Flexibilization of thermal power plants

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

Doug Waters
Director – Global Energy Service
Uniper

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• 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

Our pilot was done for Andhra Pradesh state
Market requirements are similar to other countries

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

Results show that thermal asset need to

- eventually reduce min load to 35%,
- improve ramp rates and/or,
- two shift to minimize renewables curtailments
Uniper’s Experience in Flexibilization
### Concerned about flexops?

<table>
<thead>
<tr>
<th>Damage</th>
<th>Risks</th>
<th>Process Safety</th>
<th>Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>Damage</td>
<td>Competence</td>
<td>Fuel supply</td>
</tr>
<tr>
<td>Trade unions</td>
<td>Outage strategy</td>
<td>OEM recommendations</td>
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<tr>
<td>Ash/gypsum etc…</td>
<td>Permit</td>
<td>Grid code</td>
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<tr>
<td>Fatigue vs creep</td>
<td>“It’s the grid/states problem”</td>
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“My plant is old/special…”

“How am I going to get paid for it?”
Uniper flexible operations toolkit – plant, process & people

**Internal support framework**
- Potential improvement options, risks & benefits
- Current operational headroom without further investment
- Dedicated resources available
- Appropriate change control processes

**Scenarios and modelling**
- What the market rewards now & in the future
- Role in market & potential role for future

**Plant and operations optimisation**
- Level of information available concerning plant design
- Plant capabilities (max/min load, loading rates, etc)
- Underlying design / parameters that govern operation

**Training, competency and ownership**
- Level of operational expertise (strength / depth of team)
- Openness to and ownership of change
- Analytical capabilities to understand performance

**Operational flexibility**
- Availability of data-sets
- Maturity of monitoring of operational practices
- Understanding absolute performance and variability

**Processes and procedures**
- Plant operating techniques, practices and improvement
- Level of consistency
- Opportunity to operate & vary to prototype improvements

**Data management and use**
- Performance Monitoring
Uniper Flexibility Results – different things in different markets

- Faster to grid
  - 50% reduction NDZ for Hot Starts

- Faster to full load
  - 10% reduction in Hot Start time to full load
  - 10% reduction in £/MWhr

- Cheaper to run
  - 25% fuel cost reduction per Hot Start
  - 10% reduction in £/MWhr
  - Down to 11% minimum load

- Faster off the bars
  - 60% reduction in time to shut down

- Warmer longer for the next start
  - 10% reduction in Hot Start time to full load
  - 50% reduction in NDZ for Hot Starts
  - 60% reduction in time to shut down
Ratcliffe, UK – 4x500MW subcritical
“flexibility is a journey not a destination”

Different scenarios at different times
From baseload to two-shifting to summer cold to non-energy services

<table>
<thead>
<tr>
<th>To February 2019</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Unit 4</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starts</td>
<td>2169</td>
<td>2509</td>
<td>2608</td>
<td>2232</td>
<td>9518</td>
</tr>
<tr>
<td>Hours</td>
<td>311,761</td>
<td>301,573</td>
<td>307,631</td>
<td>288,438</td>
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Uniper’s Lead Flexible PS at Kingsnorth (4x500MW) achieved 14800 starts at the time of closure in 2012.
The lead unit had over 4000 starts.

Privatisation 1990
Competing with New CCGTs in operation

Miners strike 1984-85

Renewables growth

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

<table>
<thead>
<tr>
<th>Reduction in technical minimum</th>
<th>Increase in ramp rates</th>
<th>Faster start-up/shut down times</th>
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<tbody>
<tr>
<td>- Quality of coal</td>
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<tr>
<td>- Control system tuning below 60% load</td>
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<td></td>
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<tr>
<td>- Turbine Driven feed pump flow induced vibration</td>
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<td></td>
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<tr>
<td>- Flame Stability</td>
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<tr>
<td>- Number of control panel interventions</td>
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<tr>
<td>- Vertical wall and superheater platen overheating risk</td>
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<td></td>
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<tr>
<td>- Extended wet mode operations</td>
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<tr>
<td>- Low stack temperature</td>
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<td></td>
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<tr>
<td>- Unavailability of robust condition monitoring tools &amp; employee training</td>
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<td></td>
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<tr>
<td>- Unavailability of start up system</td>
<td></td>
<td></td>
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<tr>
<td>- Quality of coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Turbine Driven feed pump change over</td>
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<tr>
<td>- DCS modifications</td>
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<td>- Operator skill shortfall</td>
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<tr>
<td>- Level of automation</td>
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<td>- Start reliability of equipment</td>
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<td></td>
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<tr>
<td>- Unavailability of start up system</td>
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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

**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

<table>
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<th>Estimated Cost</th>
<th>Timescale</th>
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<tr>
<td>Sampling system - $$</td>
<td>6 months</td>
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<tr>
<td>Fuel evaluation tool - $</td>
<td></td>
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<tr>
<td>Coal blending facility improvement - $$$</td>
<td>12 months</td>
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<tr>
<td>Flame Detection $$</td>
<td>Suitable Outage</td>
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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).
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
  - 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
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

Target 2: 200MW @ 2 Mills
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

Target 3: 120MW @ 1 Mill
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
Thank You