Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

February 8 & 9, 2010 Chattanooga, TN

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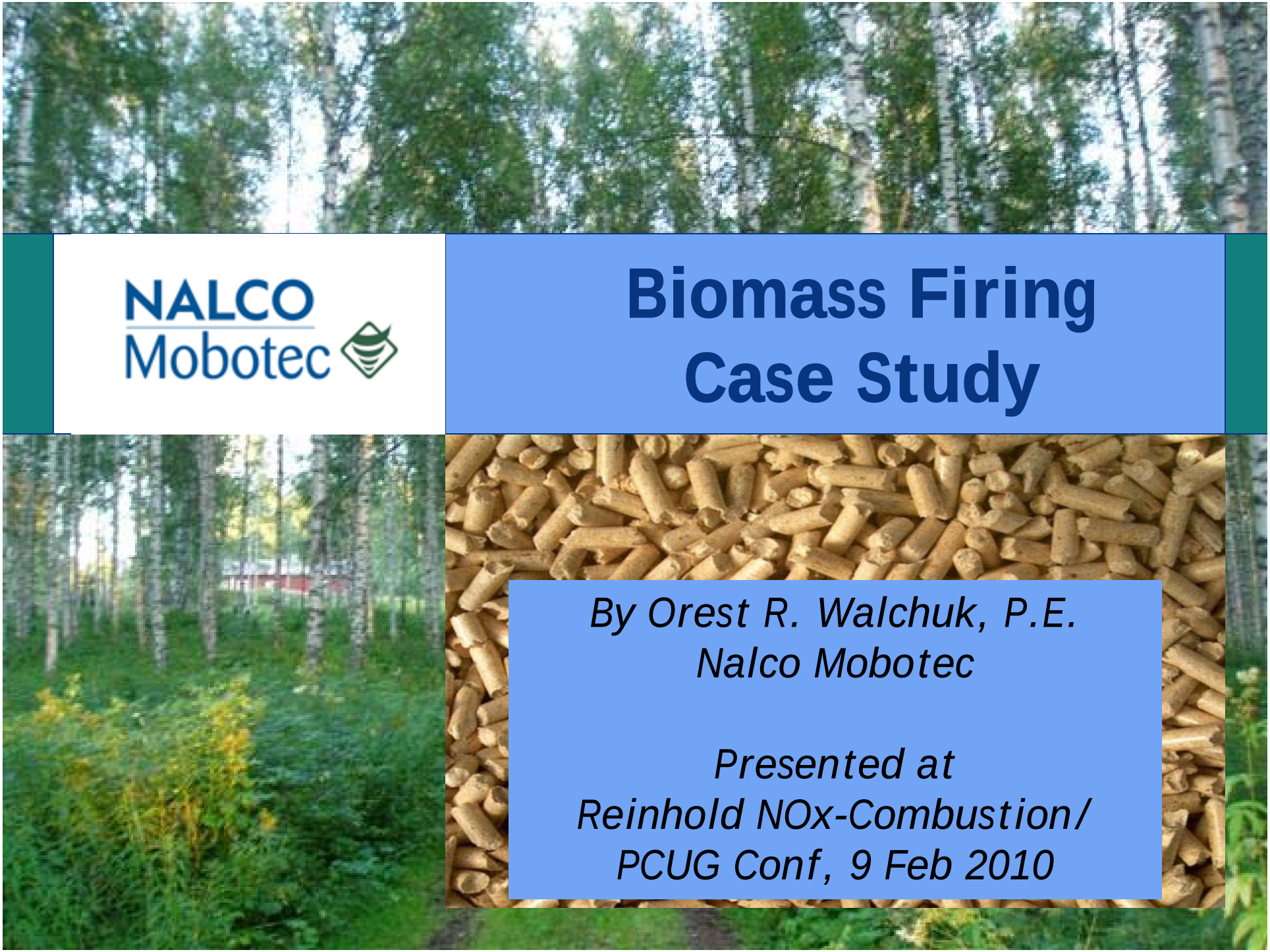


NALCO Mobotec

Biomass Firing Case Study

By Orest R. Walchuk, P.E.
Nalco Mobotec

Presented at
Reinhold NOx-Combustion/
PCUG Conf, 9 Feb 2010

Who We Are

NALCO Mobotec is a Multi-Pollutant / Combustion Enhancement Technology Solutions Provider

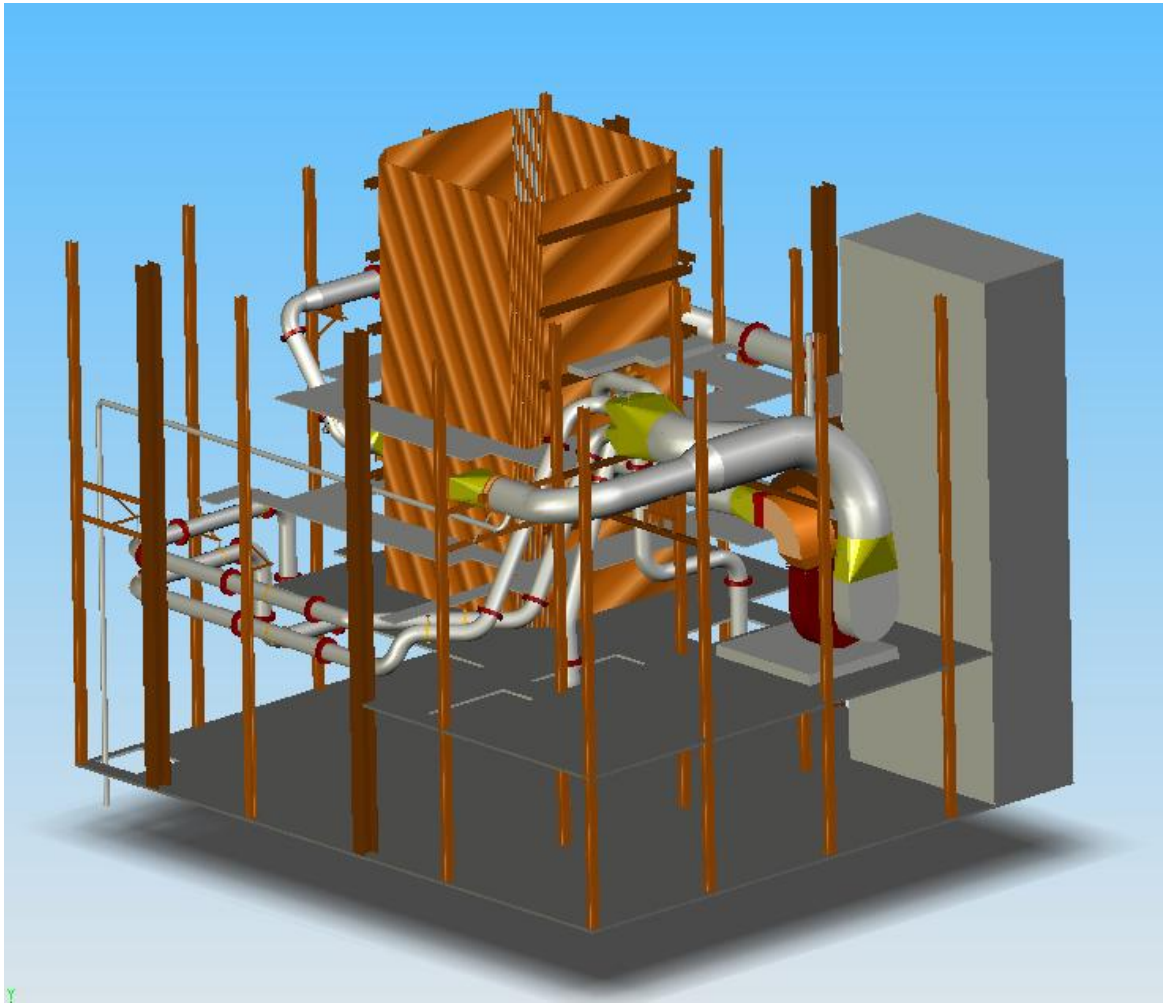
Began as *Mobotec AB,* a Swedish Company, by Dr. Goran Moberg

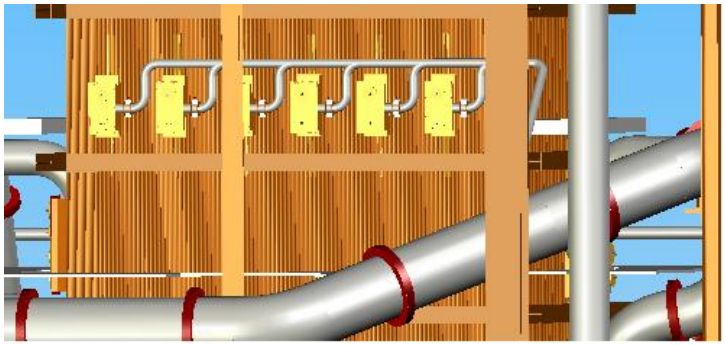
Progressive development of multi-pollutant technologies for utility and industrial combustion sources

Became NALCO Mobotec in 2007

Revenues of $43 mil US in 2008 vs. $27 mil in 2007

Foundation – ROFA®& Rotamix®





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Pulverized Wood Conversion Projects

• Helsingborg	(Sweden)	240 MWt	100% Wood
• Wroclaw	(Poland)	179 MWt	45% Wood / Coal
• Hässelby	(Sweden)	100 MWt	90% Wood / HFO
• Norrenergi	(Sweden x2)	90 MWt	90% Wood / HFO
• Jönköping	(Sweden)	90 MWt	100% Wood
• Nordic Paper	(Sweden)	53 MWt	100% Wood

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Biomass Cofiring Retrofit with ROFA for NOx Reduction at EdF-Wrocław Kogeneracja, Poland

Authors

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Why Biomass at Wrocław?

