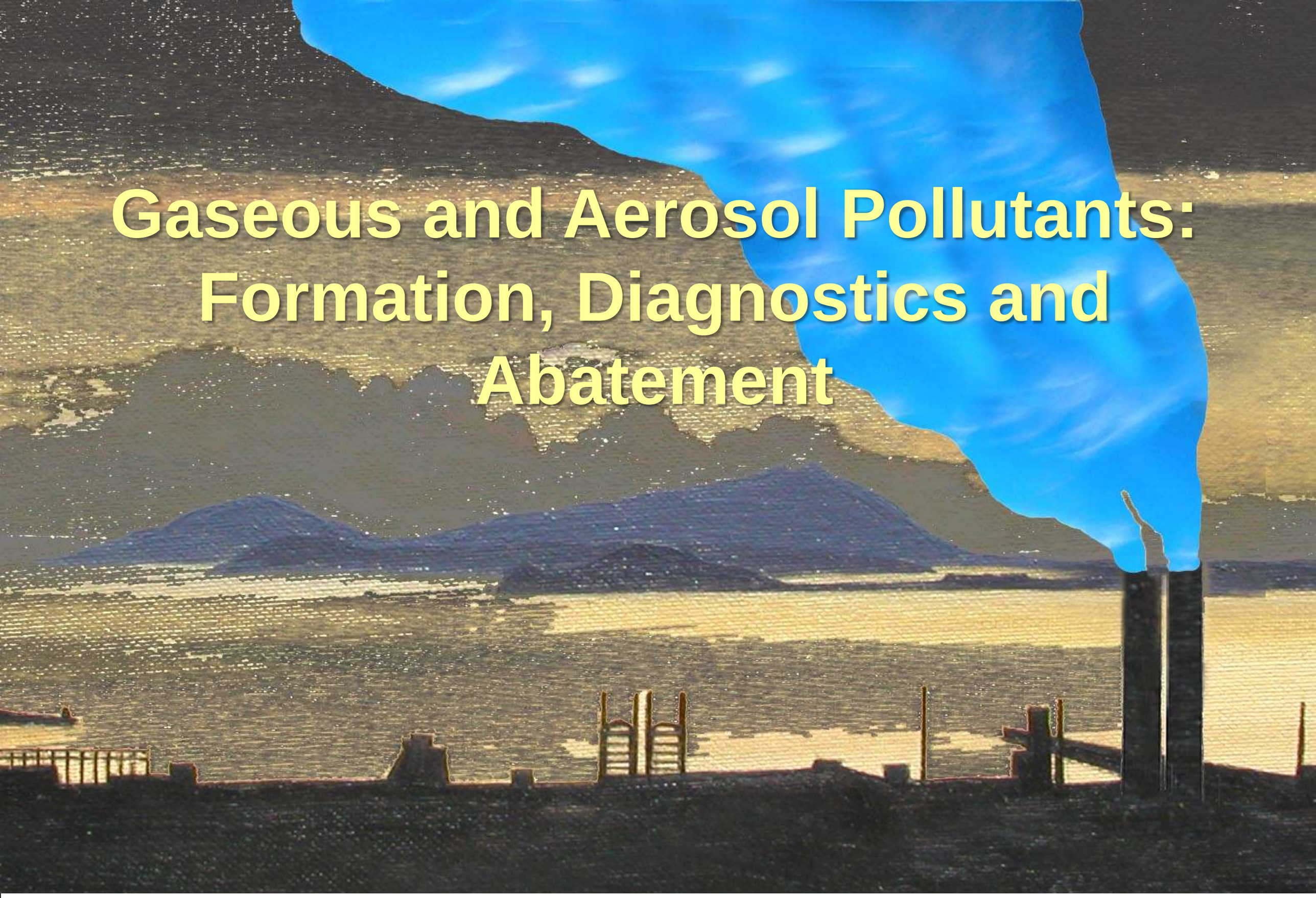
Gaseous and Aerosol Pollutants: Formation, Diagnostics and Abatement



Istituto di Ricerche sulla Combustione

Consiglio Nazionale delle Ricerche

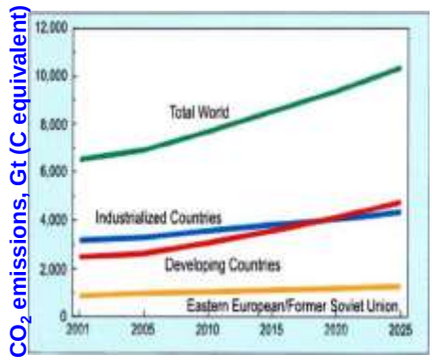
BACKGROUND

Combustion pollutants scenario

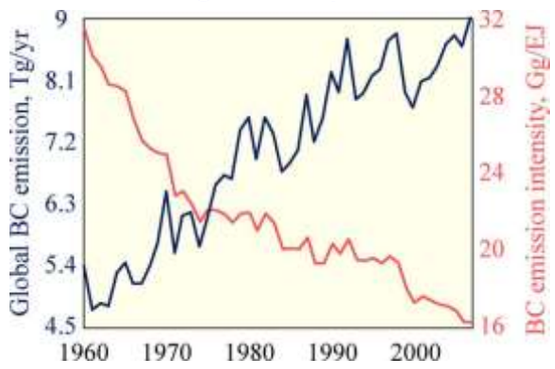
Partially solved Problems:

