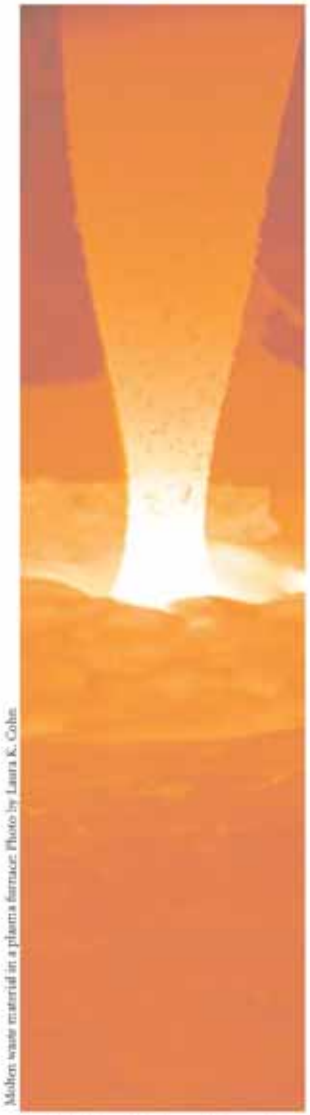
Coalition for Plasma Science

cordially invites Members and Staff to a luncheon



Molten waste material in a plasma furnace. Photo by Laura K. Cohn

Environmental Protection and Energy Savings Using Plasma Technology

Featured Speaker:
Dr. Daniel Cohn
MIT Plasma Science & Fusion Center

Catered by Red, Hot, and Blue

Wednesday, March 10, 2004
12:00 – Lunch • 12:30 – Speaker
Cannon Caucus Room

Although we may not know it, we are all familiar with plasmas. Fluorescent lights, the sun, and many large-screen TVs are all plasmas.

Plasmas are also providing practical opportunities for protecting the environment. Plasma furnaces are beginning to be used commercially to totally destroy hazardous waste and convert it into clean hydrogen and other valuable products. Tests have also shown that plasma hydrogen generation on board a vehicle can be used to provide a ten-fold reduction in nitrogen oxide pollution from diesel engine trucks and buses. Perhaps even more important are recent research results indicating that this process could potentially increase the efficiency of gasoline car engines by up to 30 percent and thereby reduce U.S. gasoline consumption by 30 billion gallons a year.

Dr. Daniel Cohn, winner of the 1999 Discover Award for Technological Innovation in Transportation, will show how plasmas can be used to save energy in the transportation sector, and protect the environment.

RSVP: Linda.Norman@ga.com; (202) 496-8212

The Coalition for Plasma Science is a group of organizations, companies and individuals joining forces to increase awareness and understanding of plasma science and its many applications and benefits for society. For more information about CPS call 1-877-PLASMAS (1-877-752-7627), send an email to CPS@plasmacoalition.org, or check out the group's web site at www.plasmacoalition.org

Environmental Protection And Energy Savings Using Plasma Technology

Daniel R. Cohn

Plasma Science and Fusion Center

Massachusetts Institute of Technology

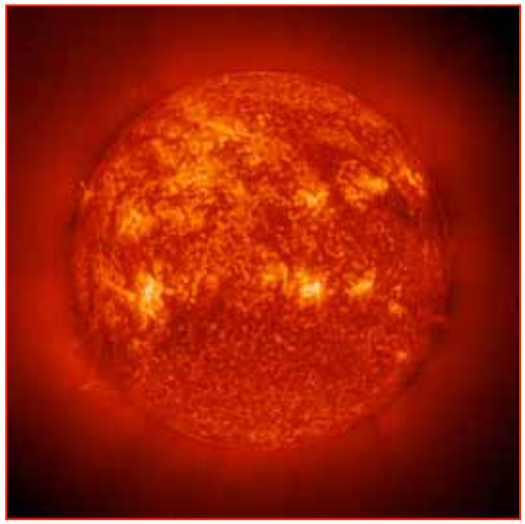
March 10, 2004

Plasmas

Plasmas are electrically conducting gases.

Neon sign

Lightning



Sun

Emerging Applications of Plasma Technology

Environmental Protection

- Destruction of waste
- Reduction of pollution from diesel trucks and buses

Energy Savings

- High efficiency, clean gasoline engines

about Plasmas

from the Coalition for Plasma Science

Cleaning the Environment

"Water and air, the two essential fluids on which all life depends, have become global garbage cans." – Jacques Cousteau

To Cousteau's list of global garbage cans we can add the earth beneath our feet. Soil, air and water have all suffered from the effects of industrial waste and pollution, making the quality of our environment a vital issue for our time. To help with problems of greenhouse gases, like carbon from factories and automobiles, and with concerns about "global warming," researchers are developing new ways of aiding the environment by using plasmas.

Plasmas are fundamentally different from other states of matter. While solids, liquids and gases have no electrical charge, plasmas contain lots of freely moving ions (positively charged particles) and electrons (negatively charged particles). This difference makes plasmas able to transform pollution into environmentally safer materials. The transformation can occur through heating or through interactions involving particles that are not available in regular gases.

Plasma can be used to clean and monitor smoke stack emissions.

To process pollutants efficiently, plasmas generally operate at about atmospheric pressure. This is a relatively high pressure for plasmas, much higher than is used in plasma applications like fusion energy and computer chip manufacturing, which operate at low pressure – near vacuum conditions. Imagine trying to bottle a bolt of lightning – a naturally occurring plasma at atmospheric pressure – and you can get some idea of how difficult it is to control and use man-made atmospheric-pressure plasmas.

Mastering this difficulty can help lead to a cleaner environment. When operated in what is called 'thermal mode,' all the particles in the plasma (electrons, ions and neutral particles) get uniformly hot. In plasmas the temperature of the charged and neutral particles can become much higher than is possible with incineration, so they can destroy waste more thoroughly. Furthermore, creating a high temperature thermal plasma requires little gas flow because no air or oxygen is required, while an incinerator requires large amounts of air to burn wastes. Consequently plasma furnaces could be used instead of incinerators to process municipal waste more thoroughly and with less combustion exhaust.