- Higher revenue
  - Subsidies for CO_2 neutral fuels (e.g., $/kWh)
- Large Combustion Plant Directive (LCPD)
  - NOx needs to be below 200 mg/Nm^3 @ 6% O_2 in 2016
  - For wood:
    - 200 mg/Nm^3 ~ 100 ppm @3% O_2 ~ 0.15 lb/MMBtu
- Drivers
  - Political
  - Regulatory
  - Economic Incentives

Wrocław Boiler

- Rafako OP-230 boiler
  - 230 t/h steam flow
  - Electricity: 25 MWe to 55 Mwe
  - District heating: up to 179 MWt
- Corner fired
  - LNB and SOFA were installed before ROFA
  - 27 m x 7.5 m x 8.4 m

Biomass Project Overview

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- Goals
  - 45% of heat input with Biomass
  - 200 mg/Nm^3 NOx
  - No ill effects (LOI, Heat Rate, Corrosion, etc)
- Scope
  - Fuel Handling
  - Milling / Feeding
  - Combustion Improvement / Staging
  - CFD Modeling / Design
  - EPC Project
- Results
  - Load, NOx, LOI, and CO

Fuel Handling

- Fuel Yard
  - Located near the river
  - Fuel: Pellets, delivered by barge
  - Covered Storage
- Transport
  - Enclosed pneumatic belt
  - 1000 meter away
  - Fire detection/suppression systems

Milling

- Day use - Pellet Silo
- Milling
  - Feeder
  - Redundant systems
    - 2 Blowers (downstream; suction)
    - 2 Hammer Mills
    - 2 Cyclones (drops into power silo)
- Safety
  - Fire detection/suppression systems
    - Firefly spark detection

Milling System

A: Pellet Silo
B: Cyclone
C: Powder Silo

Hammer Mill

Hammer Mill

Cyclones Separation (downstream from mills)

Feeders

- Four separate volumetric feeders
- Four blowers (upstream)
- Bridge breakers
- Load cells on the powder silo
  - Gravimetric feedback
- Constant transport air flow
- Three-way split before biomass burners to change injection level
  - to match the coal burner elevation

Feeders

Biomass Burners

Combustion Improvement

- ROFA
  - Rotating Opposed Fired Air
  - Boost fan
  - High velocity air discharge
  - Turbulent mixing in the upper furnace

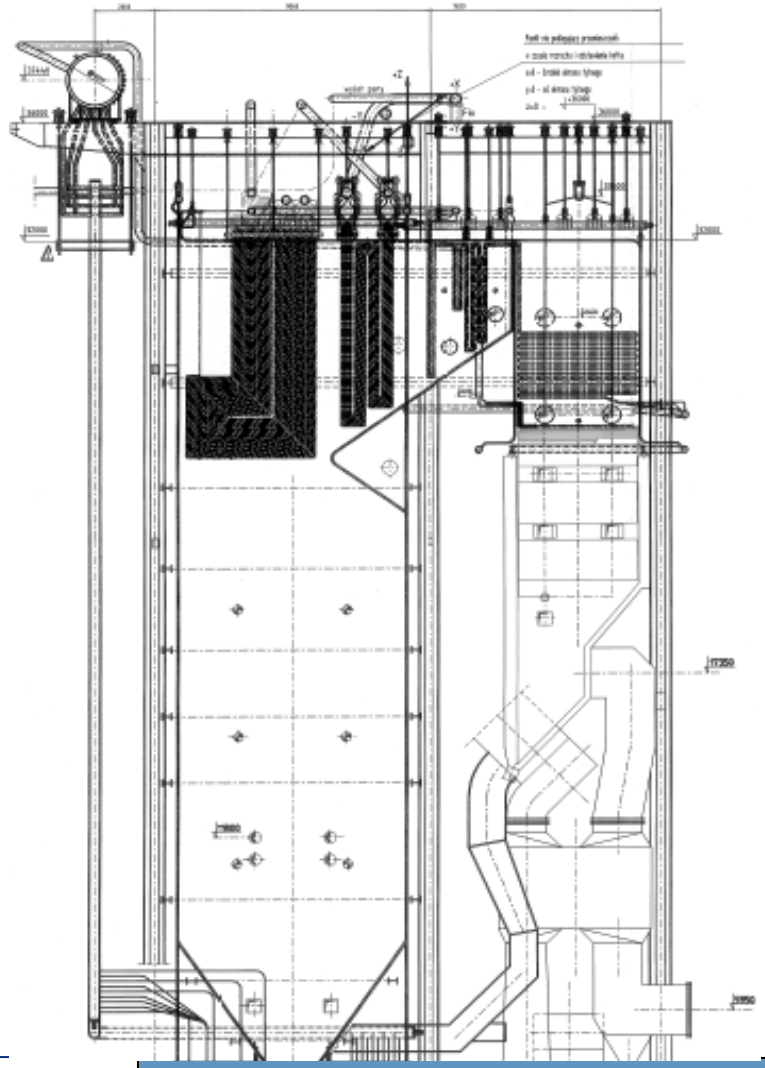
- Staging
  - NOx reduction
  - ~30% TAF

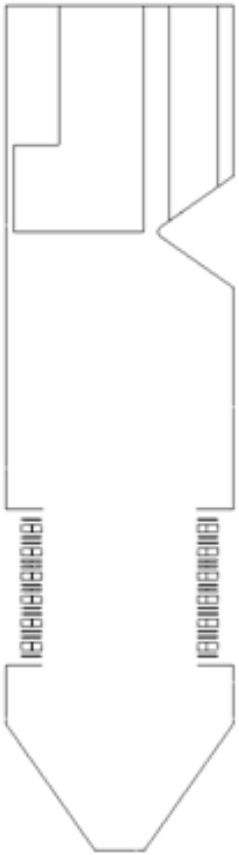
Design

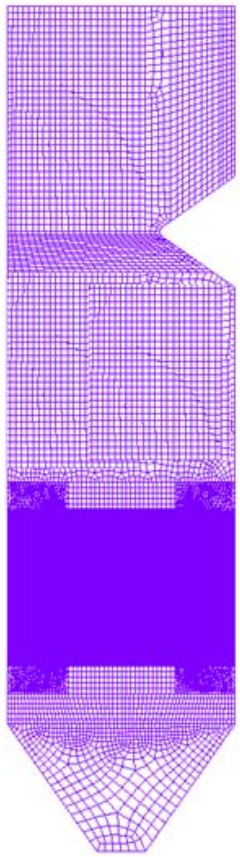
- CFD modeling

- Biomass differences
  - Large particle size (< 2 mm)
  - Non-spherical shape
    - Drag
    - Enhanced O_2 diffusion to the char surface
  - Faster devolatilization
    - Swelling during devolatilization
  - Faster char reactions
    - Due to the carbon micro-structure (spongy)

