

DEER 2002

**PLASMA ASSISTED CATALYSIS SYSTEM
FOR NO_x REDUCTION**

BY NOXTECH

With the Support & Cooperation of DOE

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 Autocatalytic Process that is patent (three) protected (boilers & IC engine powered generators):**
 - **ICE Generators: Currently being produced and sold**
 - **Boilers: Successfully demonstrated under license 200 MW boiler**
- **Transportation Market patent (one basic) protected Plasma process: 80 hp Plasma System prototype demonstrated 94% NOx reduction next generation system being fabricated**

Autocatalytic Noxtech System Capabilities

- **Controls NO_x to 30 ppm for diesel, NG, coal fired combustion**
- **Concurrent Depletion of UBHC, CO, Soot, & NH₃ slip**
- **Can use polishing catalysts to achieve very low levels of NO_x (10 ppm) & particulates**
- **Low operating costs: no catalyst replacement, uses low grade urea**
- **Low operating back pressure minimizes fuel consumption**

Commercial Status Advanced Noxtech Technology Auto-Catalytic NO_x Reduction system

IC Engine/generators

- **Commercial sales of systems to treat the exhaust of diesel and natural gas powered generators in 2002.**
- **Projected market of over \$500 million (retrofits of 7500 MW's) in California and \$5 billion US: Stand-by diesel powered and bio-diesel powered generators**

Boilers

- ❖ **License granted to Mitsui-Babcock Corporation**
- ❖ **Noxtech process has been successfully demonstrated on a TVA 200 MW coal fired boiler located in Kingston TN by Mitsui-Babcock anticipate 4 additional coal fired boiler installations fourth quarter 2002.**

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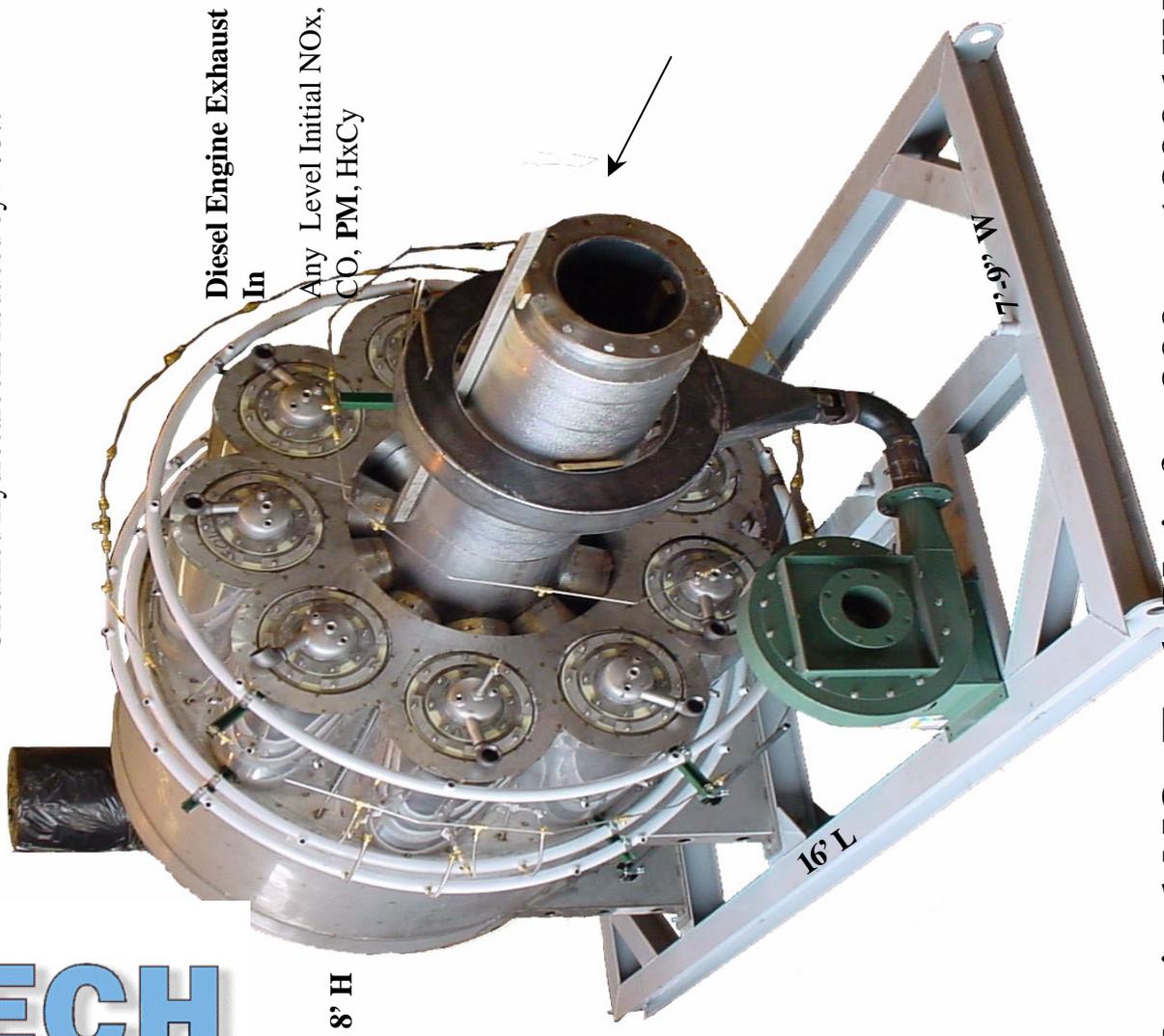
Treated Exhaust Out