Plasmas also reduce the need for expensive gas filters (commonly called "scrubbers") designed to decrease the amount of pollutants released into the atmosphere. In addition, the plasma process eliminates ash, which in present municipal incinerators is considered hazardous enough to bar from interstate transport. Instead of ash, high-temperature plasmas in arc furnaces can convert materials into a glassy substance, separating out the molten metal, which can then be recycled. The stable glassy material can be used in landfills with essentially no environmental impact, since it cannot leach into the soil. Plasma furnaces are being used in Honolulu and Japan to treat hospital and municipal wastes. When environmental laws require scrubbers to be used on smoke stacks, plasma processing of waste could become the least expensive alternative.

There are also nonthermal atmospheric pressure plasmas, those in which only the electrons get hot. These plasmas are effective against other kinds of pollution. Since energy is not required to heat all the particles to a high temperature, nonthermal plasmas can selectively and efficiently destroy pollutants targeted by the hot electrons and by unique chemical species that the hot electrons create. Nonthermal plasmas can destroy pollutants such as volatile organic compounds (VOC) from cleaning fluid or manufacturing solvent vapors, as well as nitrogen oxides in automobile exhaust.

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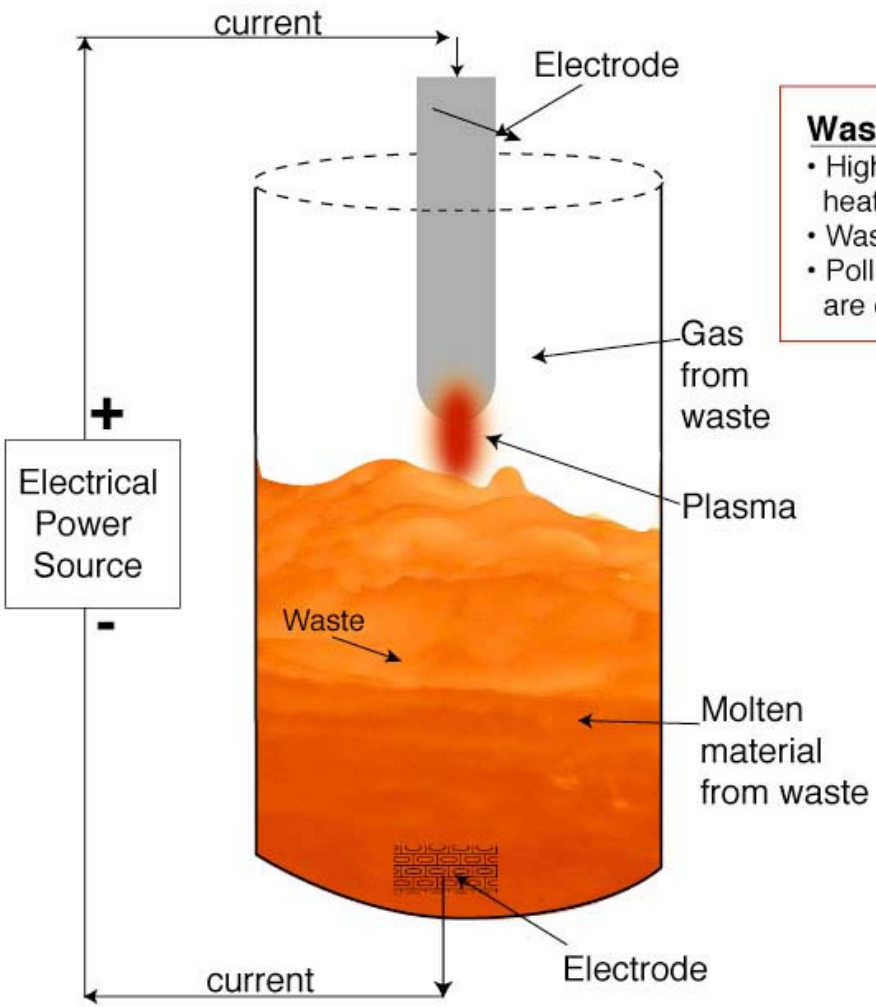
Other Applications

- Sterilization
- Water Purification
- Cleaning of Smoke Stack Emissions
- Environmental Monitoring

