- environmental sampling and handling of particulates, trace elements and organics and inorganic/organic leachability capabilities; and
- non-intrusive laser measurements (Coherent Anti-Stokes Raman Spectroscopy).

Facilities supporting this research:

- 3.6 GJ/h (1 MW thermal) flame research tunnel furnace that can be fired by coal, oil, natural gas, or other specialty fuels and burners;
- non-intrusive laser measurements (CARS, see Figure 6);
- intrusive measurements of temperature, gaseous speciation, heat transfer and radiation profiles;
- 3.6 GJ/h (1 MW thermal) circulating fluidized-bed combustor;
- 3.6 GJ/h (1 MW thermal) gas fired rotary kiln for waste conditioning and remediation;
- mini-pilot-scale circulating fluidized bed reactor for sorbent studies;
- laboratory-scale equipment for micro-analysis;
- 3.6 GJ/h (1 MW thermal) pilot scale research gasifer;
- 1.3 GJ/h (350 kW thermal) pilot-scale pressurized entrained flow gasifier;
- 3.6 GJ/h (1 MW thermal) bubbling fluidized bed combustor;
- two fully-instrumented appliance testing cells for residential system development, allowing efficiency and emission determinations; and
- 4 GJ/h (1.1 MW thermal) pilot-scale-grate boiler.

Centre of Excellence for Stationary Combustion

CFF's people and facilities, combined with its research network make this group the Canadian Centre of Excellence for stationary combustion. CFF welcomes joint projects with industrial parties and other organizations that wish to make use of its combustion research facilities and expertise.

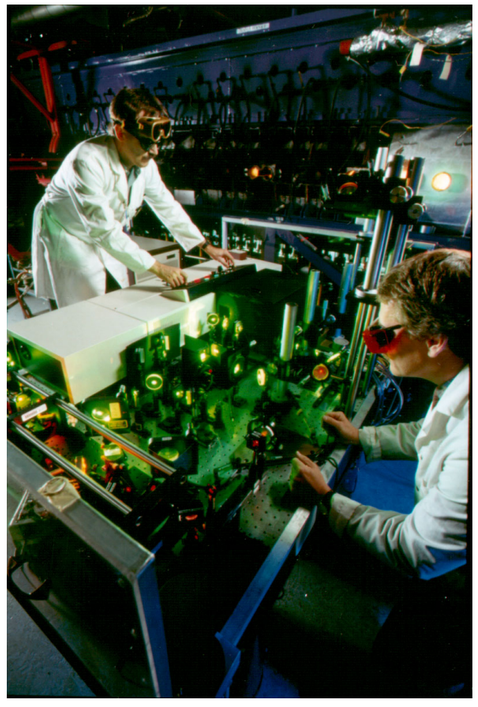

Figure 6: CARS

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ENERGY TO BURN

CLEAN ENERGY TECHNOLOGIES

For many industries that use stationary-source combustion, improved efficiency and fuel substitution embody the promise for coping with concerns about stricter environmental requirements. More than that, they promise also to maintain the competitiveness in domestic and off shore markets. Through world-class facilities and expertise, the Clean Fossil Fuels and Power Generation group at the CANMET Energy Technology Centre - Ottawa (CETC-O) plays an important role in helping industry achieve these goals.

In partnership with industry, CETC-O conducts research aimed at reducing the risks and costs associated with introducing process changes, technological innovations and new products, thereby helping industry in meeting environmental standards and staying competitive.

Another important role played by CETC-O is the establishment of networks with industry, governments and universities in affairs pertaining to combustion research, thereby providing Canadian clients and stakeholders with market intelligence. Industry recognizes CETC-O, a research arm of Natural Resources Canada, as an impartial and independent expert with whom confidential information can be shared without compromising competitive advantages.

Clean Fossil Fuels and Power Generation (CFF) group is Canada's centre of excellence in pilot- and demonstration-scale research and development for combustion, including computer modelling of all types of fuel or combustibles in stationary equipment.

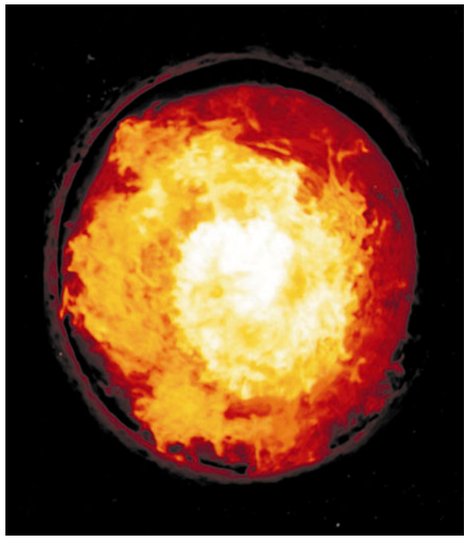

Figure 1: Low Swirl Oil Flame

Many concerns have been mitigated because of its successes:

- finding reliable methods for burner evaluation;
- determining combustion performance and emission characteristics of coal, oil, biomass, natural gas and specialty fuels (see Figure 1); and
- finding the means for the increased use of alternative and renewable fuels from agricultural and wood wastes.