CFD Model Geometry

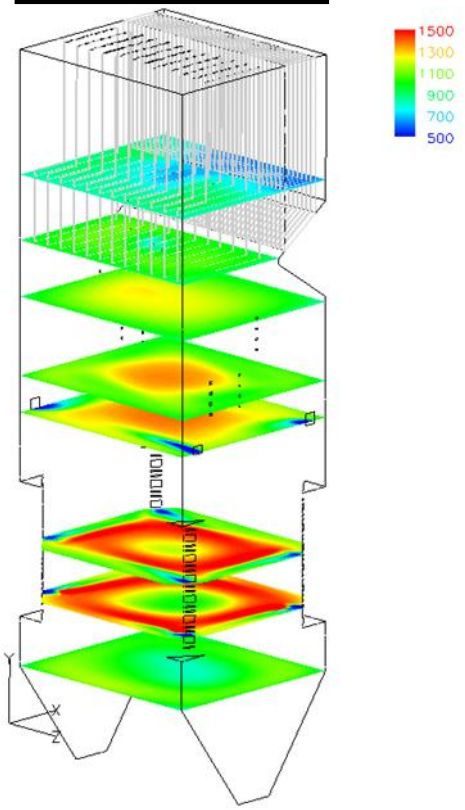




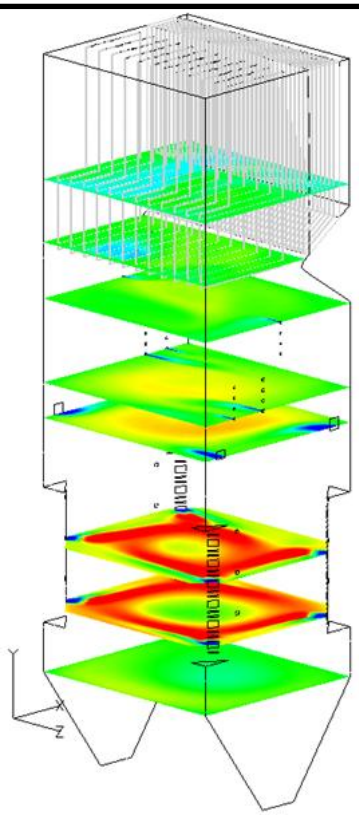


Temperature

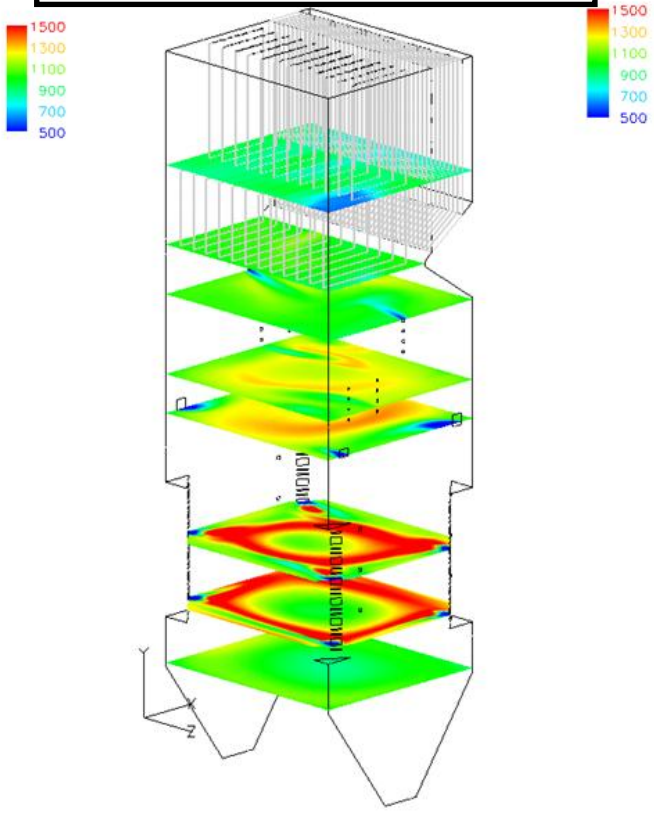
Baseline



ROFA - Coal



ROFA - Biomass



NOx

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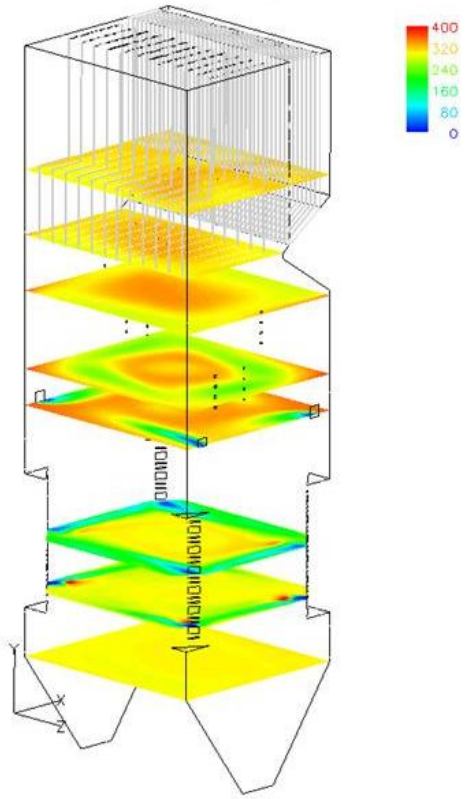
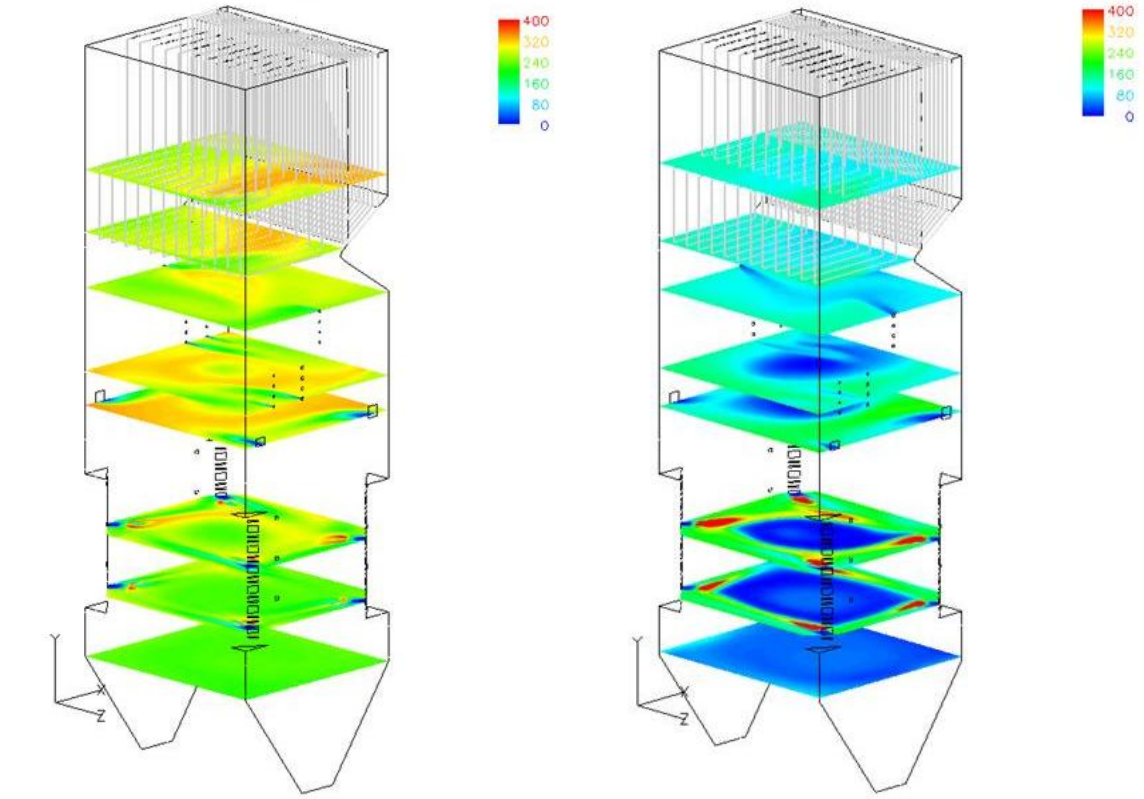
Baseline



