GREENBANK
Enhancing Performance

Ammegen
Part of the Greenbank Group UK Ltd

- **Enhancing Performance**
- **Improving Combustion Efficiency**
- **Reducing Plant Emissions**

*Including Advanced $NO_X$ & $SO_X$ Reduction*

www.ammegen.com

# Delivering Tailored Solutions

Modern generating requirements demand that all thermal generating plants conform to refinements in environmental legislation, flexible operating regimes and variable fuel diets.

There has never been a more important time to optimise boiler plant operations than today.

Optimising fuel delivery and enhancing boiler performance that delivers tangible improvements in emissions and efficiency, and allows higher performance levels under variable load conditions, needs expert solutions.

Ammegen offers the highest quality, tailored and cost-effective solutions by balancing performance and cost to meet the customer's needs.

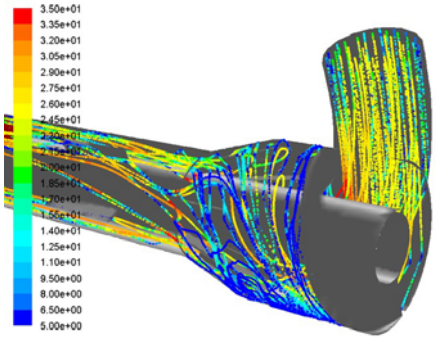
Our proven expertise and comprehensive range of technology provide scalable, modular and flexible solutions to achieve combustion optimisation. Importantly, our range of solutions provide an attractive return on investment and favourable alternatives to high-capital, conventional systems.

We provide industry leading international engineering services beginning with customised plant evaluations, in-house Computational Fluid Dynamic modelling, project management, detail design, field service, commissioning and tuning services.

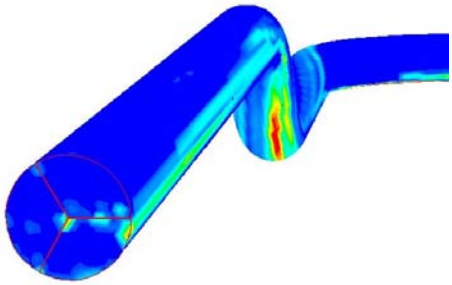
## Our unique mix of technology and know-how can deliver:

- **Combustion Optimisation via Improved Fuel/Air Distribution**
- **Advanced Combustion Modelling**
- **Combustion Optimisation via Burner Upgrades and/or Replacement**
- **Over-Fire-Air and Advanced OFA Technology**
- **Selective Non-Catalytic Reduction Technology**
- **Sorbent Injection Systems**
- **Fuel Switch Design (Coal to Gas or Biomass)**

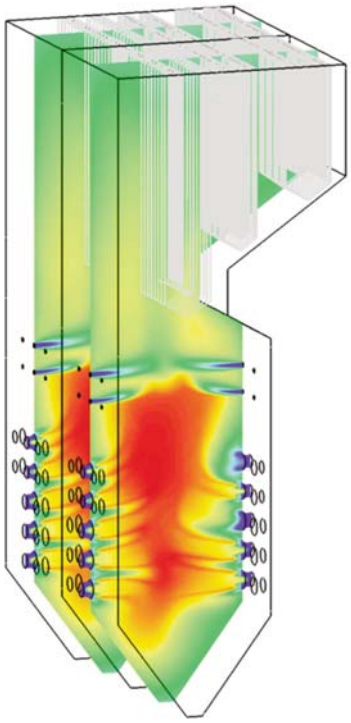
***Contact us to discuss sustainable solutions to plant operational problems.***




*CFD Model showing PF Introduction into Burner*



*PF Concentration in Pulverised Fuel Pipeline*



*Combustion Model Analysis for Coal Combustion*

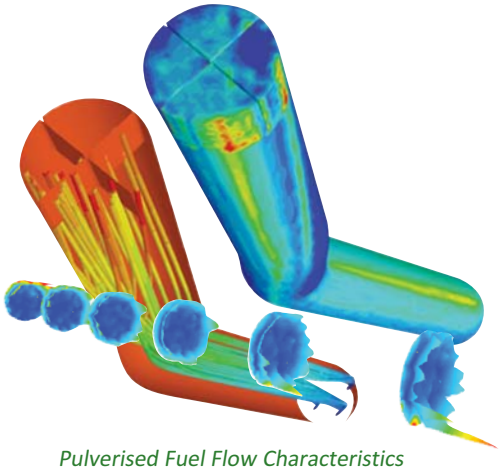
# Improved Fuel/Air Distribution

Improvement in fuel distribution across the burner zone, and the boiler load range, is critical for delivering improved combustion and the associated optimisation of boiler performance.

