+VC)
	Unit loading %	Addl. Paisa/ Kwh			
Minimum load with significant load following	90%	0	0	0	**0**
	80%	0	0	0	**0**
	70%	2.1	3.31	0	**5.4**
	60%	7.5	3.31	0	**10.8**
	50%	15	3.31	2.5	**21.3**
	40%	23.2	3.31	2.5	**29**
	30%	34.6	3.31	2.5	**40.5**
Weekly start		23.2	60.22	14.8	**98.2**
Daily start		7.5	257.39	65.2	**330.1**
		Typical 500 MW Unit			
	Unit loading %	Addl. Paisa/ Kwh			
Minimum load with significant load following	90%	1.1	0	0	**1.1**
	80%	3.4	0	0	**3.4**
	70%	6.7	7.15	0	**13.8**
	60%	12.6	7.15	0	**19.7**
	50%	20	7.15	0	**27.2**
	40%	27.6	7.15	0	**34.8**
	30%	38	7.15	0	**45.2**
Weekly start		27.6	69.18	10.7	**107.5**
Daily start		12.6	307.74	43.5	**363.8**

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.

Thank You for patient listening

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