ROFA - Coal

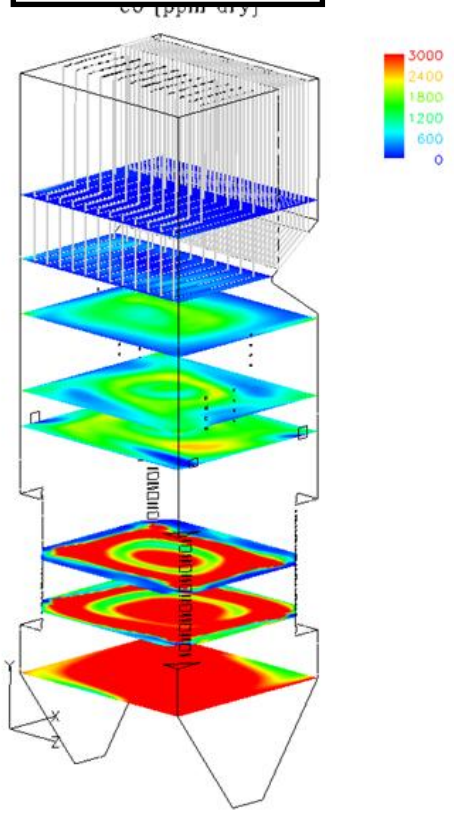


ROFA - Biomass

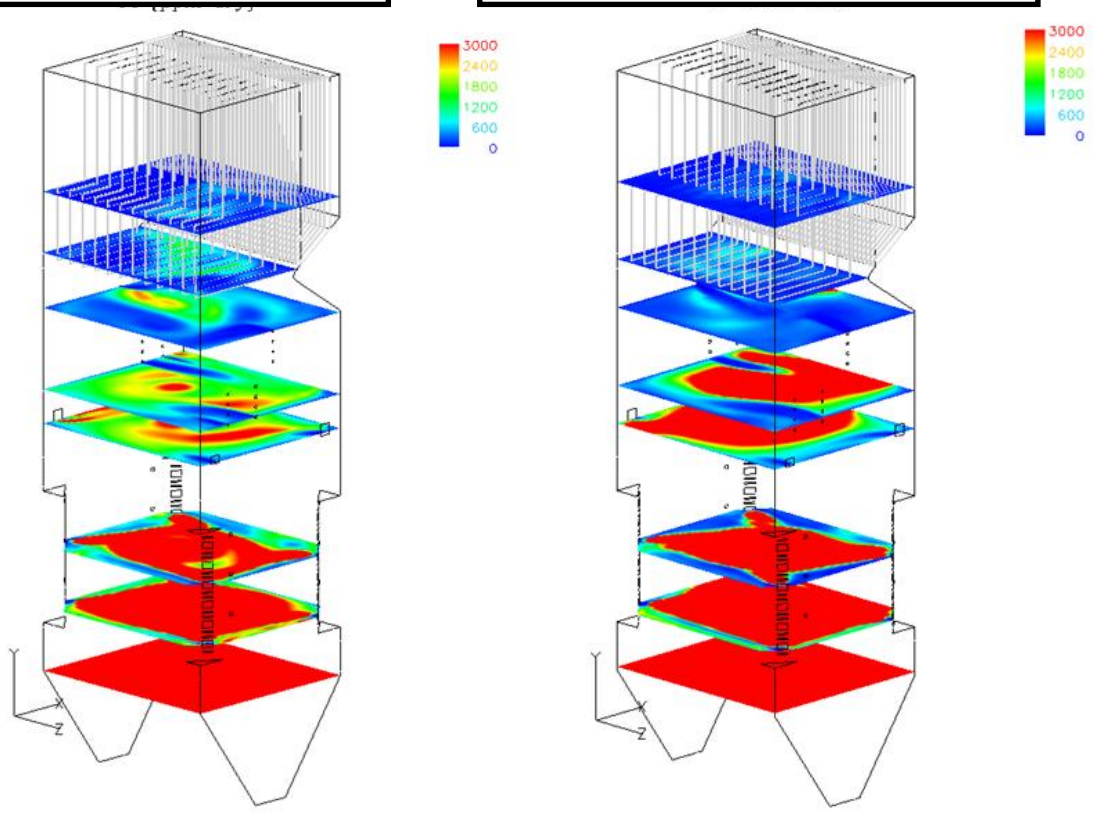
CO

NALCO Mobotec

Baseline

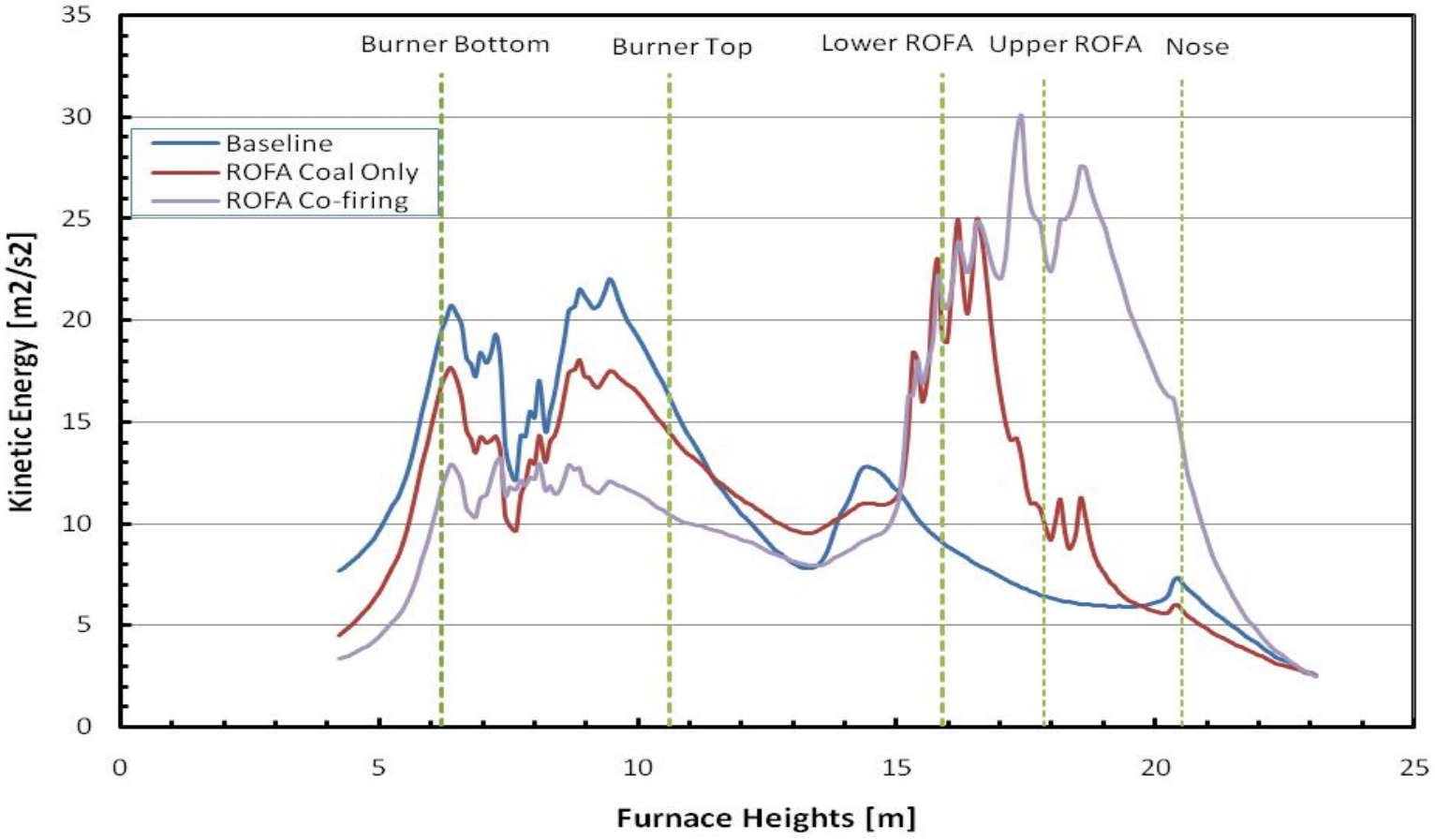


ROFA - Coal



ROFA - Biomass

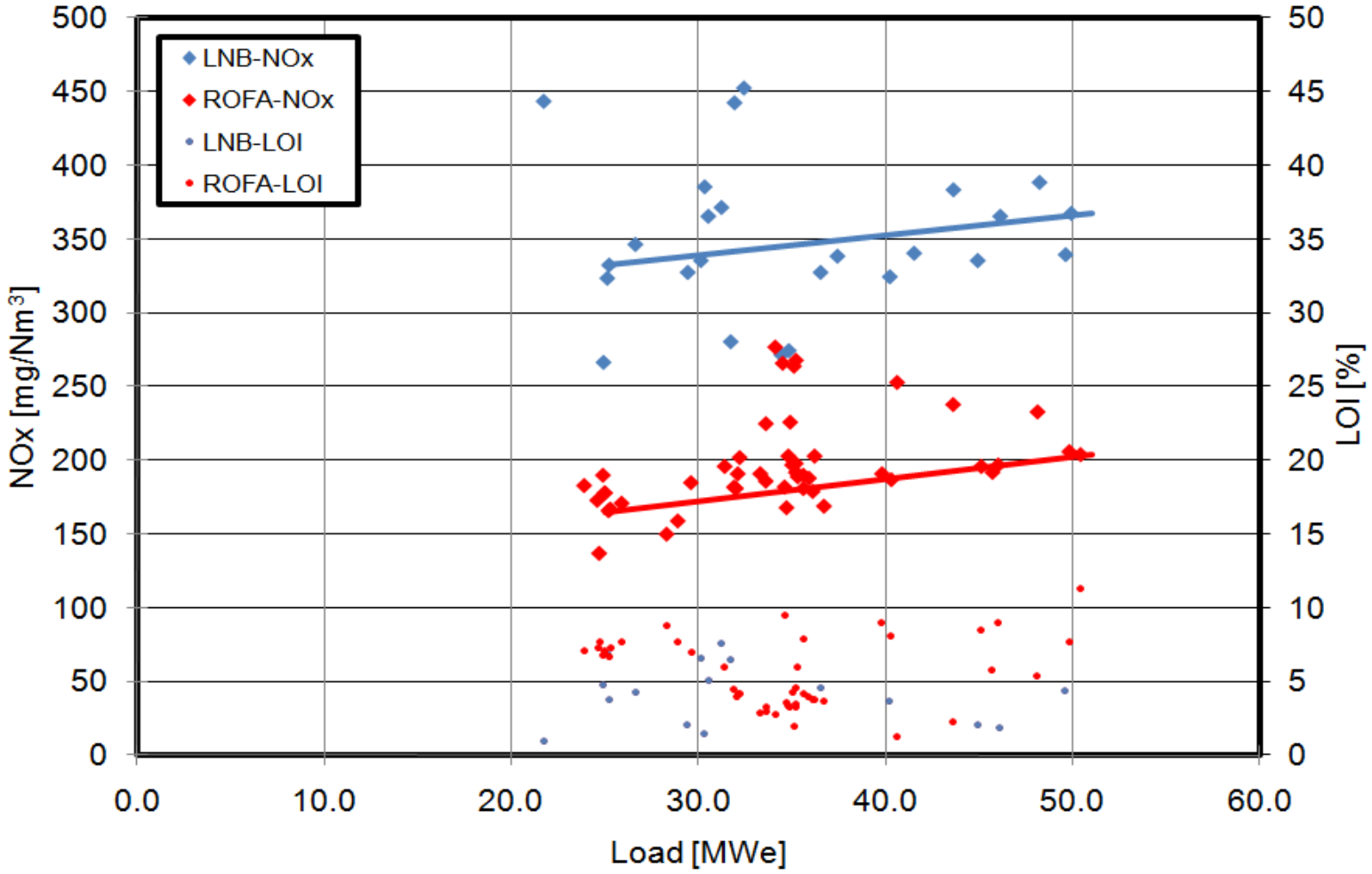
Kinetic Energy



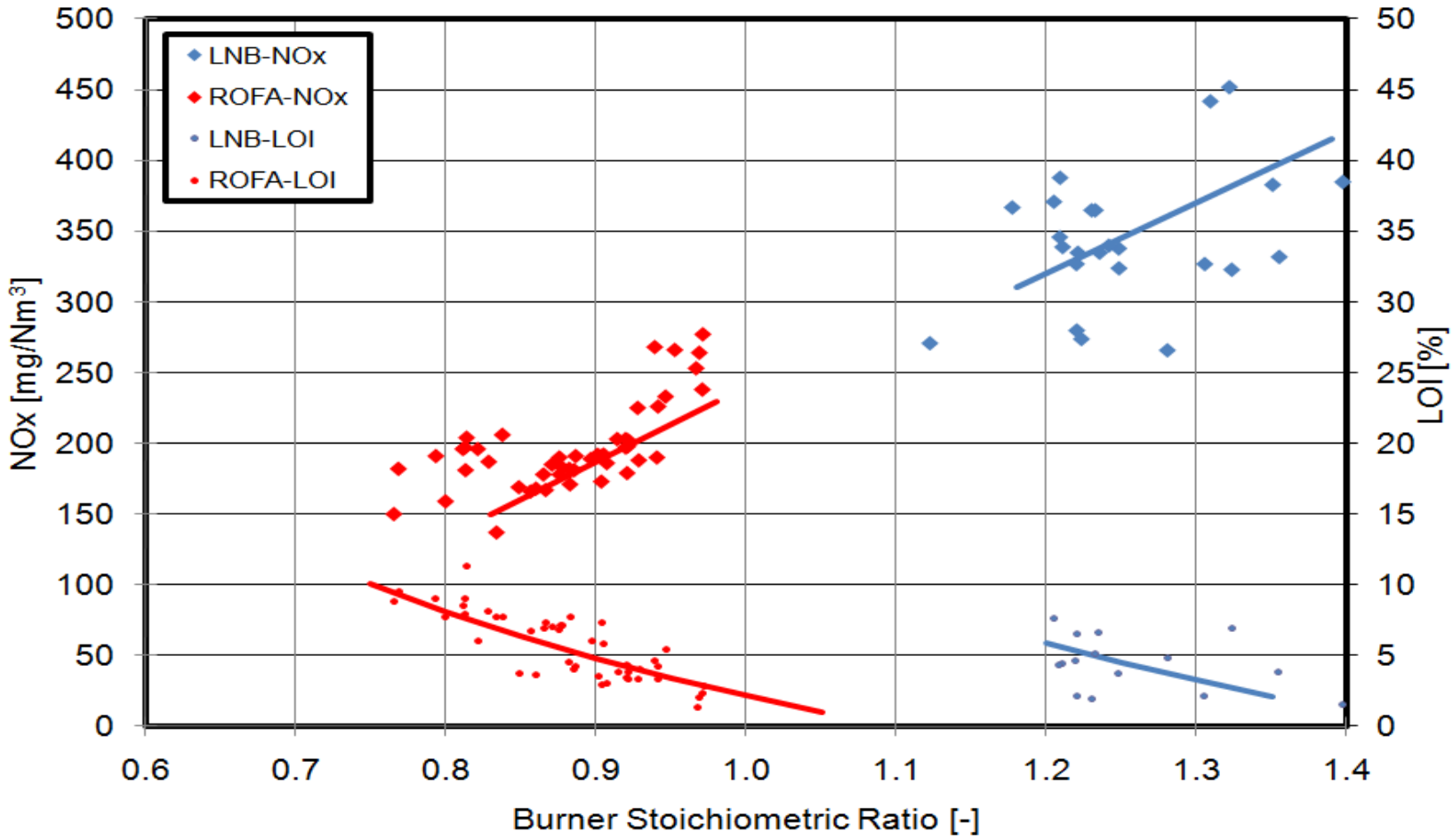
Field Results

- Tuning started in April 2009
- Tuning finished in May 2009
- Only tuning data is presented
  - Performance testing preformed in December 2009
- Online LOI measurement

