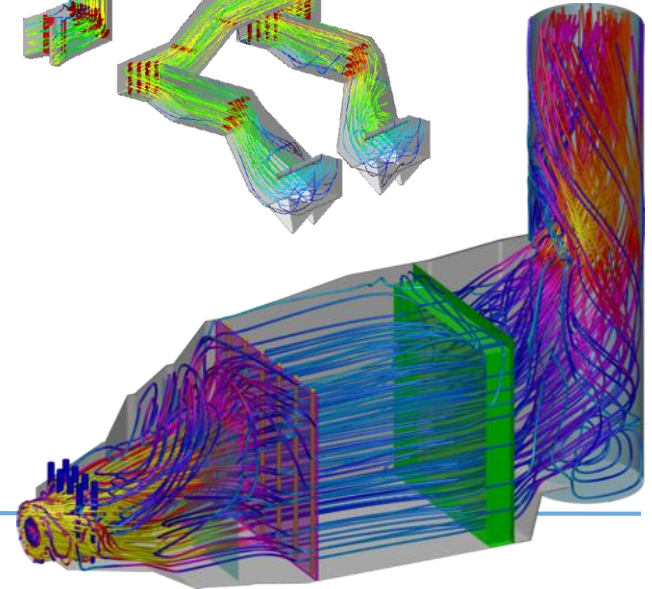
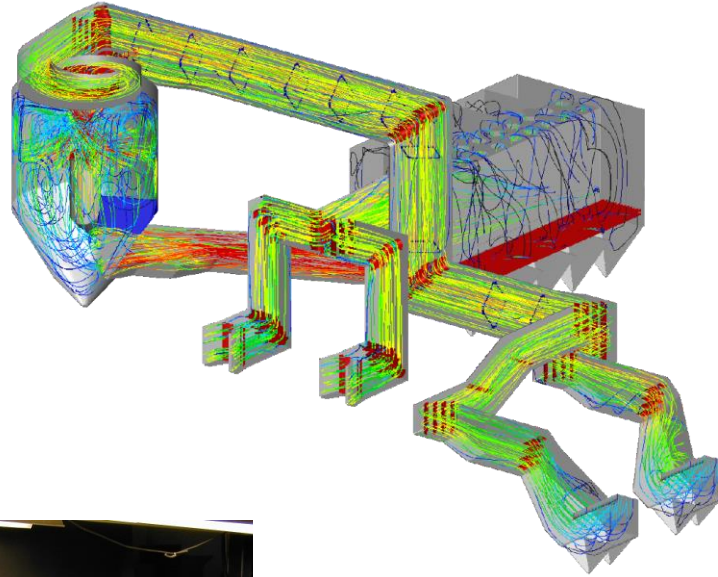

Flow Modeling: Boiler and AQCS with dual fuel burning

Robert Mudry, P.E.
Airflow Sciences Corporation

WPCA/Duke Co-Firing Seminar
Spartanburg, SC
October 2, 2019

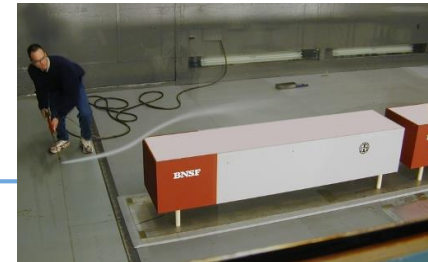
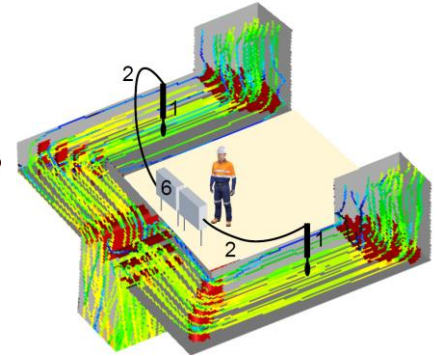
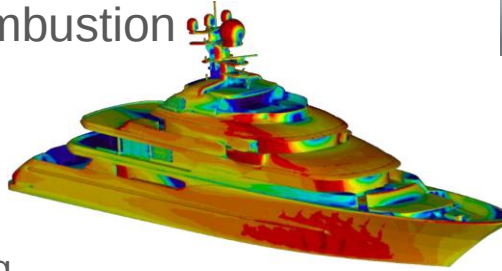
Agenda

- Flow Modeling Basics
- Applications
 - Boiler performance, heat rate
 - AQCS optimization
 - Gas leak detection



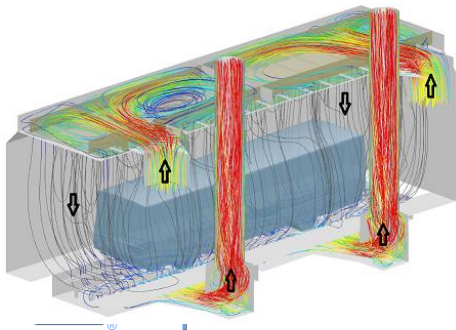
About Airflow Sciences

- Expertise is with fluid dynamic engineering, heat transfer, thermodynamics, and combustion
- In business since 1975
- Consulting Engineering Services
 - CFD simulation
 - Laboratory prototype fabrication/testing
 - Wind tunnel testing
 - Field testing
- CFD Software Development
- Flow Test Equipment
- Flow Calibration Lab



About your speaker

- Flow modeling and testing for 31 years
- Entire career at Airflow Sciences (started as summer intern)
- Rocket scientist at heart – degree is in aerospace engineering
- Focus on power industry, optimization of boilers and AQCS
- Occasional work in auto, aerospace, food processing, and other industries
- Father of 4, husband of 1
- Decent volleyball coach, mediocre golfer



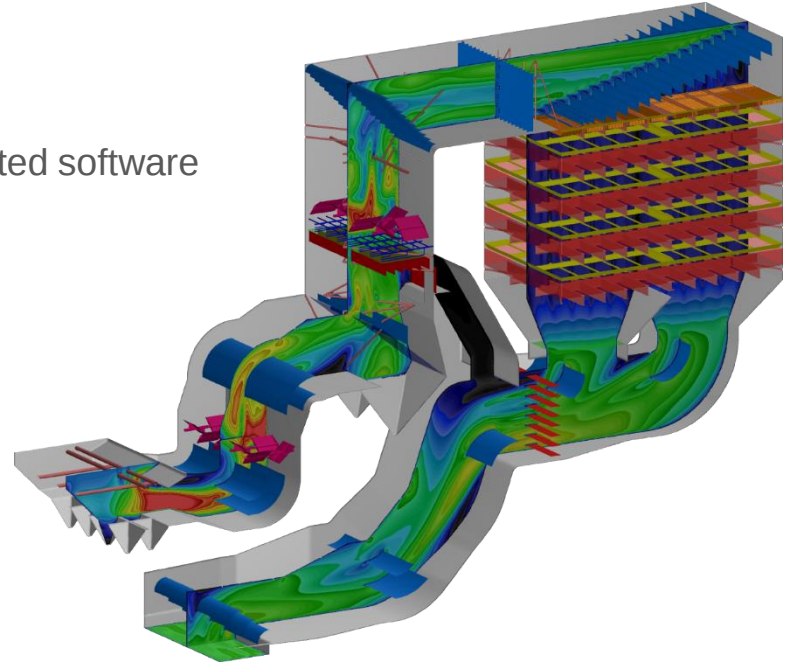
Flow Modeling Basics

- Physical flow model
 - Scale representation of actual geometry
 - Use Typical scale 1:8 to 1:16
 - “Cold flow” modeling
 - Visualize flow with smoke
 - Simulate ash deposition
 - Measure flow properties
 - Velocity
 - Pressure
 - Species and temperature mixing



