DEER 2003

Noxtech's PAC System Development and Demonstration

BY NOXTECH

With the Support & Cooperation of DOE

NOXTECH

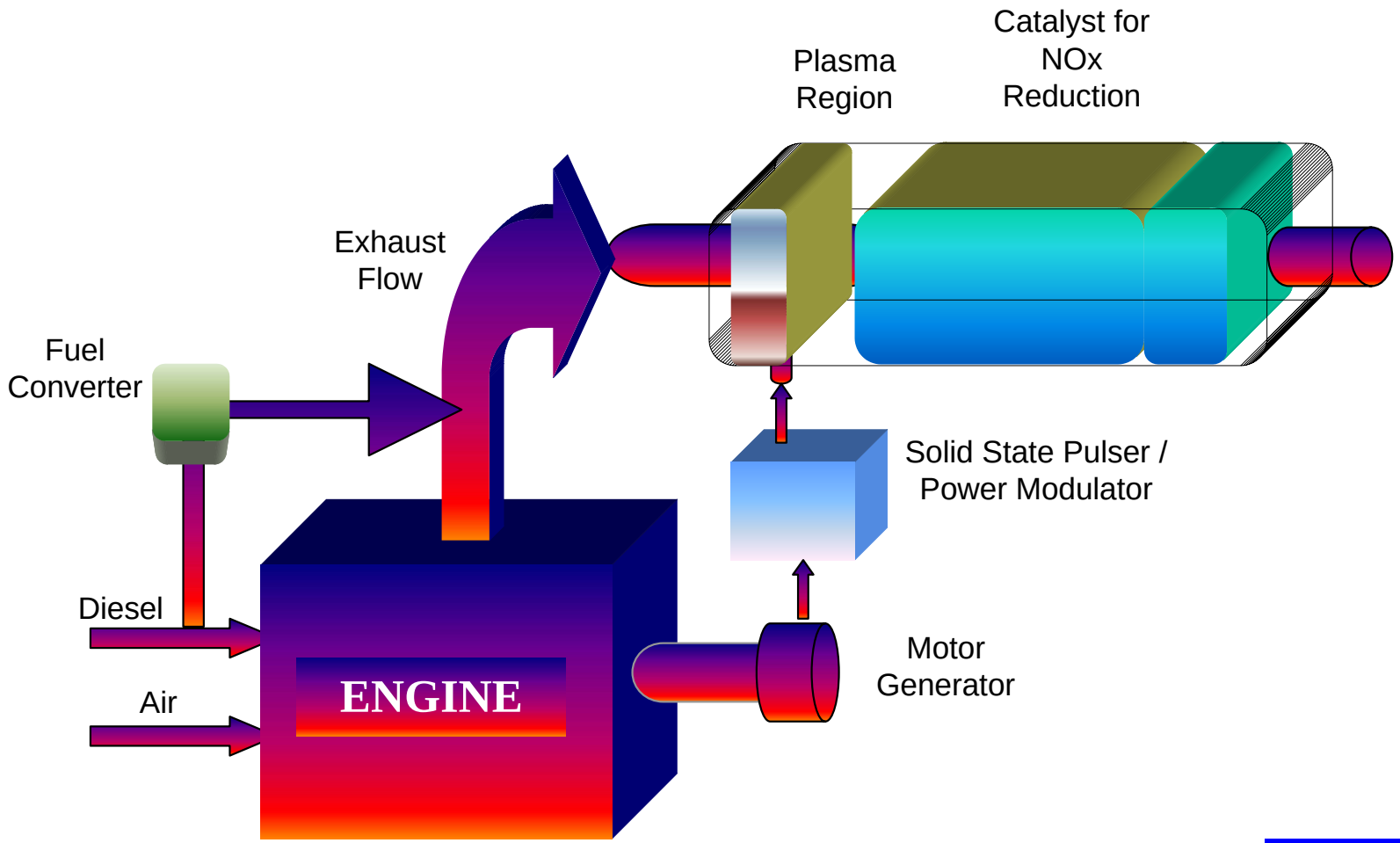
Noxtech, Inc.