Disposal of Waste is a Growing Worldwide Problem

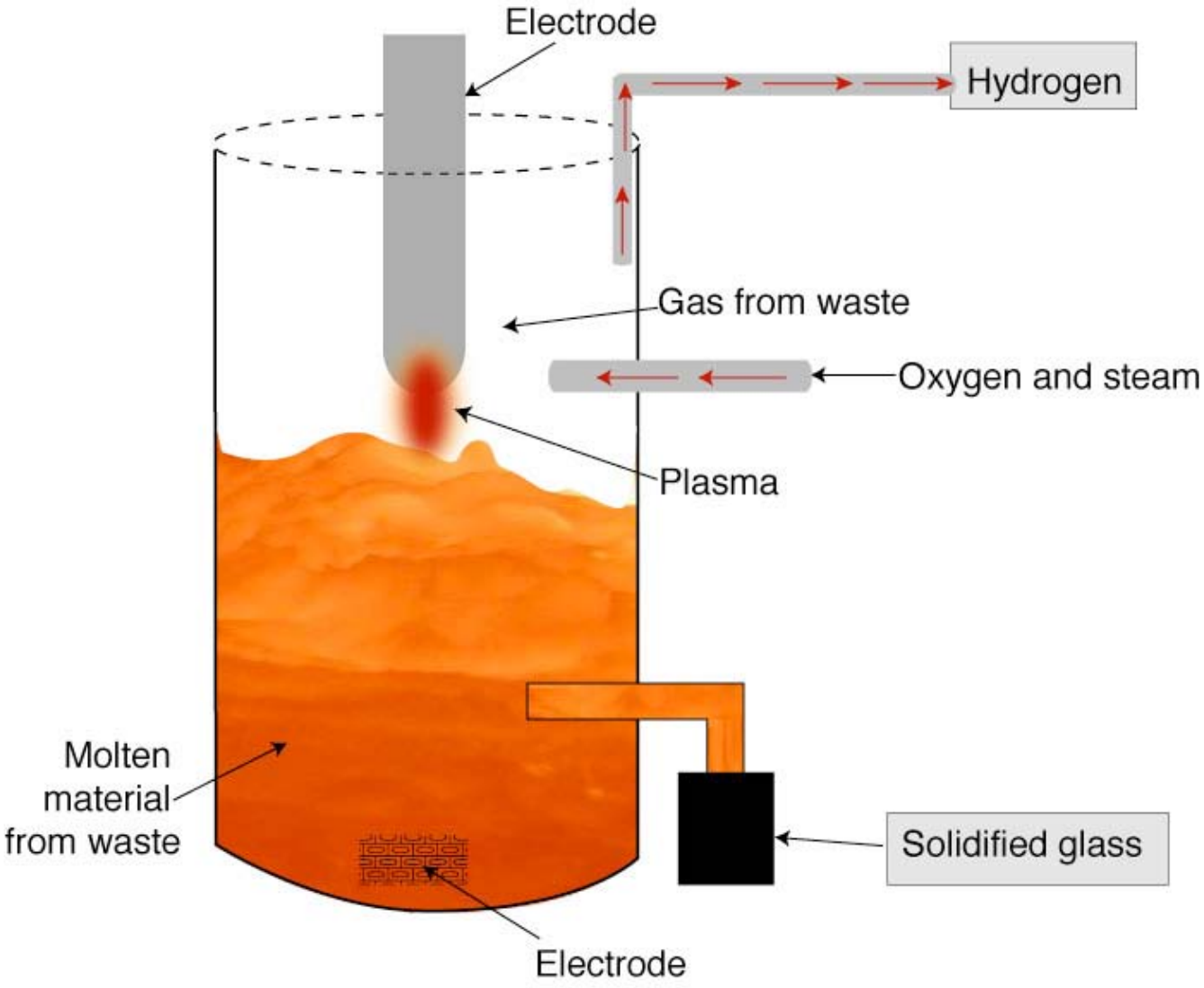
Destruction of Waste in Plasma Furnace



Waste Destruction Process

- High temperature plasma heating disintegrates waste
- Waste is not incinerated
- Pollutants from combustion are eliminated

Waste to Hydrogen



Plasma Furnaces Are Beginning to be Used Commercially: Destruction of Medical Waste in Honolulu, Hawaii

Plasma Enhanced Melter™

Model 4 unit in Hawaii

Integrated Environmental Technologies, LLC

Molten Waste Material in Plasma Enhanced Melter™

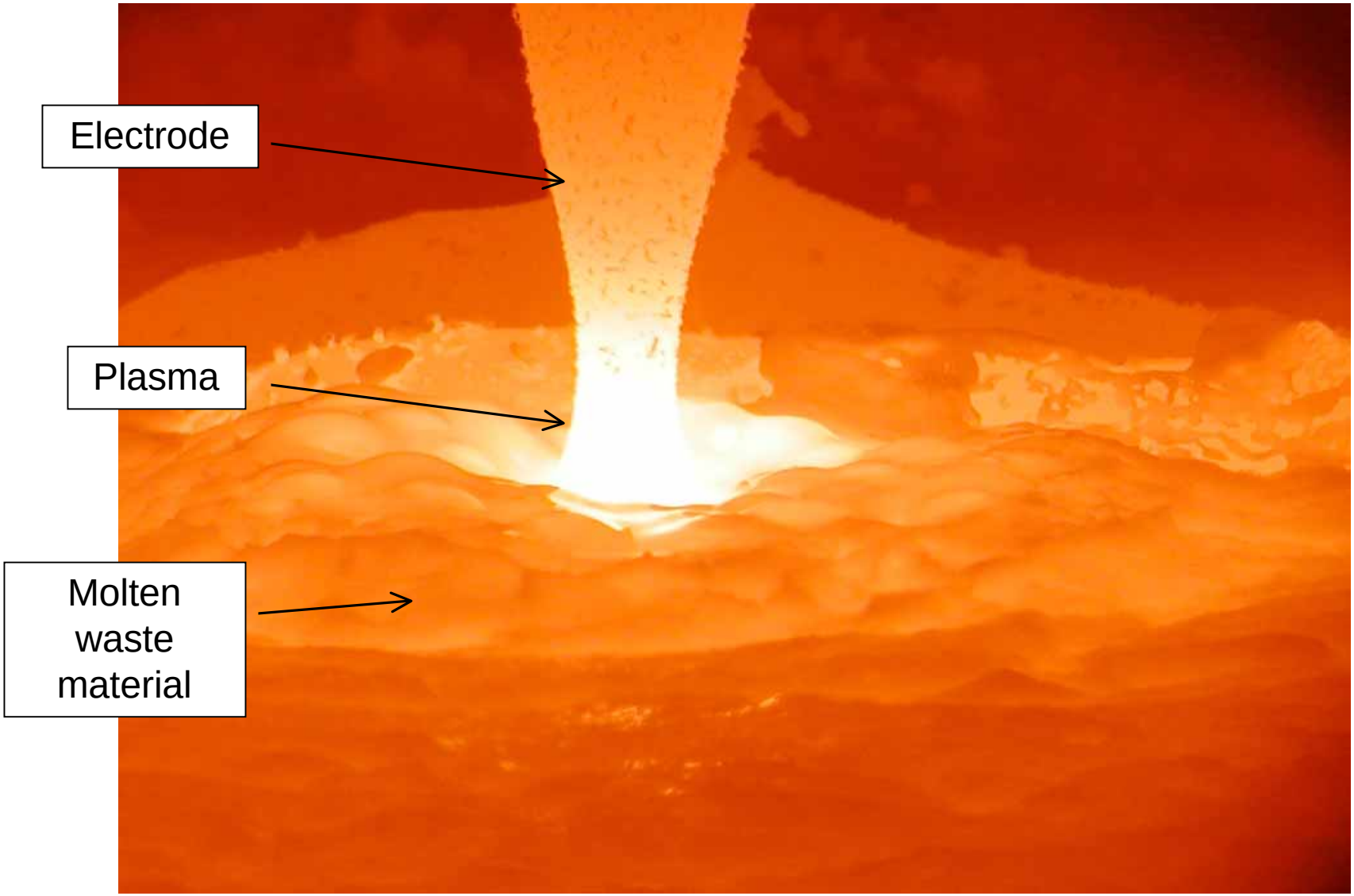


Photo by Laura K. Cohn

Production of Molten Material Without a Plasma

Ash Residue is Converted into Glass

From medical waste processed in Hawaii

Potential Uses:

- construction material
- sandblasting grit

Test Facility for PCB Hazardous Waste Destruction in Okinawa, Japan

Integrated Environmental Technologies, LLC

Advantages of Plasma Furnace

- Virtually eliminates dioxin and other air pollutants
  - Eliminates hazardous ash
  - Recycles waste into clean hydrogen and other products
- Versus landfilling
  - Eliminates water, soil and air pollution
  - Eliminates methane emissions (potent greenhouse gas)
- Economically attractive

Other Plasma Furnace Applications

- Reduces volume of radioactive waste and stabilzes it

DOE Hanford site
Richland, Washington

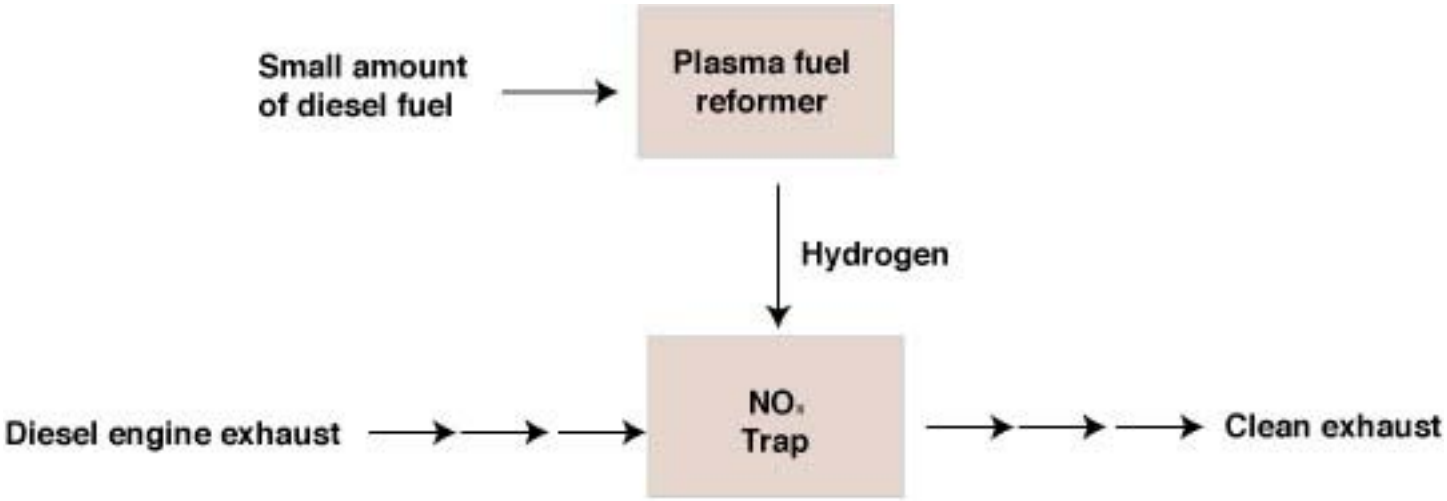
- Destroys chemical weapons

Need For Diesel Vehicle Exhaust Treatment

EPA regulations for heavy diesel trucks and buses in 2010 require large reductions in exhaust pollutants.