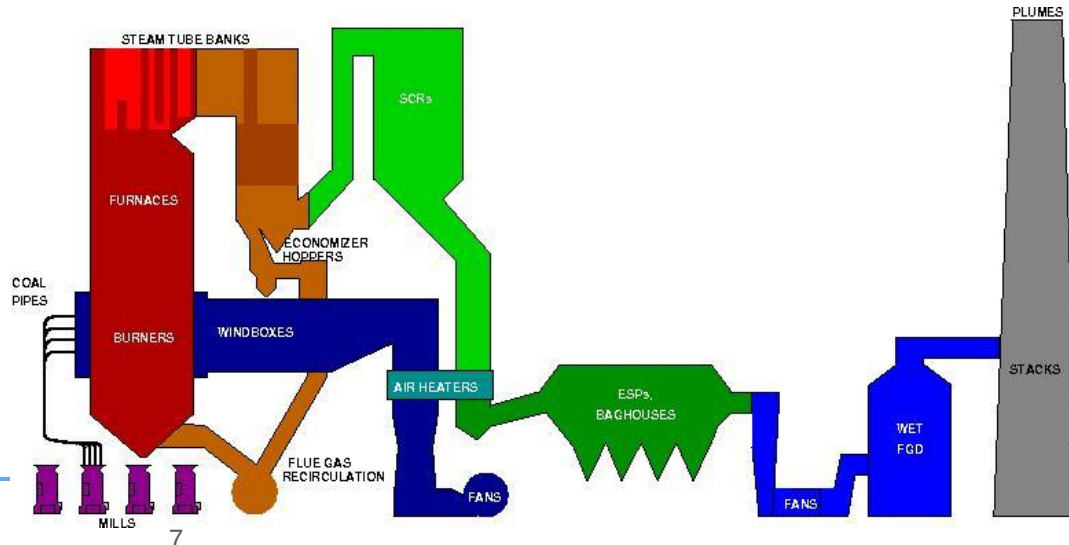
Flow Modeling Basics

- Computational Fluid Dynamics (CFD)
 - Numerical simulation of flow
 - Utilize high speed computers and sophisticated software
 - Calculate flow properties
 - Velocity
 - Pressure
 - Temperature
 - Chemical species tracking
 - Reactions and combustion
 - Particle streamlines



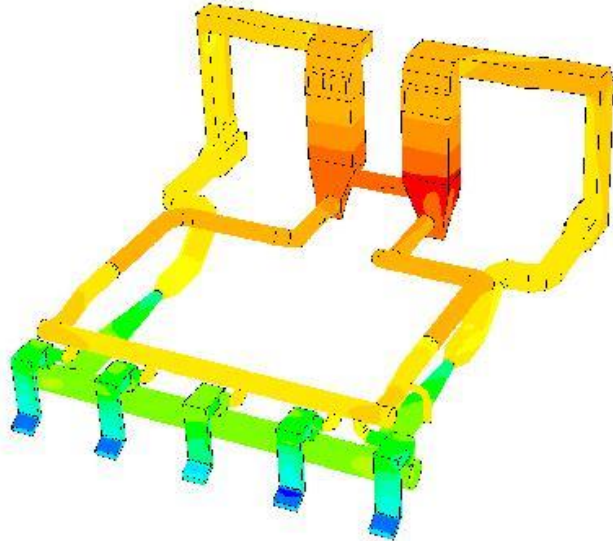
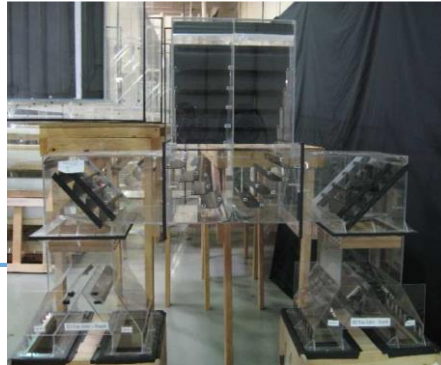
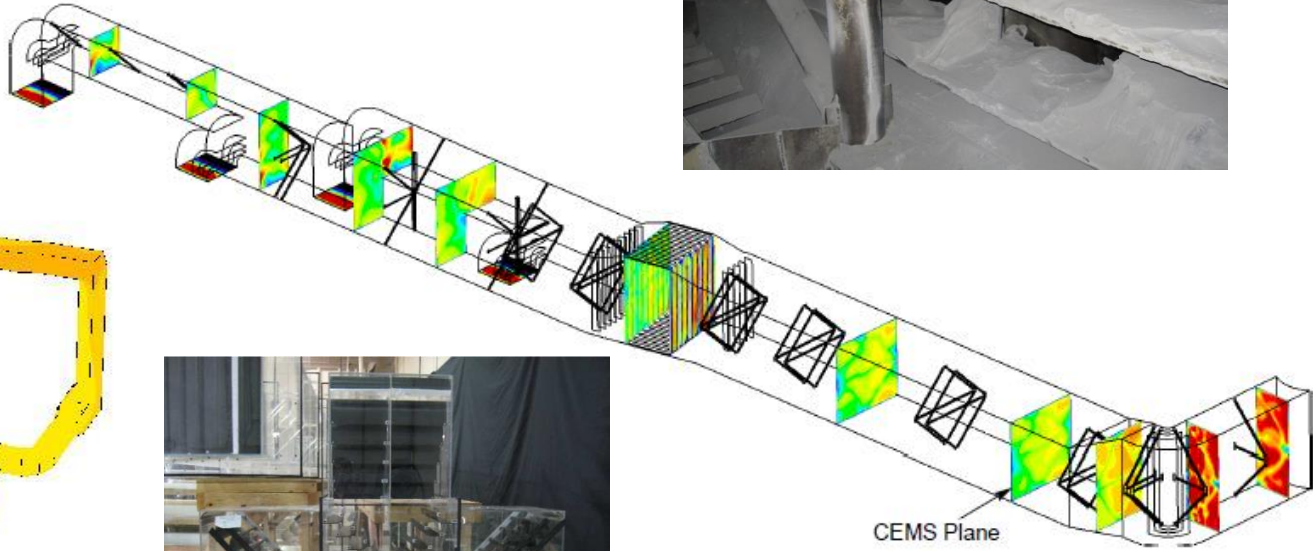
Flow Modeling Applications

- Modeling can optimize equipment “Fan-to-Stack” and beyond
 - Fans and ductwork
 - PA/SA/OFA/fuel balance
 - Furnace combustion, NO_x, slagging
 - Backpass heat transfer, erosion
 - SCR
 - Air heater
 - Sorbent injection
 - ESP/PJFF
 - FGD
 - Stack
 - Dispersion, plumes
 - Water, steam, condenser