< 0.4 g/bhp-hr NOx

< 50 ppm CO

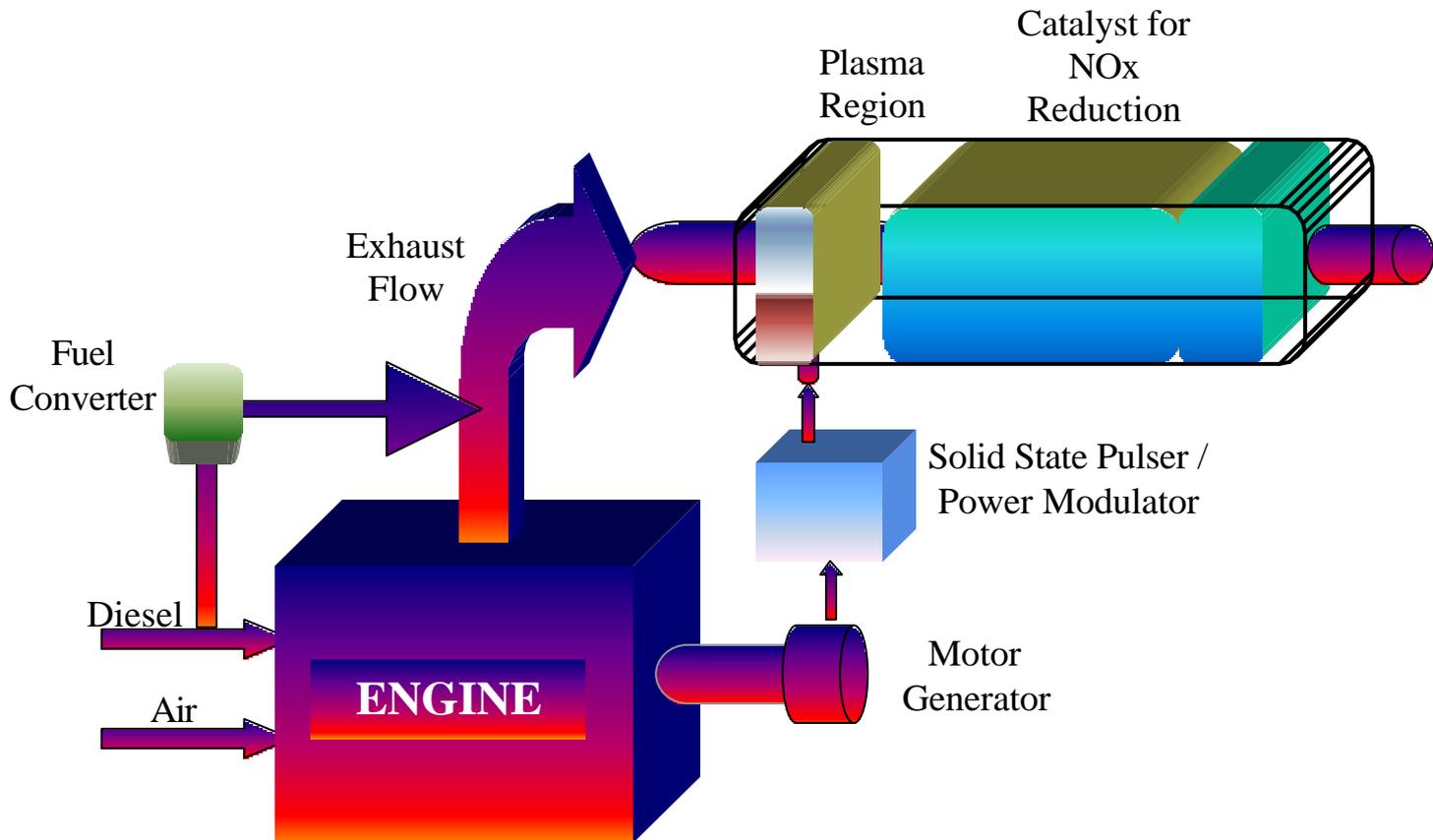
PM reduced by > 95%

Unburned Hydrocarbons Reduced by > 95%



**Typical NOxTech Unit for 800 to 1800 kW
Standby Diesel Engine Generator,
(Without Integral Heat Exchanger) Total Weight: 8000 lbs**

PAC SYSTEM SCHEMATIC



Program Objectives 2002

❖ Fully characterize (parametric studies), redesign and refine 80 Hp system with advanced (practical, semi-commercial) components:

- Thyatron pulser ----> solid state pulser

- diesel fuel conversion system: improved performance/design

- Develop & improve catalysts: spheres --> monolith, enhanced performance: space velocity, available surface, selectivity

