# Worldwide Pollution Control Association

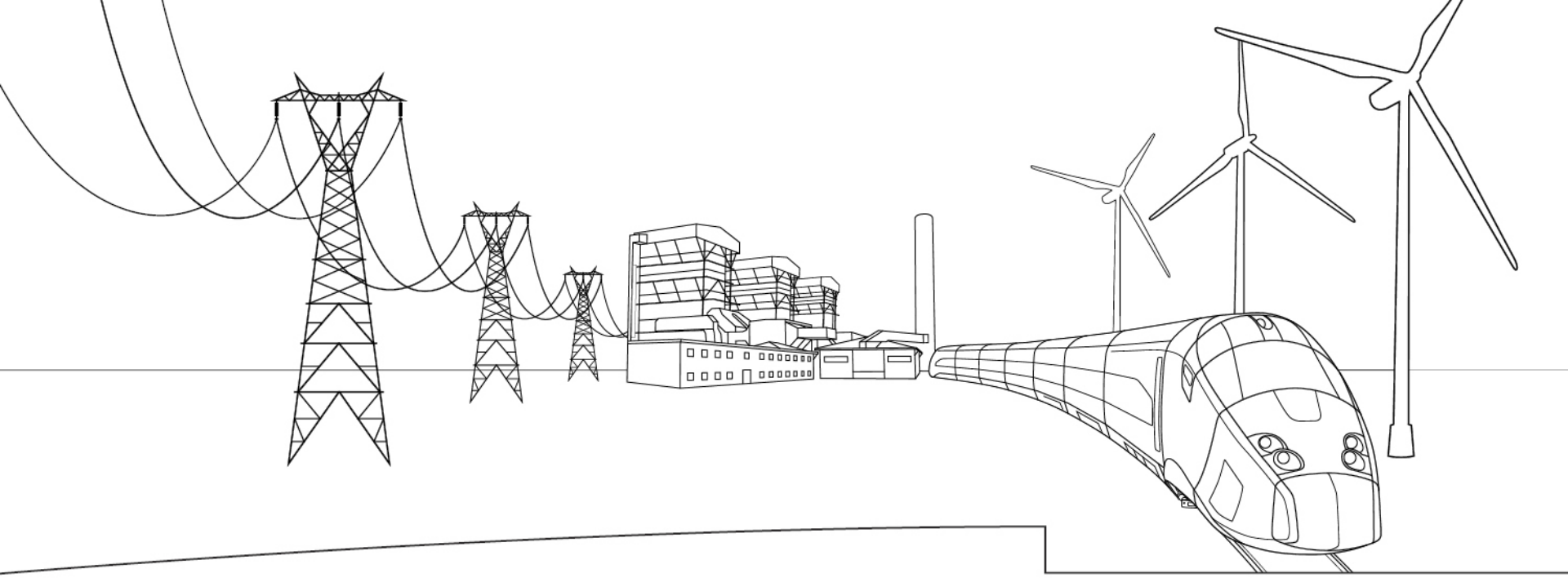

## WPCA-Entergy

## "Increasing Energy Efficiency of Existing Units" Seminar

## January 22, 2014



Visit our website at www.wpca.info



# Ways to Increase Boiler & Auxiliary Equipment Efficiency

Danny Gelbar
Manager of Performance Design Engineering

The Woodland, Texas

1/22/14

ALSTOM
Shaping the future

# Items To Be Covered

- **Boiler Efficiency Improvements**
- **Auxiliary Equipment Improvements**
- **Repowering of Existing Boilers**
- **Optimize Plant Retrofit**

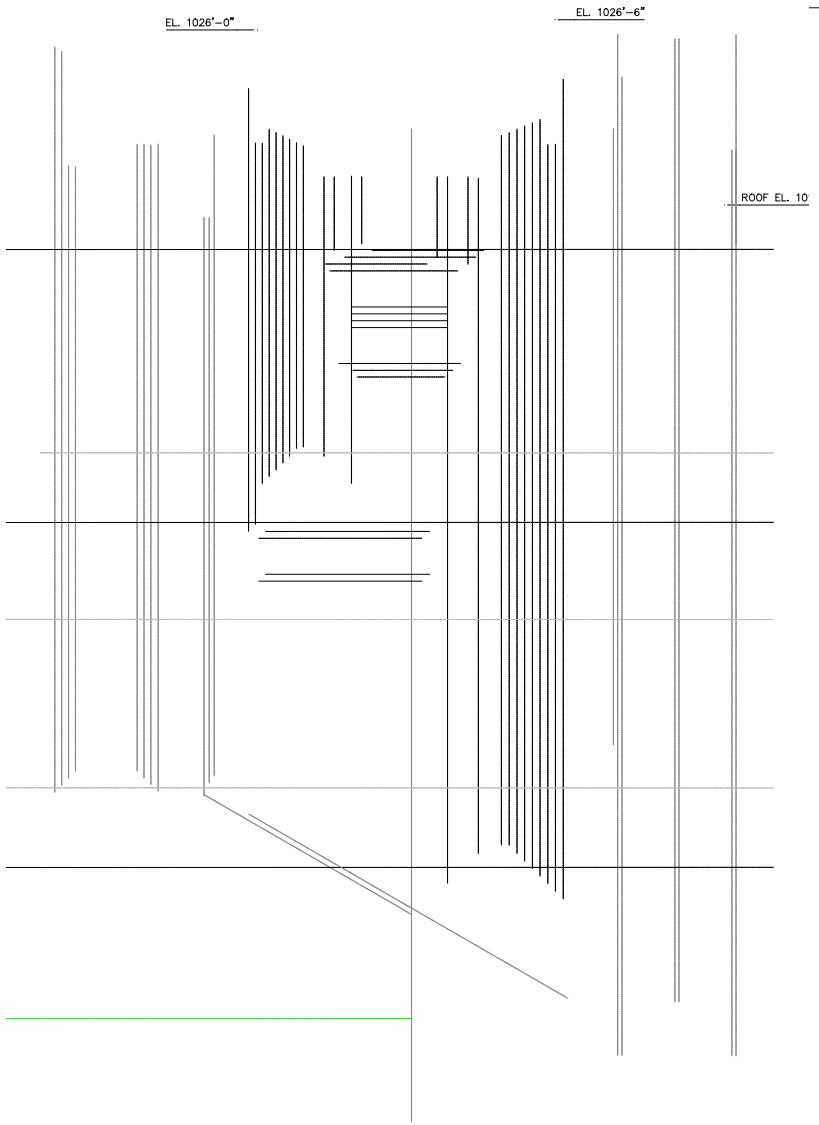
# Boiler Efficiency Improvements

# Superheater, Reheater & Economizer

- SH & RH Steam Temperatures
- SH Desuperheater
- RH Desuperheater
- Economizer Redesign
- Reduce Sections Draft Losses
- RH Steam Side Pressure Drop (Normally about 30 psi)

# Existing 400 MW Boiler

- Plugging of Lower Portion of Front RH Pendant
- Tight 9” Spacing between RH Assemblies