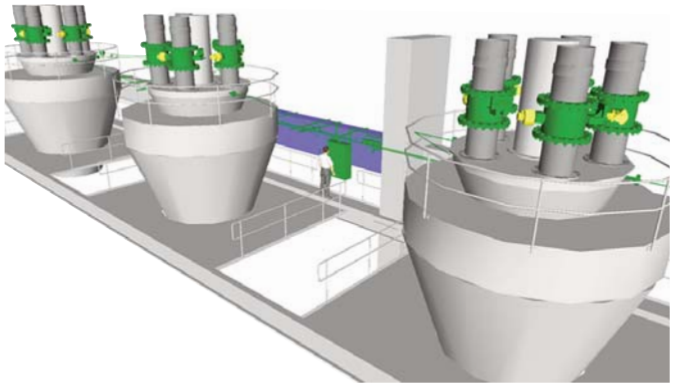
This is achieved through accurate measurement, the understanding of fuel flow characteristics and the associated velocity specific to each and every pipeline, followed by the necessary adjustment to fuel flow using the latest flow-balancing technology. This allows improved alignment of air flow and fuel flow, thereby helping to establish the optimum air-to-fuel ratio.

Addressing improved fuel distribution and associated burner-to-burner AFR is fundamental to managing emissions to air such as $NO_X$, CO, particulates and so on. It is also fundamental to addressing other combustion performance-related challenges associated with fireside corrosion, burner life and carbon-in-ash as well as slagging and fouling within the furnace.

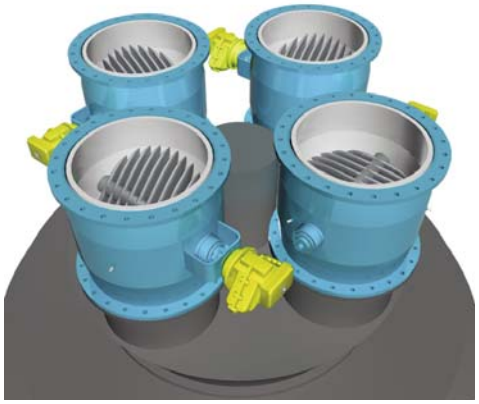
Delivery of improved combustion stability is also fundamental to improved flexible operations and minimum stable generation.



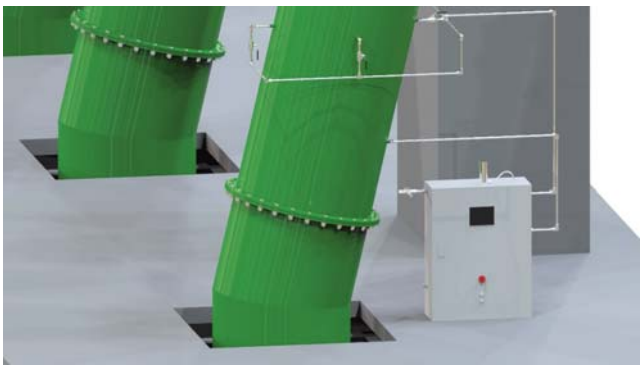
*Pulverised Fuel Flow Characteristics*



*Monitor particle fineness and milling performance using Greenbank **MillMaster®** online particle size analyser*



*Improve PF distribution and air-to-fuel ratio on multi-outlet mills using Greenbank **CoalFlo®** PF balancing dampers*



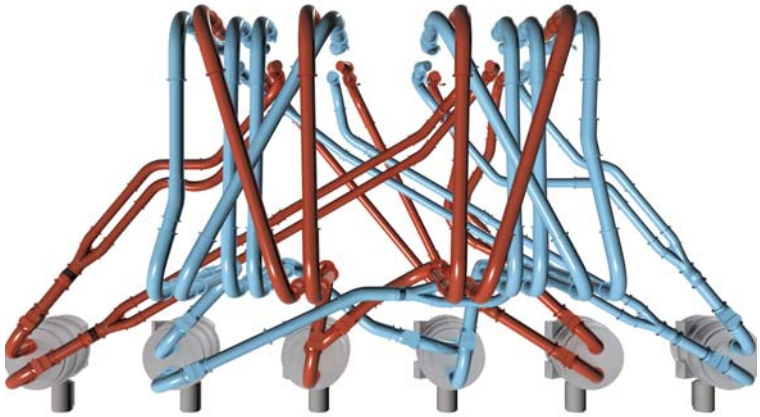
# Fuel Flow Measurement and Control

In addition to fuel distribution, pulverised fuel (PF) particle size distribution can have a significant impact on burner combustion performance. Appropriate management of the milling system is essential to improving PF particle size distribution. Therefore, online measurement and monitoring of mill exit PF particle size distribution will help facilitate appropriate mill management and ensure fuel is delivered to the burner zone at the required particle size distribution.