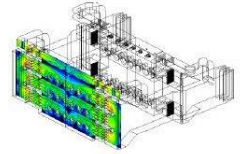
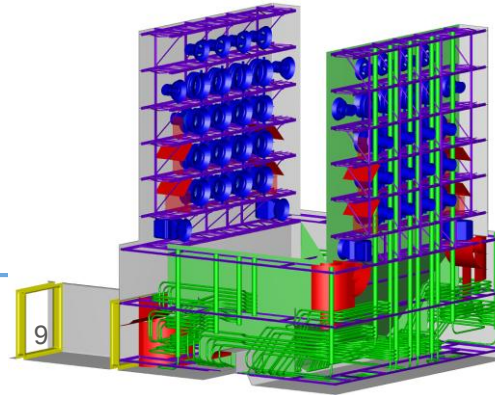
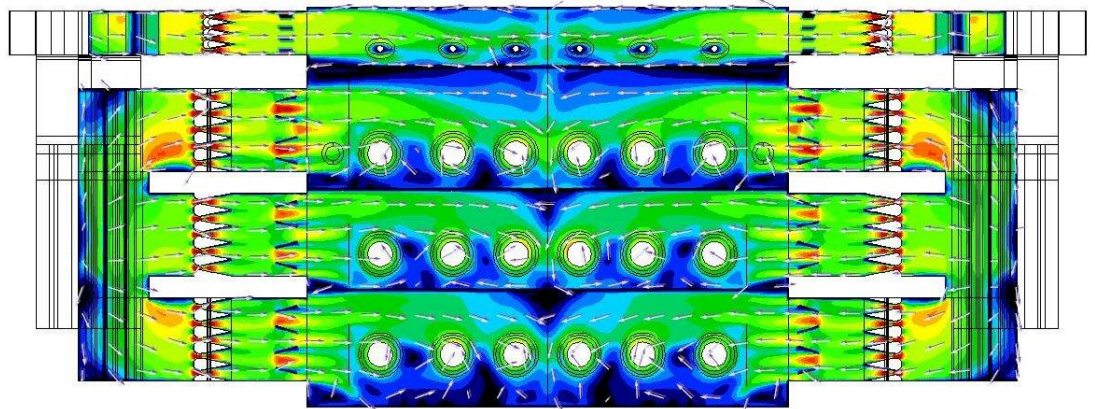
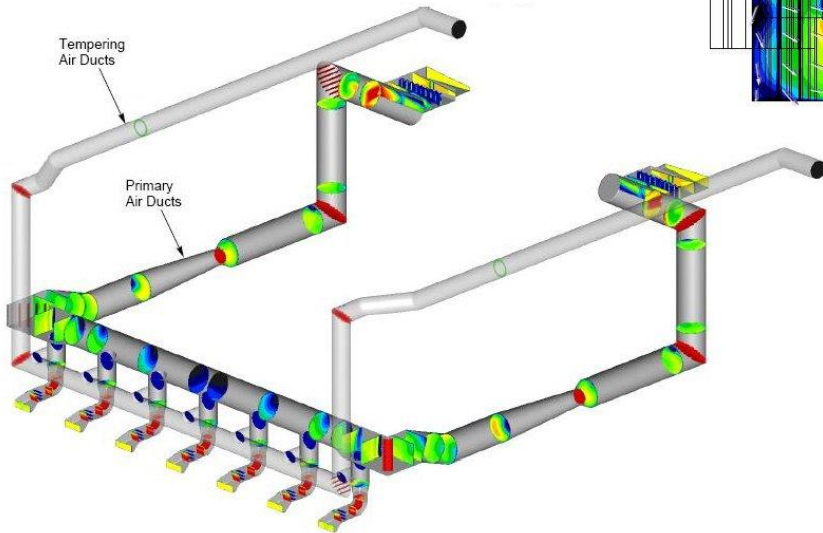
Fans and Ductwork

- Velocity patterns, erosion
- Pressure drop
- Ash accumulation



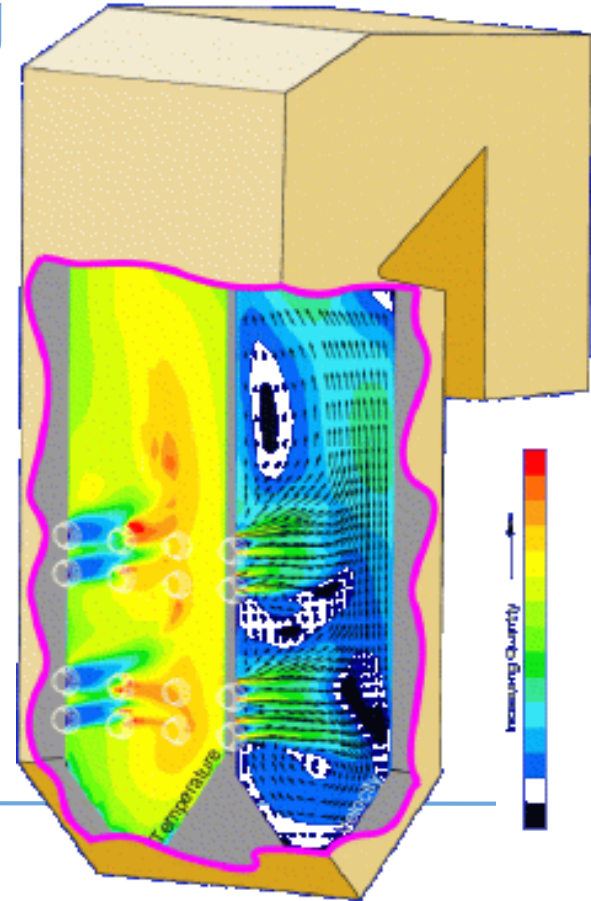
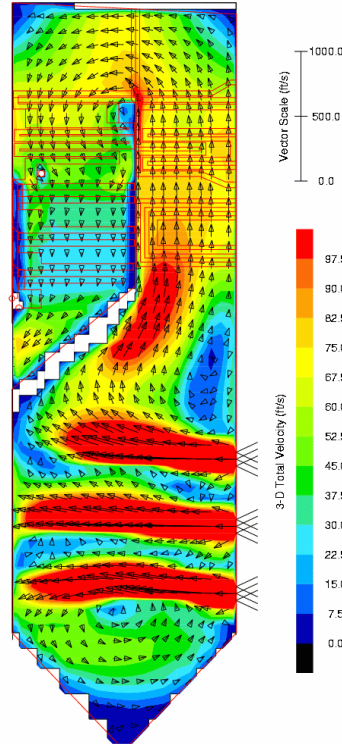
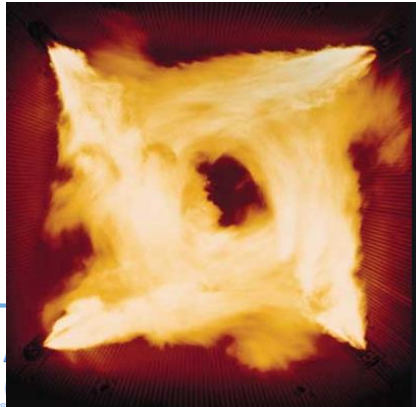
PA/SA/OFA/Fuel Balancing

- Optimize combustion
 - Balance PA flows
 - Equal coal flow per burner
 - Windbox and OFA balance