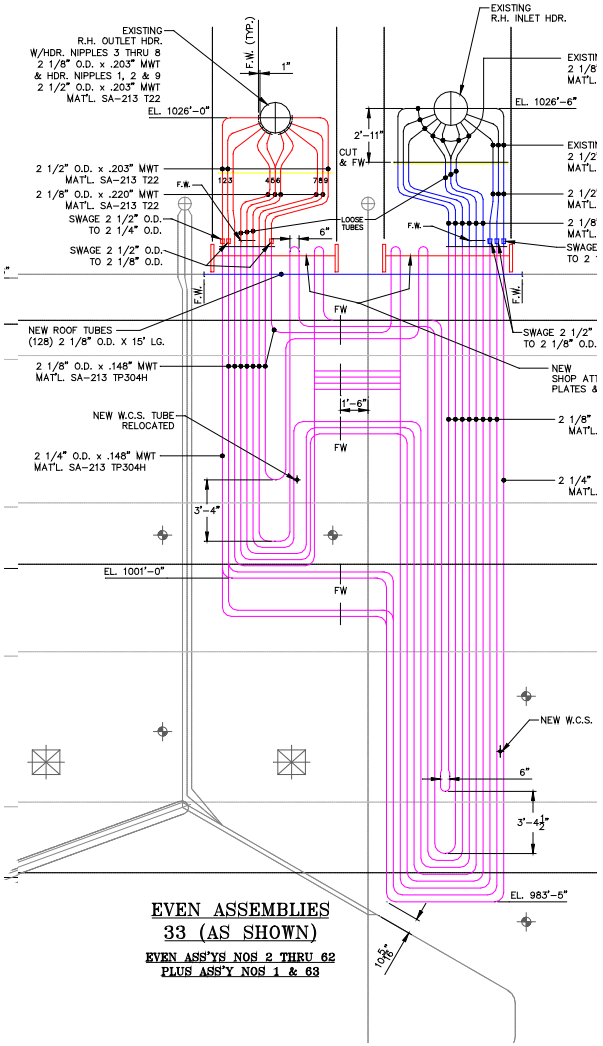





ALSTOM

# Modified 400 MW Boiler

- Installed Short and Long Front and Rear Alternating Pendants








ALSTOM

# Superheat Steam Temperature Increase

## PARAMETRIC VARIABLES

1.60 Fuel Cost $/Million BTU

600 Generator Output MW

80.00 Capacity Factor Percent

| Yearly Fuel $ Savings |
| --- |
| $188,375 |

10,200 Assumed Net Unit Heat Rate - Btu/KWhr

1,005 New SH Steam Temperature - deg.F

985 Present SH Steam Temperature - deg.F

*Calculations are based on 1986 EPRI Report CS-4554 on "Heat RateImprovements Guidelines for Existing Fossil Plants"*

**-28.00 Btu/kWh Effect on Heat Rate**

**0.27% Change in Heat Rate**





ALSTOM

# Reheat Steam Temperature Increase

## PARAMETRIC VARIABLES

1.60 Fuel Cost $/Million BTU

600 Generator Output MW

80.00 Capacity Factor Percent

10,200 Assumed Net Unit Heat Rate - Btu/KWhr

1,005 New RH Steam Temperature - deg.F

980 Present RH Steam Temperature - deg.F

| Yearly $ Savings |
| --- |
| $218,650 |

*Calculations are based on 1986 EPRI Report CS-4554 on "Heat RateImprovements Guidelines for Existing Fossil Plants"*

**-32.50 Btu/kWh Effect on Heat Rate**

**0.32% Change in Heat Rate**





ALSTOM

# Superheat Desuperheater Spray Flow Reduction

**PARAMETRIC VARIABLES**

| | |
|---|---|
| 1.60 | Fuel Cost $/Million BTU |
| 600 | Generator Output MW |
| 80.00 | Capacity Factor Percent |

| Yearly Fuel $ Savings |
|---|
| $96,071 |

| | |
|---|---|
| 10,200 | Assumed Net Unit Heat Rate - Btu/KWhr |
| 0 | New Spray Flow - lbs/hr |
| 204,000 | Present Spray Flow - lbs/hr |
| 4,080,000 | Main Steam Flow - lbs/hr |

*Calculations are based on 1986 EPRI Report CS-4554 on "Heat Rate Improvements Guidelines for Existing Fossil Plants"*

**-14.28 Btu/kWh Effect on Heat Rate**

**0.14% Change in Heat Rate**





ALSTOM

# Reheat Desuperheater Spray Flow Reduction

## PARAMETRIC VARIABLES

1.60 Fuel Cost $/Million BTU

600 Generator Output MW

80.00 Capacity Factor Percent

10,200 Assumed Net Unit Heat Rate - Btu/KWhr

0 New Spray Flow - lbs/hr

188,550 Present Spray Flow - lbs/hr

3,771,000 Cold Reheat Steam Flow - lbs/hr

-102.00 Btu/kWh Effect on Heat Rate

1.00% Change in Heat Rate

| Yearly $ Savings |
| --- |
| $686,223 |

*Calculations are based on 1986 EPRI Report CS-4554 on "Heat RateImprovements Guidelines for Existing Fossil Plants"*