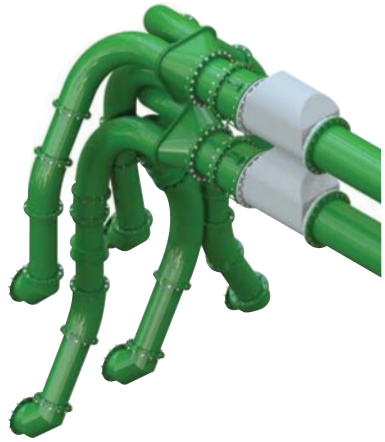
Whilst addressing and managing key influencing factors such as burner-to-burner fuel distribution, fuel quality and particle size distribution are essential to delivering improved combustion and boiler performance, there are also other factors that must be taken into account. Management of combustion zone stoichiometry (theoretical plus excess air necessary for complete combustion) is a further key element that must be addressed.

Combustion zone stoichiometry is managed via the addition of appropriate primary and secondary air flow to the furnace. Getting the balance right is extremely important but is often undermined via excessive 'uncontrolled' furnace air ingress (tramp air) at other locations such as the air-heater and duct seals.

*Measure PF distribution and velocity using Greenbank **PFMS®** online PF flow monitoring system*



*Monitor combustion efficiency directly using Greenbank **G-CAM®** carbon-in-ash (LOI) online monitor*



*Improve PF distribution and air-to-fuel ratio at pipe splitters using Greenbank **VARB®** PF diffusers*

# Computational Fluid Dynamic Modelling

Ammegen uses Computational Fluid Dynamics (CFD) modelling to simulate base condition furnace combustion, as well as to optimise our technology applications to ensure they fit with our clients' plant and business drivers.

Ammegen's research-led CFD modelling technologies can perform the vast range of calculations required to simulate the interaction of all key variables associated with combustion in utility and industrial boilers.

Each furnace, modelled by our CFD experts, is configured for its own unique fuel composition, airflow characteristics and existing equipment. The models are used to tailor our technologies to work optimally with our clients' specific systems and project objectives.

## Benefits of CFD modelling

- Enables diagnosis and solutions by identifying specific furnace operational problems
- Reduces costs by allowing designers to predict results before installation
- Enables detailed insights by providing understanding of furnace operation that cannot be obtained through testing and measurement
- Saves time by eliminating time-consuming on-site trial and error situations
- Enables pre-installation testing of fuels, equipment and plant accessories

## Our experience

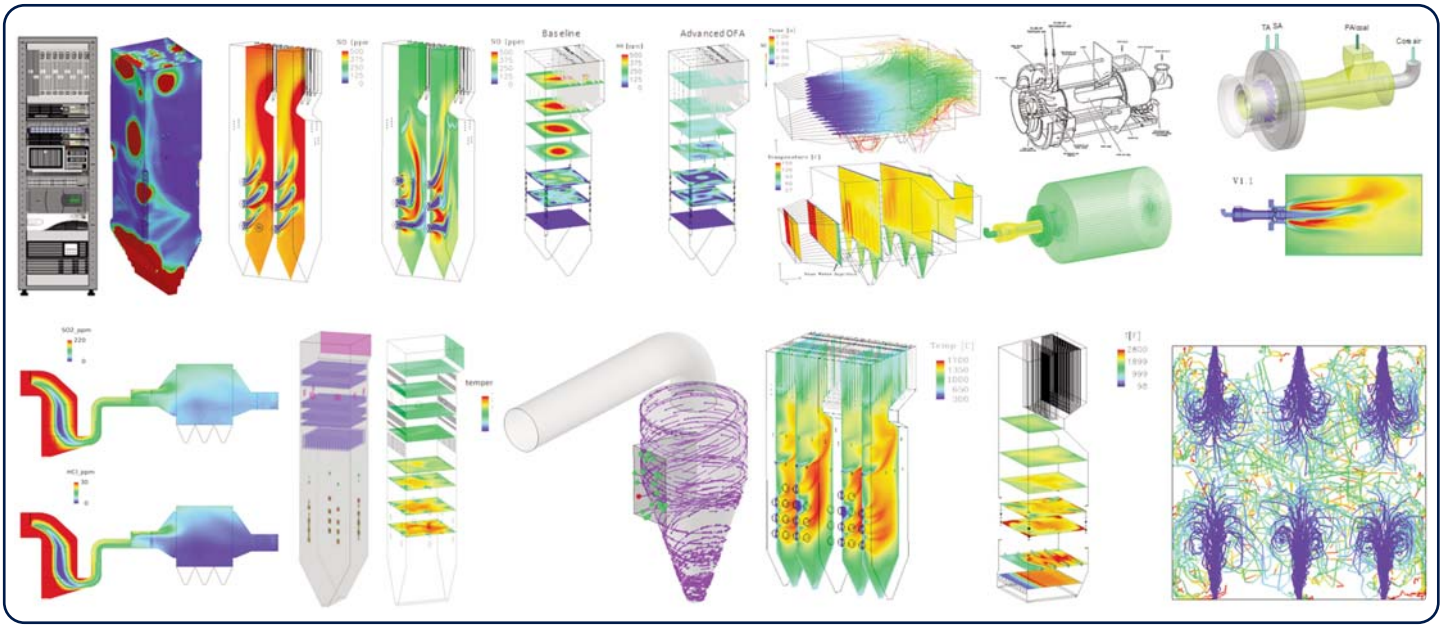
Our expertise is research-led and we have modelled over 90 models on a wide variety of boiler configurations and fuel types including:

