New Technologies for Sustainability

Disclaimer:
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NTPC Ltd
Overview

Sustainability - for profit, people and the planet

Challenges – the inevitable

Efficiency - the perpetual challenge

New Technologies - a must for sustainability

Destinations 2032 - the future
Sustainability - for profit, people and the planet

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Sustainability.... the classical definition

SUSTAINABLE

ECONOMIC (PROFITS)

EQITABLE

Bearable

VIABLE

ENVIRONMENT (PLANET)

SOCIAL (PEOPLE)

BEARABLE

EQITABLE

SUSTAINABLE

VIABLE

ECONOMIC (PROFITS)

ENVIRONMENT (PLANET)

SOCIAL (PEOPLE)
Sustainability.... in power generation

Endure the present with the best O&M practices

Embrace new technologies to meet the growing challenges

Invest in R&D to meet the future aspirations (wish-list)
Sustainability Indicators

- Cost and the financial benefits
- Efficiency of energy transformation
- Green House Gas emissions
- Availability of energy source
- Limitations to provide base load
- Land use (the foot print)
- Water use
- Social impacts on human health and quality of life
Sustainability - for profit, people and the planet

**Challenges** – the inevitable

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Destinations 2032 - the future
Ever Changing Business Environment

Environmental Regulations

Source of Power

Input Energy

PAT Targets

Transmission Utilities

Distribution Agencies

Users

Power Sector

Thermal Power (~65%)

Hydro Power (~22%)

Nuclear power (~3%)

Renewable energy sources (~10%)

Radioactive elements (Uranium, Thorium etc.)

Solar panels, Wind mills etc.

Coal, Oil & Gas

Water

Radioactive elements

Central Transmission Utilities and State Transmission utilities

Tariff Norms

Manpower Retention

Land Scarcity

Growing Competition

Fuel Shortages

Water Scarcity

Zero Discharge

Tariff Norms

Growing Competition

Fuel Shortages

Water Scarcity

Zero Discharge

Central Transmission Utilities and State Transmission utilities

Distribution Channels

Industries (38%)

Domestic (22%)

Agriculture (22%)

Commercial (8%)

Others (10%)
Sustainability - for profit, people and the planet

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Destinations 2032 - the future
Efficiency Improvement ..... a continuous endeavor

1% point improvement in average efficiency of coal based generation in the country today typically implies any one of the following:

- **15 mtpa** savings in domestic coal
- Avoidance of **8 mtpa** of coal imports
- Annual savings of **Rs 2400 to 4000 crores**
- Reduction of **18 mtpa** of CO₂ emissions
- Resultant savings in coal can support capacity addition of **3000 MW**
- Can fulfill the annual electricity needs of **30 million** average Indians
Sustain Design Efficiency … enduring the present

Typical HR Loss Areas
Indian Power Plants

High-loss category (20-40 kcal/kWh)
- Dry Flue Gas Loss
- Condenser
- Unaccountable

Medium-loss category (10-20 kcal/kWh)
- HP/IP Turbine
- RH Spray
- Cooling Tower

Low-loss category (<10 kcal/kWh)
- Unburnt Loss
- MS & HRH Temperature deviations
- Feed water Temperature deviations

Typical Break Up of HR Losses

- Dry Flue Gas Loss, 16%
- Condenser, 15%
- Turbine (HP & IP), 19%
- RH Spray, 9%
- Cooling Tower, 16%
- Others, 5%
- Unaccountables, 20%
PADO .... maximizing operational efficiency

- Performance analysis, diagnosis and optimization system (PADO)
- PADO allows the operator to have an expert online decision support for improving the plant heat rate, reducing the losses and diagnosing process deviation and system failures through root cause analysis.
- Boiler flame analysis system for combustion optimization
- Boiler flame analysis system has the potential to enable the operator to correct combustion imbalances and flame stability problems thereby reducing losses like un-burnt fuel and saving in CO2 and other emissions
- Root cause analysis system for decision support & early warning
- Help pin point minor process deviations that ultimately result in lower system efficiencies and monetary loss to the generating company
Efficiency Comparison ..... Indian Vs other Advanced Power Plants

* The efficiency of Power plants is corrected to steam Parameters 247 ata /565°C/593°C
Efficiency Improvement ..... by raising steam parameters
Efficiency Improvement ..... by modified cycle arrangement

- ‘HARP’ Cycle
- External De-Superheater
- Over Load Valve
- Dual pressure, series condenser
‘HARP’ Heater

• **Heater Above Reheat Point (HARP)** used in supercritical cycles where the top HP heater draws steam from HP turbine

• This provides increased final feed water temperature as compared to conventional cycles where the top HP heater draws steam from cold reheat

• Improved Heat Rate by ~12 kCal/kWhr
External De-Superheater

- External de-superheater used downstream of top HP heater
- This arrangement further enables increase in final feed water temperature
- Heat Rate improved by ~2 kCal/kWhr
Over Load Valve

• An over load control valve (provided in addition to the main control valves, MCV) sends main steam to an intermediate stage of HP turbine bypassing initial 3 to 5 stages

• The over load control valve(s) remain closed during normal operation and open only when peaking is required

• This eliminates/minimizes throttling losses in MCV at the rated load since no throttle margin need to be kept in the MCV for peaking purpose

• This results in heat rate improvement by 6-8 kCal/kWhr
Series Condensers

• In 800 MW units, due to large volumetric flow in LP turbine, two LPTs are employed and, therefore, it has two condensers, one per LPT.

