PSR PROGRAMME | Supporting Structural Reforms in the Indian Power Sector

Flexibilization of thermal power plants

Pilot on Using cycling flexibility of coal fired power plants to respond to the Grid fluctuations

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Agenda

- Introduction to flexibilization & need assessment for Andhra Pradesh
- Uniper’s experience in Flexibilization & process
- Diagnostic study at SDSTPS & recommendation for flexibilization
- Policy and regulatory enablers for flexibilization

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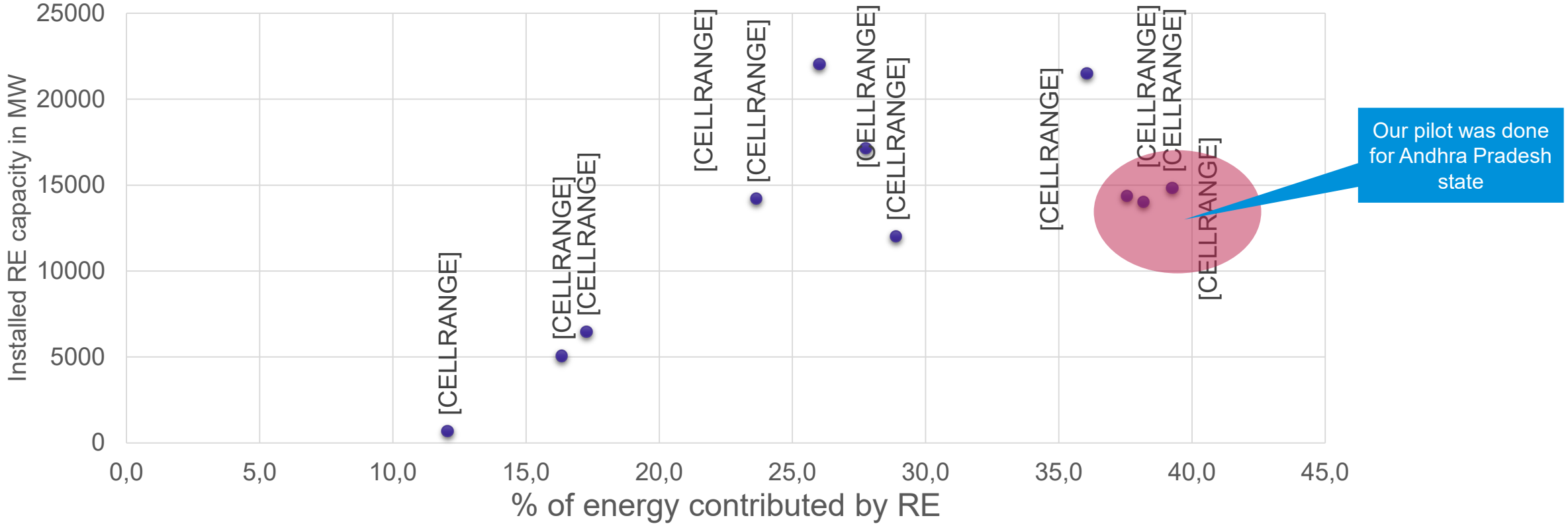
Introduction to Flexibilization & Need Assessment for Andhra Pradesh

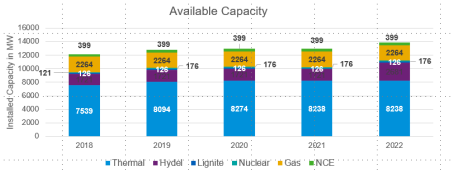
Andhra Pradesh will be one of first states to require flexops



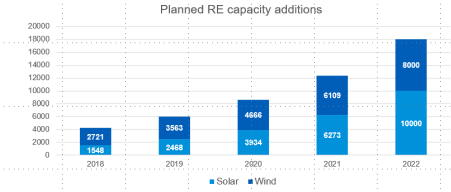
- RE rich states like AP, Karnataka, TN, Rajasthan would need highest flexibility
- Plants with high marginal cost of generation would face significant demand to operate flexibly to ensure better integrations of RE into grid

Market requirements are similar to other countries

AP Power sector - overview



- **Available capacity increases marginally from 12.1 GW in 2018 to 13.8 GW in 2022**
- Available capacity is after adjusting for Aux consumption and PGCIL losses (where applicable)
- Retirement of VTPS I,II,II considered in Sep 2019 & addition of krishnapatnam Unit III & RTPP – stage Iv considered from APR- 2019 onwards