- Nitrogen Oxides (NO_x) are major contributors to smog
- Soot

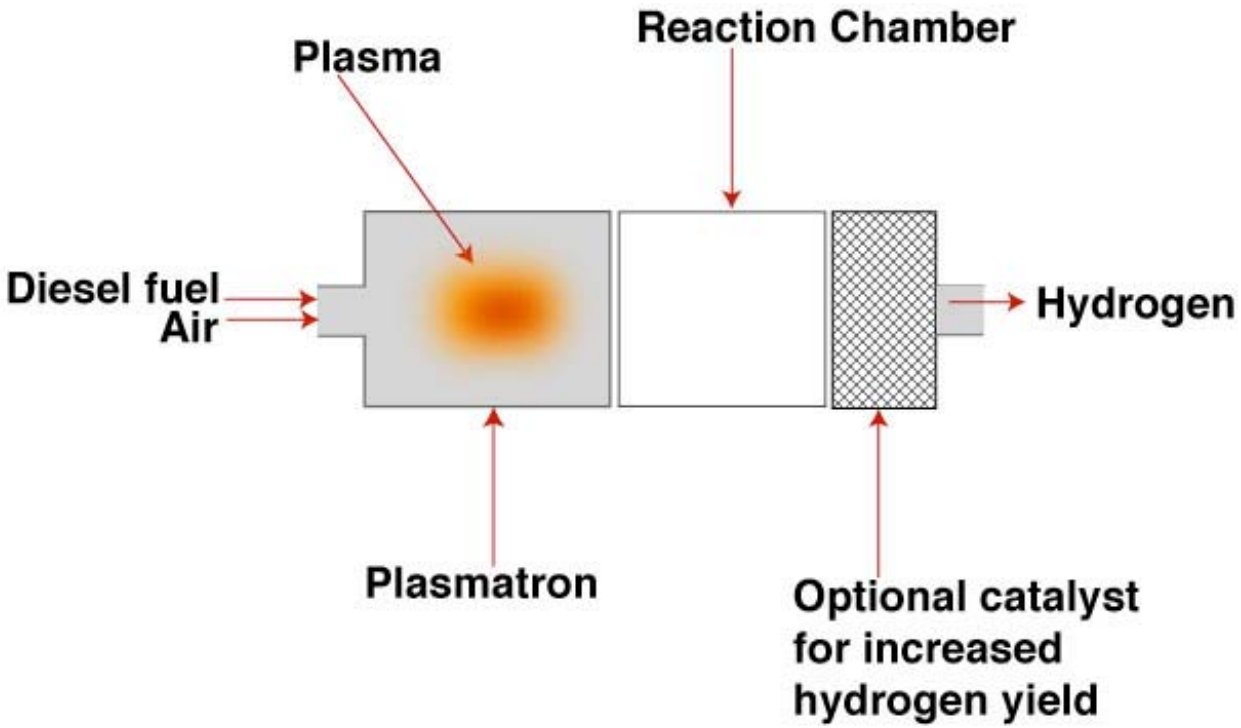
Plasma Hydrogen Enhanced NO_x Trap



Exhaust Treatment Process

- Trap captures NO_x
- Hydrogen converts NO_x into nitrogen and water

Plasma Fuel Reformer



Hydrogen Generation Process
Plasma initiates and maintains the chemical reaction which liberates hydrogen from diesel fuel.

Plasmatron Fuel Reformer

MIT laboratory version

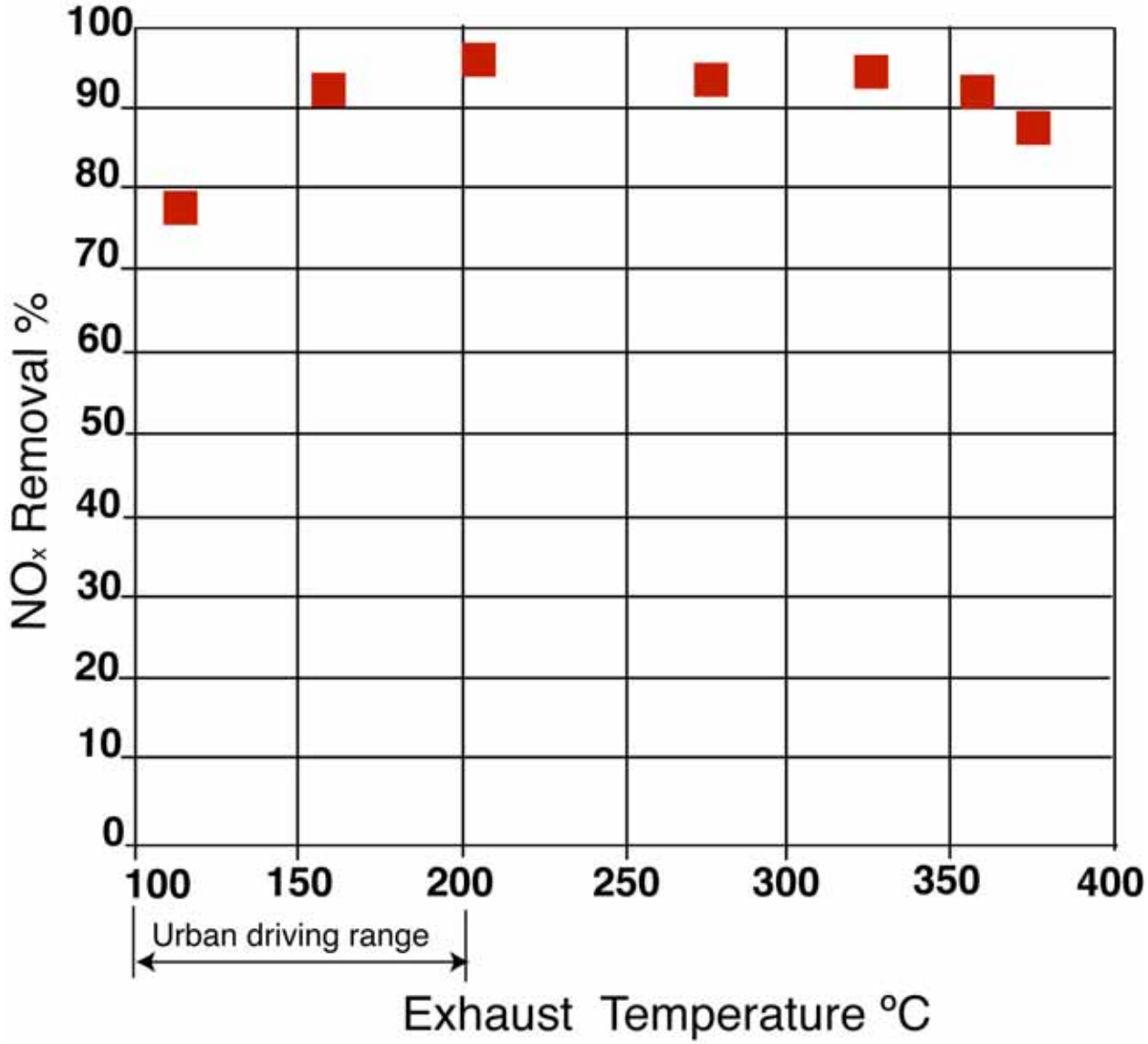
Power: 250 watts
Weight: 7 lbs.

ArvinMeritor version

Bus Tests of Plasma Hydrogen Enhanced NO_x Trap

(ArvinMeritor test track in Columbus, Indiana)