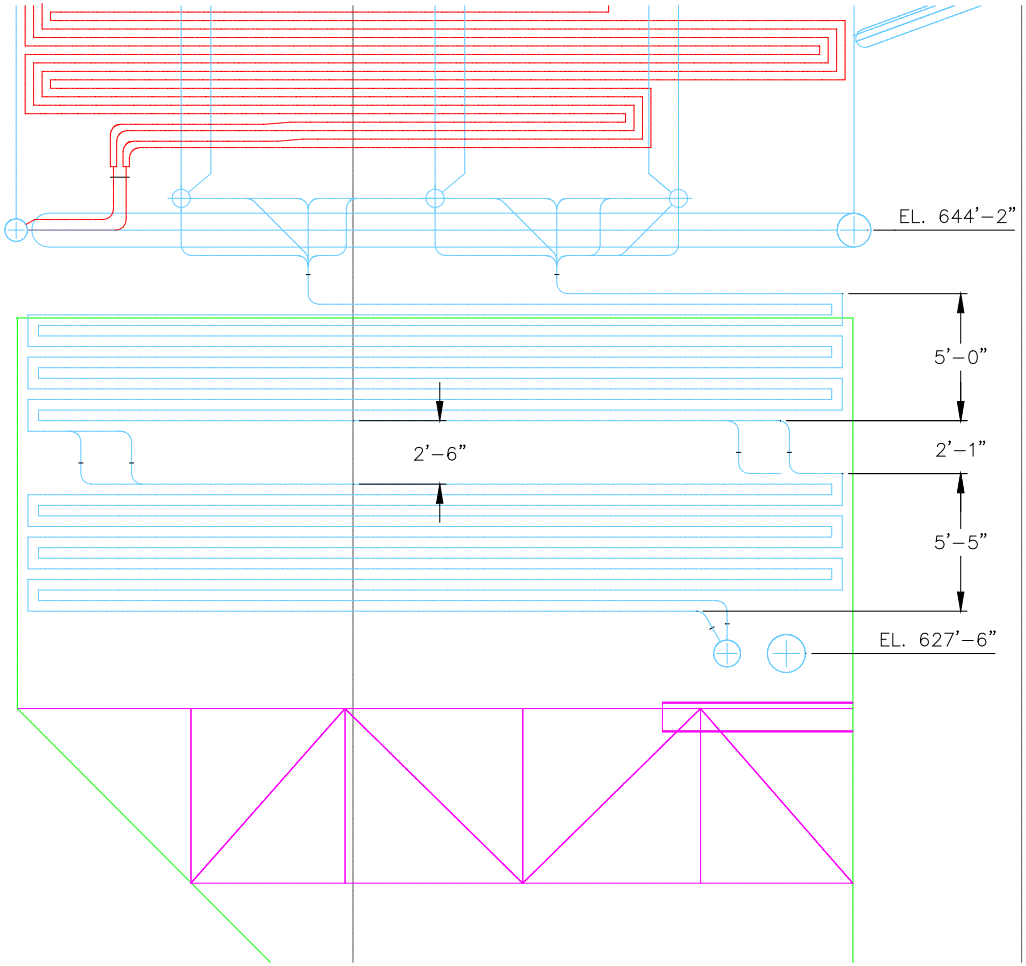




ALSTOM

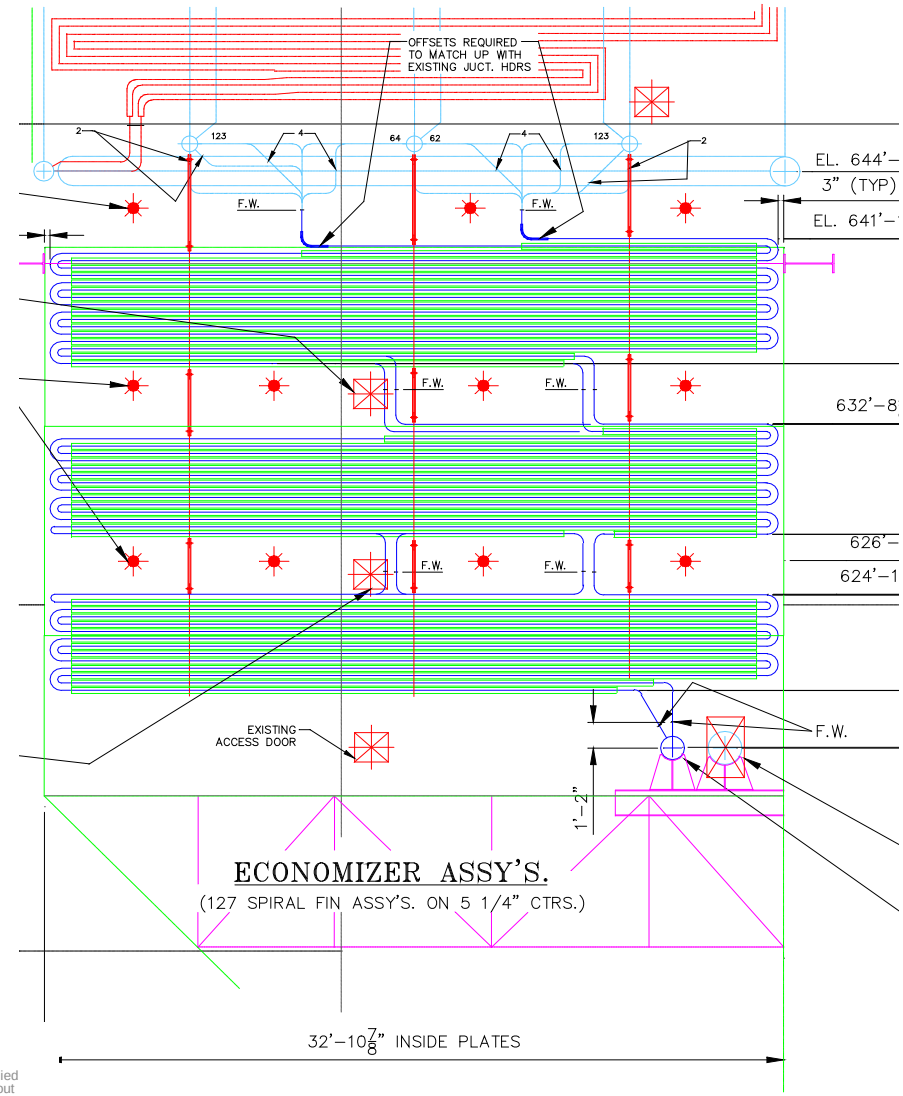
# Existing 600 MW Boiler

- Replacement Two Bank CFS Economizer
- Plugging and Fouling Were Major Problems
- High Draft Loss Limited The Maximum Load
- High Exit Gas Temp



# Economizer Modifications

- In-Line SFS Economizer Installed to Reduce Plugging
- In-Line Arrangement Allows for Improved Cleaning/Sootblowing
- Reduced Draft Loss 60%, no ID fan load limitation
- Maintain or lower economizer exit gas temperature, which improves Boiler Efficiency by 1%



# Boiler Efficiency Change with Economizer Modifications

## PARAMETRIC VARIABLES

| | |
|---|---|
| 1.60 | Fuel Cost $/Million BTU |
| 600 | Generator Output MW |
| 80.00 | Capacity Factor Percent |
| 3.00 | Yearly Fuel Inflation Percent |
| 5 | Year Evaluation Period |

| Yearly $ Savings |
|---|
| $802,600 |

| | |
|---|---|
| 10,200 | Assumed Net Unit Heat Rate - Btu/KWhr |
| 84.50 | Original Boiler Efficiency |
| 85.50 | New Boiler Efficiency |

*Calculations are based on 1986 EPRI Report CS-4554 on "Heat RateImprovements Guidelines for Existing Fossil Plants"*

**-119.30 Btu/kWh Effect on Heat Rate**

**-1.17% Change in Heat Rate**

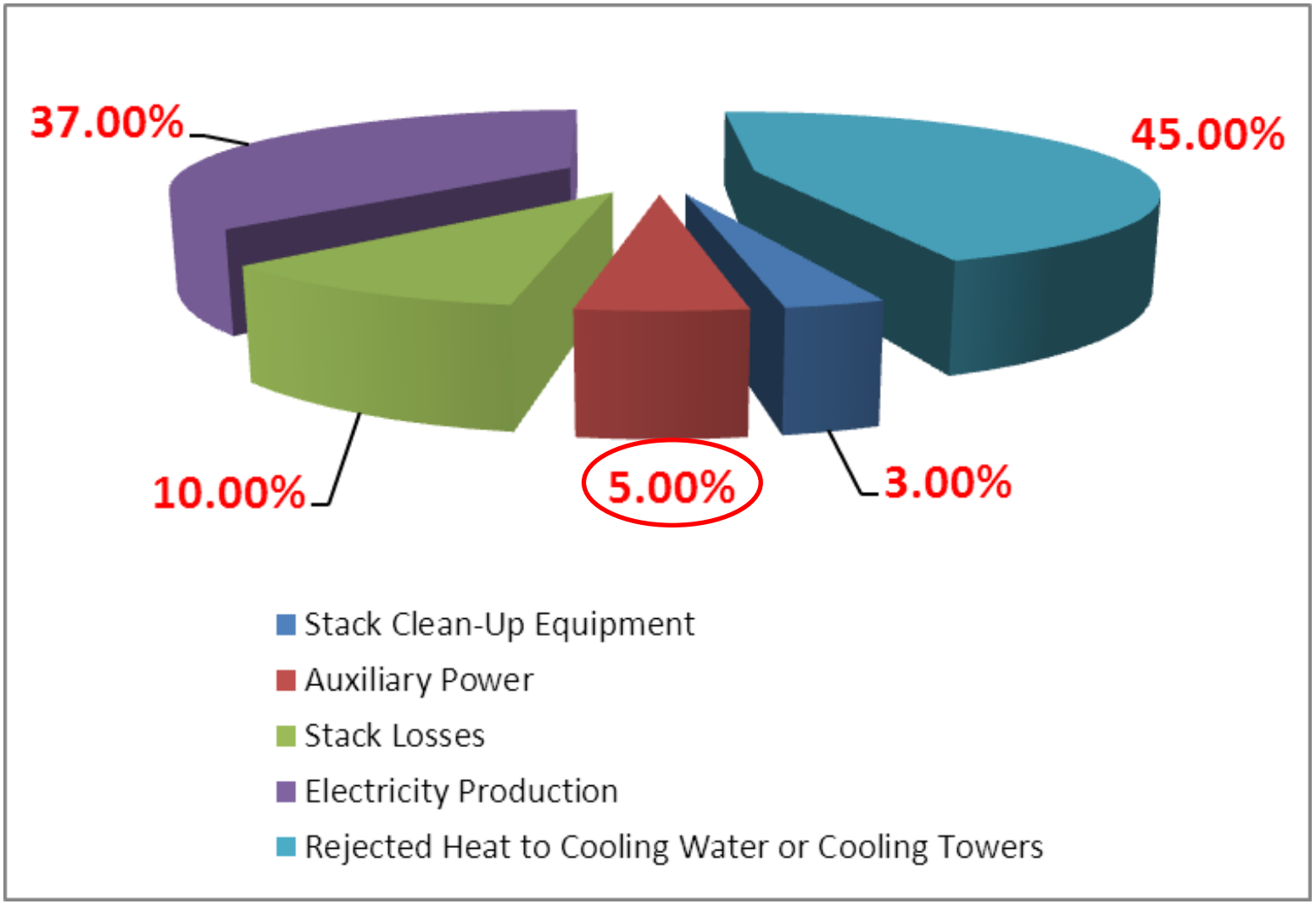




ALSTOM

# Auxiliary Equipment Improvements

# Auxiliary Equipment Improvements








ALSTOM

# Auxiliary Equipment Improvements

- Force Draft Fans
- Induce Draft Fans
- Primary Air Fans
- Pulverizers
- Boiler Water Circulation Pumps

# Force Draft Fans

- Reduce Air Flow by:
  - Decreasing Excess Air
  - Reduce Air Preheater Air Leakage
- Reduce Air Side Losses
  - Install Turning Vanes
  - Redesign Ductwork
  - Adjust Windbox Delta Pressure
  - Chance Out AH Baskets