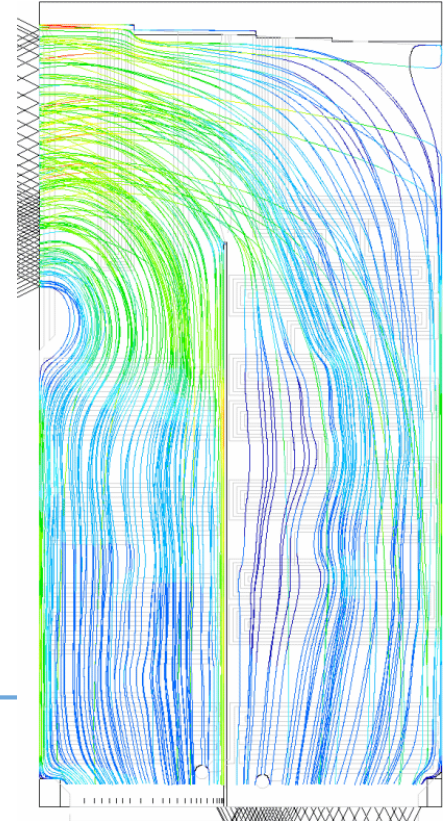
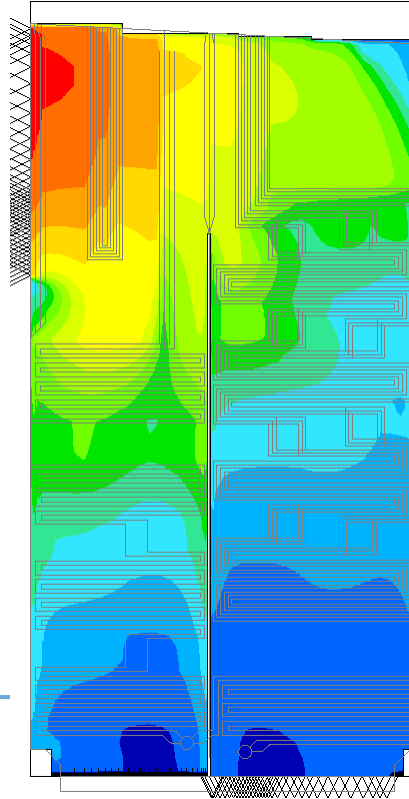
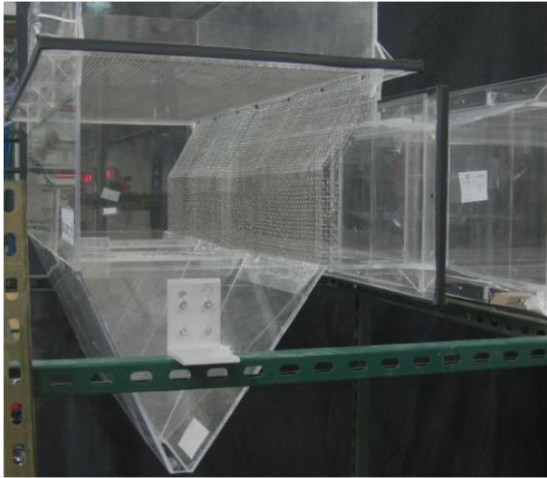
Furnace Combustion, NOx, Slagging

- Coal, gas, or dual firing
 - Reduce NOx
 - Minimize LOI
 - Improve heat transfer
 - Avoid corrosion
 - Decrease slagging
 - SNCR



Backpass, Heat Transfer, Erosion, Economizer

- Gas and particulate flow profiles
- Ash impacts on tubes and walls



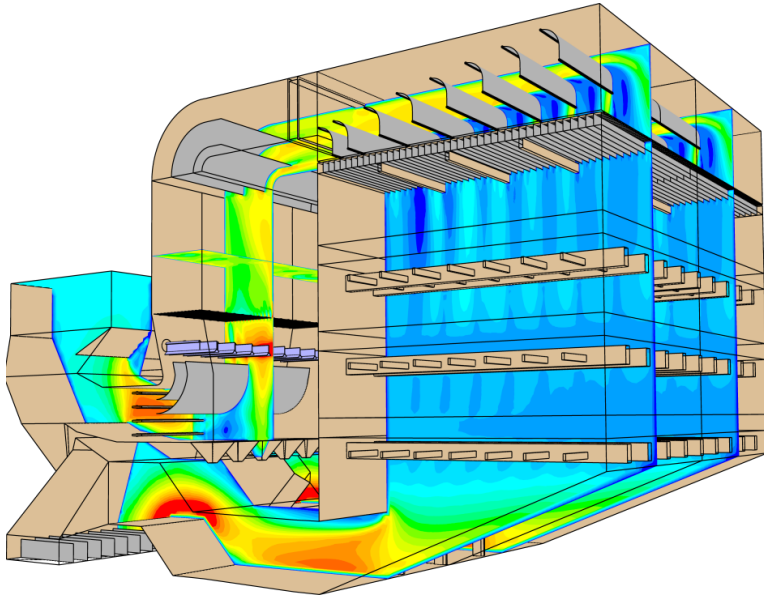
SCR Flow Modeling

Performance goals for SCRs:

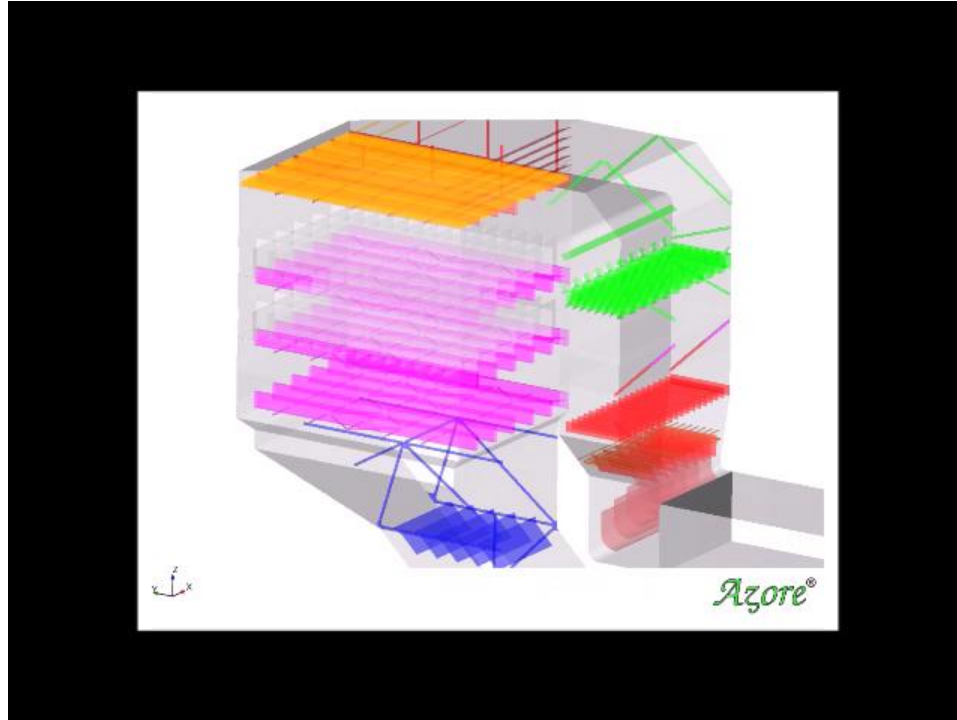
- Uniform ammonia-to-NOx ratio
- Uniform velocity at AIG
- Uniform velocity at the catalyst
- Vertical flow entering catalyst
- Uniform temperature at catalyst
- Minimize pressure loss
- Capture LPA with screen/baffles
- Minimize pluggage potential
- Minimize erosion potential