## Fuel types

- Variety of coals
- Biomass
- Biomass co-fired with coal
- Waste products
- Oil
- Natural gas
- Waste and landfill gases

## Boiler systems

- Circulating fluidised bed (CFB)
- Tangential-fired
- Wall-fired
- Waste products
- Cyclone
- Stoker/grate-fired
- Kilns



# Advanced $NO_x$ Reduction and Over-Fire-Air

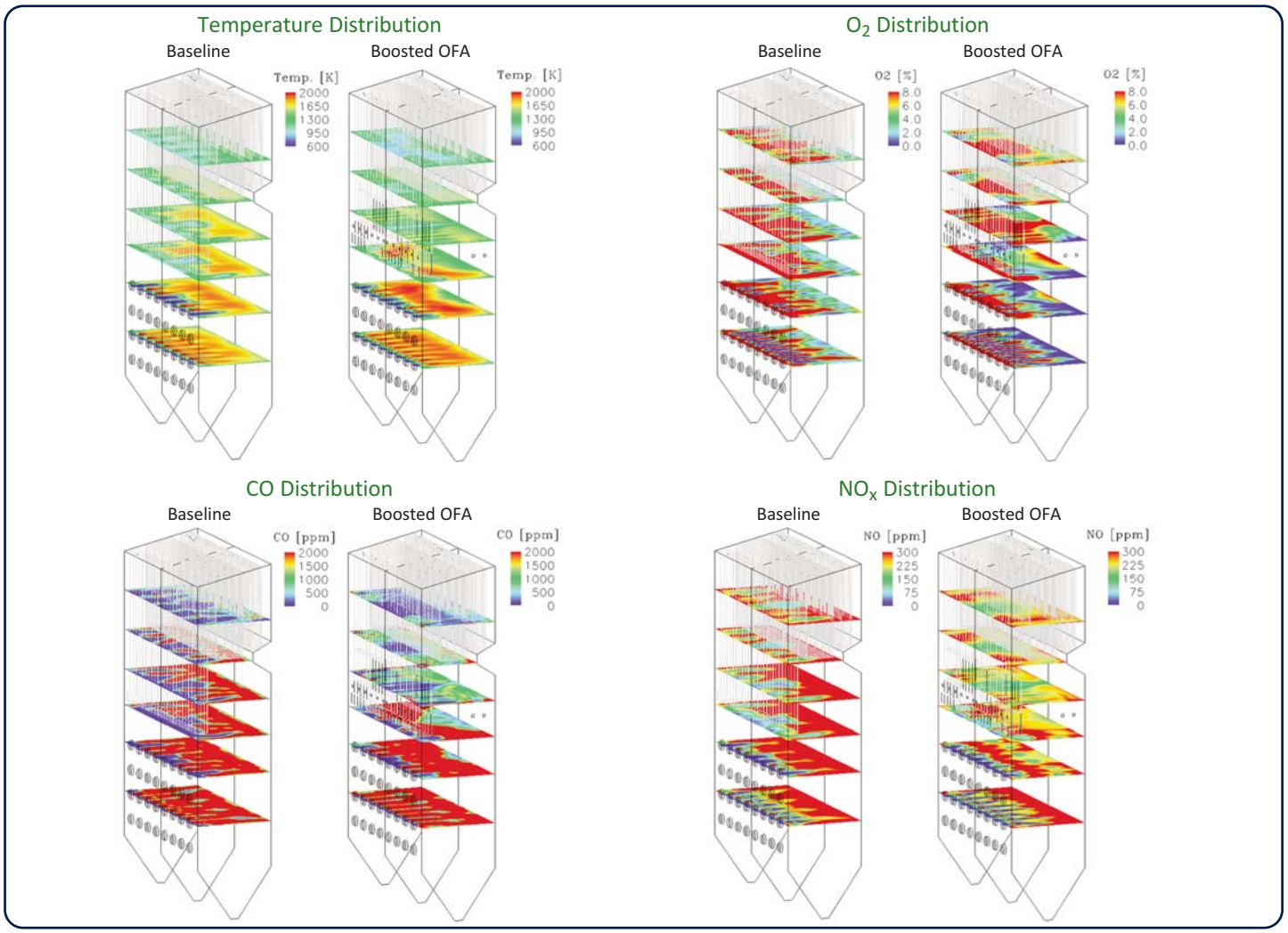
Ammegen is a pioneer in providing cost-effective $NO_x$ emissions solutions across a wide range of combustion processes. Our advanced over-fire-air (OFA) and selective non-catalytic reduction systems are the core of our $NO_x$ emissions reduction portfolio.

