

Longview Power – Reliable, Economic, Clean Coal

October 6, 2015



Longview Power Overview



- 778 MW gross (700 MW net) coal fired plant
- Located near Morgantown, WV
- Total project cost was approximately \$2.0B
- Primarily owned by major private equity firms
- Commenced operations in December 2011
- Mine mouth coal provided by conveyor
- Lowest cost generator of any coal plant in region
- Lowest heat rate in PJM power market
- Exceptionally low emissions
- Highly efficient water balance with minimal wastewater discharge (zero to surface water)

Longview Boiler Island

Amec Foster Wheeler - Boiler Island

Steam Generator - Once thru, supercritical, sliding pressure

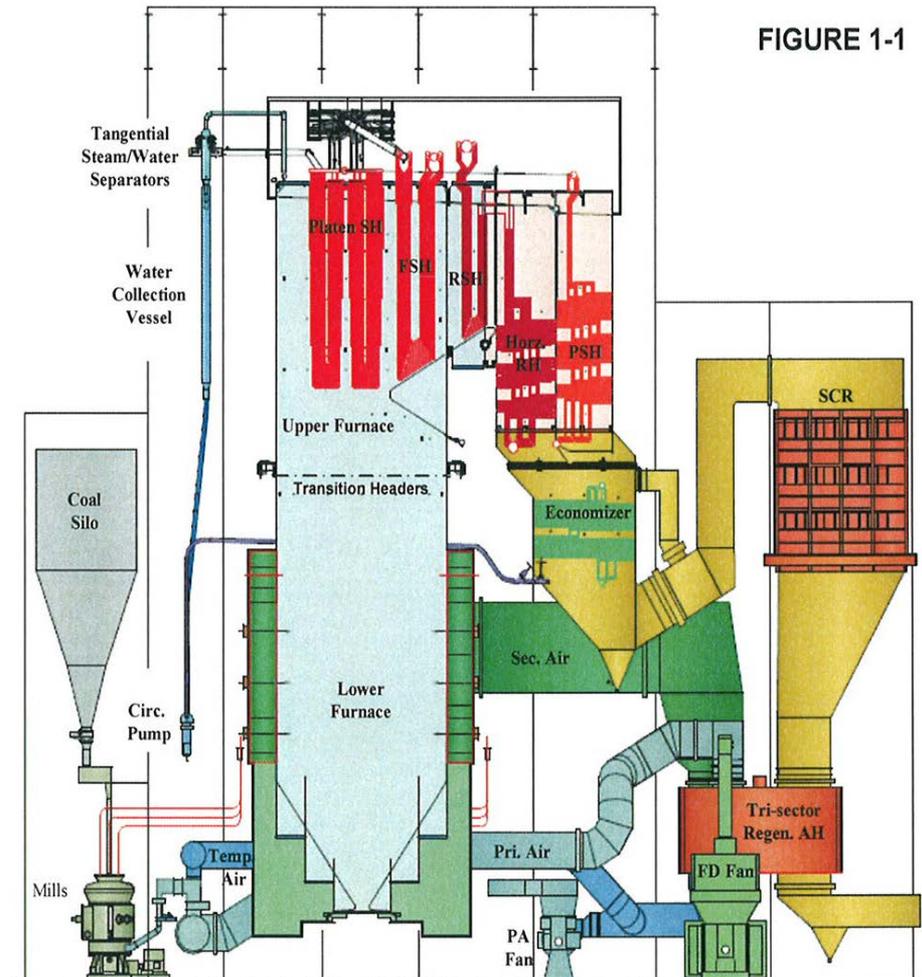
- Low mass flux vertical tube design
- Efficiency > 90%
- Rated steam flow = 4,875,000 lbs/hr
- MS/RH Steam Temps = 1,052°F/1,056°F

Combustion System

- Opposed wall arrangement
- 6 mills, full load on 5 mills
- 36 low NOx burners & 16 OFA registers

Selective Catalytic Reactor (SCR)

- 2+1 design
- Haldor Topsoe Corrugated Plate DNX-XD



Longview AQCS Islands

Amec Foster Wheeler – Air Quality Control System (AQCS)