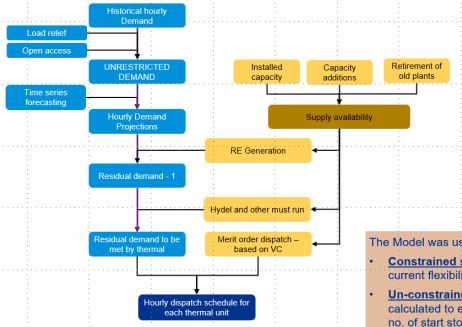
- **At 18 GW RE installed capacity, state would meet 35% of its energy needs from RE sources in 2022**
- Planned RE capacity is as per the State RE action plan
- The state has already achieved a RE installed capacity of 6000 MW as of Feb. 2018

Available thermal capacity increases marginally from 12.1 GW in 2018 to 13.8 GW in 2022

Significant renewables growth across the period

Model calculates residual demand post renewable and must runs

Description of Model used to evaluate the extent of flexibilization required for APGENCO thermal fleet



Major assumptions

- RE capacity additions as per State RE action plan
- MW's available for dispatch are calculated after adjusting for Aux consumption and PGCIL (if applicable)
- All thermal generating stations are available for 100% of time
- Hydel assumed to be operational only during 12 hours of the day morning 4am to 9 AM and 4PM to 11 PM
- Variable cost as per APERC approved for FY 16-17.

The Model was used to evaluate two scenarios

- **Constrained scenario** – where the RE curtailment was calculated based on current flexibilization constraints w.r.t MTL & ramp rates
- **Un-constrained scenario-** where the extent of flexibilization required was calculated to ensure zero curtailment of renewables w.r.t MTL, ramp rates and no. of start stops required

Constrained scenario: RE Curtailment

RE Curtailment at 55% MTL

	JAN	Feb	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2018	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
2019	0%	1%	0%	0%	0%	0%	1%	5%	1%	0%	0%	0%
2020	0%	1%	0%	0%	0%	16%	20%	27%	27%	0%	0%	0%
2021	5%	5%	0%	0%	0%	8%	11%	16%	10%	1%	2%	5%
2022	19%	21%	11%	0%	6%	19%	24%	33%	29%	16%	17%	20%

RE Curtailment at 70% MTL

	JAN	Feb	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2018	27%	13%	4%	0%	0%	9%	12%	22%	29%	7%	9%	32%
2019	32%	15%	7%	1%	1%	35%	35%	43%	51%	14%	6%	30%
2020	36%	19%	6%	0%	34%	83%	82%	80%	86%	11%	11%	25%
2021	39%	29%	13%	0%	7%	36%	39%	47%	47%	20%	22%	30%
2022	47%	40%	28%	3%	19%	45%	48%	59%	60%	40%	38%	45%

RE Curtailment at 30% MTL

	JAN	Feb	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2018	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2019	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2020	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2021	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2022	2%	3%	0%	0%	0%	2%	4%	8%	2%	0%	0%	1%

At 55% MTL, RE –curtailment will increase from negligible levels in 2018 to almost 20% in 2022

At 70% MTL, Re-curtailment will increase to 40% in 2022.

However if flexibilization initiatives are taken up and MTL's can be reduced to 30%. Re-curtailment will be <2% even at 18GW RE capacity

MTL – Minimum Technical Limit

Results show that thermal asset need to

- **eventually reduce min load to 35%,**
- **improve ramp rates and/or,**
- **two shift**

to minimize renewables curtailments

Unconstrained scenario (1/2)

Average No.of Start/stops per day in 2022

	JAN	Feb	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Krishnapatnam TPP (JVP) Stage I (2X800MW) Unit-1	2	2	2	0	2	2	2	2	6	2	2	2
Krishnapatnam TPP (JVP) Stage I (2X800MW) Unit-2	2	2	2	0	2	2	2	4	4	4	2	2
Krishnapatnam TPP (JVP) Stage II (1X800MW) Unit-3	4	2	2	2	4	4	4	0	2	2	2	4
RTPP Stage-II	2	6	2	4	4	2	0	0	0	6	2	6
RTPP Stage-III	2	6	2	4	4	0	0	0	0	4	8	2
Rayalaseema TPP Stage IV Unit- 6 (600MW)	2	2	2	4	4	0	0	0	0	2	8	2