These systems are custom engineered to your unique application and can be applied individually or in combination with a range of integrated systems to ensure compliance with your specific and evolving needs. Our systems are customised to fit each client's unique system properties and plant configuration. CFD combustion modelling is a vital element in our design evaluation and optimisation, used to support the development of your tailored solution.

## Our Approach to OFA

- In conjunction with burner replacement or upgrades
- OFA and/or advanced boosted or hybrid OFA depending on $NO_x$ reduction requirements
- Customised design to fit specific furnace configuration
- CFD combustion modelling to locate the OFA nozzles
- Maximising $NO_x$ reduction whilst maintaining or improving combustion performance

*Below: CFD combustion models of baseline and boosted OFA for a 600MW wall-fired furnace.*



# Selective Non-Catalytic Reduction Design and Optimisation

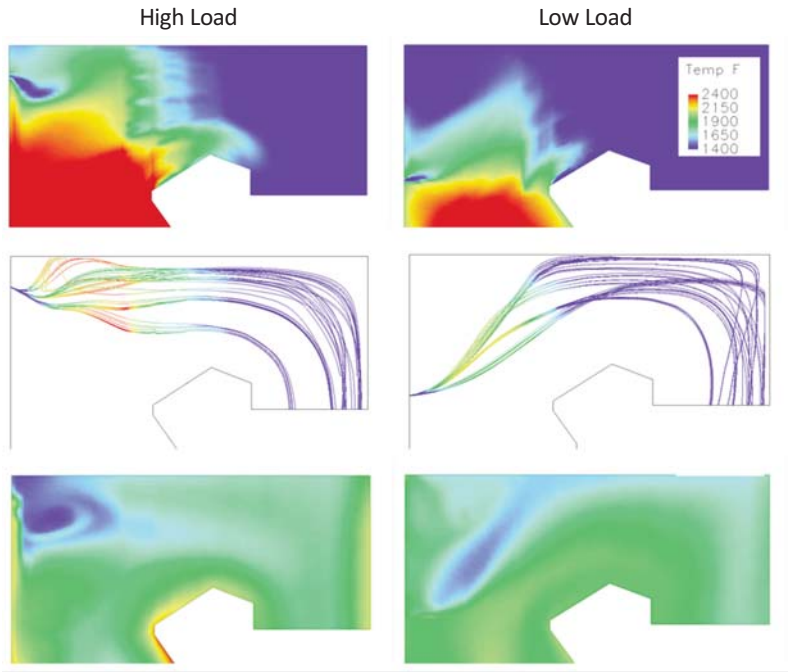
Selective Non-Catalytic Reduction (SNCR) is usually installed as an add-on to primary low $NO_x$ combustion technology. Because annual chemical costs are typically the largest consideration, the core design principle of our SNCR system is to optimise chemical injection locations and maximise mixing to increase chemical utilisation.

Through advanced feedback-control algorithms and on-site tuning, the system adapts to load and temperature changes in the furnace to preferentially introduce chemicals where the temperature is most favourable for $NO_x$ reduction. This technique increases the efficiency of reactivity, decreasing reocurring chemical usage.