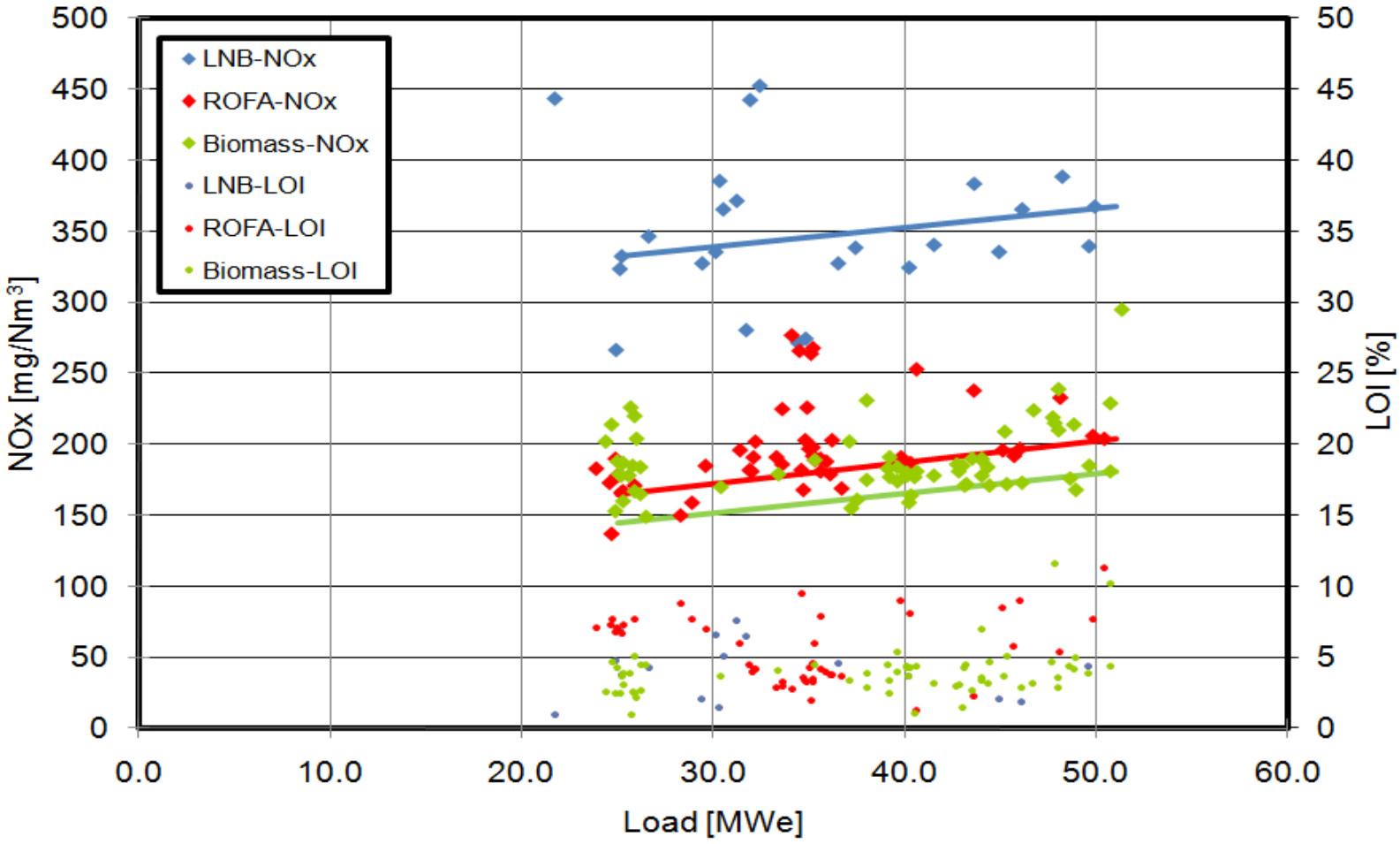
Results - NOx and LOI *versus* Load Coal Firing



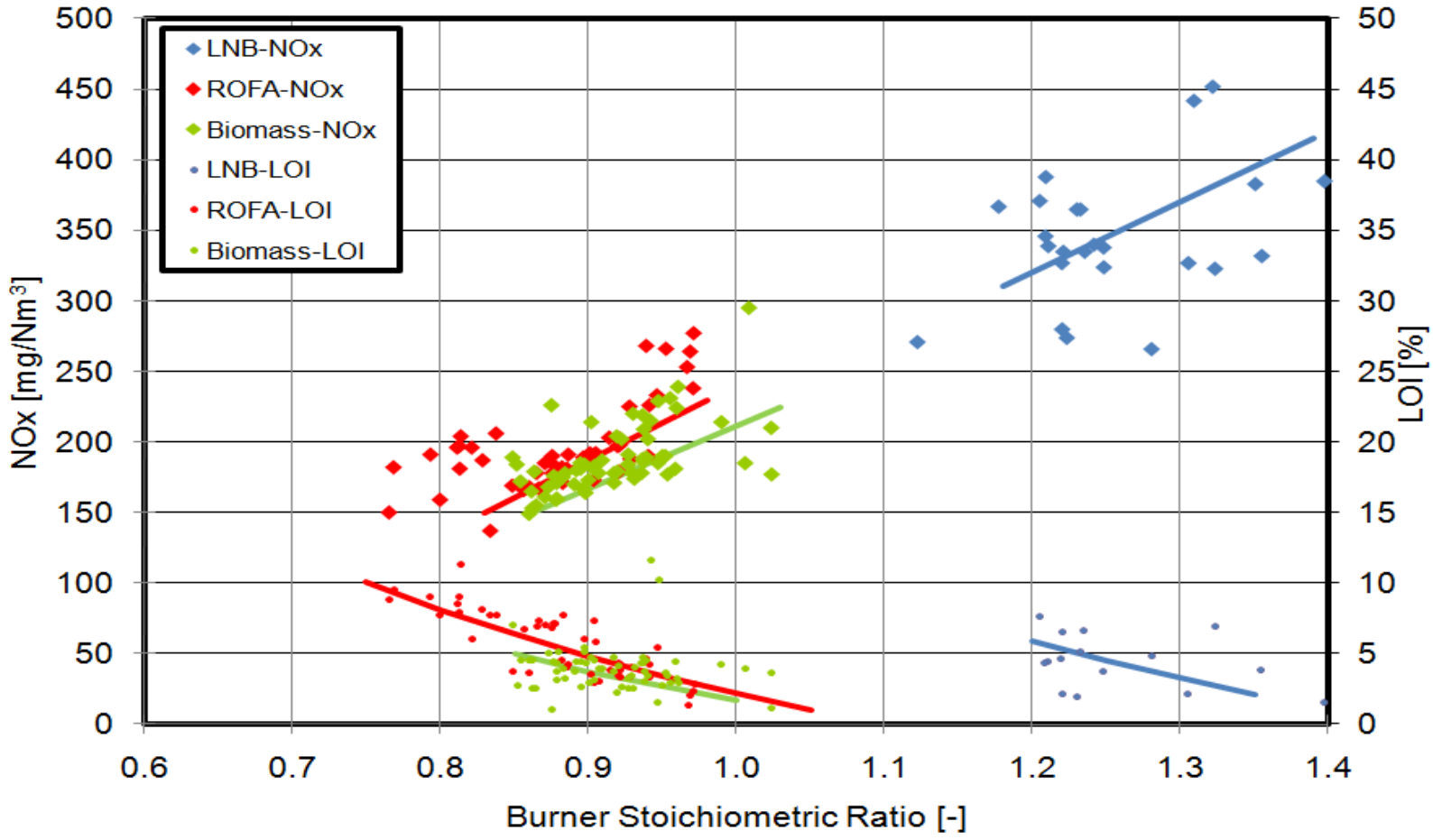
Results - NOx and LOI *versus* BSR Coal Firing



NOx and LOI *versus* Load (including biomass pellets)



NOx and LOI *versus* BSR (including biomass pellets)



Unburned Carbon Reduction

- The ash content of the biomass is lower than coal
  - Coal ash = 3.3 mg/kJ
  - Biomass ash = 1.3 mg/kJ
- When firing 45% biomass, the ash loading is reduced by 28%
  - 45% biomass ash = 2.4 mg/kJ
- Therefore a constant LOI is equivalent to a 28% reduction in unburned carbon

SOx and Mercury Reduction

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- Since sulfur and mercury content is also lower with biomass, SOx and Hg emissions are reduced

- SOx is reduced by 36%
  - Coal sulfur = 0.22 mg/kJ
  - Biomass sulfur = 0.04 mg/kJ
  - 45% bio sulfur = 0.14 mg/kJ

- Mercury reduction likely more than 40%
  - Hg was not measured for this project
  - Typically, biomass Hg is < 10% of coal Hg
  - Higher biomass chlorine will increase Hg capture

NOx and LOI *versus* Load (including biomass)