- Of all the thermal Units RTPP Units face very high cycling operation. However this is limited to certain months of the year. since due to their higher cost they will not be scheduled during high RE months (June to September)
- On the other hand Krishnapatnam units face consistent cycling requirement throughout the year (11 out of 12 months)

% operating time below MTL (time considered only when plant schedule is >0)

	JAN	Feb	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
Krishnapatnam TPP (JVP) Stage I (2X800MW) Unit-1	5%	21%	10%	0%	9%	6%	8%	27%	33%	0%	5%	0%	10%
Krishnapatnam TPP (JVP) Stage I (2X800MW) Unit-2	29%	13%	6%	0%	5%	36%	0%	67%	86%	19%	6%	28%	24%
Krishnapatnam TPP (JVP) Stage II (1X800MW) Unit-3	55%	17%	14%	4%	6%	33%	60%	0%	100%	9%	24%	23%	29%
RTPP I	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
RTPP Stage-II	0%	44%	0%	6%	27%	0%	0%	0%	0%	14%	8%	20%	10%
RTPP Stage-III	0%	40%	0%	0%	0%	0%	0%	0%	0%	17%	14%	33%	9%
Rayalaseema TPP Stage IV Unit- 6 (600MW)	0%	33%	18%	18%	33%	0%	0%	0%	0%	60%	60%	50%	23%

- The % of time for which the plant will be dispatched below its MTL (i.e. 55% of rated capacity) would be highest for RTPP and Krishnapatnam. For instance, in July 2022, Krishnapatnam's Unit – II is expected to have a PLF of 20% and operate 73% of that time below MTL

Uniper’s Experience in Flexibilization

Concerned about flexops?

Damage Risks Process Safety Regulations

Costs Damage Competence Fuel supply

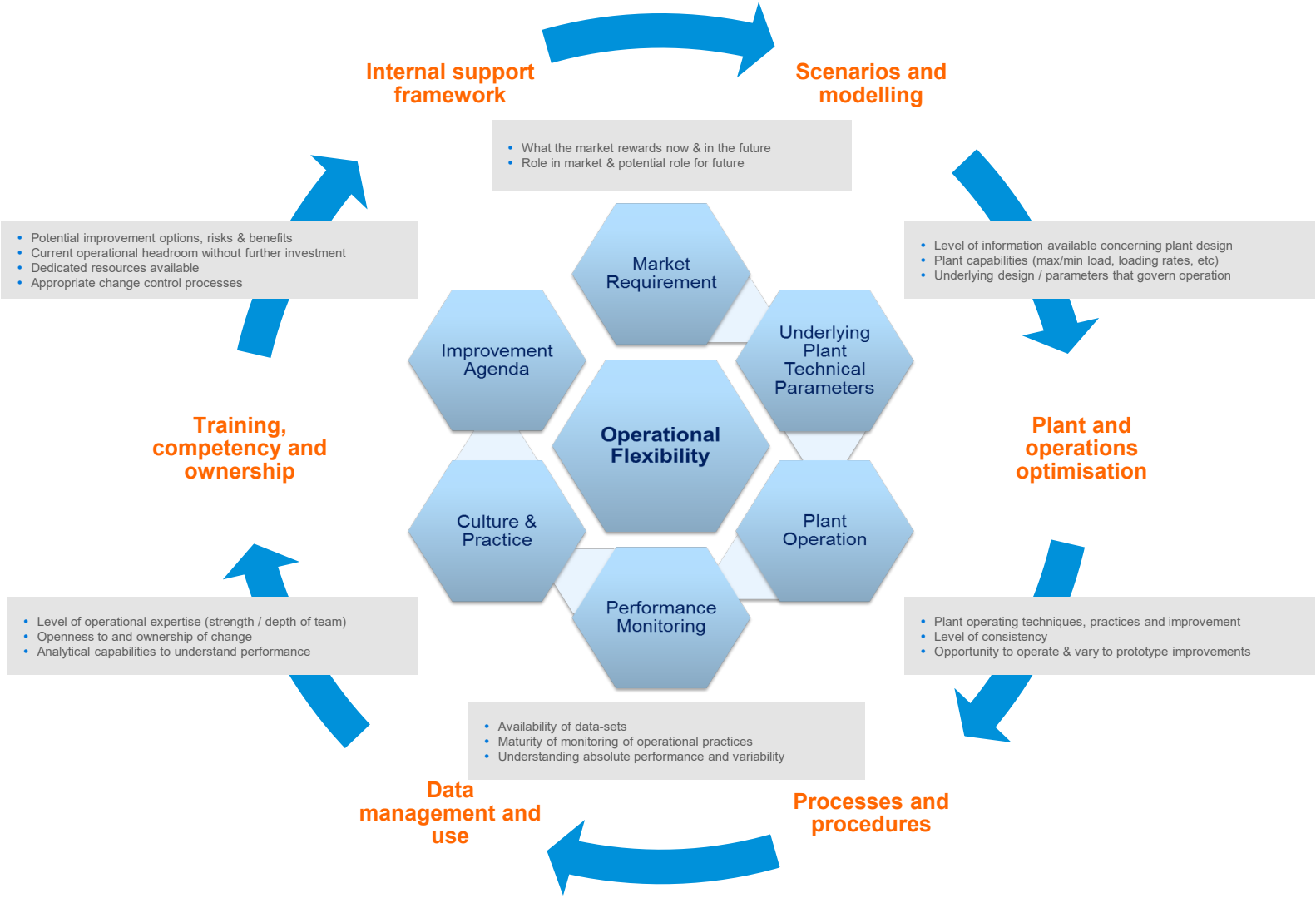
Trade unions Outage strategy OEM recommendations