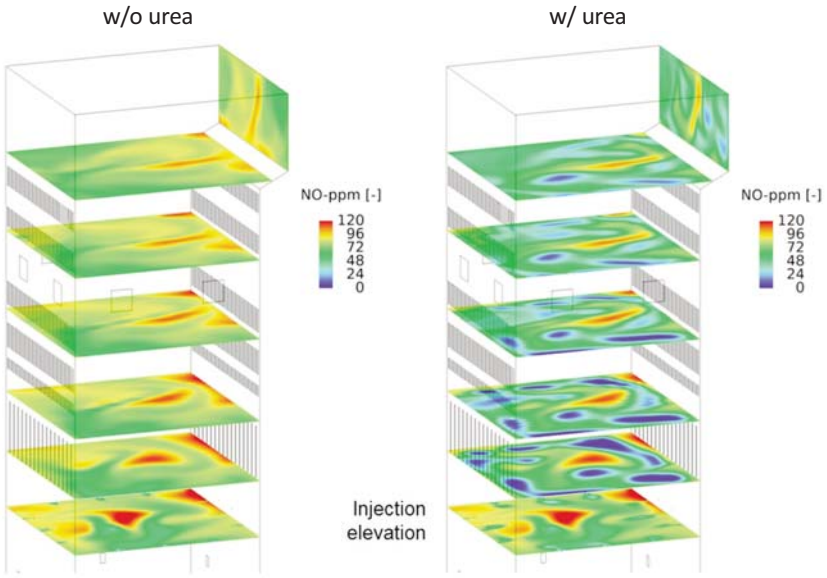
## Our Approach to SNCR

- Maximising low $NO_x$ combustion before considering SNCR
- Temperature measurement is one of the most important design parameters
- CFD of SNCR chemistry to locate nozzles
- Nozzles engineered with different angles
- Multi elevation for load change
- Adjustable urea concentration
- Individual lance urea flow control
- High chemical utilisation efficiency
- Low water usage to minimise efficiency loss
- Reliable system

*SNCR urea distribution skids.*




*Models of furnace temperature (upper), urea injection trajectory (middle) and $NO_x$ concentration (lower) of SNCR system, as applied to a 700MW boiler.*



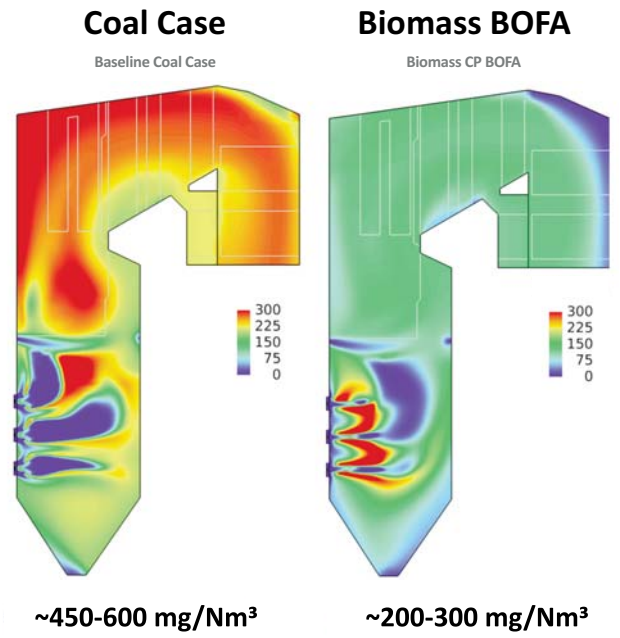

*Model of furnace outlet $NO_x$ concentration without (left) and with urea injection (right) for a 350MW tower furnace burning lignite.*

# Fuel Switch Combustion Engineering

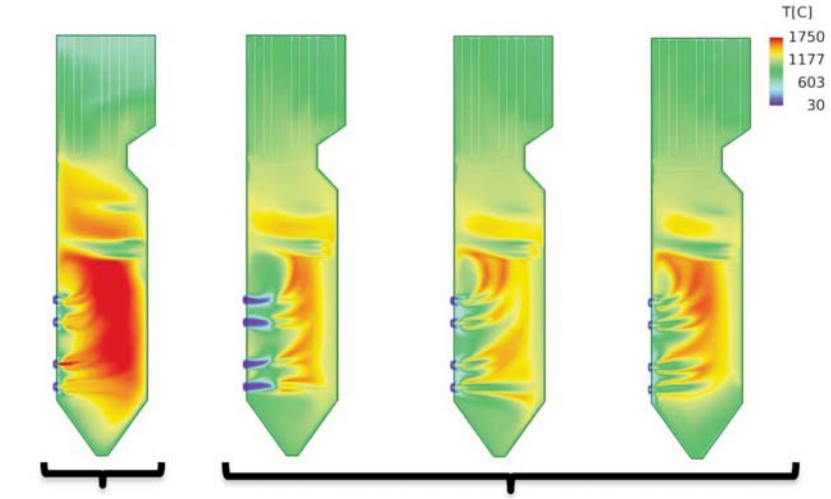
Ammegen provides solutions for fuel-switching, including coal to gas. Our biomass conversion and co-firing projects prioritise combustion efficiency and minimal thermal de-rate, ensuring regulatory emissions compliance. We provide expertise on fuel quality, its impacts on combustion efficiency and balance of plant. By determining an optimised firing configuration, identifying fuel size distribution, predicting effects of heat transfer changes and establishing potential for slagging, fouling and corrosion, we have capabilities to evaluate and manage the most important aspects of a conversion.