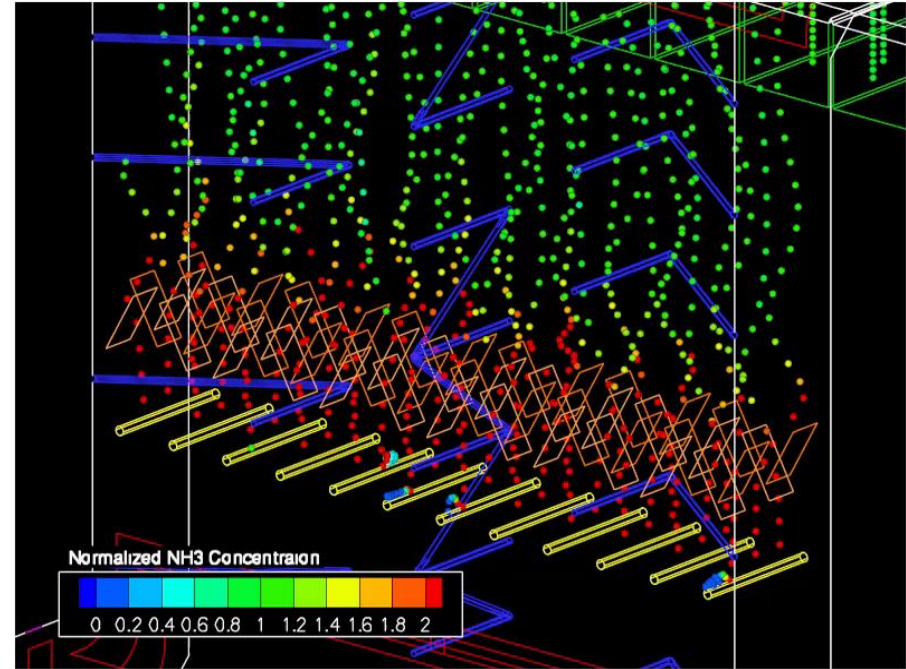
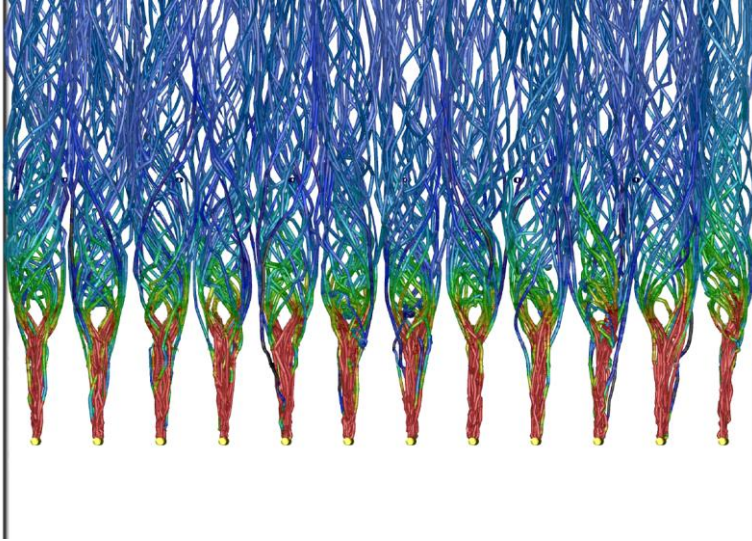
SCR Flow Modeling