Ash/gypsum etc… Permit Grid code “My plant is old/special…”

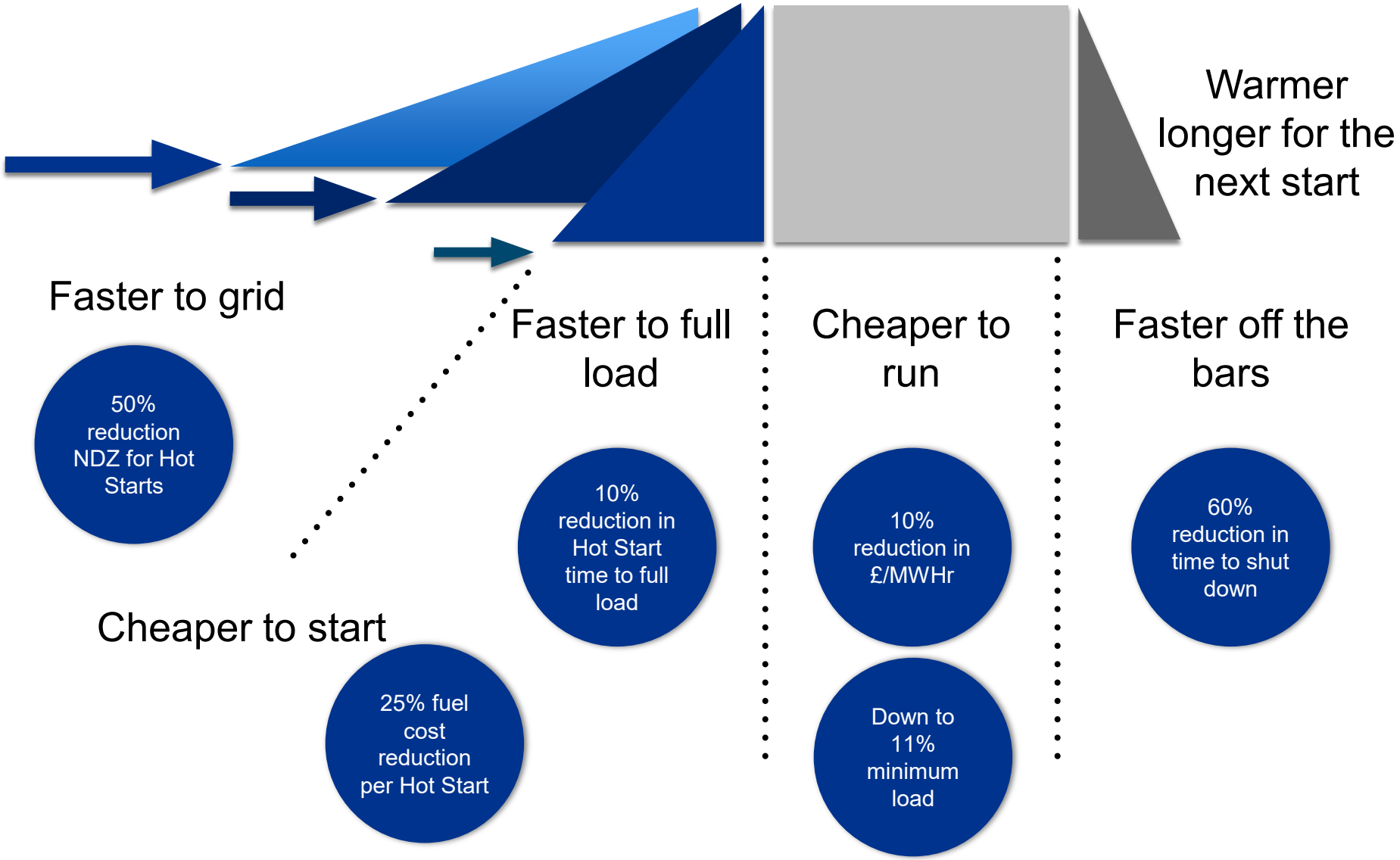
Fatigue vs creep “It’s the grid/states problem”