- plasma reactor -----> smaller more efficient

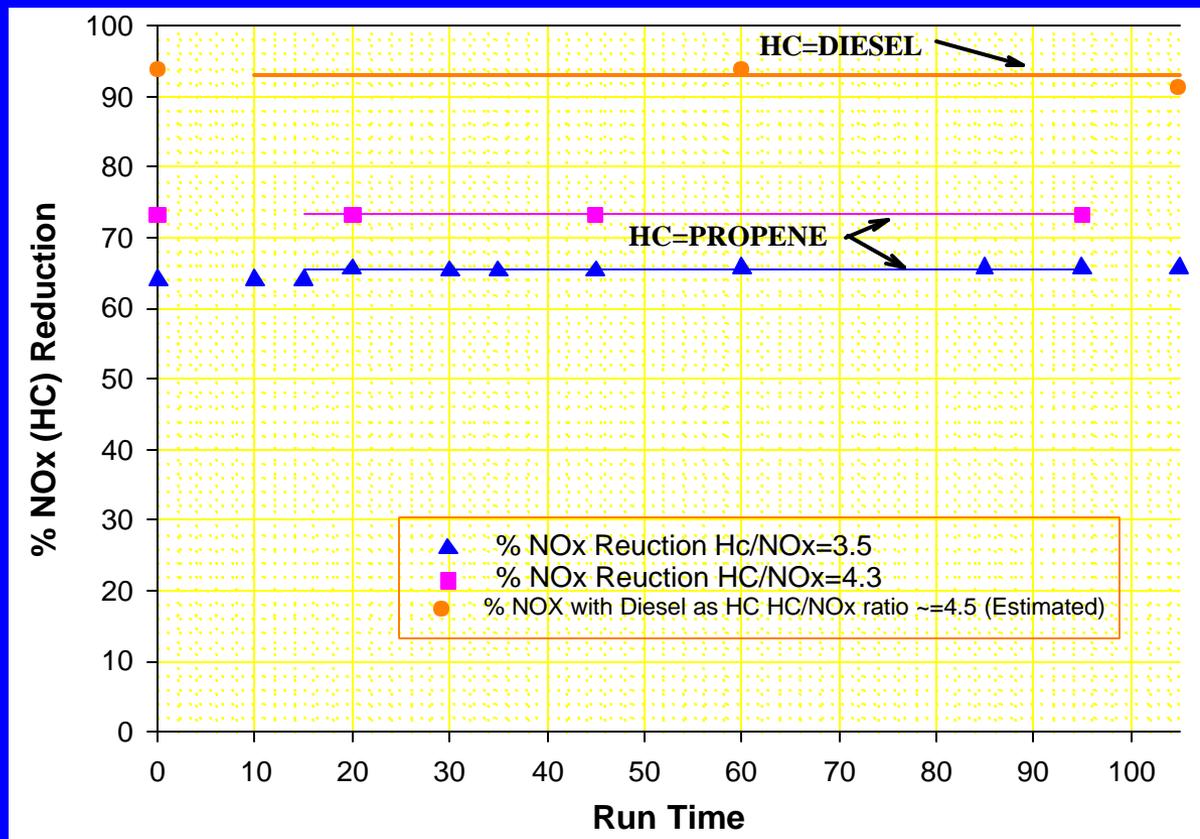
❖ Scale, design 250 Hp system.

❖ Supply 80 hp prototypes for third party evaluation

Plasma Program Accomplishments

- **Demonstrated 94% NO_x reduction @30,000 on original design 80 hp system**
- **Performed parameter studies to obtain design data for advanced unit**
- **Resigned, 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's 80 Hp Plasma Assisted catalyst system Performance at Steady state with 1988 Cummins 80 Hp Engine



Some data on steady state run with Series B Engine and Diesel and Propene as HC reductant source.

Sp. Plasma energy = 17.5 J/lit :