## Our capabilities include:

- Burner modification
- Evaluating impact of fuel properties on furnace combustion process (e.g., moisture content, particle size, volatile matter content, etc.)
- Control of slagging and corrosion formation
- Evaluation of impact on furnace exit gas temperature and hence steam temperature and boiler efficiency
- Evaluation and design of emissions control systems




*Above:*
*Modelling shows predicted $NO_x$ emissions between coal and biomass with BOFA $NO_x$ reduction technology.*



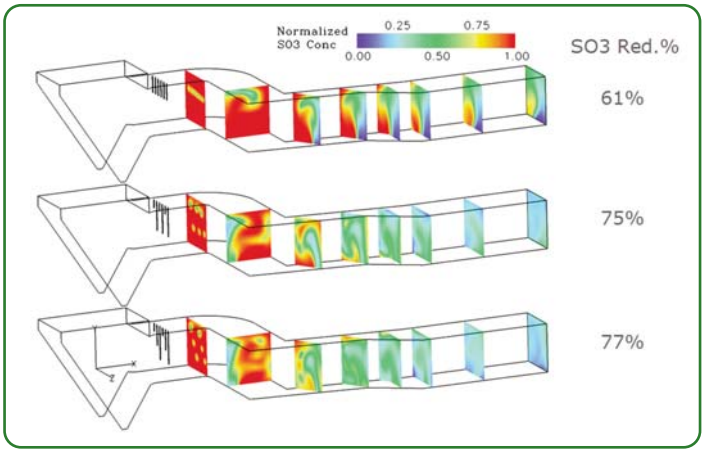

**Coal** - stable flame **Wood** - from detached to attached

*Left:*
*Modelling shows significant combustion differences between fuels and burner settings*

# Dry Sorbent/Activated Carbon Injection

Dry Sorbent Injection (DSI) and Activated Carbon Injection (ACI) technology are usually installed either before or after the air preheater. Dry sorbents can be injected to remove targeted pollutants, including $SO_2$, $SO_3$, HCl and mercury, allowing for customised regulatory compliance strategies.

We uniquely utilise CFD as a tool to optimise the design of the injection system and evaluate a wide variety of injection options to reduce overall CAPEX and OPEX for the customer.



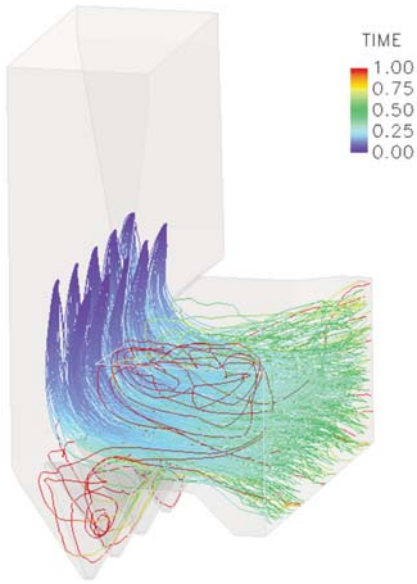

*CFD predictions illustrate the improvements gained by changing lance injection configuration to achieve reductions for the same input, and to achieve a more uniform conversion of SO3. In this case, SO3 improvements from 61 to 77% were achieved for a DSI system on a 450MW unit.*

In order to optimise a sorbent injection system, a CFD model is used as a cost-effective tool to assist in the design of the system and lance configuration. CFD models provide detailed information on flue gas flow, flue gas temperature, sorbent dispersion in duct, location of reaction, and optimisation of lance locations and positioning for maximum sorbent dispersion. The enhanced dispersion yields better sorbent utilisation, resulting in higher reduction capabilities and lower sorbent consumption.

Ammegen has significant modelling experience and capability in the design and optimisation of DSI and Activated Carbon Injection (ACI) technology for removing pollutants from flue-gas:

- Hydrated lime + $SO_3$
- Hydrated lime + $HCl/SO_2$
- Trona + $HCl/SO_2$
- Limestone + $SO_2$
- Activated carbon + $Hg/HgCl_2$

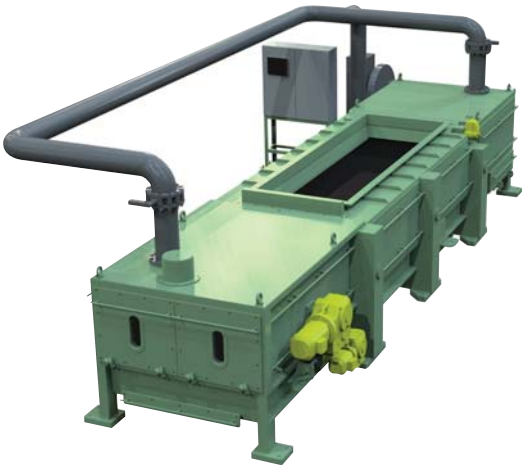
An advanced CFD model provides 'real-life' predictions, including not only the mixing and flow-related output that a conventional CFD can provide, but also gas species concentration and reduction predictions.