• It is possible to circulate the condenser cooling water in series through the two condensers – CW exiting one condenser enters the other condenser

• In such an arrangement the first condenser operates with better vacuum than the other

• This arrangement of dual pressure series condensers results in heat rate improvement by ~14 kCal/kWhr
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Destinations 2032 - the future
Technology Adoptions

- Supercritical Technology
- 400 KV GIS
- Numerical Relays and Networking systems on IEC 61850
- High Concentration Slurry Disposal
- Concrete Volute Circulating Water Pumps
- Flue Gas Desulphurization
- Energy Efficient Motors & Lighting
- Variable Frequency Drives
- Sub Station Automation
- Field Bus Technology
- Wireless C&I Devices
- Integrated and Secure DDCMIS Systems
Pipe Conveyors .... environmentally desirable

- Minimize transfer points
- Carries material over steep angle of ascent and descent
- Enables Bi-Directional material flow
- Totally enclosed to prevent spillage and pilferage.
- Easily routed through undulated terrain like marsh lands, hilly terrain as well as habitat area.
High Concentration Slurry Disposal

- High concentration slurry disposal system with 60-70 % (w/w) concentration using positive displacement pumps
- Widely adopted for recent stations
- Technology not yet proven for larger distance conveying >10 kms
Flue Gas Desulphurization (FGD)

- Use of 30% imported coal blended with domestic coal is now the norm of the day.
- Indian coal is low-Sulphur coal (0.3% to max 0.5%) but certain imported coals have higher Sulphur (0.8% to 2%).
- A 30:70 blended coal may, thus, have Sulphur close to 1%.
- Moreover, there may be plants, especially the coastal ones, which will be firing only high sulphur imported coals.
- Thus, requirement of FGD becoming mandatory in future looks imminent.
**FGD Technology ...an overview**

<table>
<thead>
<tr>
<th>FGD Technology</th>
<th>Wet Limestone-gypsum</th>
<th>Sea Water Based System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorbent</td>
<td>Limestone</td>
<td>Sea Water</td>
</tr>
<tr>
<td>Coal Sulphur Limit</td>
<td>No such Sulphur content limit</td>
<td>For low to medium sulphur content (limitation due to large amt of sea water required)</td>
</tr>
<tr>
<td>Removal efficiency</td>
<td>Above 95%</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>Process</td>
<td>Complex</td>
<td>Simple</td>
</tr>
<tr>
<td>Sorbent source</td>
<td>Local</td>
<td>Coastal Plant</td>
</tr>
<tr>
<td>Sorbent Utilization</td>
<td>Good</td>
<td>-</td>
</tr>
<tr>
<td>By-product</td>
<td>Gypsum</td>
<td>Treated Sea water</td>
</tr>
<tr>
<td>Aux. Power</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Reference Plants above 250 MW</td>
<td>Many</td>
<td>Many</td>
</tr>
<tr>
<td>Maturity of Technology</td>
<td>Matured</td>
<td>Matured</td>
</tr>
</tbody>
</table>

*Coal Sulphur Limit:* No such Sulphur content limit for low to medium sulphur content (limitation due to large amount of sea water required).

*Operating Cost:* Low for both technologies.
Flue gas De- Sulphurization System

Flue gas, after ESP & ID fan is routed through FGD system.

Gas-to-Gas Heater may be used to heat clean FG with hot FG.

Absorber / Scrubber where the SOx absorption/removal reaction takes place.

Reagent – limestone slurry / sea water.

By-product (gypsum).

Waste / effluent.
Sea Water based FGD

- Sea Water FGD has lower capital cost & running cost as compared to wet limestone FGD
- The system is simpler, requires no extra re-agent & requires no by-product handling and disposal
- The only effluent is spent sea water which is oxidized and mixed with sea water to bring it back to normal sea water pH, COD and temperature
- For coastal plants, sea water based FGD is being adopted
Electrical Systems .... Powering for Reliability and Safety

- 765 KV Switchyard and 400 kV GIS for Power Evacuation
- Integrated Controls, Protection and Monitoring of Electrical auxiliary supply Systems through advanced Numerical Relaying and SCADA controls
- On Line health Monitoring systems for Generators and Transformer CMS systems
- Internal Arc Safe MV Switchgears & Safe Termination (Form IV) LV Switchgears for SAFE operations
- High Efficiency Motors and Variable Frequency Drives
- Engineering Software for system designs and analysis
Gas Insulated Switchgears .... Reducing Foot Prints