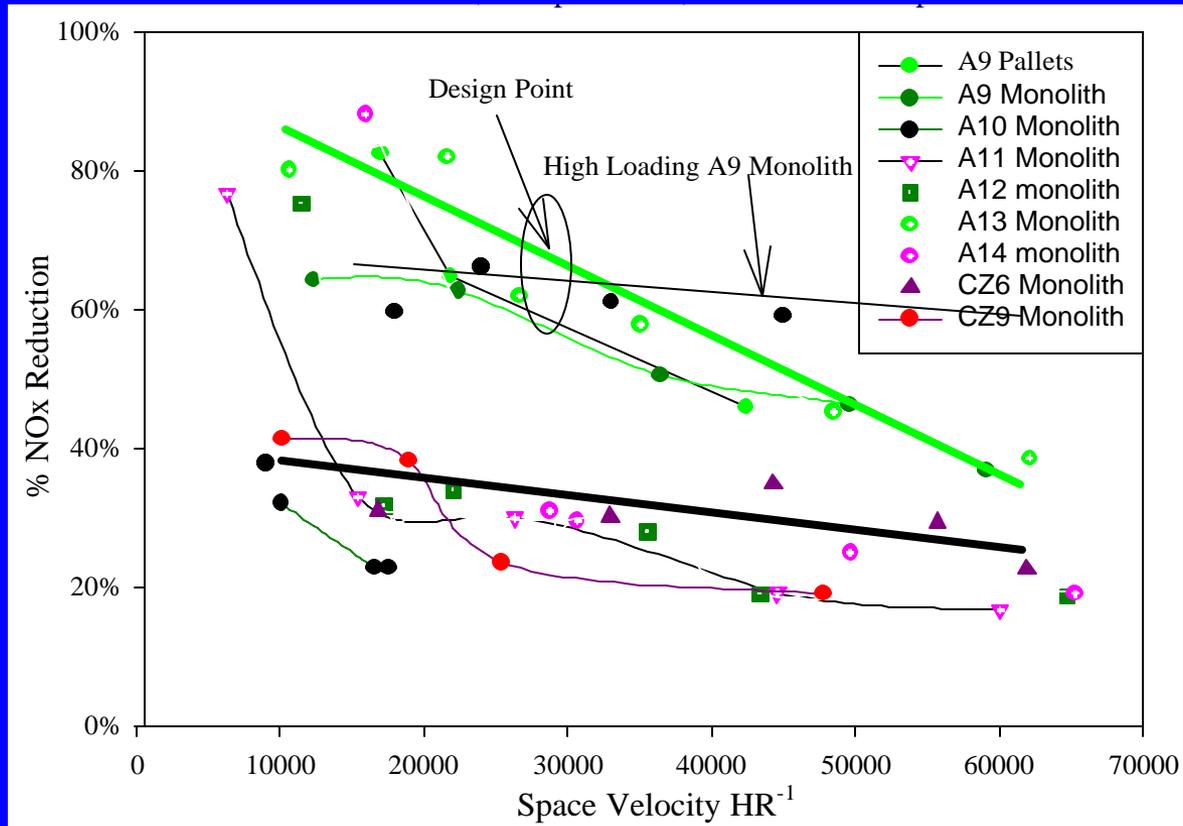
Engine load = 48

Hp : Diesel Exhaust

Conclusion

Initial testing shows good NOx reduction can be achieved with PAC system operating with diesel as a reductant source.

NO_x reduction Vs. Space velocity for catalysts tested in phase 2(2002)



HC/NO_x Ratio = 5

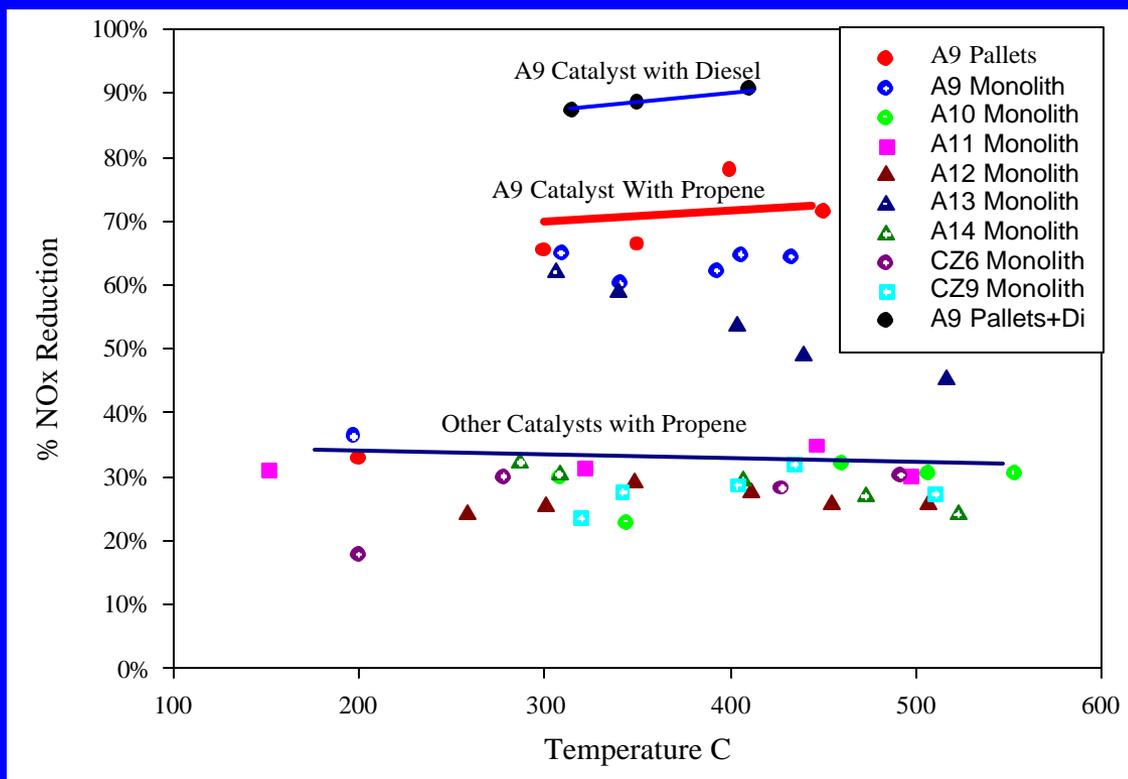
Temp = 350°C

**HC source=
Propene**

Simulated gases

300 PPM NO_x Feed

Temperature vs. NO_x Reduction for catalysts tested in phase 2(2002) on a bench reactor