Successful Test of NO_x Removal

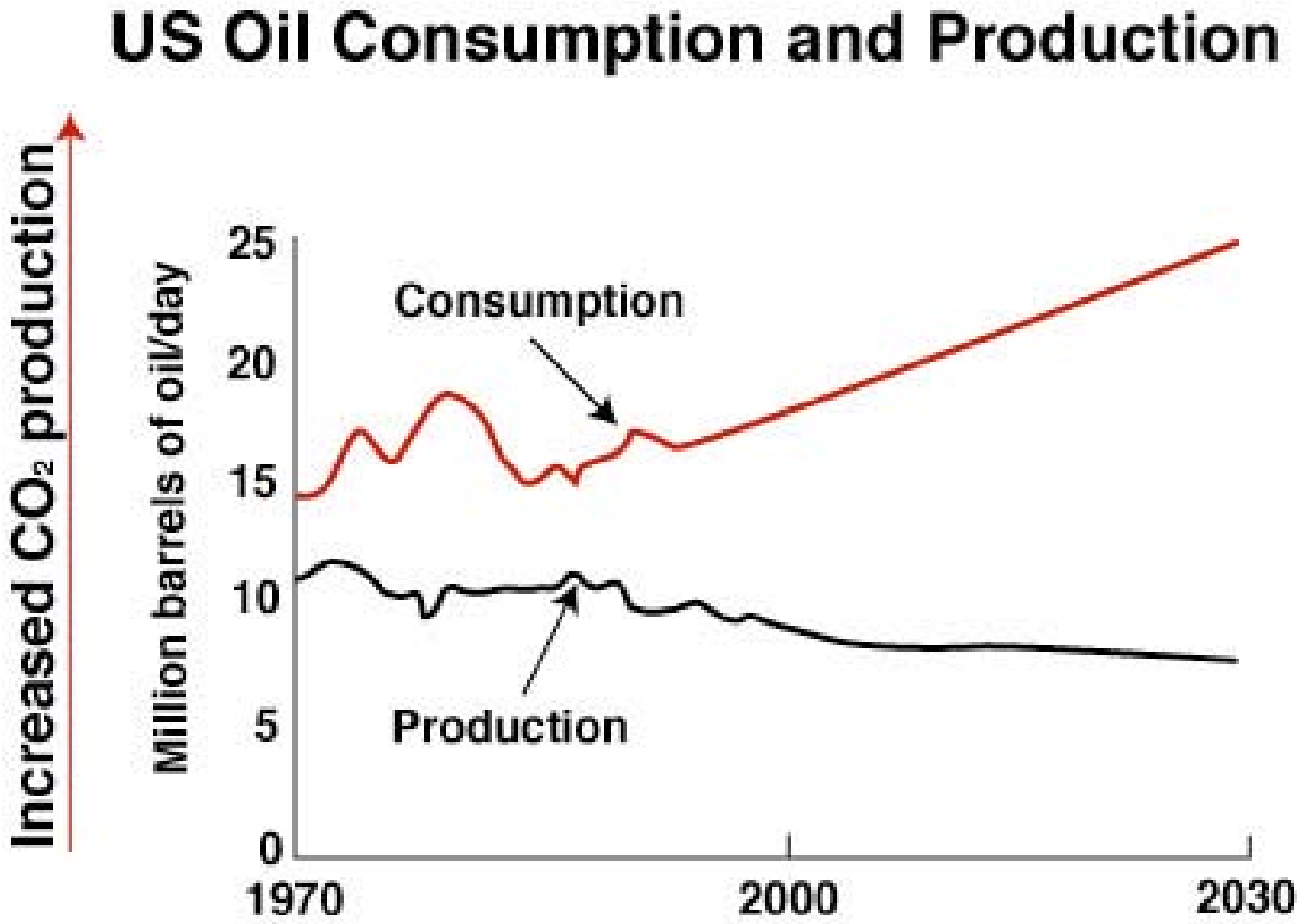


October, 2003

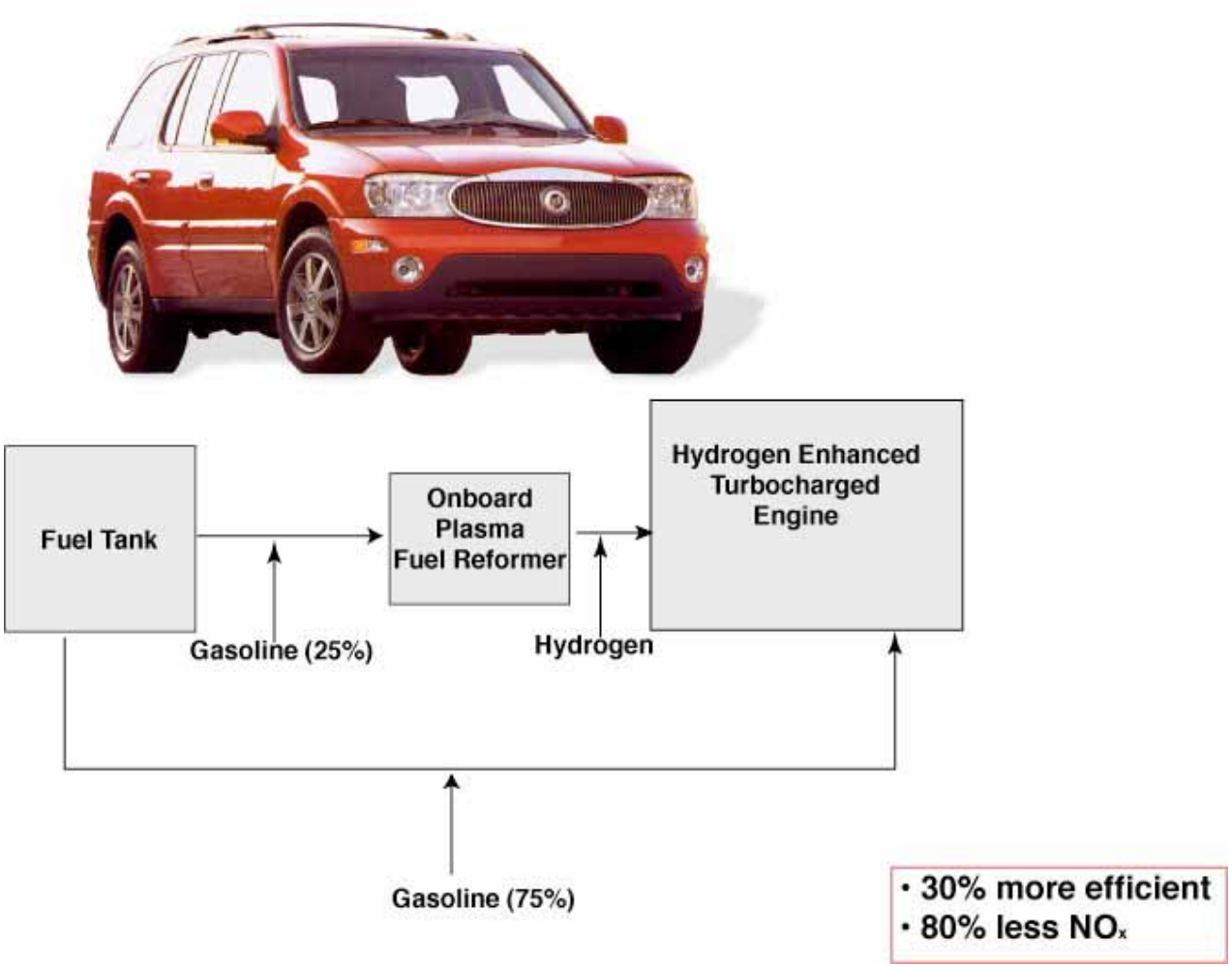
MIT'S PLASMA BUS Researchers at the ArvinMeritor Corporation and MIT's Plasma Science and Fusion Center have unveiled a diesel-powered bus that emits 90 percent fewer nitrogen oxides than the conventional version. Electric current from the vehicle's generator creates plasma—hot, electrically charged atomic fragments—that transforms diesel into a hydrogen-rich gas that then scours pollutants from the vehicle's exhaust-treatment system. This is the first time such an apparatus has been used in a fully functional vehicle. Daniel Cohn, leader of the MIT project, says his team's "plasmatron" fuel reformer could clean up the diesel engines in commercial trucks and buses, which are a leading source of transportation pollution in the United States. The plasmatron could also give cars and light trucks a boost, cutting emissions and raising the efficiency of gasoline engines by up to 30 percent for as little as $1,000 per vehicle. —*Alex Stone*