“How am I going to get paid for it?”

Uniper flexible operations toolkit – plant, process & people

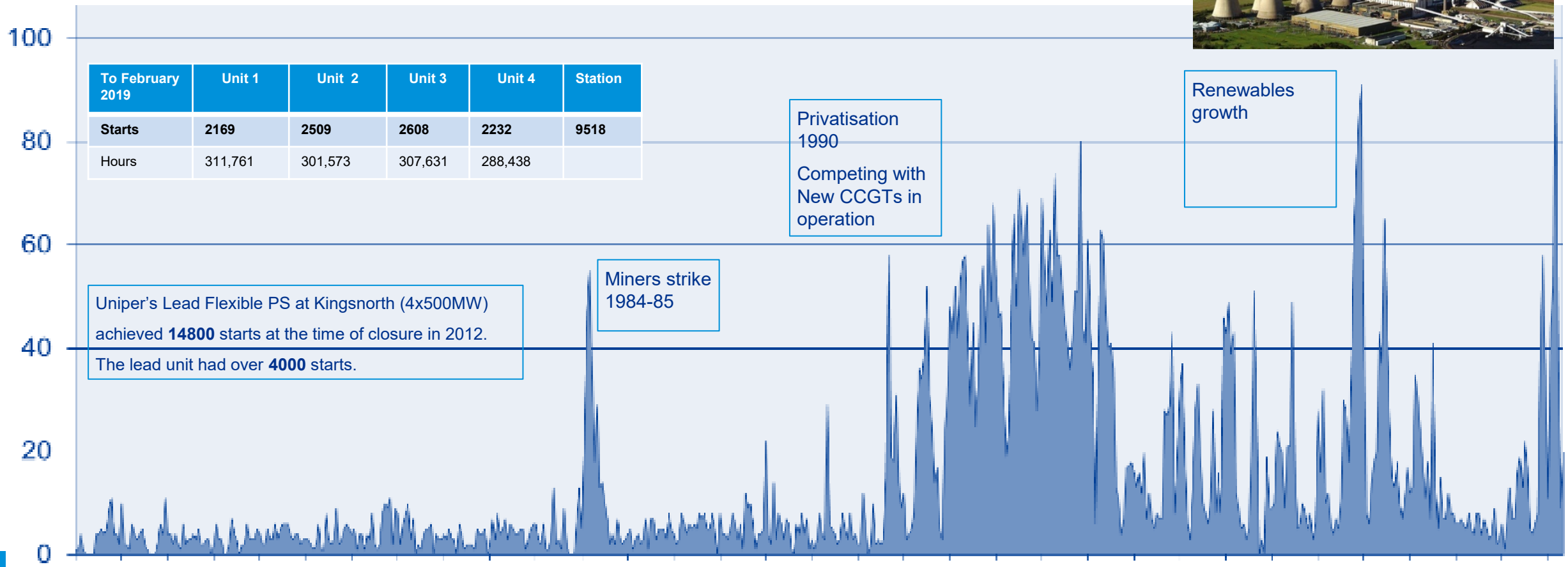


Uniper Flexibility Results – different things in different markets



Ratcliffe, UK – 4x500MW subcritical
"flexibility is a journey not a destination"

To February 2019	Unit 1	Unit 2	Unit 3	Unit 4	Station
Starts	**2169**	**2509**	**2608**	**2232**	**9518**
Hours	311,761	301,573	307,631	288,438	