HC source= Propene

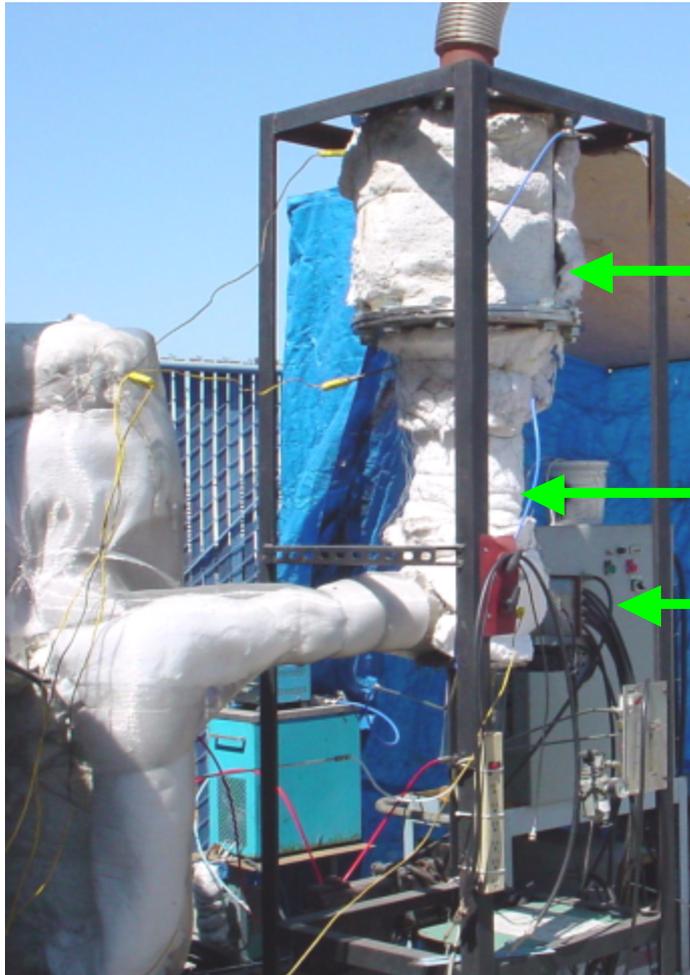
HC/NO_x = 5:

NO_x feed = 300 PPM

Simulated gases

Sp. Velocity 30K HR⁻¹

Initial 80 Hp Plasma Assisted catalyst system

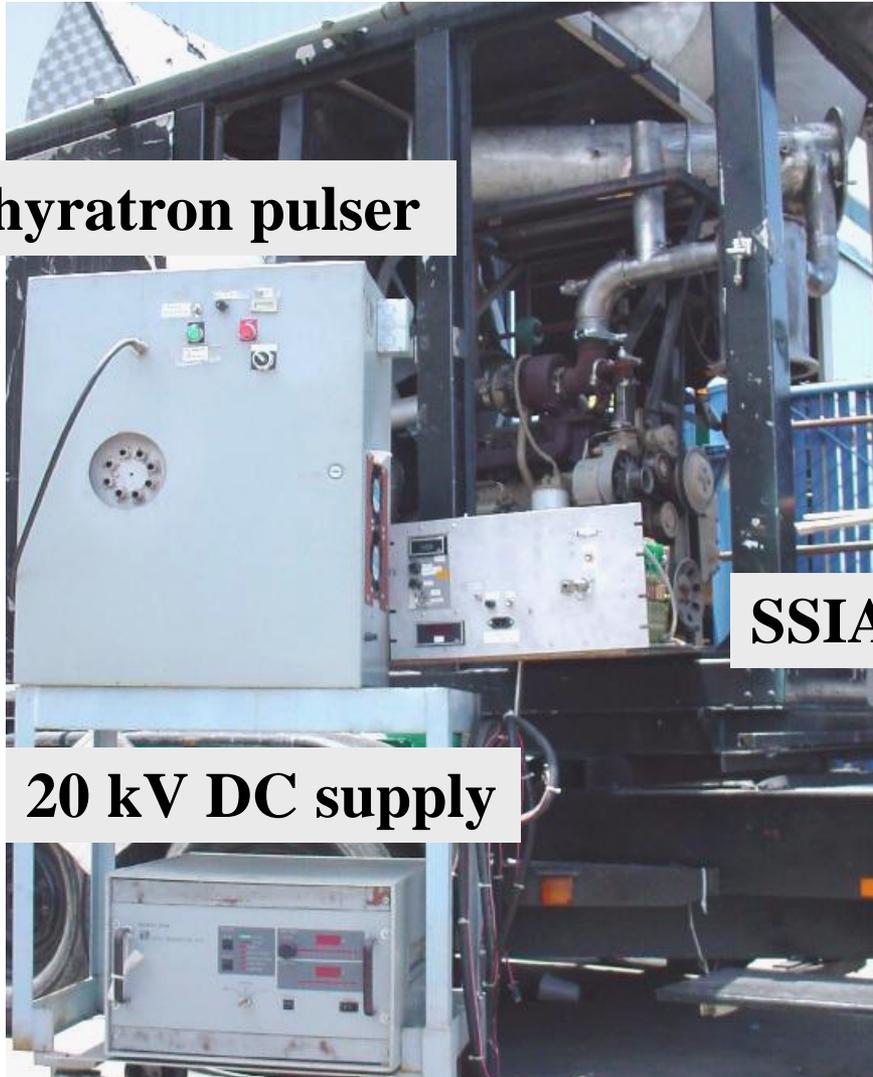


← **Catalytic Reactor**

← **Co-axial Plasma reactor**

← **Thyatron based power supply**

Initial Power Supply & Pulsar 80 hp Unit



Thyratron pulser