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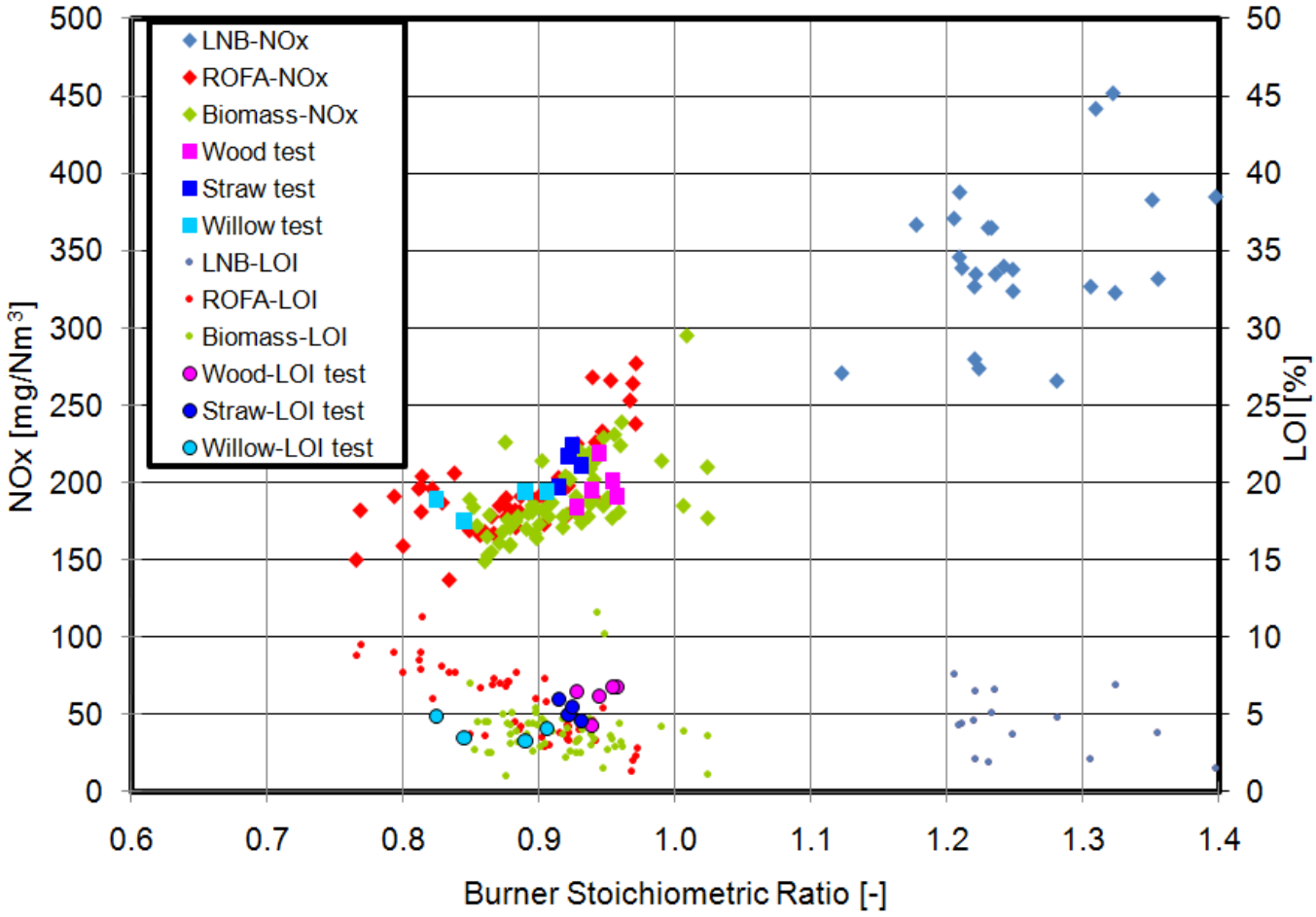
Biomass tested:
- Straw
- Willow
- Wood



Summary

- A complete biomass cofiring project has been completed by Nalco Mobotec and partners
- 45% of the heat input has been replaced with biomass
- ROFA has been installed and has reached 200 mg/Nm^3, while maintaining LOI below 5% (required for ash sales)
- No SNCR was required to meet 200 mg/Nm^3
- Significant SOx and Mercury reduction
- The next step is to increase the biomass heat input and allow for operation with coal off

INTERMISSION

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A Feasibility Study Concept to Convert the 227 MWe Atikokan Generating Station to Fire 100% Biomass Pellets

OPG Atikokan Generating Station

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Why Biomass in Ontario?

- Ontario Canada to eliminate coal by end of 2014
- Biomass is carbon neutral and does not contribute to global warming
- Conversion to biomass requires less capital relative to most alternatives, i.e. greenfield
- Co-benefit: reduction of other pollutants
  - NOx, SOx, Hg, PM

OPG Atikokan

- 230 MWe B&W opposed fired boiler
- Low-sulfur lignite-fired, with LNB
- 65% of fly ash is sold
- Low capacity factor

Feasibility Study

- Constraints:
  - Utilize pelletized biomass without auxiliary fuel
  - Utilize existing plant infrastructure
    - Maintain the ability to revert to coal
  - Fuel storage capacity of 10 Days (at MCR)
  - Rail or Truck Pellet Delivery
  - Safe Operation

- Nalco Mobotec's Process:
  - Identify and Evaluate Alternatives
  - Prepare Cost Estimate of Viable Options (±30%)

- Final Study
  - 558 Pages
  - Only a summary of key conclusions follows

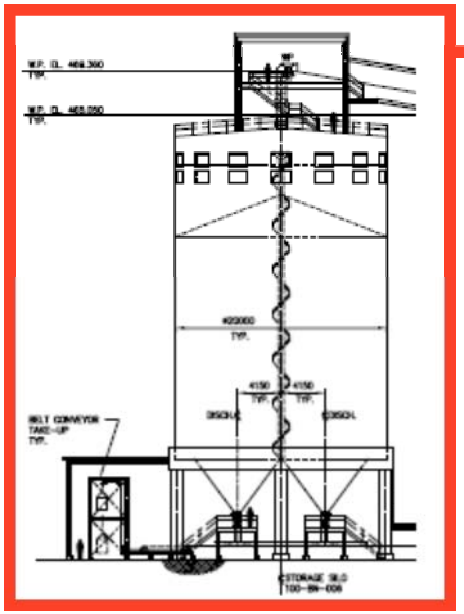
Delivery, Storage, and Conveying Options