Acid Mist Reduction

- Hydrated lime injection system

Particulate Matter (PM) Removal

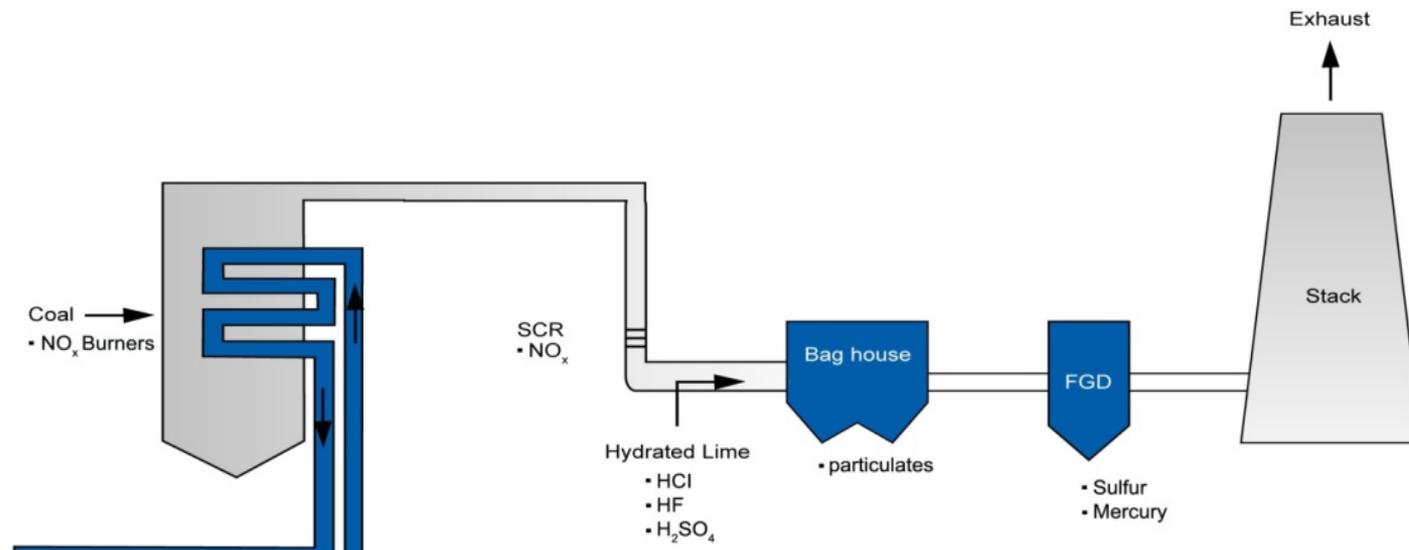
- > 99% Removal pulse jet fabric filter (PJFF)

SO₂ Removal

- Wet Flue Gas Desulfurization System (FGD)
- Up to 99.5% removal

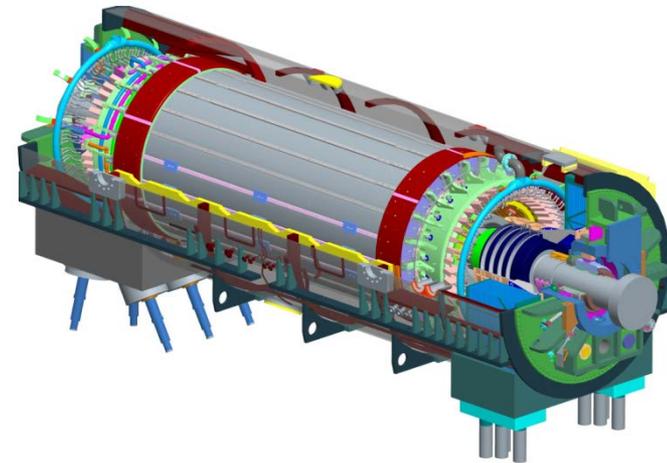
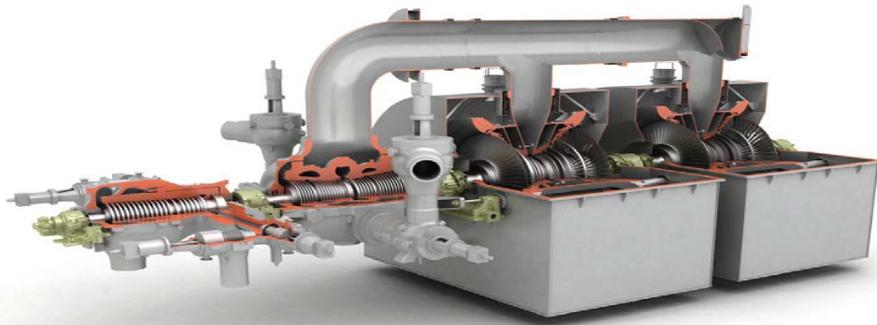
Mercury Removal