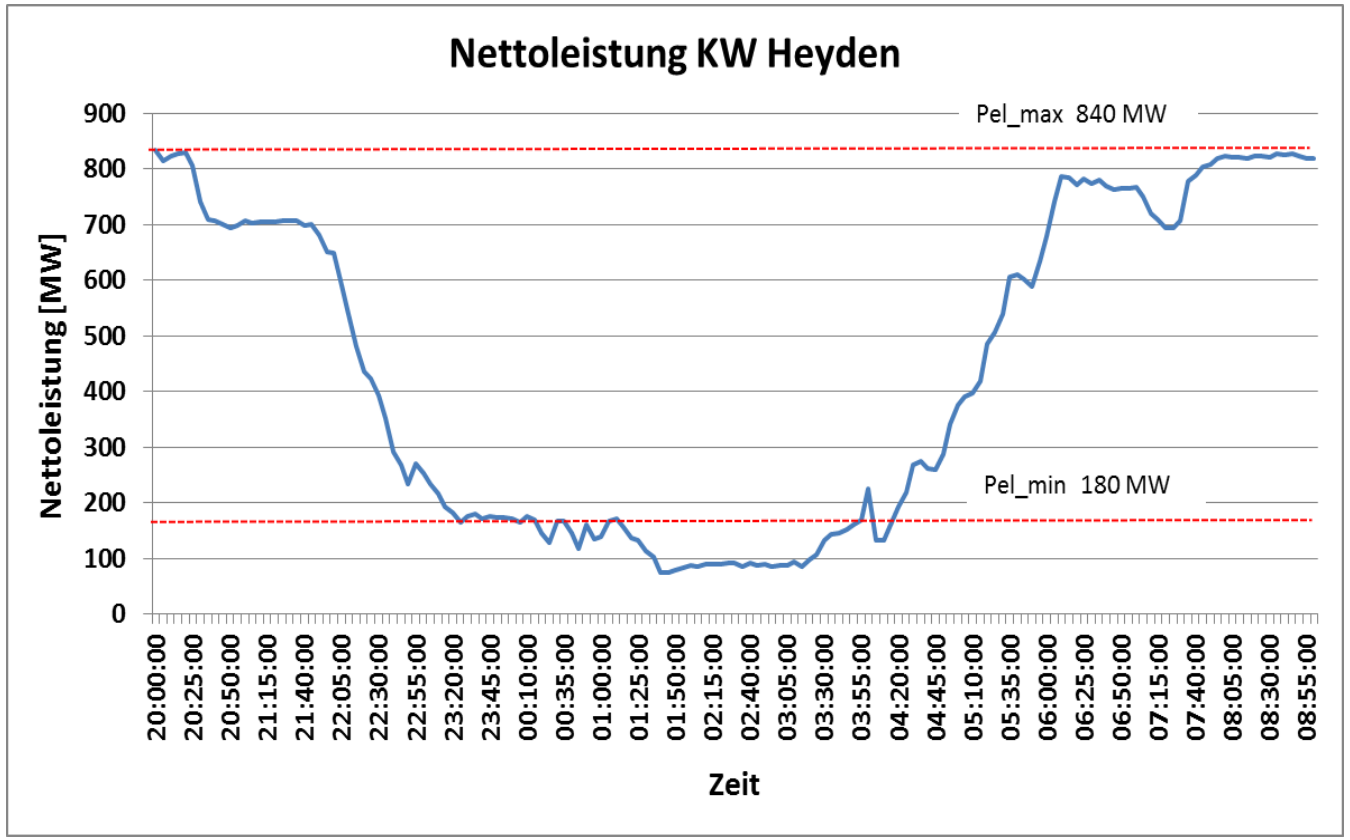
Starts per month For Ratcliffe Power Station 4x500MW – First 50 years of operation (1966 to 2016)

Different scenarios at different times

From baseload to two-shifting to summer cold to non-energy services

Heyden 11% min load on one mill / no oil

Plant commissioning	1987
Installed Capacity	800 MW
Today's capacity	920 MW el
Efficiency at full load	41%
Steam	2700 t/h
Supercritical Pressure	215 bar
Supercritical Temperature	544 Deg C
Intermediate pressure/Temp	46 bar/ 545 Deg C
Flexibility	
Min Load	20% / 180 MW
since 01.06.2017	11% / 100 MW
Ramp rate	15….20 MW/Min
Hot start time to grid	1 Hour
Hot start time to Full Load	3 hours



2015: Assessment and evaluation of viability

2016: Planning and implementation of testing

2017: Optimisation, available 01.06.17

Diagnostic study at Sri Damodaram Sanjeevaiah Thermal Power Station (SDSTPS)