Delivery – Truck/Rail

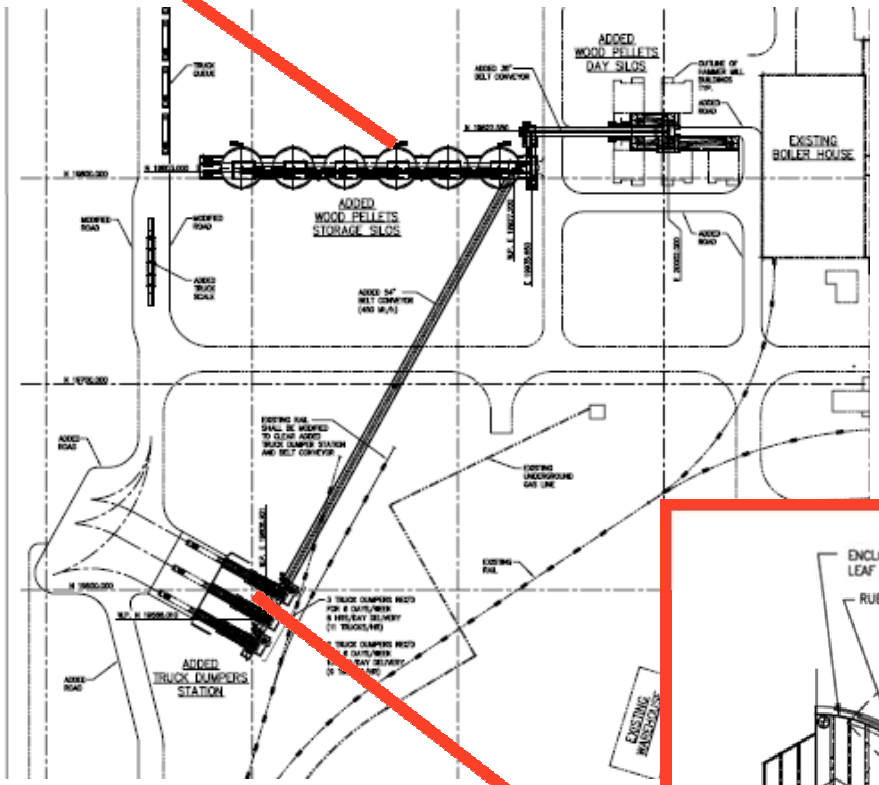
Conveying

Storage – Silos/A-Frame Bldg

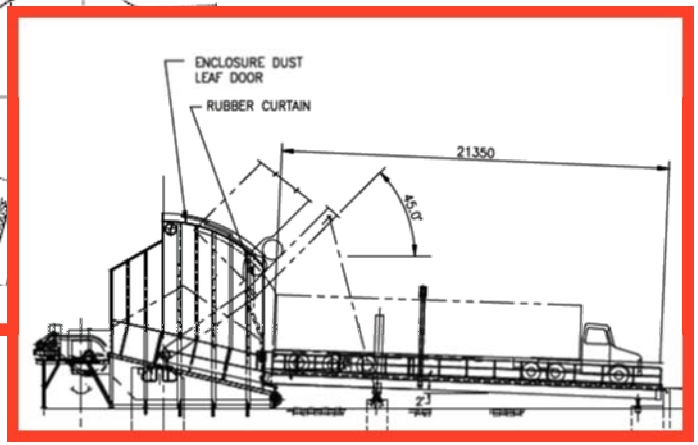
Delivery, Storage, and Conveying



PELLET
STORAGE SILOS



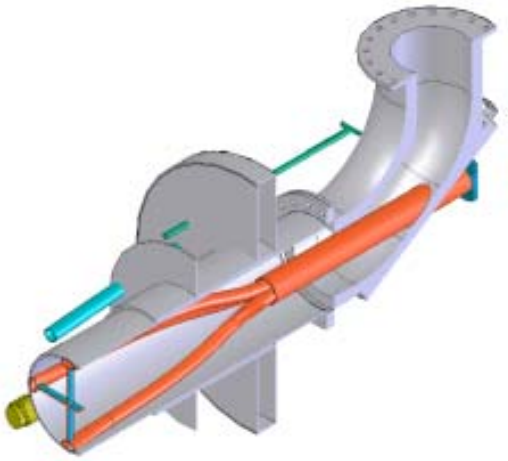
TRUCK DUMP



Day Storage, Milling, and Firing Options

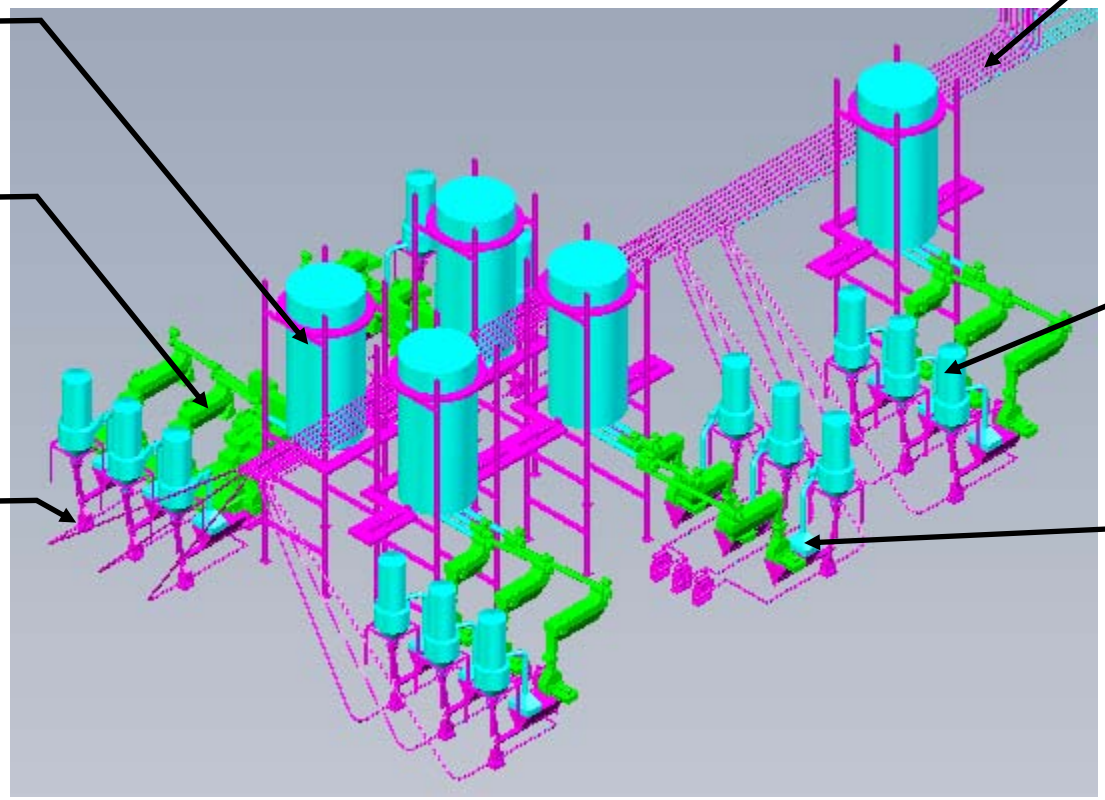
Day Storage

Pulverizers/Hammermills

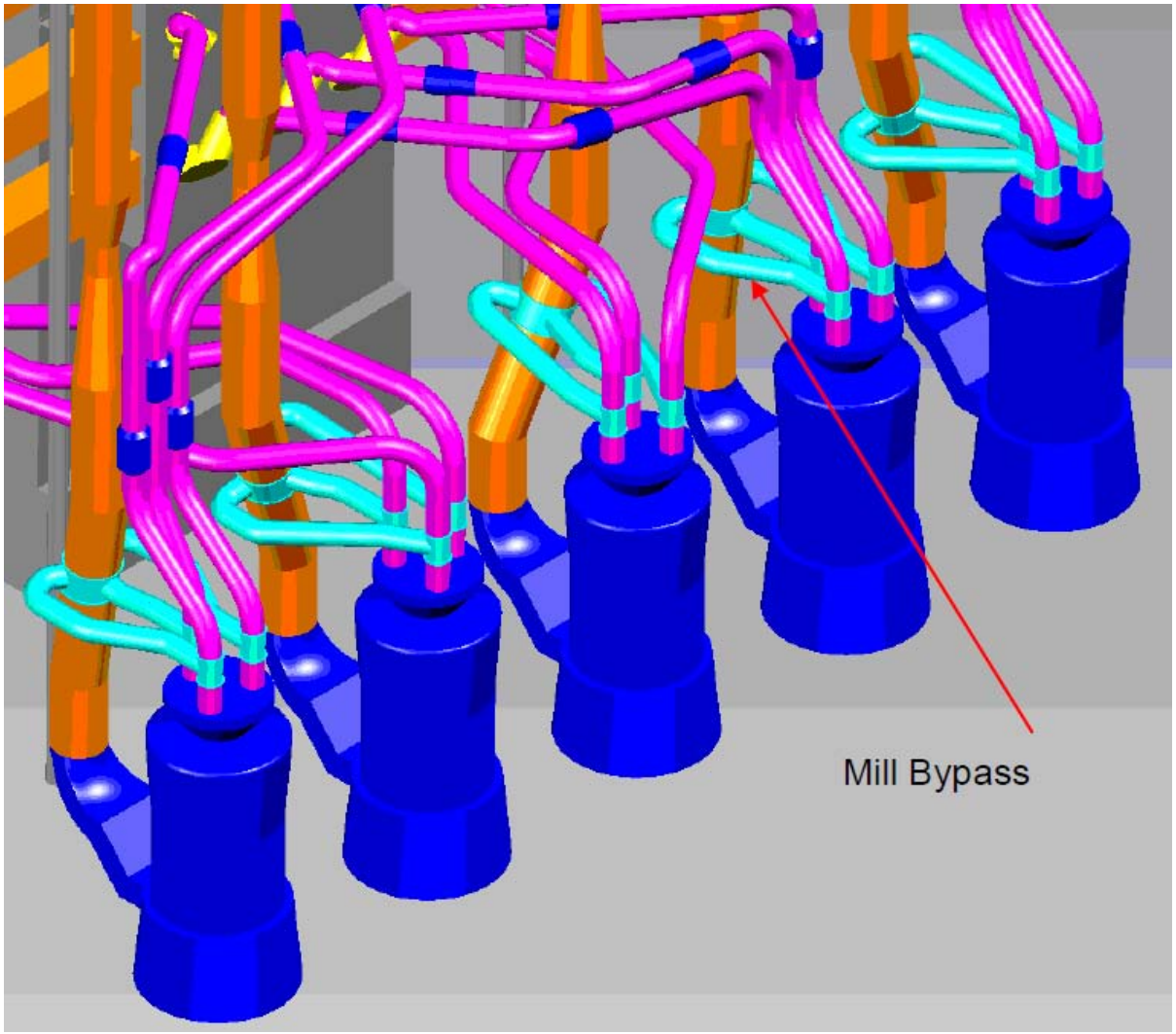


Burner Mods

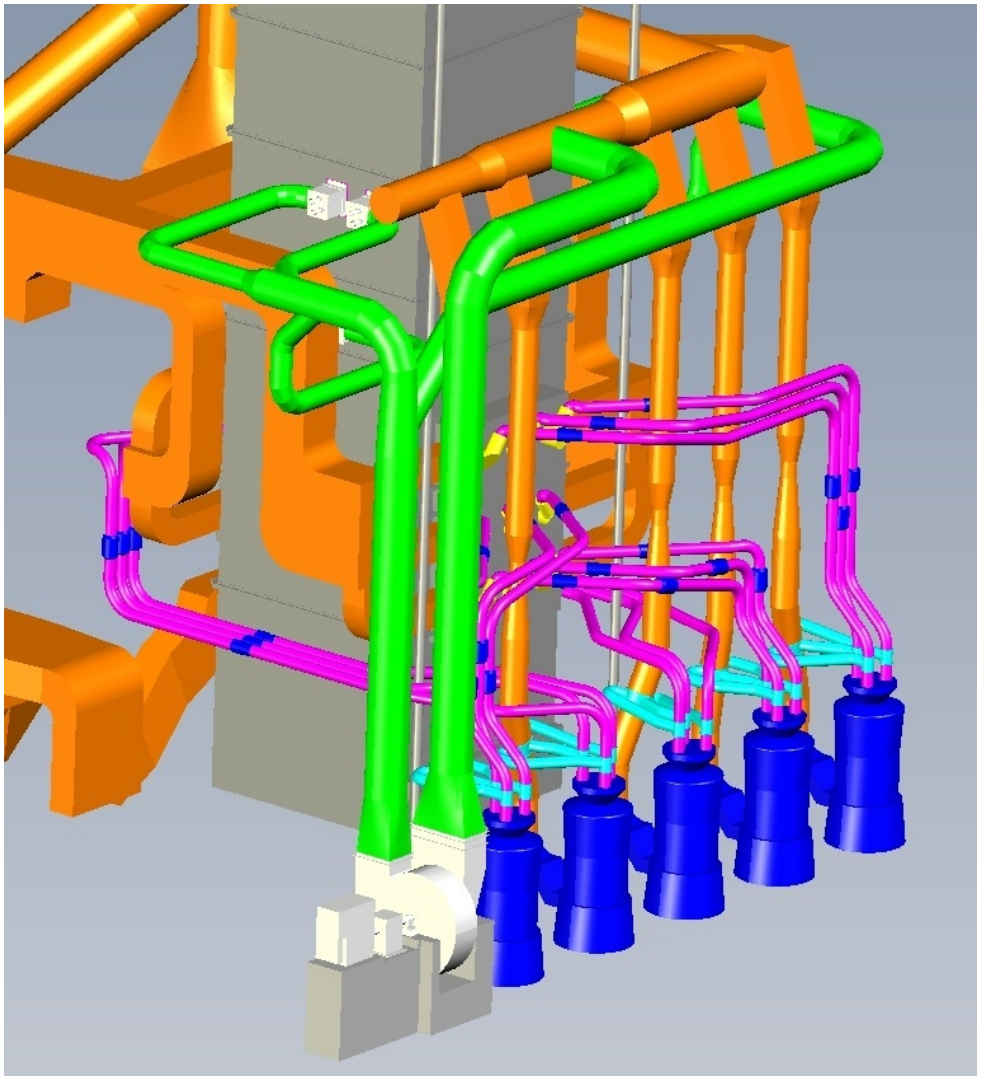
Day Storage and Milling



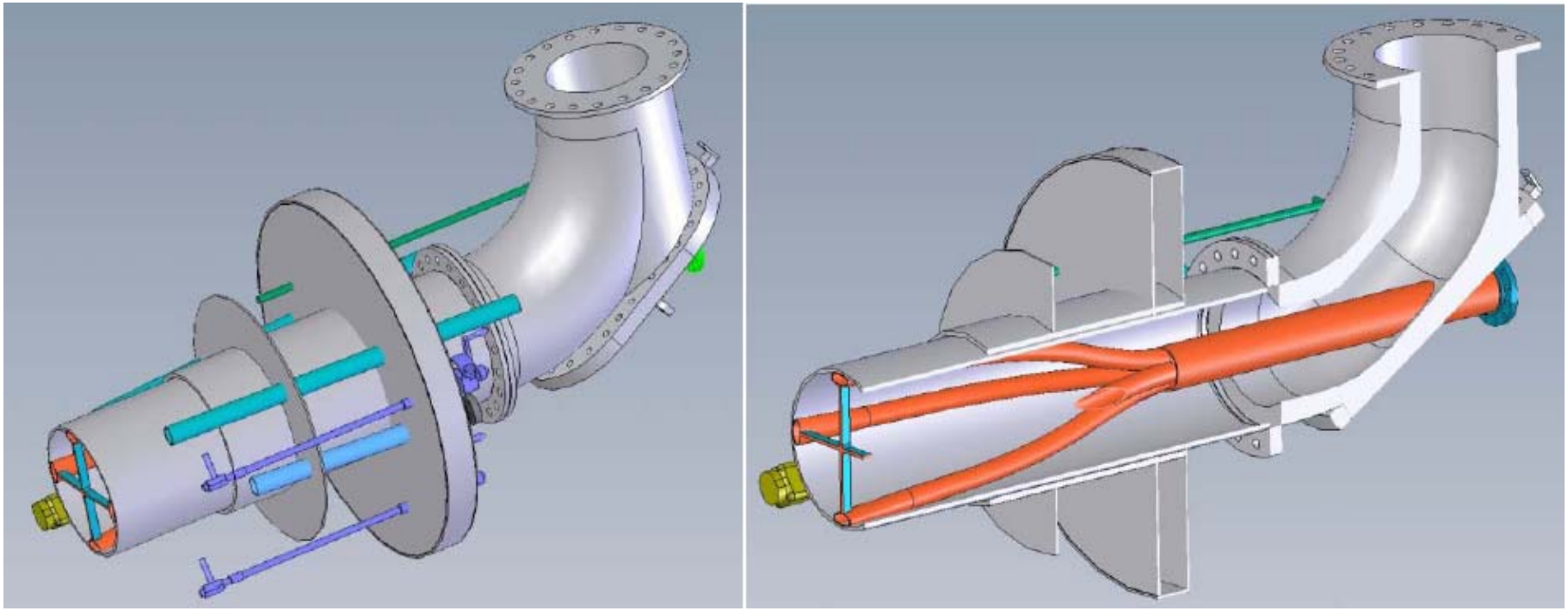
Coal Mill Bypass Modification



ROFA Installation



Burner Modification



ESP Modifications: New Hoppers, TR Set Mods, O_2 Monitoring

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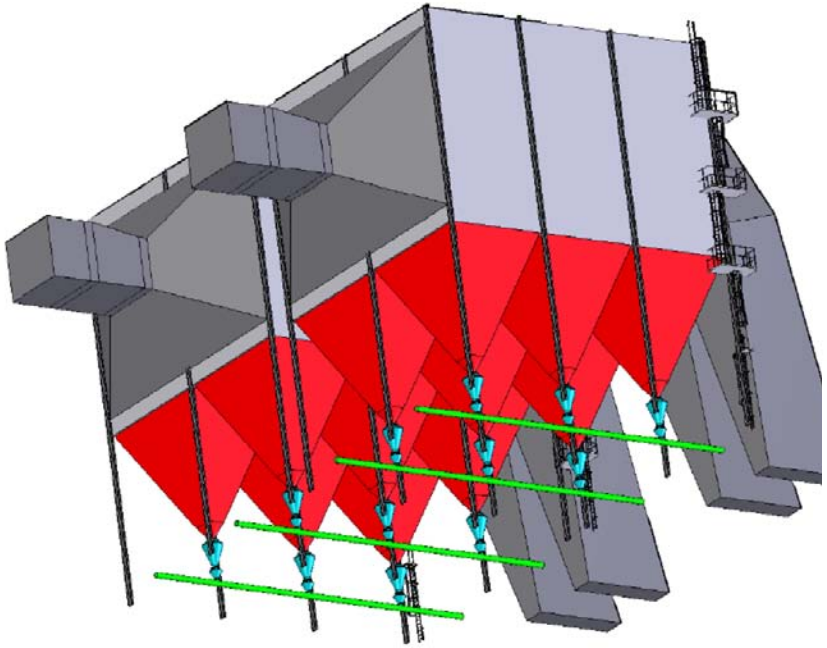

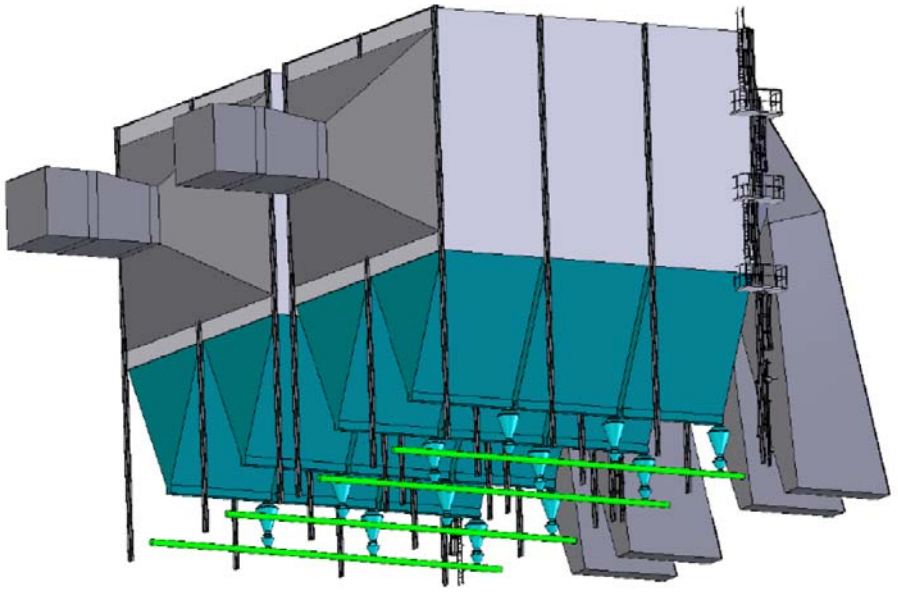

Modeling
CFD ↔ Steam-Side Thermal

- CFD Model
  - Combustion and Heat transfer to match 100% biomass testing
  - Predict FEGT
  - Model alternative cases: biomass, burner mods, ROFA
- Steam-Side Thermal Model
  - Determine unit thermal efficiency
  - Effect on SH temp, RH temp, Stack Temp
- Design
  - Optimize operational modes for 100% biomass
    - PA air temperature and quantity
    - Flame stability, heat release, and coking
    - ROFA design / Burner modifications
  - Increase combustion efficiency
    - Reduce LOI, CO
    - Control SH/RH temperature

Emissions of SOx and Mercury

- Sulfur and mercury is reduced in biomass
  - Wood pellets