- Significant mercury removal with combined AQCS equipment



Longview Steam Turbine & Generator

Thermal Energy → **Mechanical Energy** → **Electrical Energy**
(Boiler) **(Steam Turbine)** **(Generator)**



Siemens HMNN 770 MW Turbine System

- Tandem Compound Design: 1x single flow HP, 1 x double flow IP, 2 x double flow LP Sections
- Inlet steam conditions 3600 psi, 1050F
- 5,027,000 lbs/hr of steam flow @ VWO

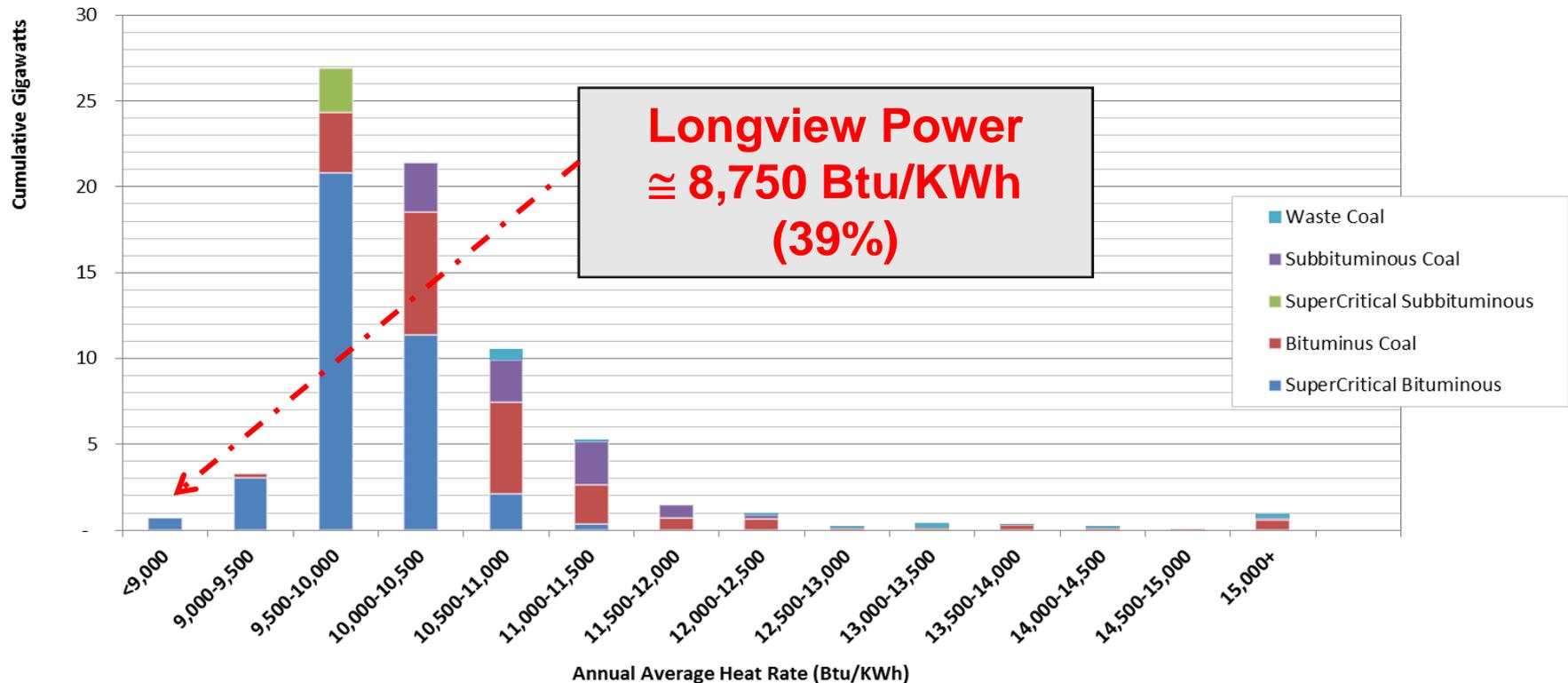
Siemens Model # SGen6-3000W Generator

- Rated for 807MW/hr
- Directly coupled to the turbine
- Hydrogen inner cooling
- Water-cooled stator winding
- Up to 99% operating efficiency

Best in Class Technology

Longview is the most efficient coal-fired unit in PJM market.

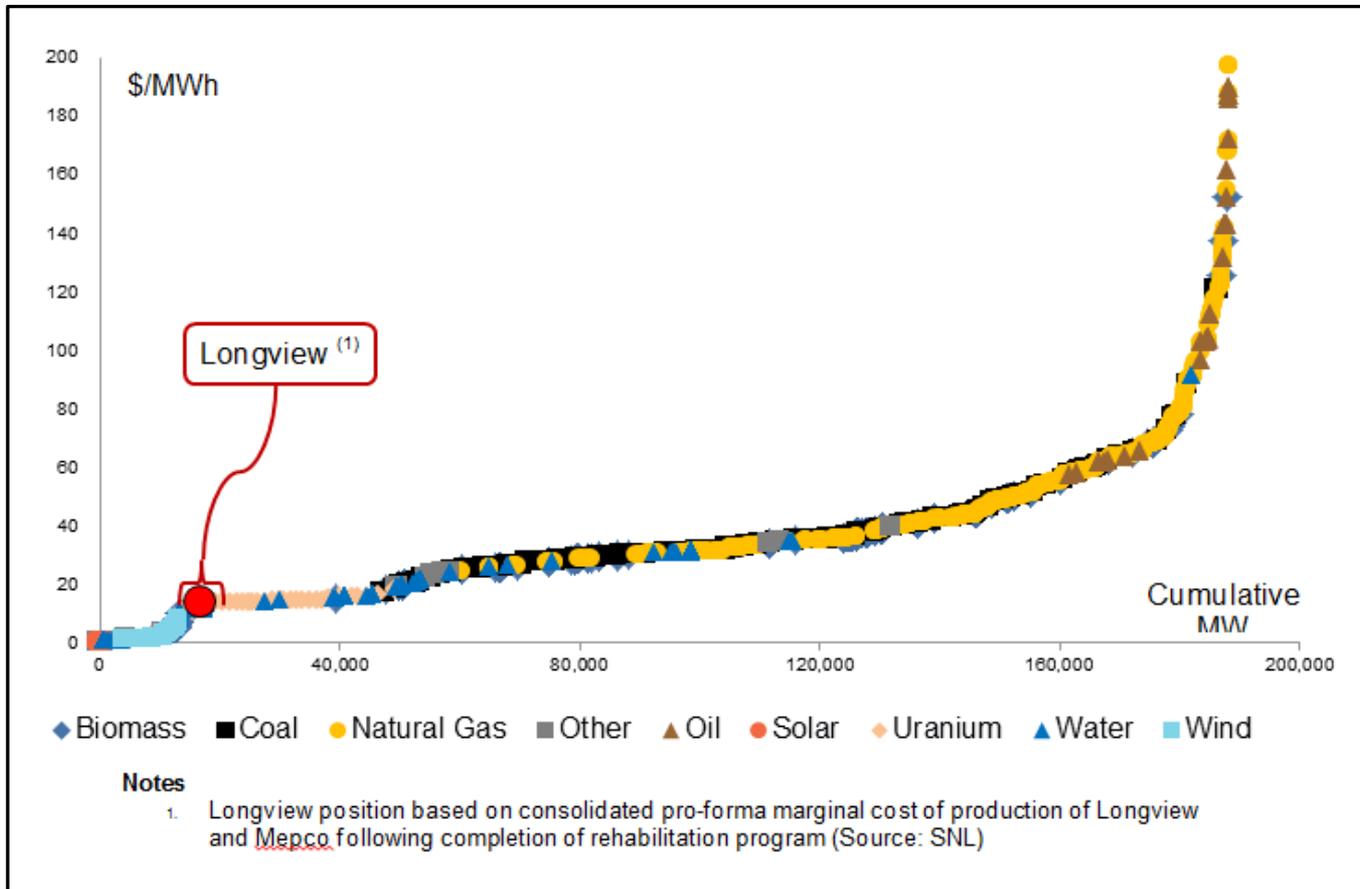
Heat Rate, Fuel Type & Technology Class
of Coal-Fired Generating Units in PJM