*CFD model to determine injection locations and number of injections to obtain the best coverage of sorbent downstream before air-heater inlet*

# Greenbank Boiler Products and Systems Overview

## Measurement, Control and Efficiency Improvement Products



**GravMaster®**
Pressurised Gravimetric Feeder

**CoalFlo Damper®**
Mill Outlet Balancing Damper

**MillMaster®**
Particle Size Analyser

**VARB®**
Pulverised Fuel Rope Diffuser

**PfMaster®**
Pulverised Fuel Monitoring System

**G-CAM®**
Carbon-in-Ash Analyser

# About

Ammegen Limited is a joint venture combining the strengths of Greenbank Group (UK), Nitec Energy Services (Canada) and Reaction Analytic Solutions Corporation (USA) to bring performance enhancement and advanced air pollution control solutions to the global market for the reduction of $NO_X$, CO, $SO_2$, $SO_3$ and HCl. This includes both pre- and post-combustion technologies.

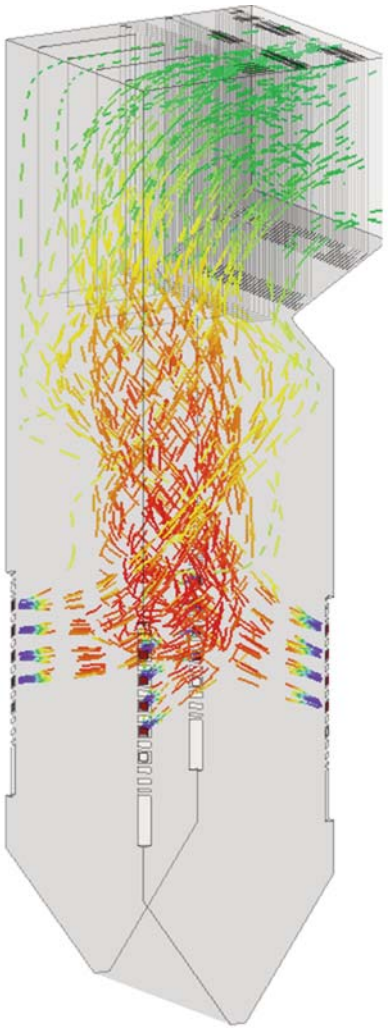
We have a proven record in the development and delivery of combustion technologies for the global market and a reputation for on-time delivery of projects. With over 18 years of computational fluid dynamic experience, Ammegen can accurately model a wide range of plant systems, from fuel delivery, burner design, furnace combustion optimisation, and flue gas duct design, to proprietary chemistry modelling and sorbent/reagent reactions. Our experts have research-driven experience in developing over 90 models on a wide variety of boiler configurations and fuel types. Our customers draw on our reputation for continual technological refinement and bespoke solutions.

Ammegen provides an integrated solution to plant operators incorporating computational fluid dynamic study and analysis with the technological solutions tailored to optimise furnace combustion and air pollution control. Our efficiencies are backed up with guarantees.

We deliver a unique portfolio of combustion improvement products and technologies, together with a wide range of technical solutions, aimed at increasing efficiency and reducing greenhouse emissions at small and large thermal power generating plants. In short, our services and equipment offer the customer a sustainable model of plant optimisation. Our integrated solutions empower the customer to manage and monitor their own plant, with ongoing support and spares.

## The Ammegen Team Combustion References Include:

- Over 90 furnace combustion references
- Unit capacity ranging from 20MW to 700MW
- A variety of fuels, from coal, biomass, natural gas to heavy oil
- A variety of furnace configurations, including tangential-fired, wall-fired, stoker, fluidised bed, kilns, etc
- Furnace combustion, mixing and heat transfer evaluation
- Combustion optimisation through burner setting adjustment
- Over-fire air (OFA) design
- Selective Non-Catalytic Reduction (SNCR) design
- Furnace sorbent injection evaluation and design

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## The Greenbank Group UK Ltd

Incorporating:

**Ammegen Ltd**
**GAIM Ltd**
**Greenbank Engineering Services Ltd**
**Greenbank India Pvt Ltd**
**Greenbank Terotech Ltd**

Wear Protection and Lining Systems
Pipework Ductwork and Supporting Systems
Biomass Conveying Systems
Heavy Industrial Fabrication and Machining Facilities
Combustion Optimisation Products and Systems
CFD andDEM computer modelling
Continuous and Gravimetric Weighing Products and Systems
R&D and Test Facilities
$NO_x$ Reduction
Advanced-Over-Fire-Air
Advanced SNCR System

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