# Induce Draft Fans

- Reduce Gas Flow by:
  - Decreasing Excess Air
  - Lower Gas Temperature
  - Reduce Air Preheater Air Leakage
- Reduce Gas Side Losses
  - Install Turning Vanes
  - Redesign Ductwork
  - Chance Out AH Baskets

# Primary Air Fans

- Reduce Air Flow by:
  - Reducing AH Air Leakage
  - Lower Air by taking a Pulverizer Out of Service
- Reduce Air Side Losses
  - Install Turning Vanes
  - Redesign Ductwork
  - Chance Out AH Baskets
  - Change Out Coal Piping

# Pulverizers

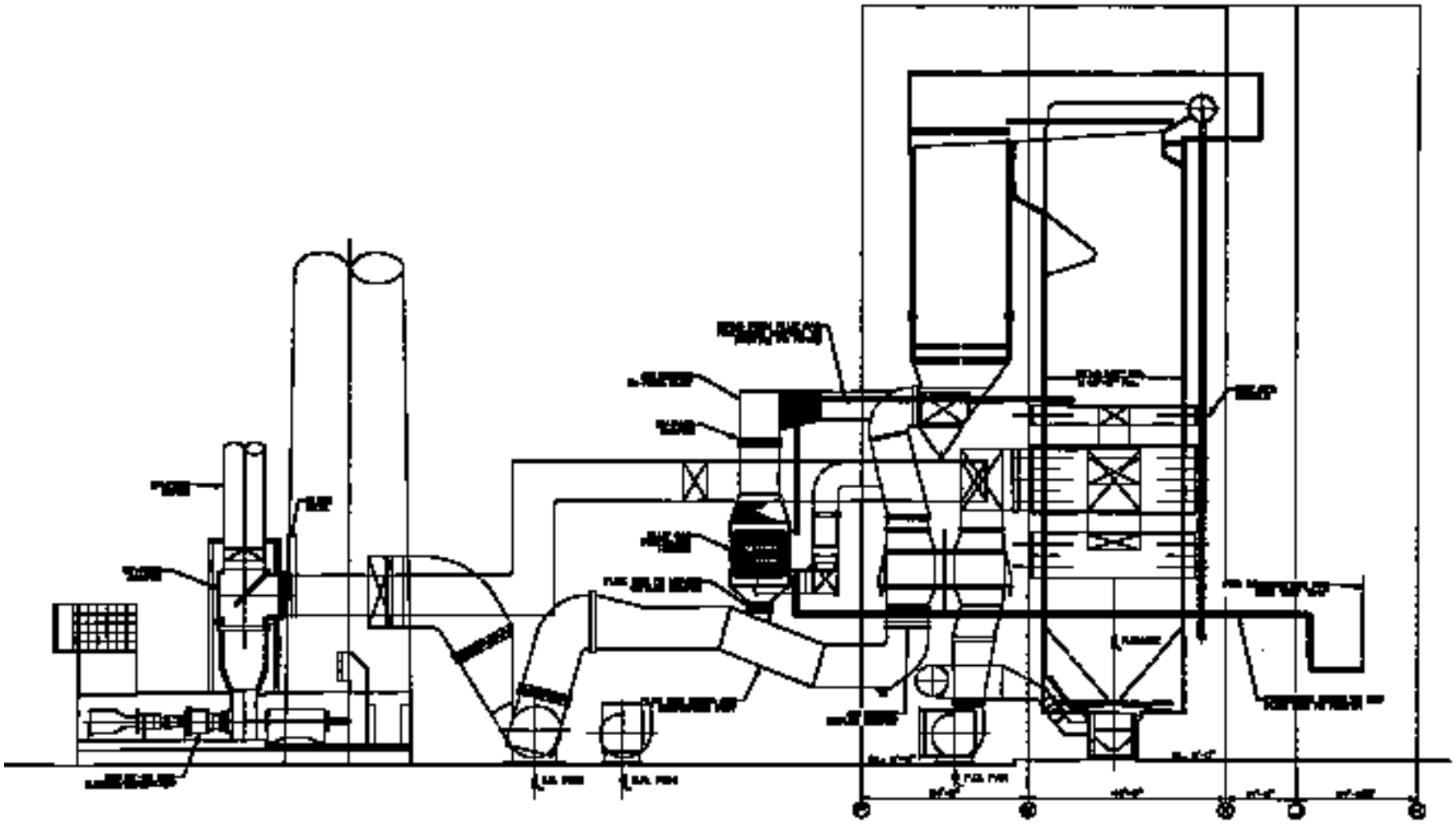
- Reduce the Number of Pulverizers in Service
- Change the Coal Being Fired with One that has a higher Hardgrove Grindability and lower Moisture Content or Change the Coal Fineness Leaving
- Increase the pulverizer outlet temperature which raises the air flow through the Air Preheater. The affect on Boiler Efficiency can increase by up to 0.5%.
- Install More Efficient Motors

# Boiler Water Circulation Pumps

- **Take one of the of the Boiler Water Circulation Pumps out of service if permitted by OEM.**
  - **Most Controlled Circulation Boiler were designed with 4 out of 4 pumps in service at MCR. The OEM can evaluate the waterwall circulation system to determine if the unit can operate with 3 out of 4 pumps in service**