Source: Velocity Suite Nov-2012

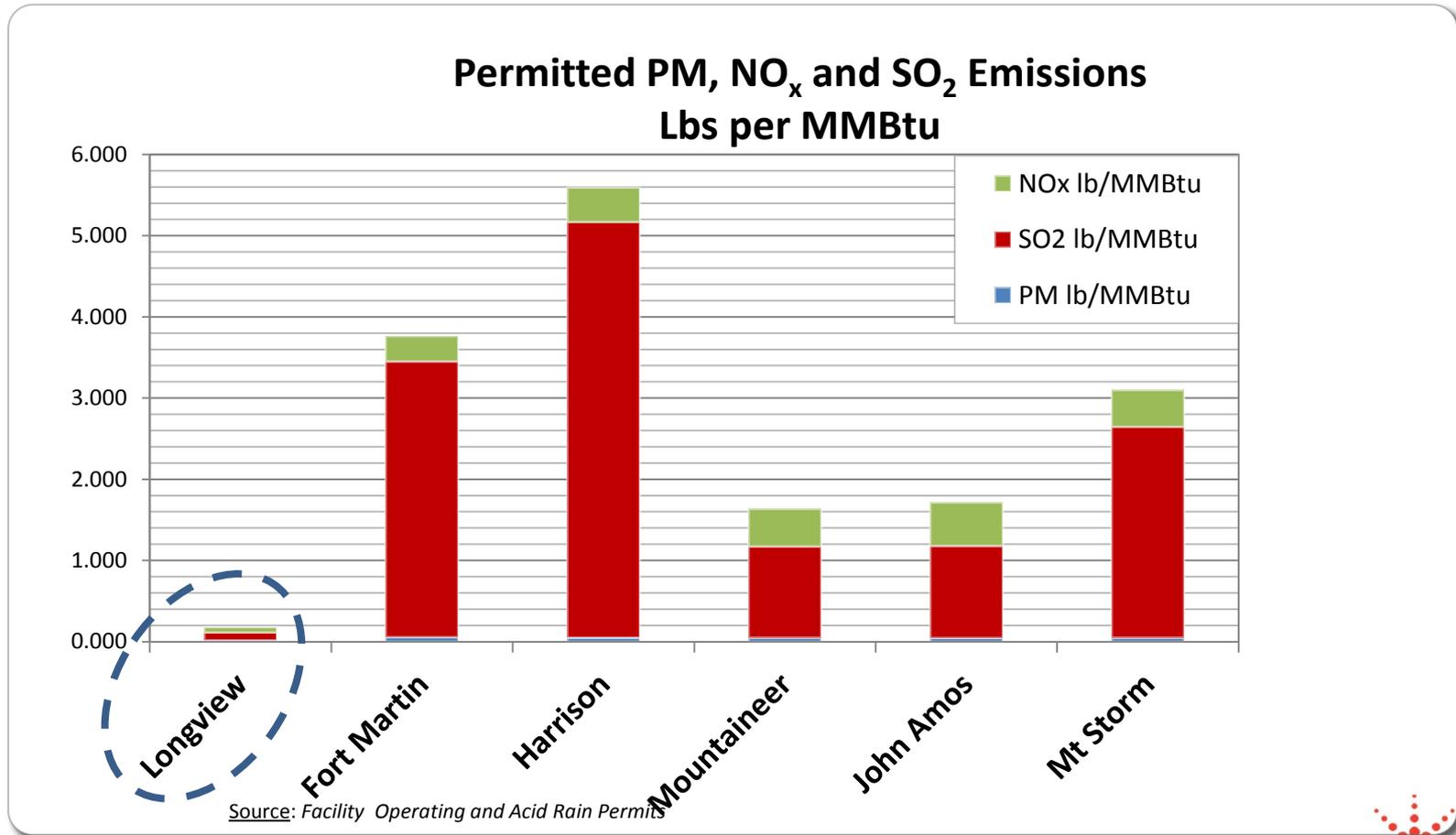
PJM Dispatch Curve (Marginal Cost of Dispatch by Unit)