SCR Flow Modeling

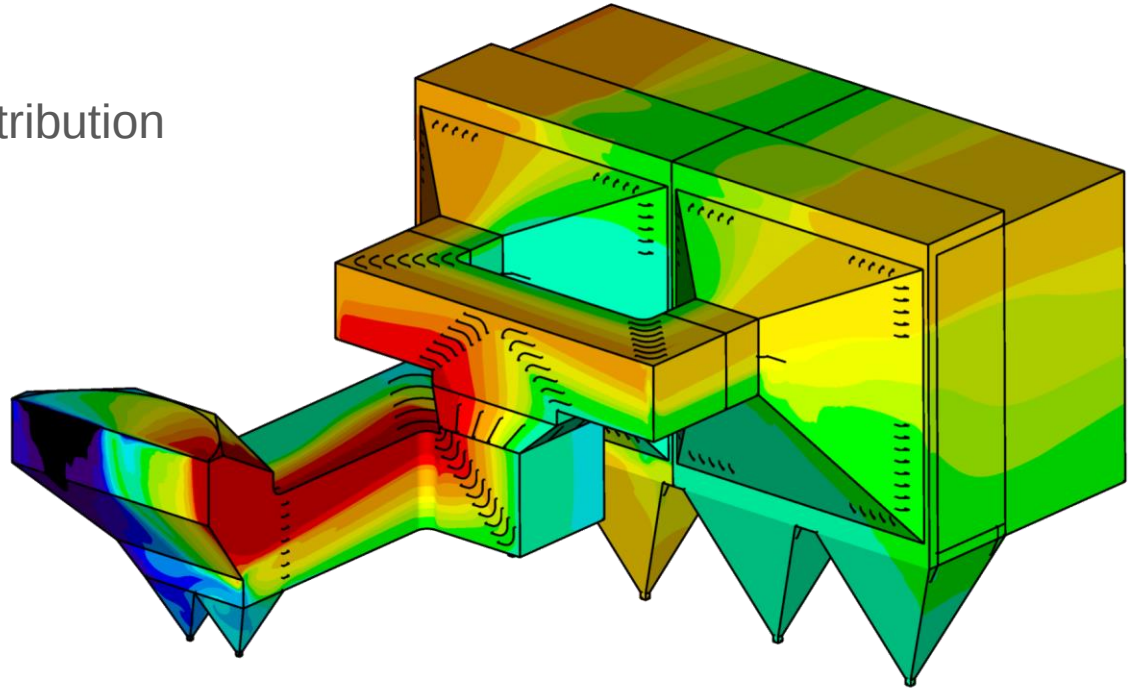


SCR Ammonia Mixing



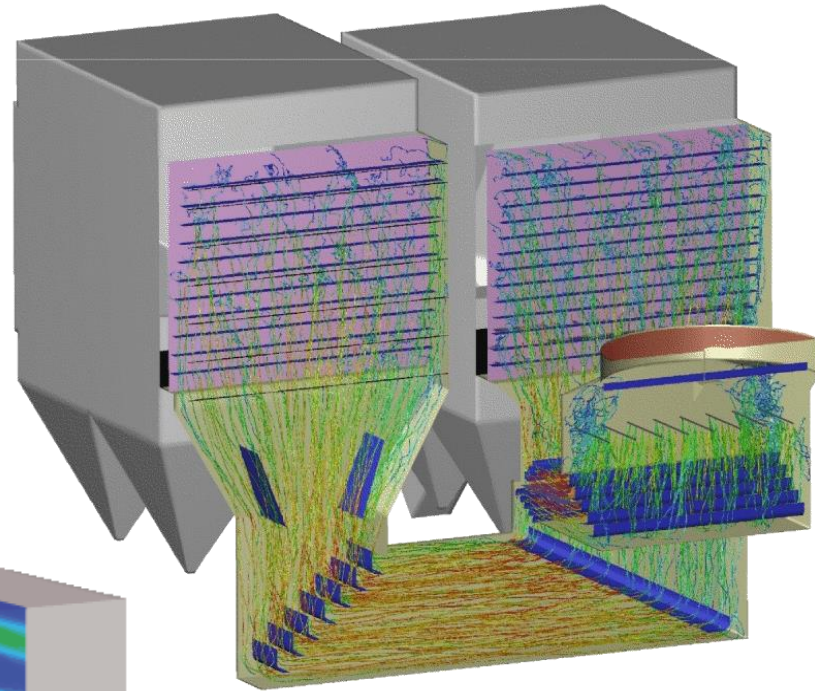
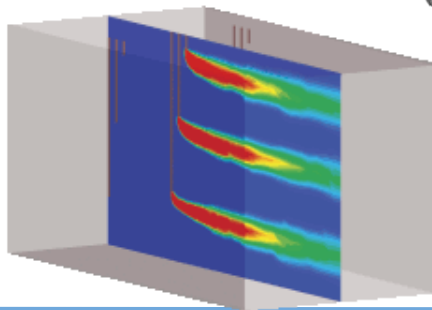
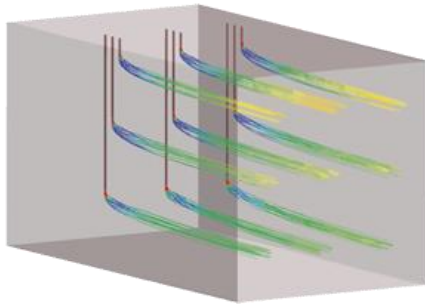
Air Heaters

- Flow and temperature distribution
- Pluggage
 - Particulate
 - ABS
 - Inleakage



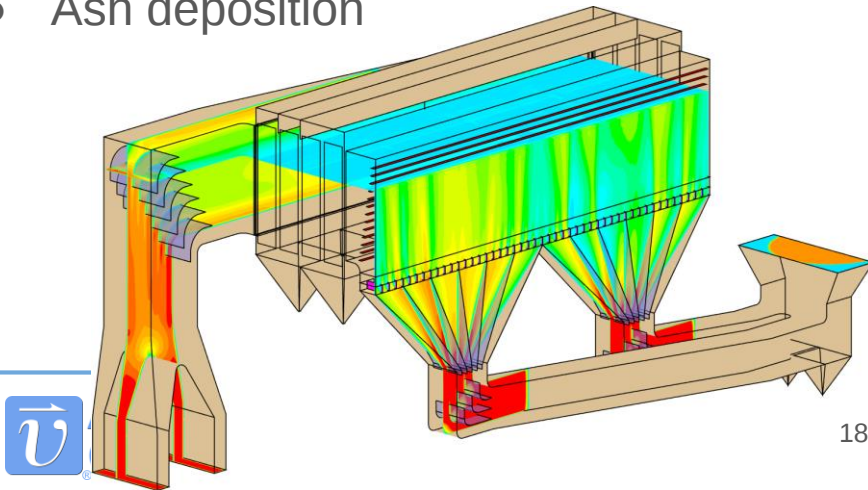
Sorbent Injection

- Injection upstream of baghouse or ESP
 - Activated carbon
 - Lime, Trona, SBS, etc.
- Uniform injection
- Mixing
- Maximize residence time



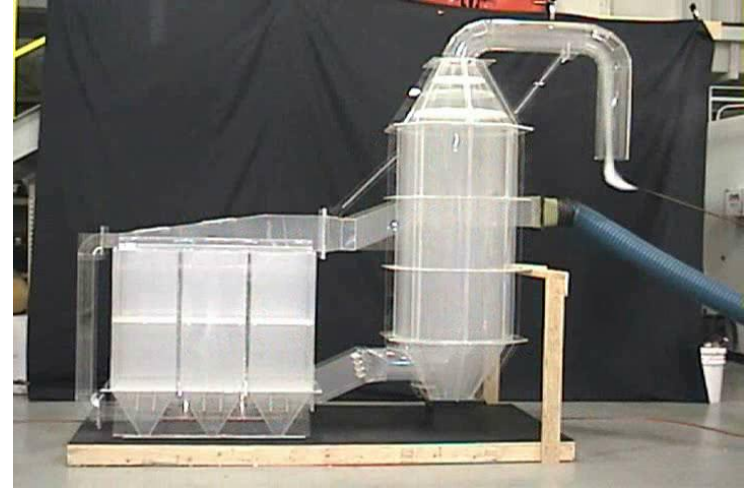
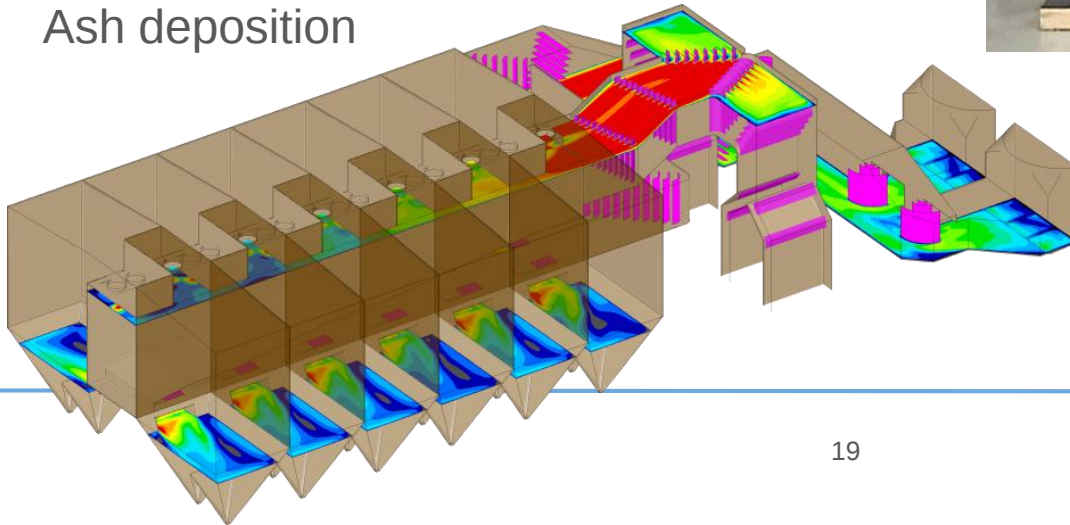
ESP / PJFF

- Flow uniformity
 - ICAC flow uniformity guidelines
 - Flow balance
 - Velocity distribution
- Pressure loss
- Ash deposition