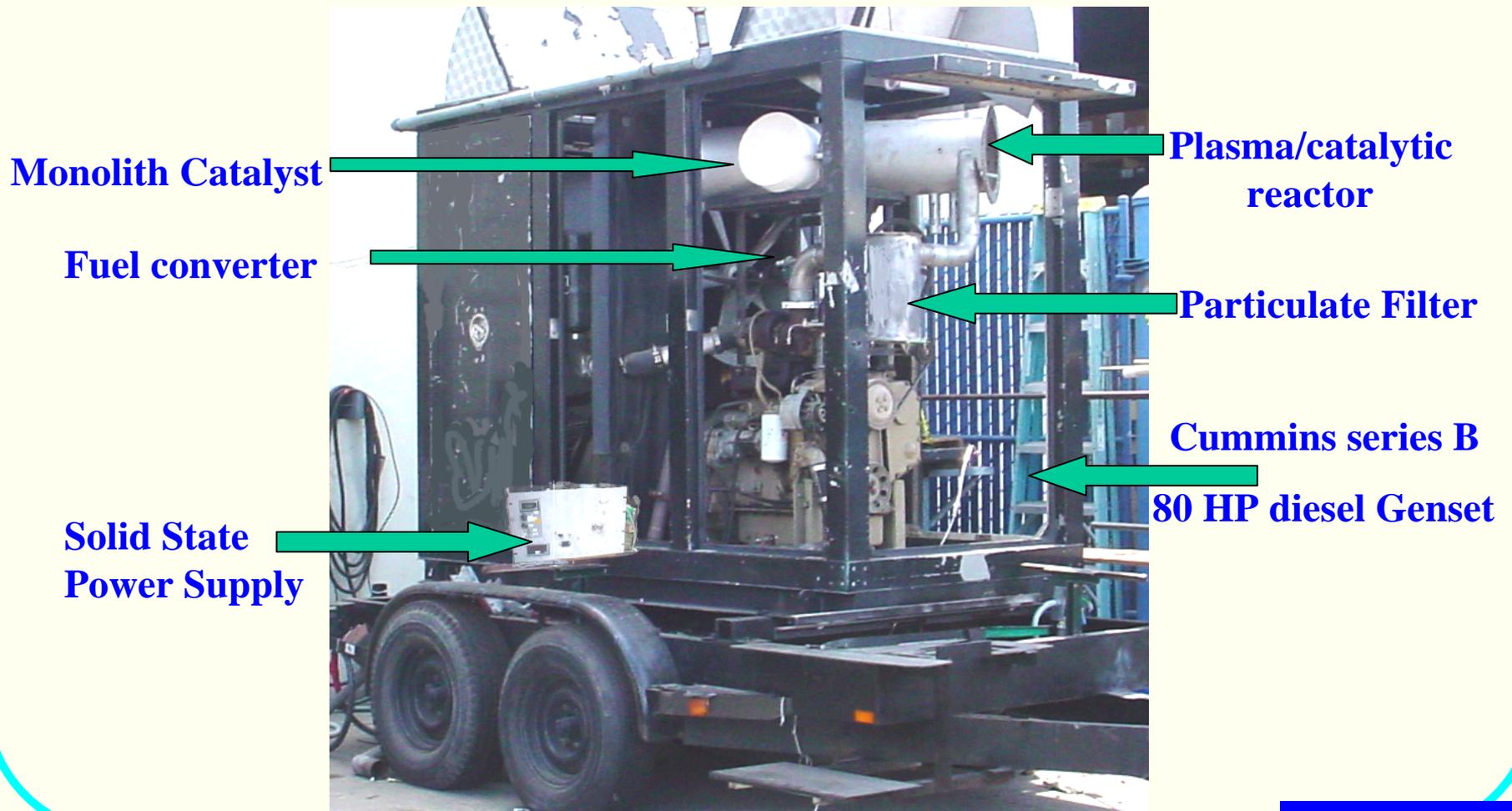
Plasma-catalytic reactor

60 kW diesel generator

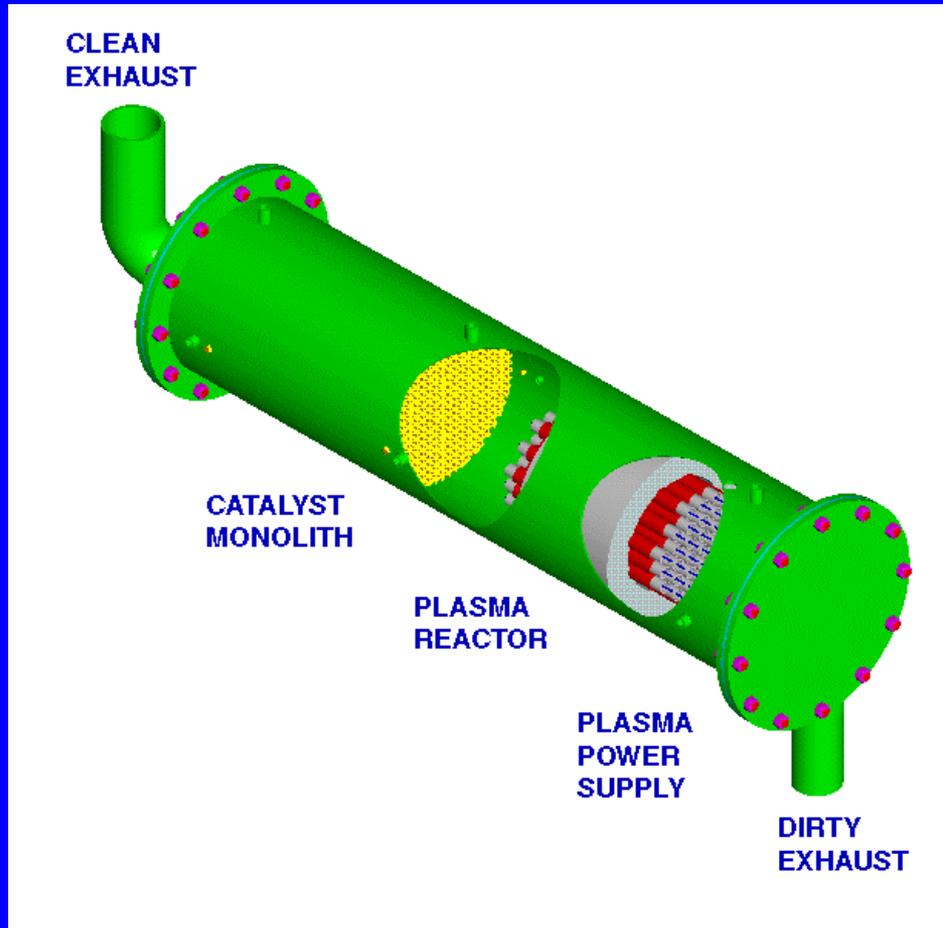
SSIA pulser

20 kV DC supply

Noxtech Advanced 80 hp Plasma System



NOXTECH'S INTEGRATED 80 HP PAC SYSTEM



Overall

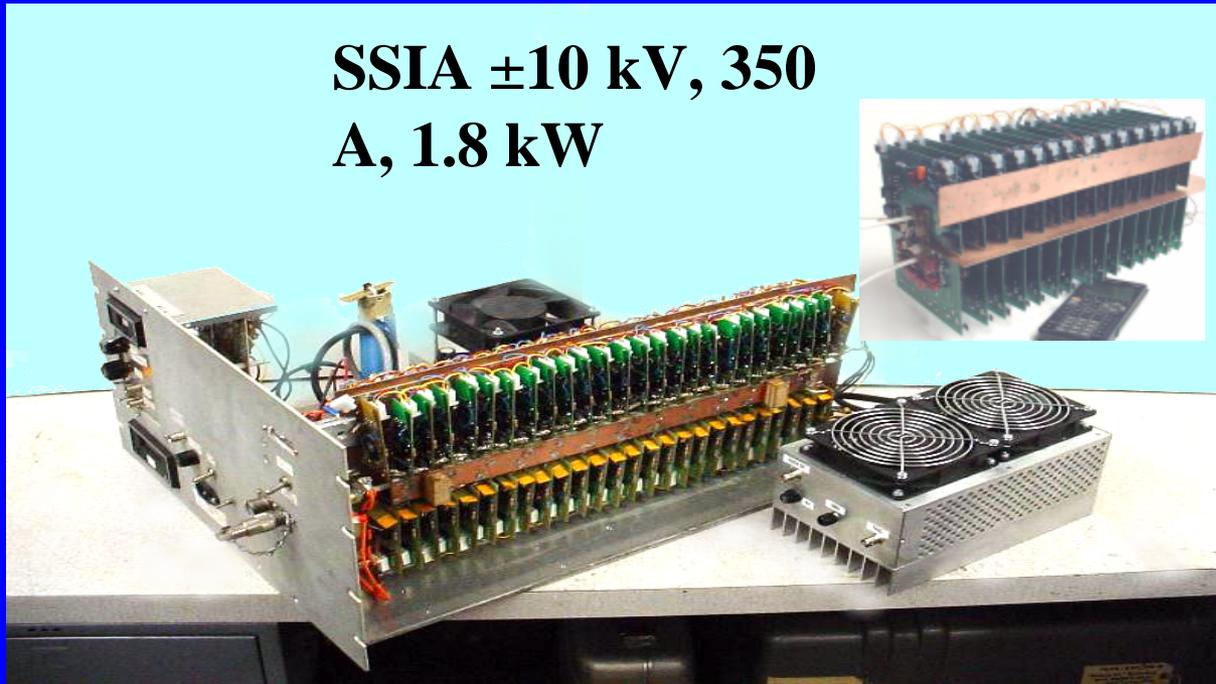
10" OD X 45" Long.