- Delaware Corporation registered to do business in California
- MBO from Cummins Engine CO 1996: Total $28 million invested (Cummins & Noxtech) emissions control technology
- DOE, CEC & AQMD supplied significant funding for all technology developed.
- Stationary Markets: patent protected (four) Autocatalytic Process for boilers and IC engine powered generators:
  - ICE Generators: Currently being produced and sold
  - Boilers: Successfully demonstrated 200 MW boiler & being marketed under license Mitsui Babcock
- Transportation Market patent (one basic) protected Plasma process: 80 hp Plasma System prototype demonstrated 94% NOx reduction next generation system being fabricated

NOXTECH

PAC System Schematic

$NO_X + HC(Diesel) \xrightarrow{Plasma} NO_2 + HC\ (Radicals) \xrightarrow{Catalyst} N2 + O_2 + CO_2$

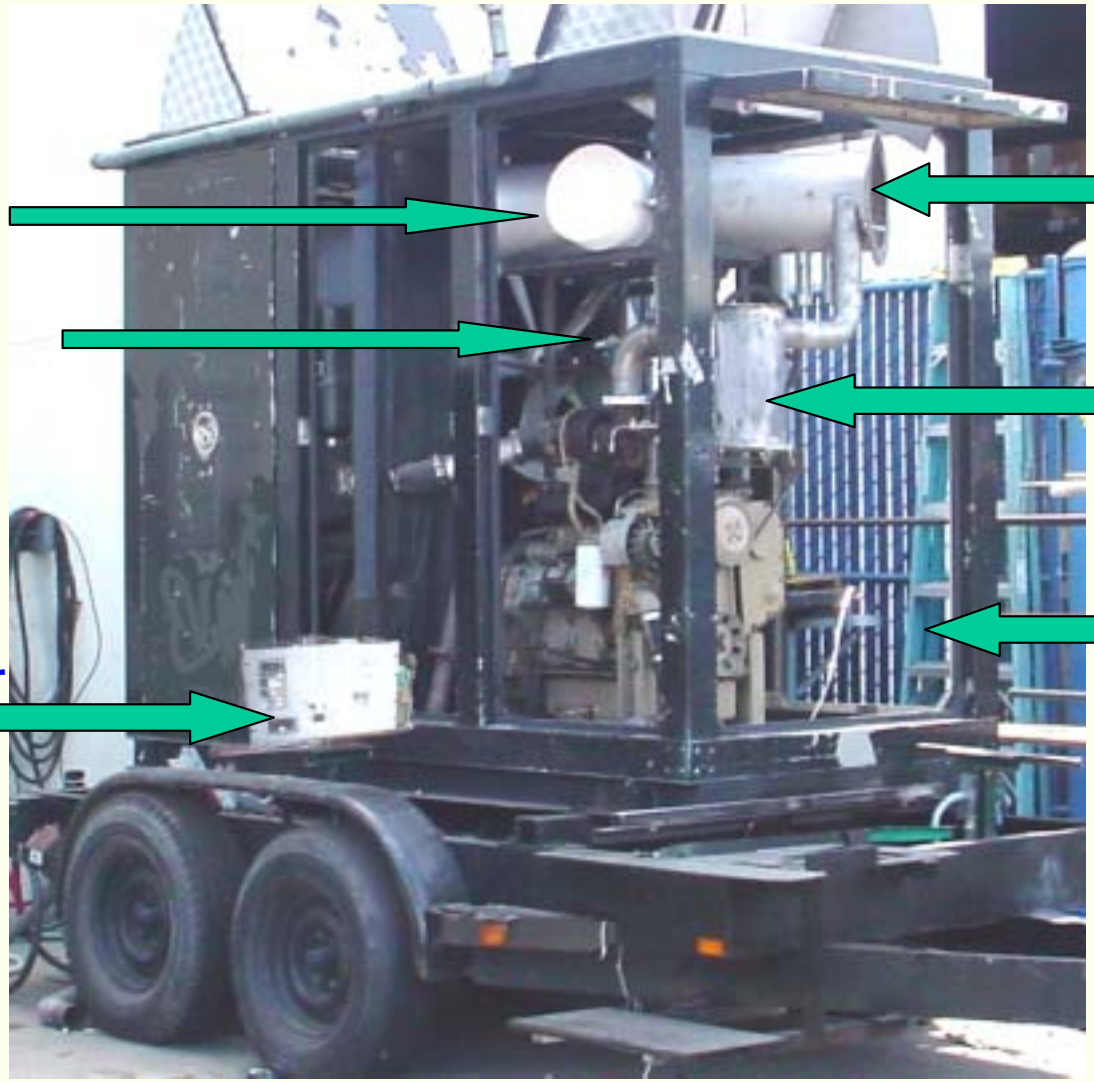


NOXTECH

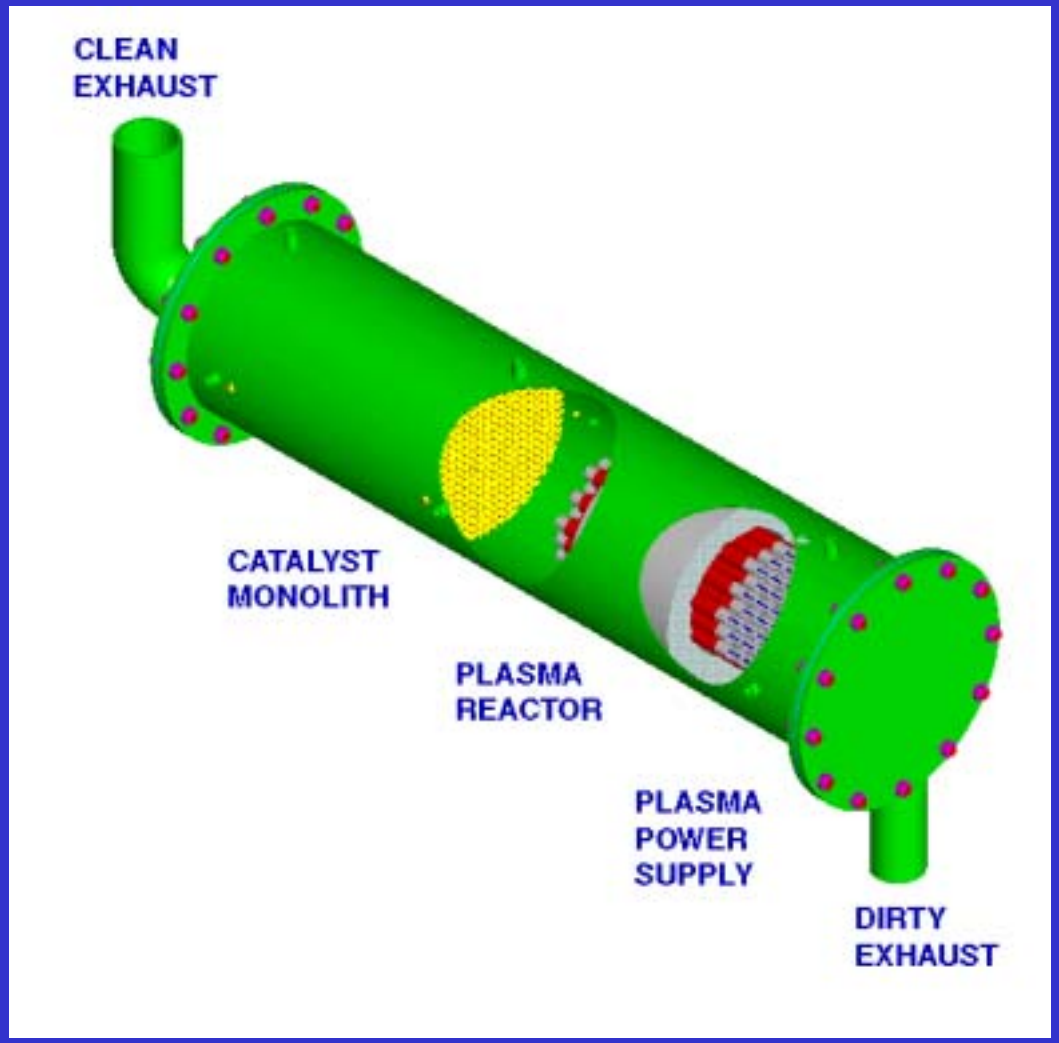
Plasma Program 02'Accomplishments

- Demonstrated 94% NOx reduction @30,000 sv on original design 80 hp system
- Performed parameter studies to obtain design data for advanced unit
- Redesigned, built and currently evaluating an advanced version of the original 80 hp capable prototype.
- Demonstrated technical viability & improved design/performance of all system components:
  - Diesel fuel converter: demonstrated ability to use No. 2 (500 ppm off-highway) diesel fuel as a reductant
  - Pulser: converted to solid state major reduction in size and components
  - Plasma reactor: reduced size, improved efficiency, simplified construction/fabrication
  - Demonstrated a sulfur tolerant ceramic catalyst, with broad temperature activation range

Noxtech Advanced 80 hp Plasma System



Noxtech's Integrated 80 hp PAC System



Overall

10" OD X 45" Long.

Integrated in current 80 Hp Genset.

Passive system

Advanced Noxtech Solid State Pulser

NOXTECH

2003 Program Objectives

- Perform third party demonstration on 80 hp diesel generator
  - 90% NOx reduction
  - 30,000 hr^{-1} and 275-500 deg F
- Component Improvement Work
  - Catalysts: increase hr^{-1}, more selective, improve low temp activity
  - Pulser: reduce size, improve efficiency, simplify fabrication
  - Reductant: refine reductant & optimize to catalyst
  - Plasma reactor: simplify fabrication, improve efficiency, reduce size