SDSTPS Current operating state

Design parameters of the plant

Installed capacity : 2 X 800 MW

Design minimum load : 440 MW (~55 %)

Design ramp rate (turbine) : 1-3% ramp down – 1-2% ramp up

Key issues facing the plant currently

- Shortage of coal – leading to regular start – stop
- Quality of coal, lower than design– difficulty in achieving full load
- Control system not finely tuned below 60%

- The plant has been operated successfully at a minimum load of 320 MW for a short duration and has also gone down to 280 MW in one instance of coal shortage.
- The current market scenario facilitates a mostly base load operation with a few instances of regulation.
- Lack of any incentive to compensate flexible operation

Flexops process has idenitifed key roadblocks

Reduction in technical minimum

- Quality of coal
- Control system tuning below 60% load
- Turbine Driven feed pump flow induced vibration
- Flame Stability
- Number of control panel interventions
- Vertical wall and superheater platen overheating risk
- Extended wet mode operations
- Low stack temperature
- Unavailability of robust condition monitoring tools & employee training
- Unavailability of start up system

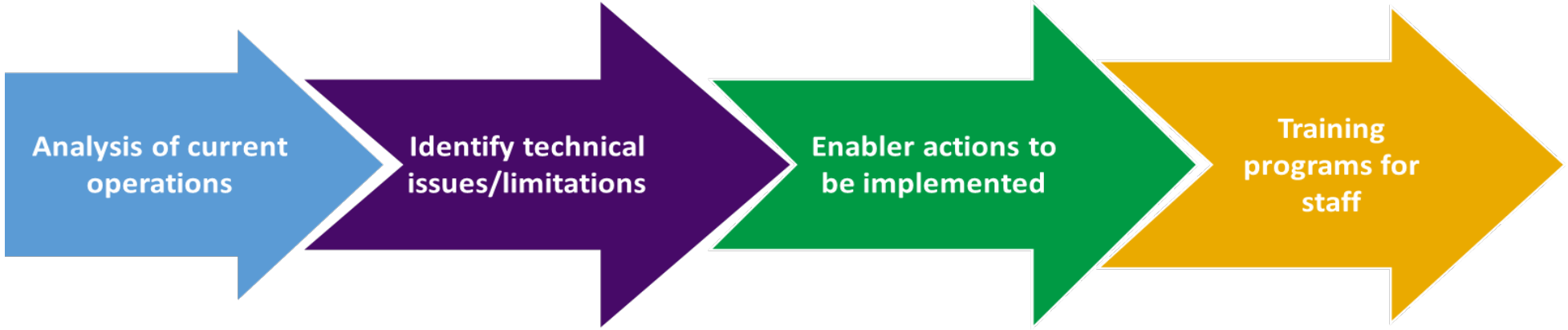
Increase in ramp rates

- Quality of coal
- Turbine Driven feed pump change over
- DCS modifications

Faster start-up/shut down times

- Operator skill shortfall
- Level of automation
- Start reliability of equipment
- Unavailability of start up system

Process for Implementing flexibilization



The interventions can be categorized as:

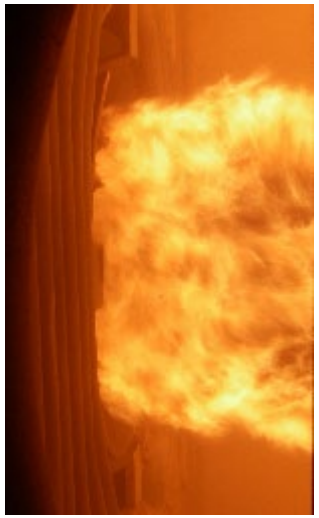
- **Plant & process -** associated with the plant
  - Interventions to address issues such as coal quality and flame stability, low back end temperatures, issues with turbine driven boiler feed pump etc.
  - Installation of Computerized Maintenance Management System (CMMS) for ensuring tracking and completion of all maintenance works
- **People -** for repeatable flexible operation
  - Training programs to ensure operator competence for managing flexible operation of plant

Plant & process example - Coal Quality and Flame Stability

Issue

- Variability in coal quality leading to combustion instability
- Inadequate flame detection – current 3 mill operation limitation

Unstable Flame



Stable Flame

Solutions

- Understand the effect on the boiler and challenge the mine on coal quality received through enhanced sampling program and fuel evaluation tool
- Ensure crushing(crusher installed), then blending of Indian and imported coals through blending facility
- Upgrade flame detection equipment to allow progression towards single mill operation