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Figure 2: Flame Probing

Pace-setting Research

CFF's combustion engineers and scientists focus on achieving, by new or improved technological means, optimal performance from combustion processes and equipment. Optimal performance is the key to more efficient use of resources and reduced environmental emissions.

Burner Evaluation

CFF's scientists and engineers apply non-intrusive diagnostic techniques to flames which assess the performance of both low-NO_x burners and low-grade, relatively cheaper fuels.

On the basis of the assessment, they can select the best burner for a given fuel-furnace combination and prescribe the optimal operating conditions for it.

Low-grade Fuels

CFF works with industry to develop fluidized bed combustion (FBC) and rotary kiln technologies. FBC is well suited for burning such low-grade fuels as coal washery rejects, petroleum coke and waste wood products. This technology offers several benefits, among them:

- long combustion residence times to achieve complete combustion;
- lower temperatures to control NO_x formation;
- the flexibility to accept a wide range of fuel types; and
- sorbents in sand or limestone beds to reduce SO_x.

Rotary kilns offer comparable benefits and an alternative means of testing, burning, or processing contaminated soils and other combustible waste materials.

Coal, Oil and Gas Combustion

CFF conducts research into all aspects of coal combustion:

- determining combustion performance, heat transfer and emission characteristics of Canadian coals and rejects for conventional power generation and other industrial uses;
- developing mathematical models of coal, oil and natural gas combustion to predict flame properties, performance and emissions; and
- studying the fundamentals of ignition, devolatilization and combustion burnouts of unreactive Canadian coals and reject materials for fuel substitution.

Biomass Combustion - Residential/Commercial Industrial Applications

To meet market needs for low-emission, high performance combustion equipment in the residential, commercial and industrial sectors, CFF works with manufacturers to improve the combustion performance of biomass-fired systems. The group conducts research into the potential for increased use of

Figure 3: Woodstove Testing

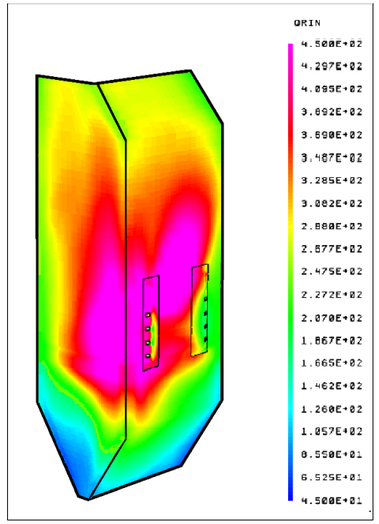

Figure 4: Incident Radiant Heat Transfer on a Utilitv Boiler Wall

alternative and renewable solid fuels as supplemental energy sources (see Figure 3). Fully instrumented facilities allow detailed evaluations of performance characteristics, including the generation of volatile organic compounds (VOCs). This research enables scientists to recommend designs for improving the combustion performance of systems to manufacturers.

Modelling/Artificial-Intelligence Systems Development

CFF's scientists model and simulate solutions to problems in thermodynamics, combustion, heat transfer and fluid mechanics aiming to optimize industrial processes (see Figure 4). In order to study combustion performance, heat transfer and emission characteristics, CFF has developed sophisticated flow simulation programs for boilers and furnaces.

Residential/Commercial Energy Systems

CFF recommends methods to manufacturers of space-heating and industrial systems for:

- improving methods for combustion performance and efficiency testing; and
- evaluating the combustion and emission performance of distillates and alternative fuels.

Analytical Capabilities

CETC-O's Analytical Services group tests the quality of fuels and combustion products and by products according to industrial standard test methods accepted worldwide.

They also deal with characterization problems regarding all aspects of fuel production and utilization.

To do so, this group operates such equipment as:

- X-ray photoelectron spectroscopy (XPS);
- scanning auger microscopy (SAM);
- nuclear magnetic resonance (NMR);
- infrared spectroscopy (IR) thermo-gravimetric (TG) and TG/IR analysis;
- gas (GC), liquid (LC), ionic (IC) and supercritical fluid (SFC) chromatography;
- high-resolution mass spectrometry (MS) and gas chromatography/mass spectroscopy (GC/MS);
- X-ray diffraction (powder XRD) and X-ray fluorescence spectrometry (XRF);
- inductively coupled plasma (ICP), atomic absorption (AA) and graphite furnace AA (GFAA) spectrometries;

Figure 5: Rotary Kiln