March, 2004

Need for High Efficiency Gasoline Engines



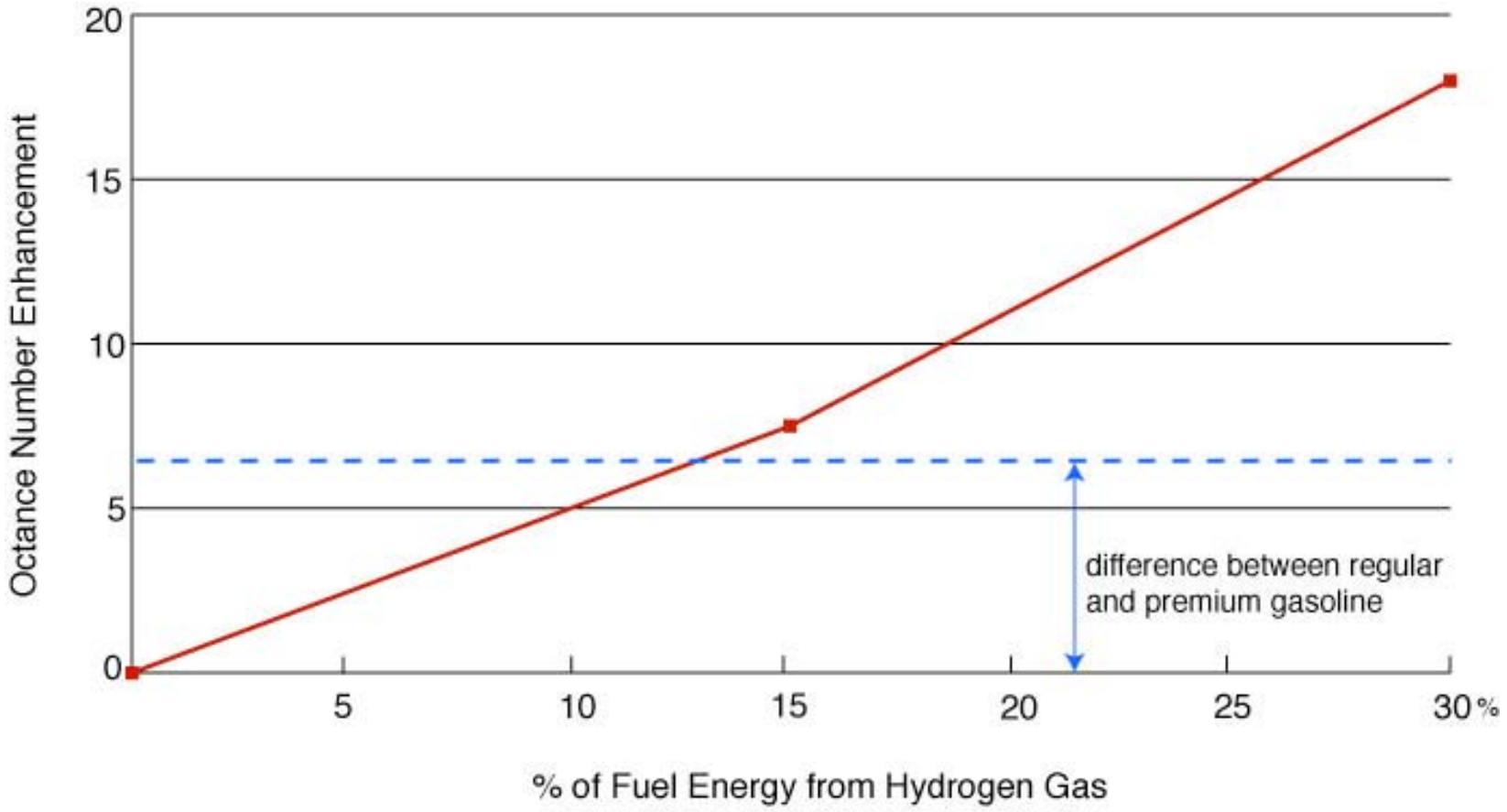
High Efficiency Gasoline Engine Using Plasma Hydrogen Enhancement



High Efficiency Operation

- Hydrogen addition provides a large increase in fuel octane number.
- High octane fuel allows higher performance engines (turbocharging, high compression ratio).
- Engines can be smaller and more efficient.
- Hydrogen addition also facilitates ultralean burn.
- Engine efficiency can be increased by up to 30%.