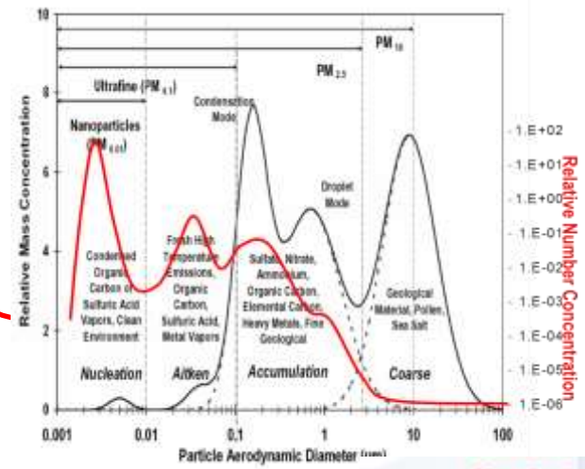
Critical Problems:

Previsional trend of CO_2 emissions increase

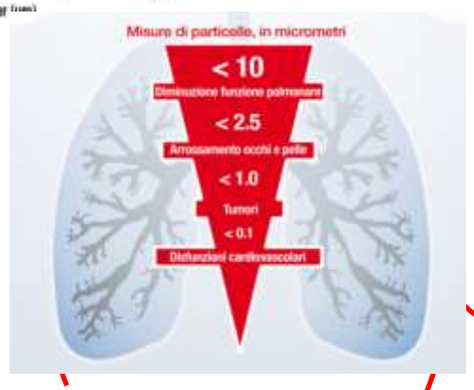


Black carbon emission increases in spite of technological improvements





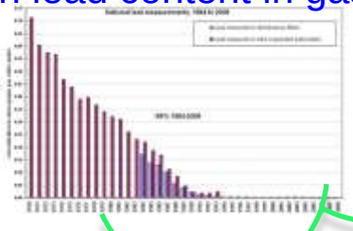
Ultrafine particles are the most abundant and deeply penetrate the repiratory system



NO_X, SO_X and heavy metals mostly local pollution problems requiring control to ultra-low emissions

Solved Problems:

Lead concentrations decreased dramatically after regulations on lead content in gasoline



The Major Challenges of the Project:

HORIZON 2020

Secure, clean and efficient energy

Smart, green and integrated transport

Climate action, resource efficiency and raw materials

EXPERTISE, METHODS AND INSTRUMENTATION

Expertise

- Combustion chemistry and physics
- Characterization of organic and inorganic aerosols
- Optics and Spectroscopy
- Mass spectrometry
- On-line and off-line chemical-physical techniques
- Reactor design and operation
- Design of catalytic systems
- Heat and mass transfer and kinetics in multi-phase systems
- Fluid-dynamics of homogeneous and multi-phase systems

Methods

- Sampling and off-line chemical and spectroscopic analysis of pollutants
- On-line advanced diagnostics and gas analysis
- CFD simulation
- Sizing methods (scattering, LII, TRFA, Scanning Mobility Particle Sizing)
- Laser spectroscopy
- Scanning Probe Microscopy
- Experimental testing and modeling of multi-phase systems

Instrumentation

- Molecular beam mass spectrometer
- Mass spectrometric, spectroscopic and chromatographic instruments
- Differential Mobility Analyzer
- Laser diagnostics
- Atomic Force Microscope
- Raman Microscope
- SEM/EDX
- Lab-scale catalytic and multi-phase reactors
- On-line gas analyzers

Researchers

M. Alfè, C. Allouis,
B. Apicella, A. Ciajolo,
S. Cimino, M. Commodo,
M. de Joannon, V. Di Sarli,
F. Greco, L. Lisi,
G. Landi, P. Minutolo,
R. Ragucci, P. Sabia,
F. Scala

PROJECT LINES

1 - Formation mechanisms of pollutants in combustion sources

2 - New diagnostics for the monitoring of regulated and unregulated pollutant emissions from combustion sources

3 - Reduction of pollutant emissions from combustion/gasification sources

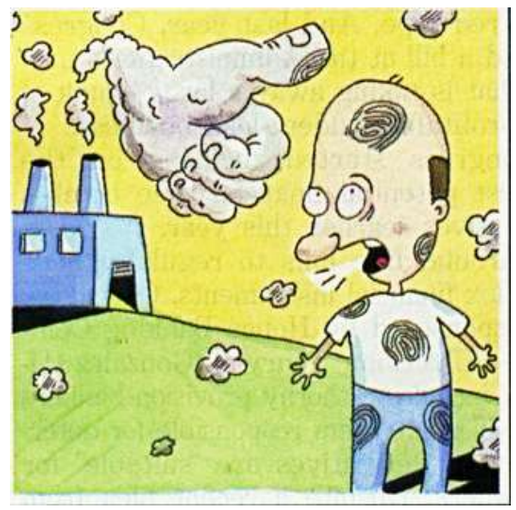
PROJECT LINE: Formation mechanisms of pollutants in combustion sources