# Repowering of Existing Boiler

# Hot Windbox Repowering

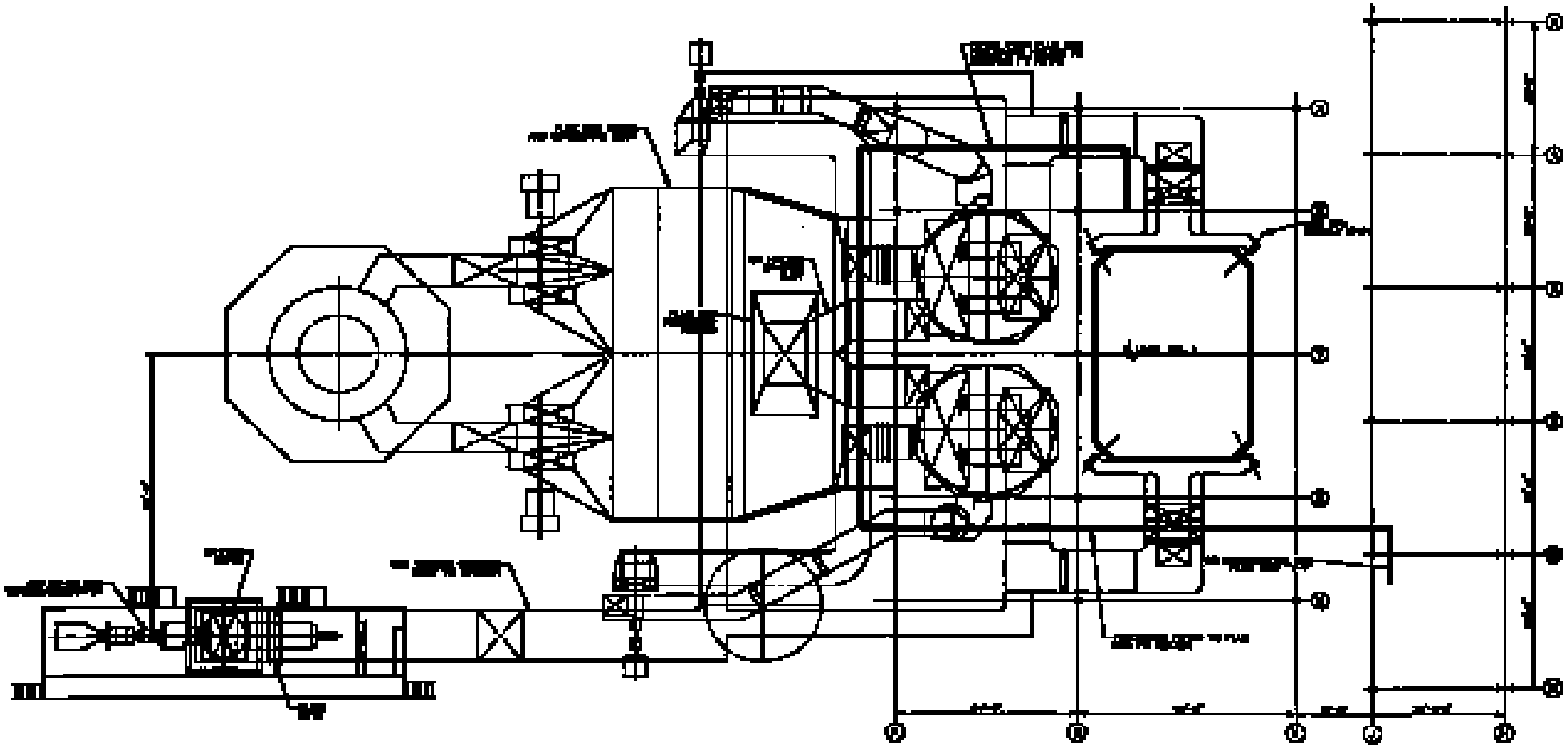






ALSTOM

# Hot Windbox Repowering





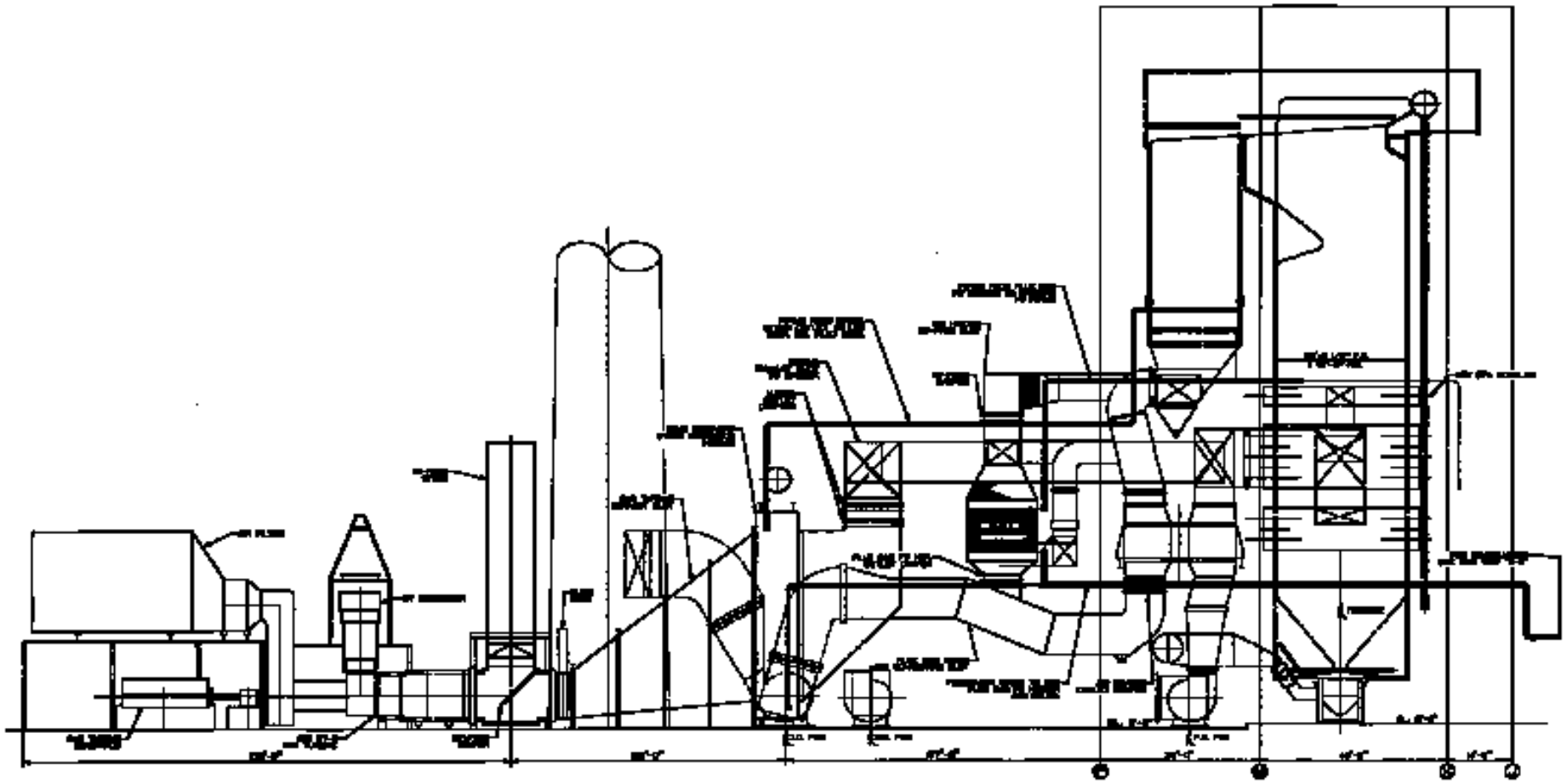


ALSTOM

# Hot Windbox Repowering

- If the boiler/turbine cycle normally puts out 200 MWs, the combustion turbine can only be about 65 MWs in size. The limitations are the following:
  - The combustion turbine exhaust is normally in the 900 degF to 1200 degF.
  - Mixed air temperature to the windbox can not exceed 800 degF since the ductwork and windbox are made of carbon steel.
  - The boiler will not be able to achieve full load, so the total MWs will only increase by 10%.
  - Must evaluate I.D, Fans capacity. However, the F.D. Fans will have lower required duty.
  - The improvement in Plant Heat Rate is in the 2% - 3% range.