Estimated Cost	Timescale
Sampling system - $$ Fuel evaluation tool - $	6 months
Coal blending facility improvement - $$$	12 months
Flame Detection $$	Suitable Outage

Process - Maintenance System Example

Enabler actions are those needed to ensure the power plant has the systems necessary for reliable flexible operation

- An effective computerised maintenance management system (CMMS) is a key enabler to ensure essential control of maintenance to achieve reliable plant for flexibility duty.
- Planned, not breakdown maintenance is key to reliable equipment.
- At SDSTPS all planned and defect maintenance are documented and manually recorded as paper copies.
- The possible installation of a CMMS is a part of a major project being rolled out by APGENCO.
- An additional awareness in predicting required maintenance can be achieved through an Advanced Condition Monitoring system (ACM).

People - Operator Training Example

Operating flexibly requires a significant higher level of competence than for steady state operation.

To achieve this an operator development program will be needed to:

- Train staff to undertake additional requirements needed to perform flexible operation.
- Create a flexible operator team from selected staff to undertake any trials
- Monitoring performance with feedback to each shift operations team is a key learning to share best practise and reduce shift to shift variations.

➢Uniper Engineering Academy

➢Engineering, operations, craft skills and management

➢Coal, CCGT, biomass, CHP plant operator training

Uniper Engineering Academy

➢ Mechanical and electrical installation & maintenance

➢ Control, instrumentation & PLC training

Implementation Road Map – Phased Approach

Example - Ultra Low Load

Current Position :
440MW @ 4 Mills

Target 1 :
280MW @ 3 Mills

Target 2 :
200MW @ 2 Mills

Target 3 :
120MW @ 1 Mill

Action A1 : Improve Coal Quality

Action A2 : Tune Control System below 60%

Action A3 : Sort TDBFP low flow & changeover issue & allow single TDBFP operation

Action A8 : Fix issue of unavailability of Start Up system

Action A2 : Further control system tuning

Action A4 : Flame detection

Action A5 : Vertical Wall & Platen overheating

Action A6 : Extended wet mode operation

Action A7: Low Stack Temps

Review all Target 2 actions to further tune

Coal quality will be defining factor of achievable limit

Operator training and experience will be key

120MW @ 2 Mills would still provide excellent level of flexibility without single mill risk

Key Enablers for Incentivizing Flexibilization

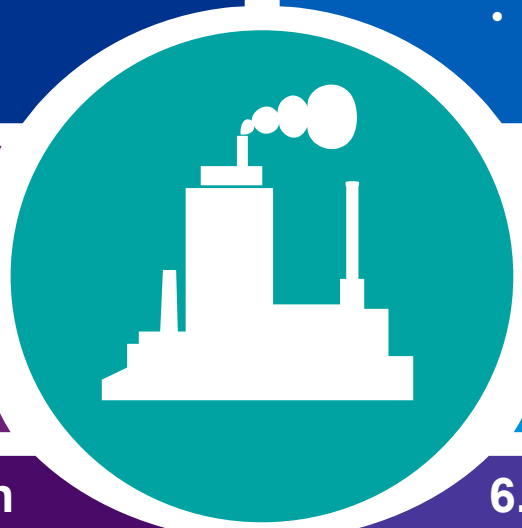
Key Enablers for Incentivizing Flexibilization

1. Regulations defining minimum load

- **Minimum load set to 55%** in 2016 for Central Generating Stations
- **Compensation mechanism for fixed costs** incurred to operate at low minimum load is required to incentivize investment

2. Economic incentives influencing plant operations

- **Contract terms and tariff structures can discourage plants from investing in flexible operation**
  - Eg: Maintenance contracts based on no. of starts, long term PPAs with fixed cost recovery



3. Faster scheduling intervals

- Enables use of existing flexibility in thermal plants
- Improves RE forecast accuracy, lowering reserve requirements

4. Ancillary services

Implementation of Automatic Generation Control Systems to ensure quick, real time response from generation stations to market requirements

5. Market design for flexible operation

- Real time electricity markets for balancing services
- Enables better price discovery, leading to higher revenue for plants low in merit order dispatch

6. Pan India code for flexibilization

- Implement pilots across plants in India for developing a holistic flexibilization code
- Develop guidelines and SOPs for flexible operation in coal plants across India

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