Present activities @ IRC

- ✓ Experimental and theoretical studies of particle inception and dynamic of granular systems
  - Particle inception
  - Surface growth
  - Particle coagulation/agglomeration
  - Oxidation kinetics
- ✓ Chemical- Physical Characterization of particulate matter from fossil and alternative fuels combustion
  - Fine and ultrafine particles
  - Organic particles
  - Inorganic particles
  - PAH and other large molecules

Mid-term vision

- ✓ Generation of a comprehensive pollutant database
  - Complete understanding of soot formation mechanism
  - Identification of new classes of pollutants
  - Identification of true sources of air pollutants using their “fingerprints”



PROJECT LINE: New diagnostics for the monitoring of regulated and unregulated pollutant emissions from combustion sources

Present activities @ IRC

Methods

- ✓ In-situ, on-line and off line advanced diagnostics of ultrafine particles
- ✓ Conventional techniques for regulated pollutants
- ✓ Development of new techniques for regulated and unregulated pollutants
- ✓ Advanced diagnostic of flame instabilities

Systems

- ✓ Fossil and alternative fuels combustion
- ✓ Laboratory flames – premixed, diffusion, laminar, turbulent
- ✓ Engines
- ✓ Domestic burners
- ✓ Pre-pilot plants

Mid-term vision

- ✓ Real-time diagnostics for regulated and unregulated pollutants
- ✓ Real time control of the stability of clean combustion processes
- ✓ Improvement of carbon capture and sequestration processes

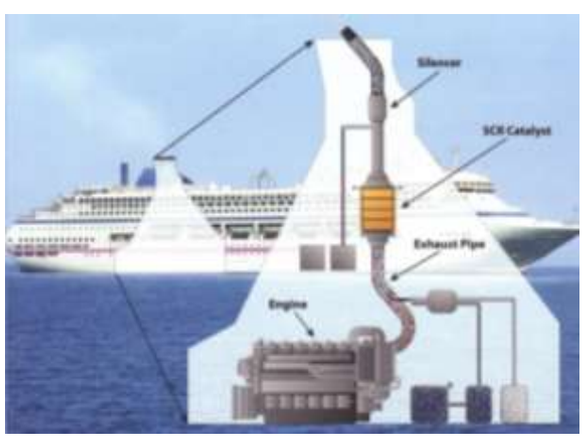
PROJECT LINE: Reduction of pollutant emissions from combustion/ gasification sources

Present activities @ IRC

- ✓ Non-conventional methods for NO_X and SO_2 reduction from combustion sources:
  - Sea Water Scrubbing + Low Temperature NH_3-SCR for combined SO_2 and NO_X reduction in marine diesel engine application;
  - NO_X storage-decomposition for automotive application.
- ✓ Development of novel regenerable Mn-based sorbents for enhanced mercury vapor capture from combustion/gasification flue gases.
- ✓ Reduction of oxygen and non-condensable gases through controlled post-combustion for purification of CO_2 streams.
- ✓ Particulate emissions reduction through water vapor condensation.
- ✓ Combined particulate and NO_X reduction in novel regenerable catalytic filters.

Mid-term vision

- ✓ Ultra-low particulate, NOX and SO2 emissions from marine engines and automotive exhausts.
- ✓ Cost-effective capture technologies for heavy metals and trace elements.



MAIN COLLABORATIONS/PROJECTS

Research partners

•Collaborations:

- Università di Napoli Federico II
- Seconda Università di Napoli
- Politecnico di Milano
- CNISM Consorzio Nazionale Interuniversitario per le Scienze Fisiche della Materia
- INFN Istituto Nazionale di Fisica Nucleare
- Centro Interdipartimentale Scansetti di Torino
- CNRS
- Ecole Normale Superieure Paris (ENS)
- Sincrotrone Trieste S.C.P.A.
- Lund University
- ENEA
- Imperial College
- Illinois Institute of Technology
- Nanyang Technological University (Singapore)

Industrial Partners

•Collaborations :

- ENEL Produzione S.P.A. – Ricerca
- Ansaldo Energia
- Elasis

Funded Projects

- CNR-MSE finanziato dal Fondo per la ricerca per il sistema elettrico per le tematiche "Carbone Pulito-CO_2 Capture" e "Biocombustibili«
- Contratto IRC-DICMAPI (UniNA) nell'ambito del progetto europeo FP7 Deecon
- Progetto TRIM Cluster "Trasporti"
- FIRB Futuro in Ricerca 2012 – Progetto SOLYST
- PRIN 2008

FUTURE VISION

- ✓ **New guidance for the Strategic Energy Technology (SET) Plan and future emission regulation**
- ✓ **Pollution source assignment**
- ✓ **Advanced sensors for smart emission control in integrated grid**
- ✓ **Reduction of the adverse impact of combustion processes on the climate and health**
- ✓ **Multi-pollutant reduction systems, combining different capture technologies in one reactor.**
- ✓ **Deep purification of CO_2 streams for compression and sequestration.**