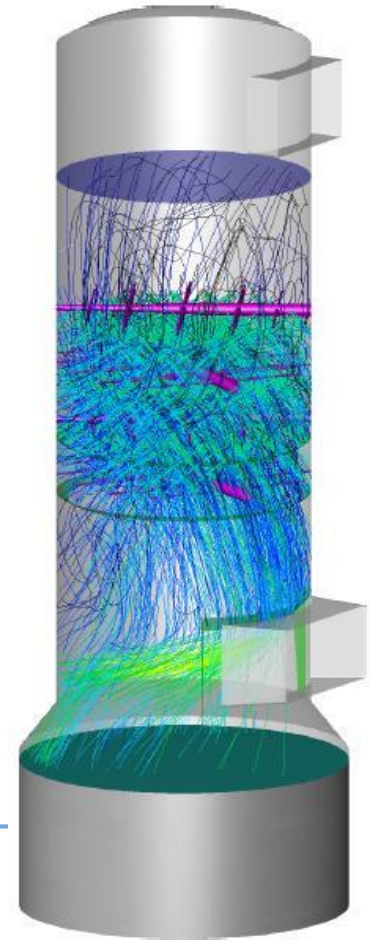
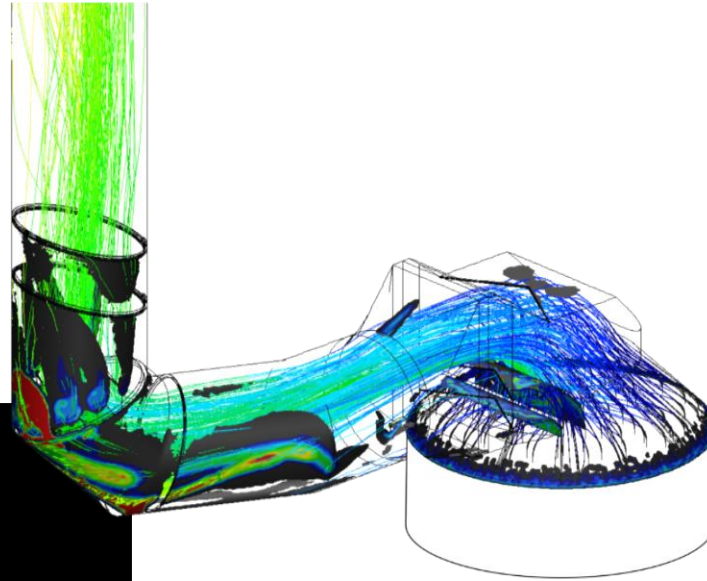
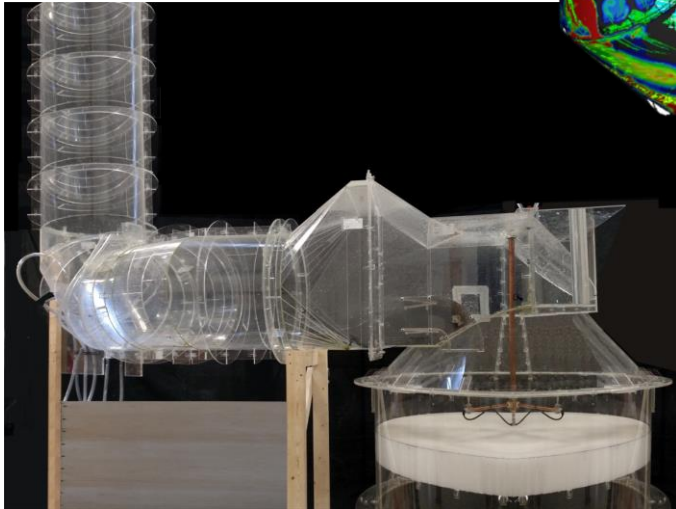
ESP / PJFF

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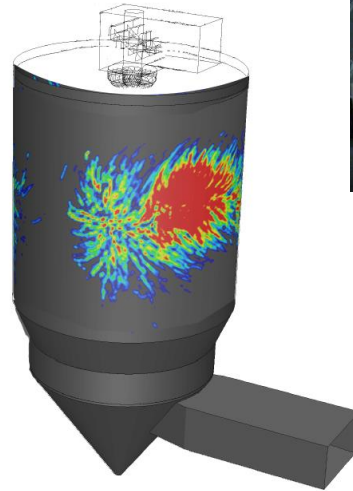
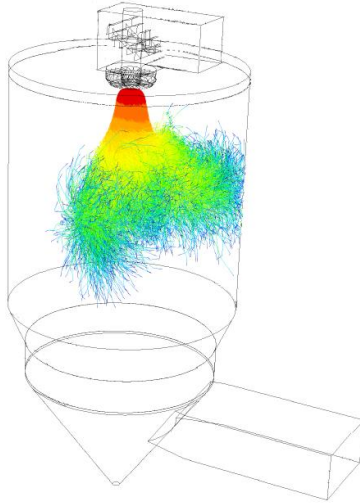
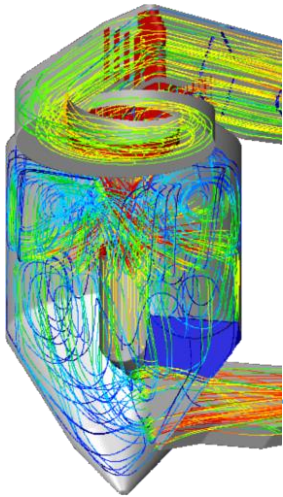
Wet FGD

- Flow uniformity
- Pressure loss
- Droplet patterns
- Spray pull-back



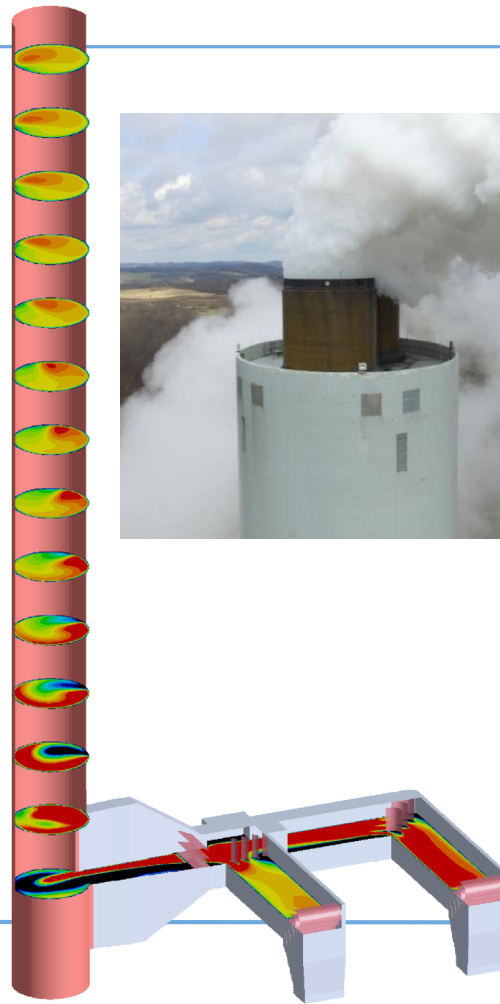
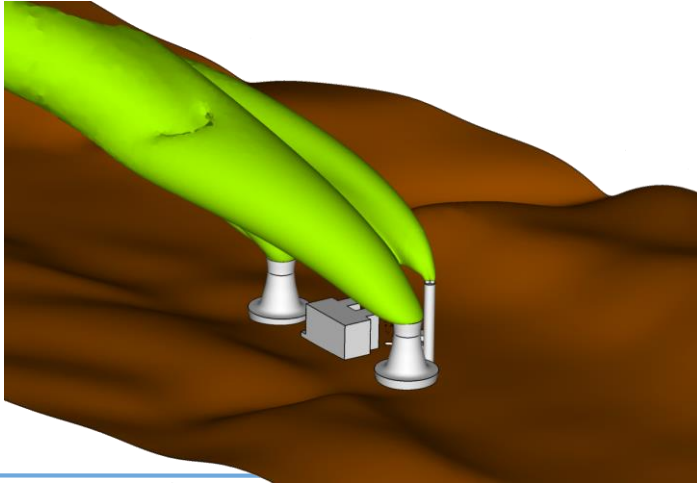
SDA