Longview is among the lowest cost generators in PJM

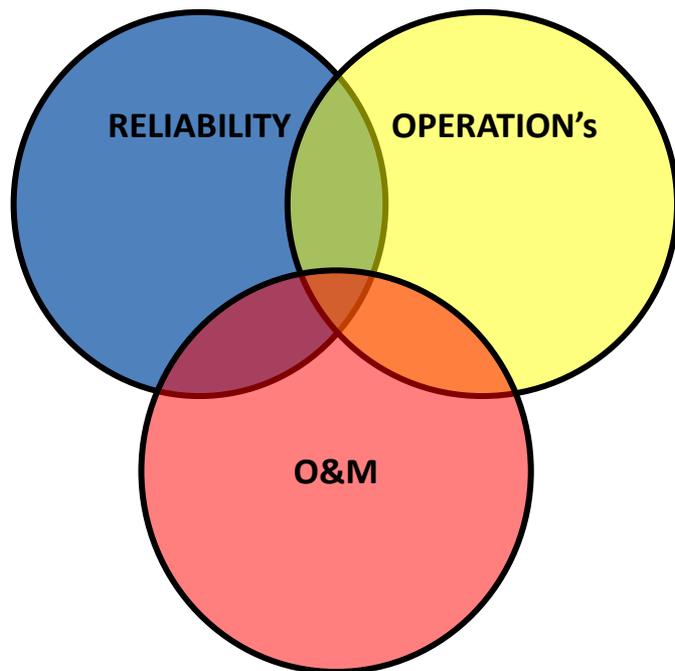


Longview Air Emissions

Longview has the lowest coal plant emissions in West Virginia.



Longview Rehabilitation –Challenge



Low Reliability

- ❖ Capacity Factor in the 60% range
- ❖ Frequent forced outage events
- ❖ Large number of derate hours
- ❖ Unnecessary unit trips and runbacks

High O&M Costs

- ❖ Frequent tube leaks and other equipment failures
- ❖ Heavy slag fall damage
- ❖ Aggressive erosion
- ❖ Inefficient use of consumables

Operational Challenges

- ❖ Lack of stability and controllability
- ❖ Excessive alarming
- ❖ Constant operator(s) intervention

Longview Rehabilitation – Solution

Engineering & Analysis

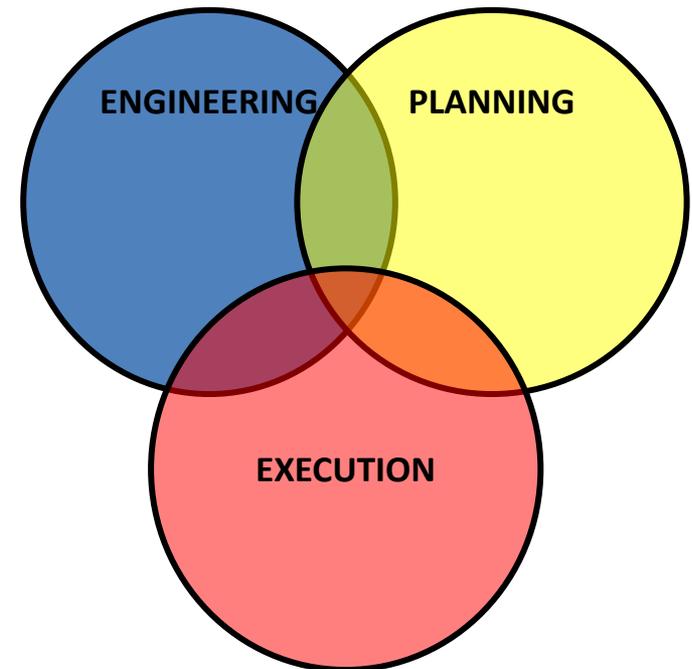
- Detailed root cause analysis
- Exhaustive modeling and testing
- Collaborative partnerships with OEM's
- Innovative use of new technology