- GIS: Compact design of allows their use in the most confined spaces
- Flexible designs and problem-free extension
- Economic efficiency
- High reliability & availability
- Low life-cycle and maintenance costs
- Good accessibility and ergonomics
- Safe operation even under extreme environmental conditions
- Environment-compatible design
SCADA Controls & Smart Networking

SMART Networking with integrated Protections, Controls, Metering and Monitoring with Dynamic online display for Reliable Auxiliary Power Supply System

- Remote Real-Time Data Visualization
- Integrated with DDCMIS
- SCADA Control with Less Cu cables
- On Line Electrical Equipment Health
- On Line Fault Diagnosis and Analysis

Operational Ease

Easy to Maintain, Flexible and Scalable

Integrated SCADA Controls for Kudgi 3 x 800 MW being Implemented
C&I systems .... moving towards Integration & Security

INTEGRATION & SECURITY

MICRO PROCESSOR BASED PLC & DCS

HARDWIRED & SEMICONDUCTOR

HARDWIRED

DESIGN VALIDATION, ASSET UTILISATION & MANAGEMENT, IT & NETWORKING

AVAILABILITY, EFFICIENCY, OPERATION EASE

RELIABILITY

SAFETY
Transformation of Unit Control Room
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Destinations 2032: A Snapshot

- 100 MW Gasifier for Indian Coal
- 100 MW IGCC Power Block
- IGCC up scaling to 500 MW
- Renewables 4800 MW
- Nuclear 14,000 MW
- USC unit 700 Deg Class
- 25% reduction in CO₂ footprint
- Renewable 11,300 MW
- 10 KW Thermo-electric Generation
- Dry Cooled Power plant
- Efficiency improvement through R&M
- 600 + Class USC unit
Advanced Ultra Supercritical (Mission 2017)

- Mission envisions development of indigenous capabilities in the field of Adv-Ultra supercritical technology with
  - 300 kg/cm² Main Steam pressure
  - 700 deg C Steam temperatures

- Indigenous Adv-USC plant’s efficiency expected in the range of 45-47% as against 35-38% for conventional sub-critical power plants

- Approx. 17% less CO2 emission compared to a typical sub-critical plant

- After development of Adv-USC technology, Mission proposes to establish an 800MWe Adv-USC Demo plant based on indigenous technology.

- Mission intends to utilize core strengths of organizations like NTPC, IGCAR, BHEL & CEA

- Mission has a time frame of 7 (seven) years, 2.5 years for R&D and 4.5 for setting up of Demo plant
Future Technologies

- Ultra supercritical Technology
- Induction of Advanced class Gas Turbines
- Integrated Gas. Combined Cycle (IGCC)
- Integrated Gas. Fuel cell (IGFC)
- 1200 KV Switchyard
- Integrated Controls and Protection Systems
- Energy Storage Systems
- Smart Grid
Future Technologies

- Safety Instrumented System for Hazardous areas
- Wireless technologies
- Intelligent device and advanced sensor technologies

- Adoption of Building Information modeling
- Automated generation of Civil GA & fabrication drawings
- Use of trenchless technology for below ground pipe work
- Use of Steel structure for TG sub structure
- Prefabricated and bolted structure
- Use of precast sections/slabs for culverts and drains
Coal Blending... sustaining fuel shortages

- Coal blending is unavoidable
- Field trials are on to determine safe blending ratio for various coals
- Blending facility soon to become an integral part of CHP design planning

Coal Consumption & Import

<table>
<thead>
<tr>
<th></th>
<th>2010-2011</th>
<th>2011-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>442 / 45 MMT</td>
<td>473 / 60 MMT</td>
</tr>
<tr>
<td>NTPC</td>
<td>138 / 10.6 MMT</td>
<td>164 / 16 MMT</td>
</tr>
</tbody>
</table>

• Compatibility of coals
• Blend Proportions
  - Optimum blend mix?
  - Maintaining desired blend proportions?
• Blending Methodology
• Safe operation
• Impact of blending
  - Cost of Generation
  - Auxiliary Power consumption
  - Environmental Emissions
  - Operating & performance parameters
Aspirations for Future

PLANT EFFICIENCY

2009: 38.6%
2017: 41%
2025: 43%
2032: 45%

AUX POWER

2009: 5.5%
2017: 5.0%
2025: 4.75%
2032: 4.5%
Aspirations for Future

- **CO₂ EMISSIONS**
  - 2032: 600
  - 2025: 624
  - 2017: 704
  - 2009: 774

- **LAND USE (ACRE/MW)**
  - 2032: 0.25
  - 2025: 0.35
  - 2017: 0.4
  - 2009: 1.0
Aspirations for Future

NON COAL CAPACITY

2009 17.7 %

2017 20%

2025 25 %

2032 30 %

HYDRO & RENEWABLE

2009 3.0 %

2017 9.33 %

2025 18 %

2032 20 %
“When the winds of change blow, some people build walls, others build wind mills”

Let us build wind mills

Thank you