# Cold Windbox Repowering

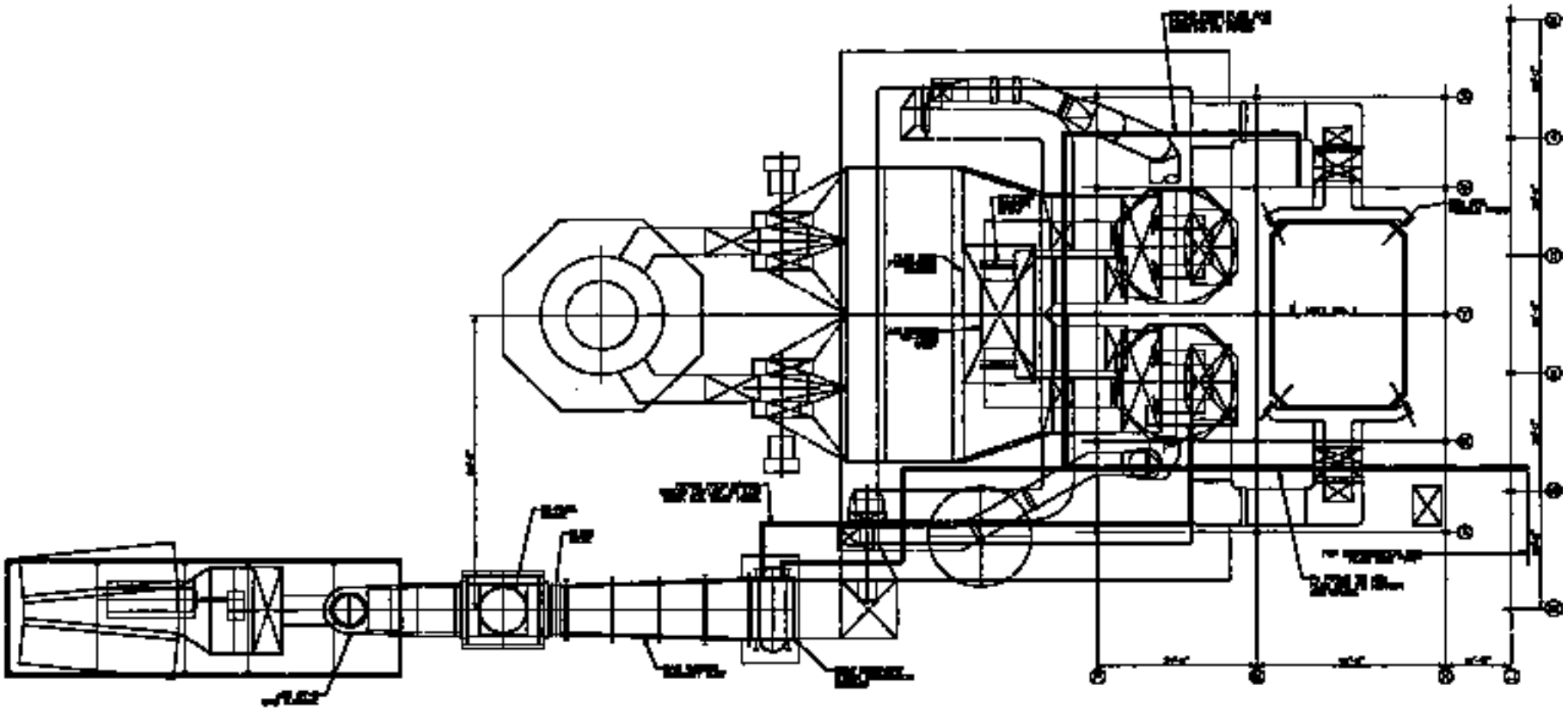






ALSTOM

# Cold Windbox Repowering







ALSTOM

# Cold Windbox Repowering

- If the boiler/turbine cycle normally puts out 200 MWs, the combustion turbine can only be about 100 MWs in size. The limitations are the following:
  - The combustion turbine exhaust is normally in the 1000 degF to 1200 degF. This flow will be cooled down to 750 degF by a small HRSG.
  - Mixed air temperature to the windbox will be below 750 degF .
  - The boiler will not be able to achieve full load, so the total MWs will only increase by 30%.
  - Must evaluate I.D, Fans capacity. However, the F.D. Fans will have lower required duty.
  - The improvement in Plant Heat Rate is in the 4% - 6% range.

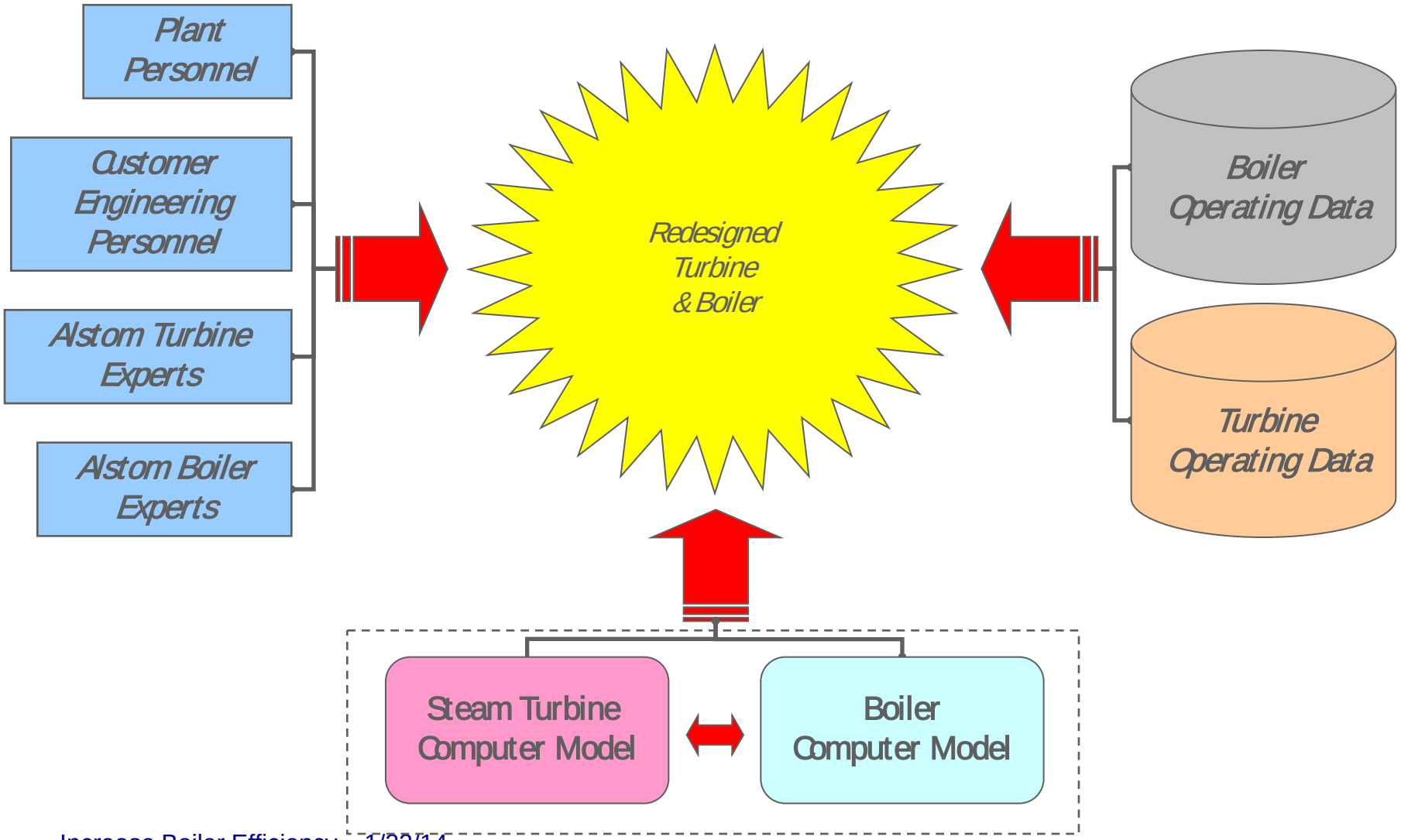
# Optimize Plant Retrofit

# Joint Project Team Review Sessions

- **J**oint **P**roject **T**eam **R**eview Sessions (**JPTR**) are an essential part of the OPR concept **unique** to Alstom
- Structured to afford the Customer an opportunity to participate with Alstom specialists in an **interactive** engineering design session
- Allow the Customer **and** Alstom to quickly work through a number of various options

- JPTR session is followed up by more detailed thermodynamic work, hardware selection and costing