Planning

- Detailed planning and project integration
- Staff augmentation in key areas
- Detailed risk analysis and mitigation strategies
- Innovative contracting strategies to ensure alignment of objectives & priorities

Execution

- Full integration of entire plant staff
- Staff augmentation in key areas



Longview Rehabilitation - Scope

Rehabilitation Component	Scope
Evaporator	Header - header arch, screen tubes, front wall panels replacement; tube material from T23 to T12/T22, optimized furnace fluid side controls
Bottom Ash System	Enlarge hopper, reconfigure conveyor, improve seal skirt, increase fill/drain piping
Combustion System	New air flow sensors, increased O2 grid resolution, new CO instrumentation, new automatic windbox flow balancing logic, extensive testing/tuning
SCR/Ammonia System	Replaced catalyst, modify in-duct heat exchangers, recommission NH3 delivery system, replace NOx instrumentation, incorporate new control logic
Economizer	Replace 450 eroded tube bends, alter biasing damper operation to reduce erosion
Pulverizers	Install new airport design, coal flow distribution devices, extensive test/tuning effort
Op Enhancements	Install intelligent sootblowing and acoustic leak detection systems
Generator	Repair causes of vibration and hydrogen leakage
Flue Gas Desulfurization	Install additional dual flow tray, lower air spargers, add spargers, new hydroclones, add filter feed pumps, piping and tank, add a decant basin
Distributed Control System (DCS)	Replace entire 12,000 point DCS with Emerson Ovation system and validate new hardware and software, train operators
Pulse Jet Fabric Filter (PJFF)	Expand PJFF by 30% to reduce dP, add ID fan isolation, increase ash handling capability

Longview Rehabilitation - Results

Component	Results
Nose and Front Wall	No more tube leaks, max tube temps 20-30% lower; improved slag shedding; heat flux within design
Bottom Ash System	50% improvement in startup times; exceptional tolerance to heavy ash/slag loading
Combustion System	Best in class control capability with significant improvements in performance: CO (↓ 70%); boiler efficiency (↑); excess air (↓ 2%); LOI ~ 2.0%
SCR/Ammonia System	Reliability issues eliminated with 15% improvement in NOx removal; 90% improvement in NH3 Slip; reliable performance
Economizer	Aggressive erosion is gone
Pulverizers	Mill performance is now best in class: 75% improvement in fuel & air pipe-to-pipe distribution. Test Results: Fineness 80%; air & fuel pipe-to-pipe deviation ±10%
Generator	Vibration and Hydrogen leakage is at levels typical of new units
Flue Gas Desulfurization	Capable of SO ₂ removal rates are at or above 99.5% Best in class performance
Digital Control System	Full control of plant with state of the art system. All past issues from prior controls have been eliminated
Pulse Jet Fabric Filter (PJFF)	PJFF addition under construction (early November completion)

Longview Current Plant Performance

- Based on July 2015 Performance Test
 - Boiler Efficiency > 90%
 - CO (lb/MM Btu) = 0.03 (Permit = 0.11)
 - NOx (lb/MM Btu) = 0.055 (Permit = 0.065)
 - Slip (ppm, 3% O2) = 0.1 (Guarantee = 2.0)

- Current Other Emissions
 - SO2 (lb/MM Btu) = 0.07 (Permit = 0.095)
 - Mercury (lb/GWHR) = 0.0031 (Permit = 0.013)

- Current Heat Rate (HHV) < 8750 Btu/KWh (>39% Eff)
 - * without PJFF expansion

- Current Capacity Factor = 97%
 - * September operation



Conclusion

- Longview had significant challenges – they are now remedied
- The rehabilitation results are best in class performance with:
 - ❖ Superior cost competitiveness
 - ❖ Best in class heat rate
 - ❖ Small environmental footprint
 - ❖ Efficient use of natural resources
- Longview substantially demonstrates what modern coal-fired plant design and operation can do for clean coal power production
- Longview will be a viable power generator for years to come and a model of clean coal and environmental stewardship