- Flow uniformity
- Pressure loss
- Flow balance
- Deposition



Stacks

- Flow distribution at CEMs
- Droplet collection
- Plume downwash

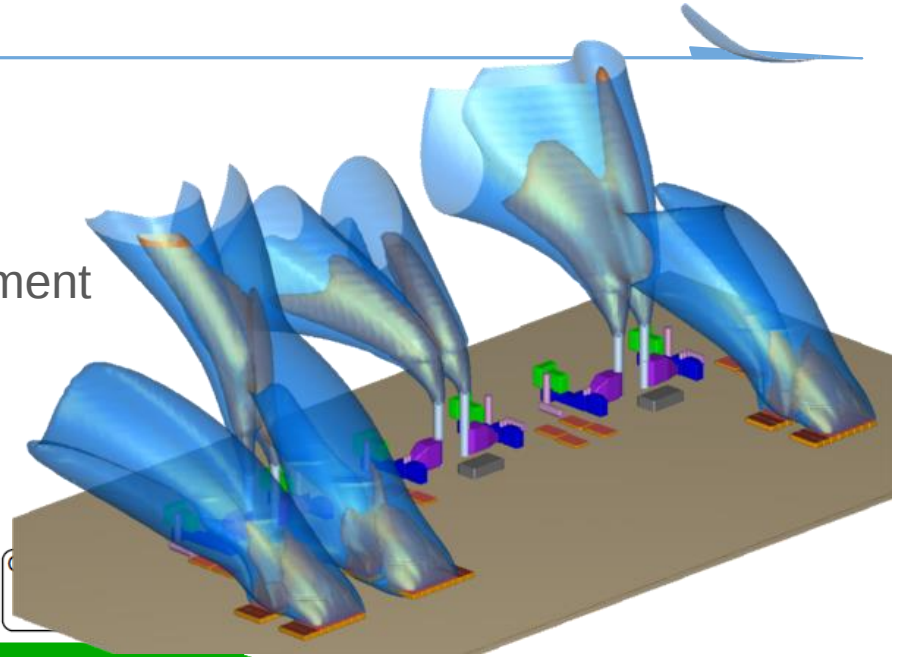
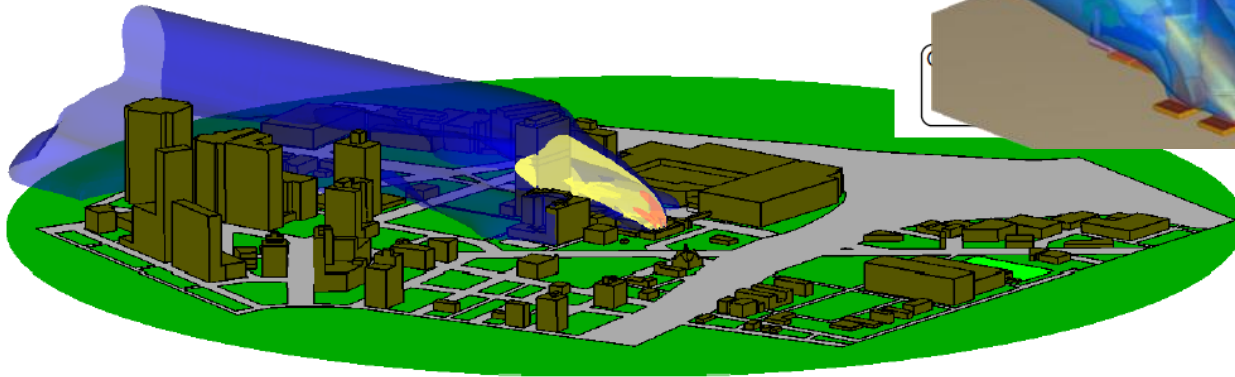


Wet Stacks



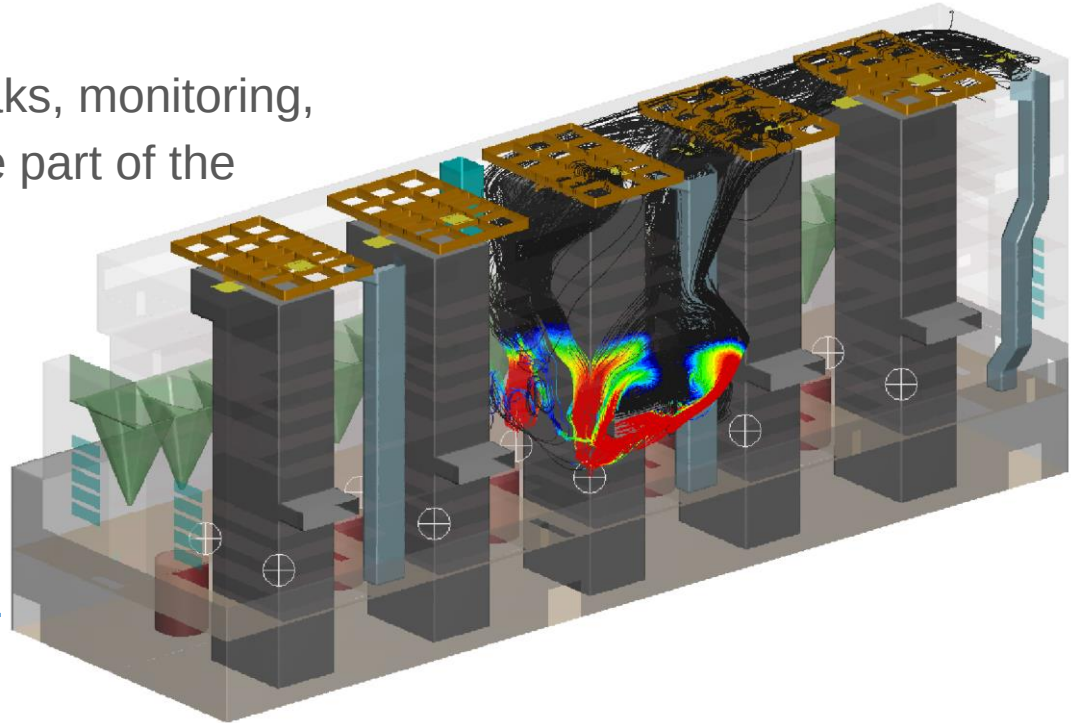
Plume Dispersion

- Flow patterns to surrounding environment
- Impact on nearby equipment



Leak Detection

- Natural gas firing at former coal plants creates new safety hazards
- CFD modeling of potential leaks, monitoring, and ventilation options can be part of the design solution



Leak Detection

- Gas leak tracking

B-253 Winter Case #1 - Boiler #27 Leaks
Fans ON (20k CFM), Doors Closed, Intake #29 Inside
25% LEL Iso-surface (View North)



Summary

- CFD and physical flow modeling are proven engineering tools to analyze flow-related issues and equipment
- Applicable to coal, gas, and co-firing plants
- Can be used to optimize air, gas, particulate, and liquid flows “from the fan to the stack”

Questions & Contact Information

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