# Joint Project Team Design Process

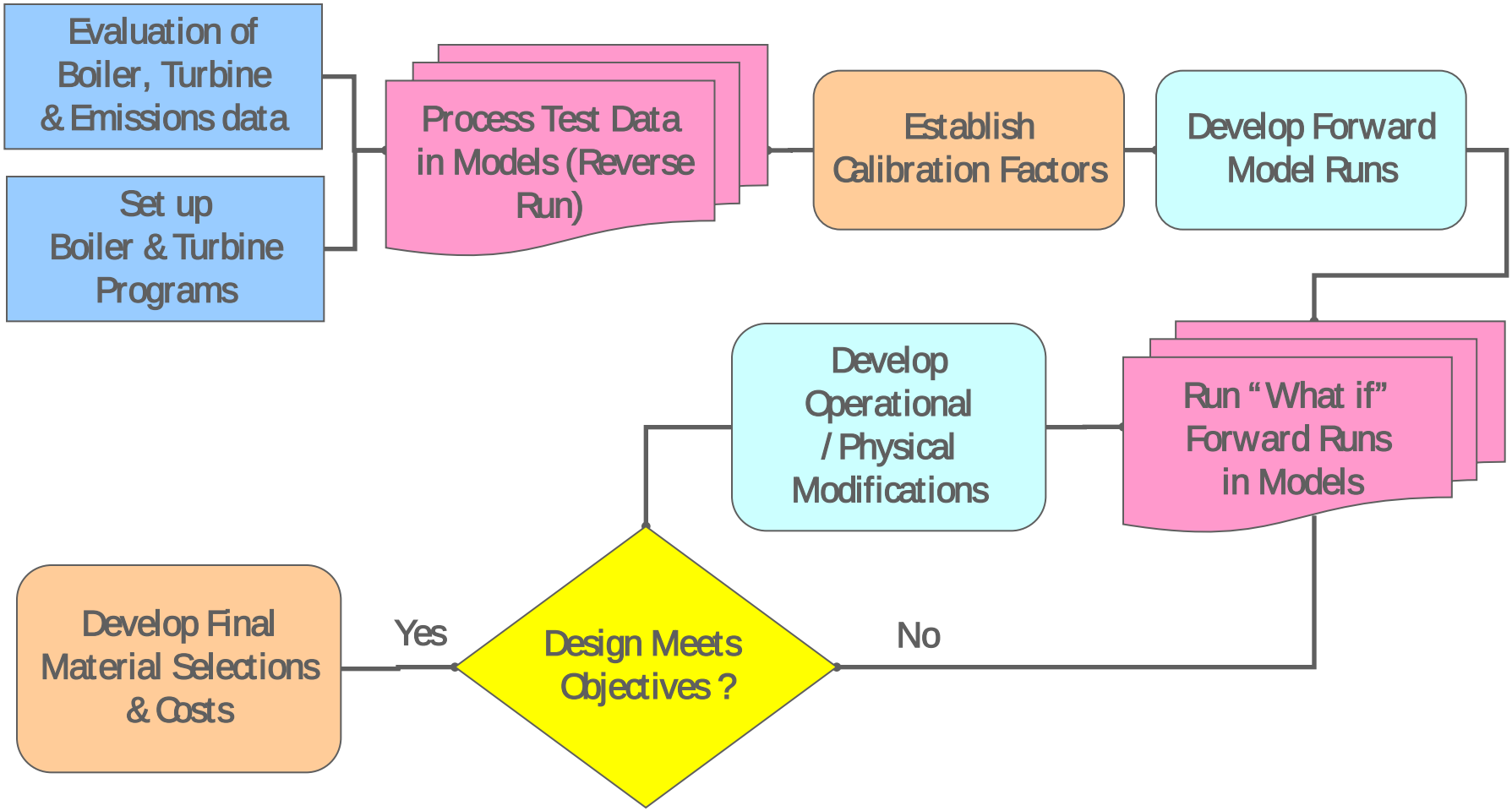







ALSTOM

# Joint Project Team Design Process



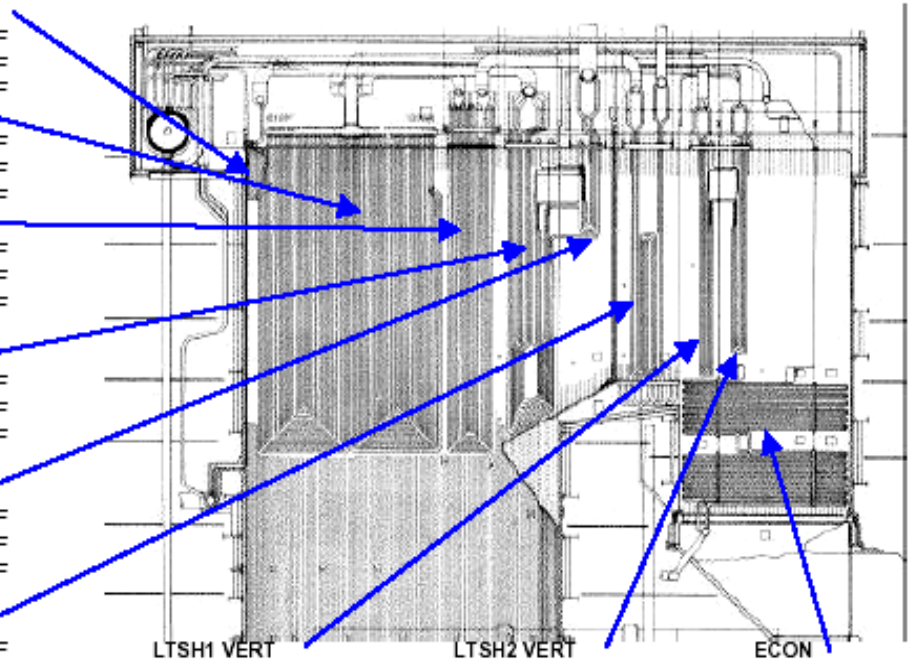





ALSTOM

# JPTDR Boiler & Turbine Model Results

Run No. 21 — Run Type: Same as Run 20 ( with new Steam Turbine Condition with RH Finishing on 9.5" centers - platenized & New In-Line SFS Econ) but running Steam Turbine at 2470psig Throttle pressure and increase main steam flow and 6 mill in Service



| | |
|---|---|
| **RH RADWALL** | |
| Fluid In | 609.9 deg. F |
| Fluid Out | 649.3 deg. F |
| Gas In | 2711 deg. F |
| **SH PANELS** | |
| Fluid In | 714.5 deg. F |
| Fluid Out | 788.7 deg. F |
| Gas In | 2711 deg. F |
| **SH PLATEN** | |
| Fluid In | 786.2 deg. F |
| Fluid Out | 876.0 deg. F |
| Gas In | 2338 deg. F |
| SEF | 0.87 |
| **RHI FINISH** | |
| Fluid In | 649.3 deg. F |
| Fluid Out | 909.5 deg. F |
| Gas In | 2179 deg. F |
| SEF | 1.01 |
| **RHO FINISH** | |
| Fluid In | 909.5 deg. F |
| Fluid Out | 1003.9 deg. F |
| Gas In | 1871 deg. F |
| SEF | 1 |
| **SH FINISH** | |
| Fluid In | 876.0 deg. F |
| Fluid Out | 1000.6 deg. F |
| Gas In | 1709 deg. F |
| SEF | 1.16 |

| LTSH1 VERT | | LTSH2 VERT | | ECON | |
|---|---|---|---|---|---|
| Fluid In | 697.7 deg. F | Fluid In | 689.8 deg. F | Fluid In | 491.4 deg. F |
| Fluid Out | 714.5 deg. F | Fluid Out | 697.7 deg. F | Fluid Out | 654.3 deg. F |
| Gas In | 1479 deg. F | Gas In | 1379 deg. F | Gas In | 1284 deg. F |
| SEF | 0.88 | SEF | 0.85 | Gas Out | 769 deg. F |
| | | | | SEF | 0.69 |
| | | | | Subcooling | 30.6 deg. F |

**General Performance Information**

| | | |
|---|---|---|
| SH Steam Flow | 3,935,613 | lbs/hr |
| RH Steam Flow | 3,535,221 | lbs/hr |
| SHO Temp | 1001.0 | °F |
| SH Desup Spray | 0.30 | % |
| RH Desup Spray | 1.10 | % |
| SHDesuperheater Spray | 11263 | lbs/hr |
| RHDesuperheater Spray | 39359 | lbs/hr |
| RHO Temp | 1004.0 | °F |
| RHDESUP OUT TMP | 610.0 | °F |
| Feedwater Temp | 491.0 | °F |
| Econ Exit Gas Temp | 769.0 | °F |
| AH TGO Uncorr | 320.0 | °F |
| AH TGO Corr | 306.0 | °F |
| Tilt | -11 | degrees |
| Excess Air | 26 | % |
| Fuel Fired | 618,334 | lbs/hr |
| Boiler Efficiency | 85.45 | % |
| NHI/PA | 2.08 | Mbtu/hr-ft2 |

**Steam Turbine Performance**

| | | |
|---|---|---|
| Output | 571,060 | KWs |
| Turbine Heat Rate | 8,128 | BTU/KW-hr |
| Superheater Outlet Flow | 3,935,613 | lbs/hr |
| Main Steam Temp. | 1,000 | °F |
| Throttle Pressure | 2,470 | psia |
| Cold RH Flow | 3,495,862 | lbs/hr |
| Cold RH Pressure | 638 | psia |
| Cold RH Temp. | 633 | °F |
| Hot RH Flow | 3,531,173 | lbs/hr |
| Hot RH Pressure | 569 | psia |
| Hot RH Temp. | 1,000 | °F |
| Reheater Spray Flow | 35,312 | lbs/hr |
| Main Condenser Pressure | 1.8 | psia |

**Mill Performance**

| | | | | | |
|---|---|---|---|---|---|
| Air In Per Mill | 197,938 | lbs/hr | Outlet Moisture | 15.66 | % |
| COAL FLOW PER MILL | 103,056 | lbs/hr | Hot Air Temperature Required | 569.6 | °F |
| NO. MILLS IN SERVICE | 6 OF 6 | | TEMPERING AIR TEMP. | 82 | °F |
| Grinding Capacity | 79.1 | % | AVAILABLE HOT AIR TEMP. | 691 | °F |
| MIXTURE TEMPERATURE | 146 | °F | | | |