- 95% decrease in SOx
- 90% decrease in mercury

Total Projected Costs

- Total projected cost (+/-30%) – 230 Mwe
  - Different options were considered

- Cost partitioning
  - 57% = Bulk Fuel Handling (Fuel Yard)
  - 27% = Day Storage, Milling, and Fuel Transport
  - 16% = Mill Bypass, Burner Modifications, and ROFA

Conclusions

- Switching to biomass reduces CO_2, SOx, and Hg
- 100% load (230 MWe) is possible without derating the boiler
  - Mainly due to switching from wet lignite to dry pelletized wood
- Maintaining FEGT is a concern due to reduced fly ash
  - With ROFA and FGR control, FEGT is controllable
- Burner modifications are required
  - Flame stability
  - To avoid resizing the PA/SA air heaters
  - Modeling predicts low unburned carbon with proposed burner mods
- ROFA System
  - Reduces LOI, CO, and NOx
  - Helps control SH/RH temperature
  - Biomass can be delivered through ROFA for more control
  - Predicted to reduce fuel consumption significantly
  - Rotamix can be used to minimize slag and corrosion

Next Phase Studies

- At Wraclaw
  - Just awarded Next Phase of CFD Modeling Study for Unit 2
  - EdF considering installing ROFA System for enhanced biomass cofiring in Unit 2 in event Unit 1 is down
  - Slagging and Fouling Study for Unit 1
    - CFD Modeling and Laboratory Characterization of pellets made from various biomass

- At OPG Atikokan
  - Tender Package to be released very soon –
    - implementation by 2012

Thank you