**Integrated in current
80 Hp Genset.**

Passive system

Noxtech's Solid-State Pulsers

**SSIA ± 10 kV, 350
A, 1.8 kW**



SSIA: 8 kV, 160 A, 0.5 kW

SSOS: 8 kV, 200 A, 250 W

PLASMA REACTOR FOR 80 HP SYSTEM



Total reactor 7" OD X 12" Length

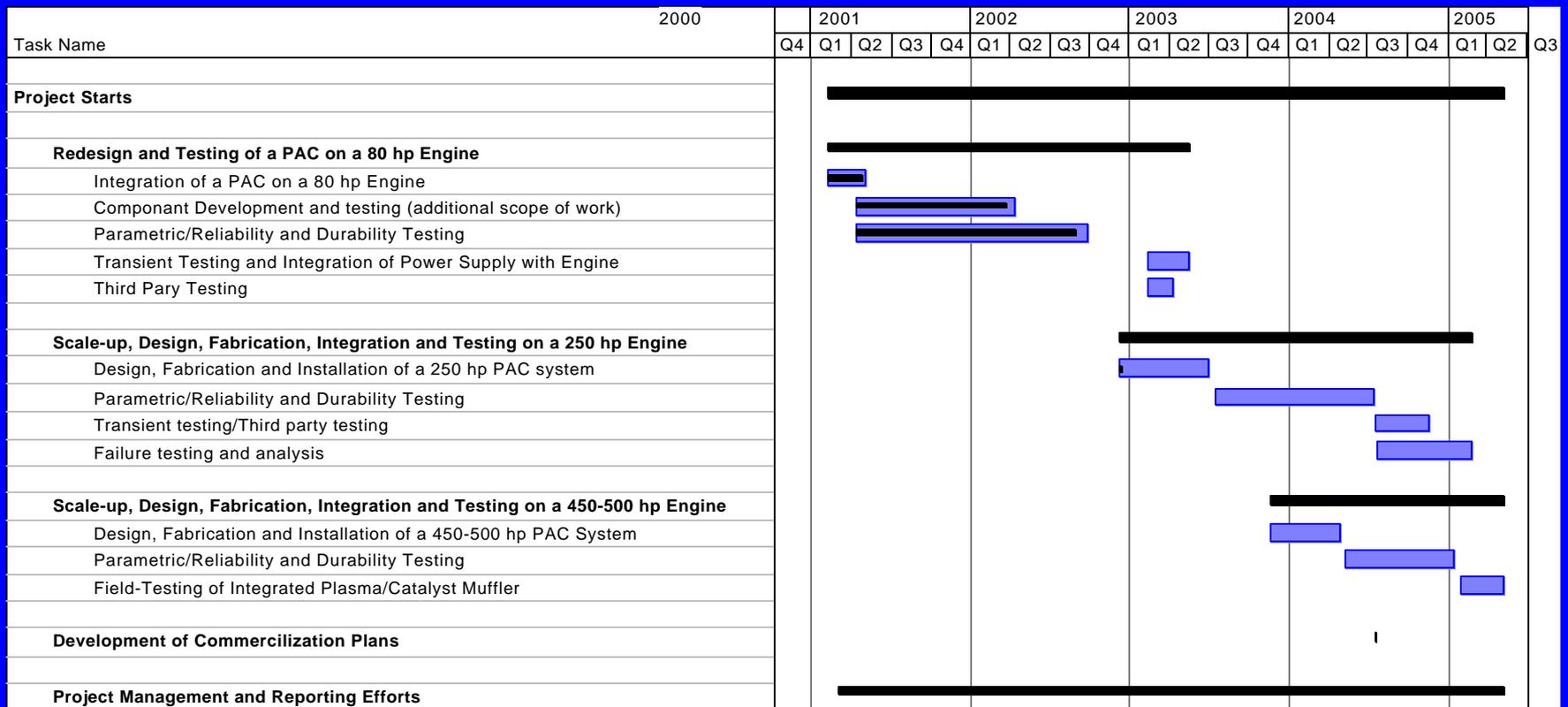
**Very High space velocity
throughput.**

Lightweight.

Project Goals & Objectives for 2003

- Evaluation of advanced 80 hp PAC prototype under transient operation
- Fabrication and demonstration of 250 hp prototype
- Third party evaluation of 250 hp prototype
- Evaluation of 250 hp prototype system under transient operation
- Continue to refine and improve system components: size, performance, efficiency, durability and producibility
- Design 450-500 hp PAC prototype

OVERALL PROJECT TIMELINE



PARTNERS



John Deere

- One of the major Diesel engine producer in the world.
- Presence in 160 countries with 37,000 work force.
- \$960 Million dollar profit in 1997 on \$12.79 Billion sales.
- Factories located worldwide.



Mack Trucks Inc.

- Founded in 1900
- One of largest producers of heavy-duty trucks and engines.
- \$105 Million dollar profit in 1998 on \$2.77 Billion sales.
- Factories located worldwide.

Sud-Chemie Prototech



- Part of Süd-Chemie AG of Munich, Germany.
- One of largest producers Catalyst, Specialty Chemicals and industrial minerals.
- Operates 25 Plants in 18 Countries.

ArvinMeritor

- ArvinMeritor is joining of two companied namely Arvin industries Inc and Meritor Automotive Inc.
- One of the largest producers of OEM and aftermarket automotive parts
- 1999 combined revenue of \$7.6 Billion dollars.

ArvinMeritor™

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