ALSTOM

# OPR Example

- HP/IP turbine retrofit ~ 5% MW improvement — **24-27MW**
- Division panel redesign reduced tube failures, improved gas flow distribution
- Larger economizer, wider gas path, improved heat rate, ΔP↓, Fan HP↓
- Economizer Exit gas temp ↓ Precip. efficiency ↑
- Improve boiler cleanliness w/ water cannons
- Improved access for maintenance
- Replaced AH - 48 vs. 408 baskets,
  - Gas side ΔP↓, Fan HP ↓

**15-18MW**

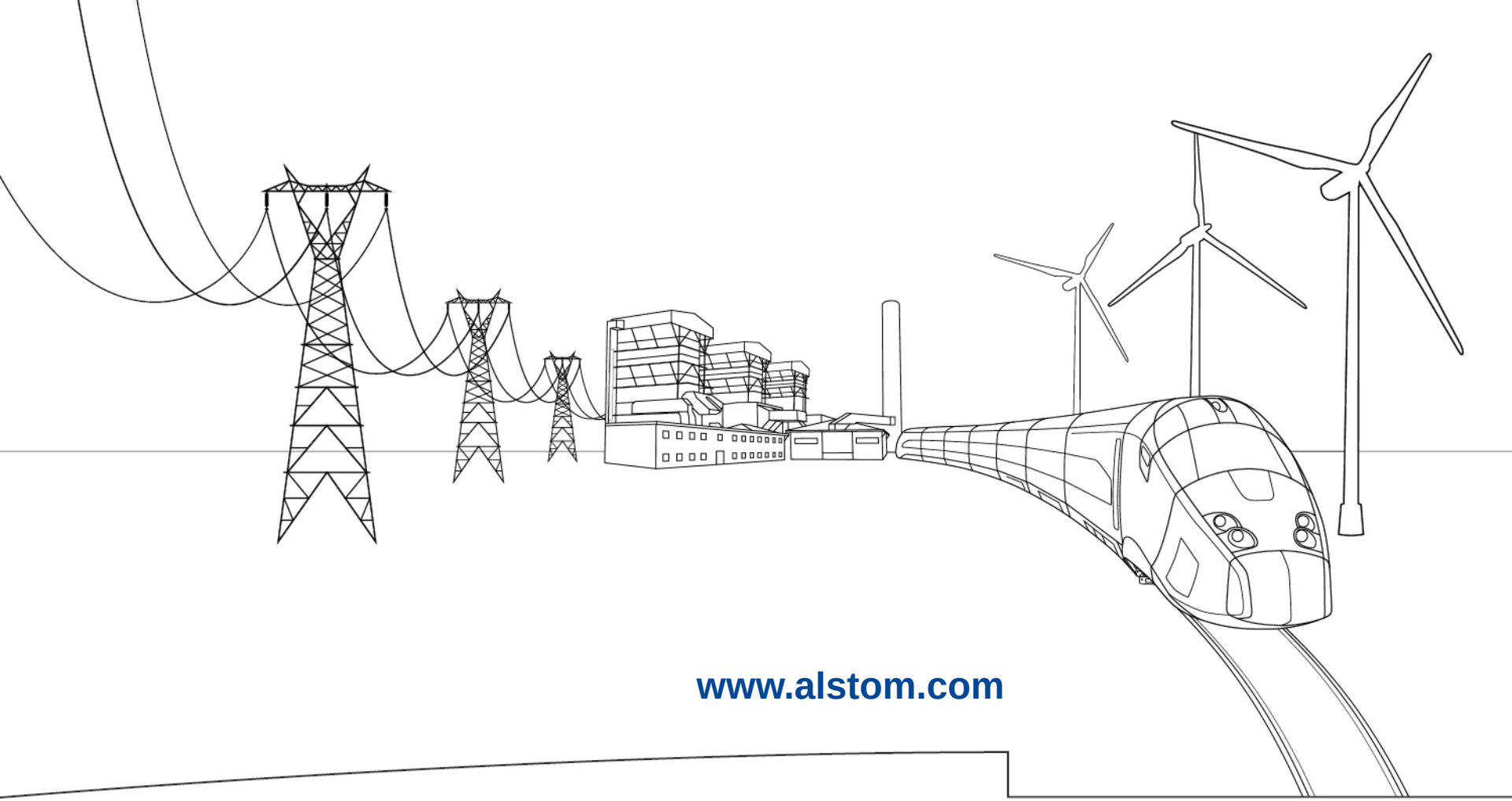
Total Net Unit Output Increase — **40- 45MW**





ALSTOM

# Questions



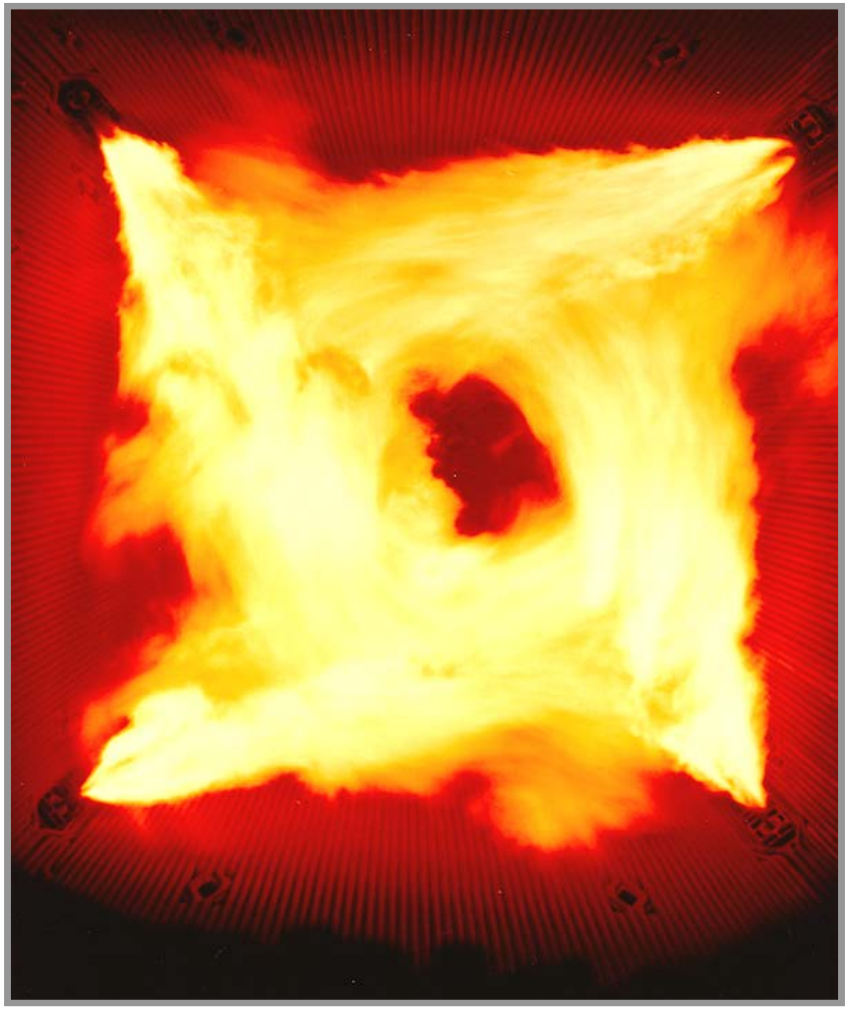
www.alstom.com

ALSTOM

*Shaping the future*

# Tangential Firing System

- Flame Pattern of Tangential Firing System







ALSTOM

# Superheater & Reheater Components

## Boiler Efficiency Effects on Heat Rate

**PARAMETRIC VARIABLES**

1.60 Fuel Cost $/Million BTU

600 Generator Output MW

80.00 Capacity Factor Percent

| Yearly Fuel $ Savings |
| --- |
| ($61,510) |

10,200 Assumed Net Unit Heat Rate - Btu/KWhr

89.33 Present Boiler Efficiency

89.25 New Boiler Efficiency

*Calculations are based on 1986 EPRI Report CS-4554 on "Heat RateImprovements Guidelines for Existing Fossil Plants"*

9.14 Btu/kWh Effect on Heat Rate

-0.09% Change in Heat Rate





ALSTOM