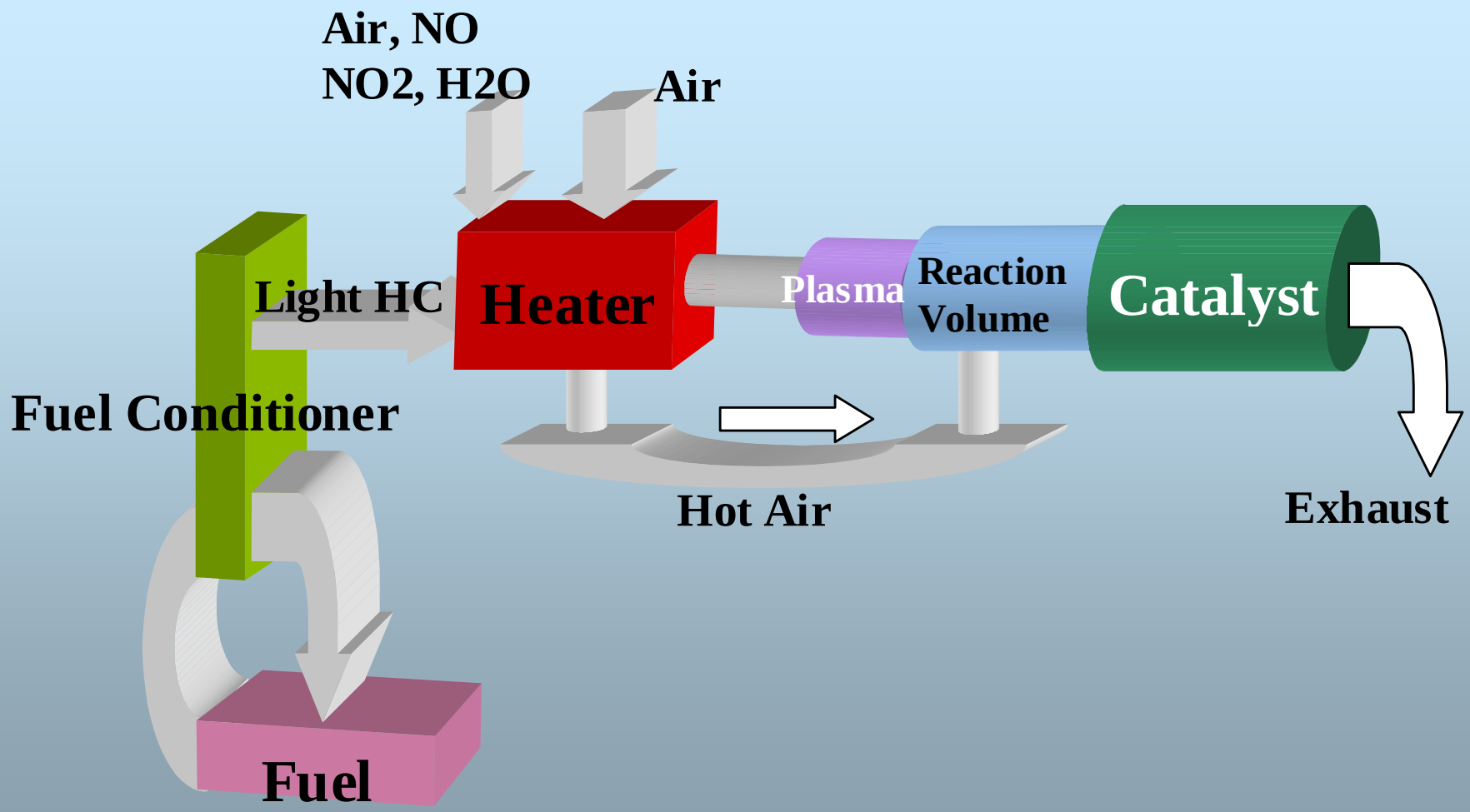
Issues for 2003 Demonstration

- Catalyst loss of activity:
  - carbon/hydrocarbon deposits
  - wash coat active surface onto monolith
- Catalyst performance improvement:
  - higher hr^{-1} (50,000)
  - low temperature operation
- Optimization of hydrocarbon reductant:
  - for plasma reactor
  - for catalyst
- Plasma reactor/pulser: size, cost and performance

60 kW Demonstration

- Engine: Cummins 60 kW “B” powered generator
- Test Conditions:
  - Two steady state load points
  - Temp range: 300-500 deg C.
  - C/NOx ratio 4-5
  - 20-30,000 hr^{-1} (catalyst)
- Measurements:
  - NOx, HC’s, CO, N_2O
  - Exhaust: temperature, back pressure
- Test Laboratory: Olson
- Attendees: Industrial & governmental experts

Noxtech Pilot Test Unit



NOXTECH

Catalyst Improvement Work

- Improvements:
  - Increase hr^{-1}
  - Low temperature activity
  - Selectivity
- Approaches:
  - Increase surface area
  - Optimize pore distribution
  - Optimize dopent levels and basic composition
  - Reliable deposition method active catalyst on monolith
  - Optimize crystal structure

Plasma Reactor Work

- Improvements:
  - Improve efficiency
  - reduce size
  - simplify fabrication
- Approach:
  - Monolithic ceramic reactor design
  - Optimize reactor geometry to minimize losses & enhance efficiency
  - Move reactor external to exhaust & treat portion of exhaust

Reductant Work

- Improvements:
  - Fuel fraction separation
  - Optimization of fuel fraction:
    - for plasma reactor
    - for catalyst
- Approaches:
  - Fraction separation: ceramic membrane
  - Fraction conditioning:
    - Thermal
    - Catalytic

Pulser Work

- Improvements:
  - Reduce size & cost
  - Improve efficiency (80--->90%)
  - Simplify fabrication
- Approach: (working with industrial partner)
  - Single crystal solid state ultra high frequency switcher
  - Tunable to optimize pulse width and frequency
  - Minimize components
  - Use magnetic amplification

Acknowledgements

- DOE: John Fairbanks, Program Manager
- Sud-Chemie: Amiram Bar-Ilan, YinYan Huang
- Noxtech Team: Barry Bhatt, Scott Blacklock, FarzanRoshdieh, Jim Cipolla, Artur Martynov, Jeff Marguglio and Victor Puchkarev