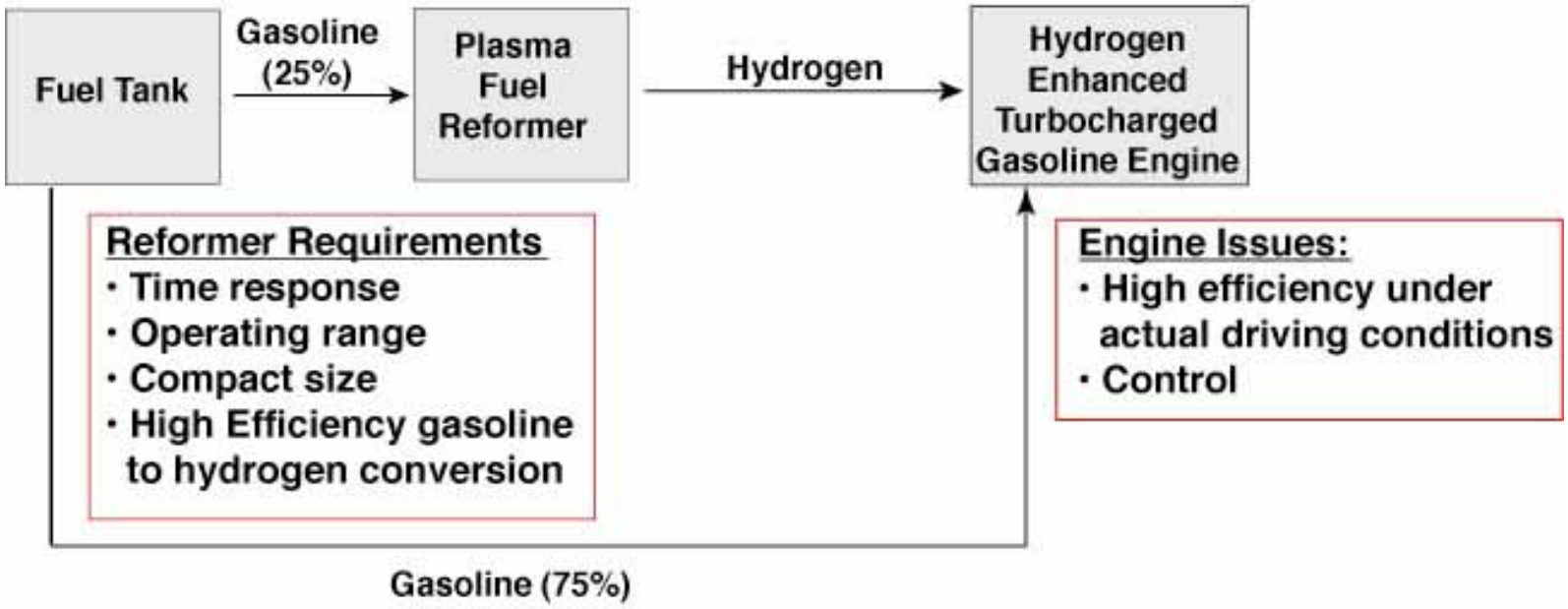
Octane Enhancement Using Hydrogen Addition to Gasoline



(From experiments at MIT Sloan Automotive Laboratory, 2003)

High Efficiency Gasoline Engine Using Plasma Hydrogen Enhancement

- Concept in laboratory test stage
- Next step: vehicle tests

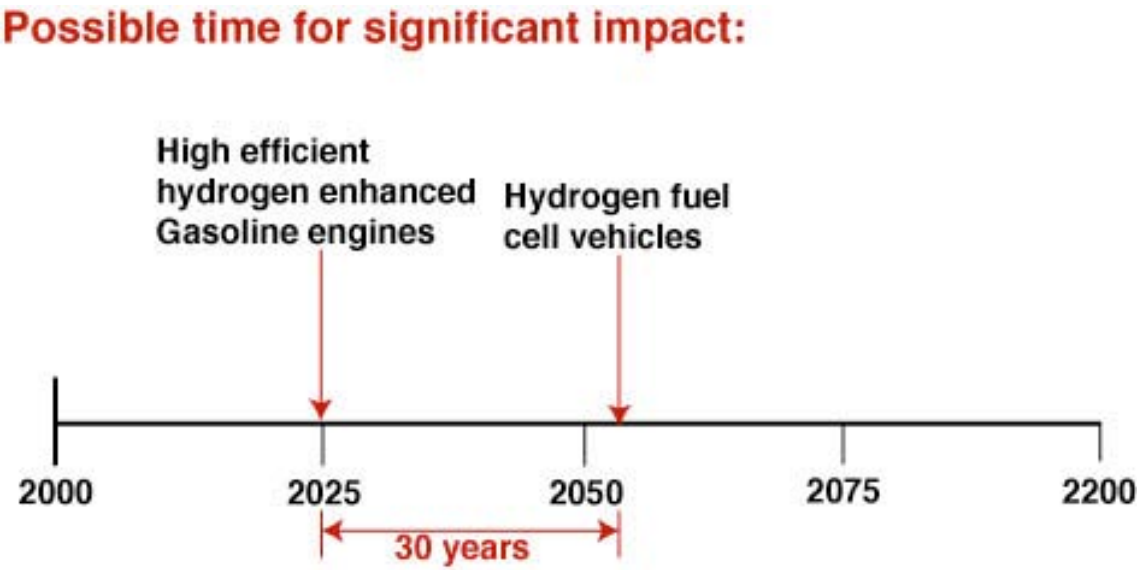


Reduced US Gasoline Consumption

- High efficiency gasoline engine could be economically attractive, and could eventually be in widespread use.
  - Additional cost projected to be around $1,000
  - Fuel savings pay back time of 3 to 6 years
- Widespread use could increase average car/light duty vehicle fuel efficiency by 25%.
- US gasoline consumption could be reduced by approximately 30 billion gallons/yr (corresponding to 2 million barrels of oil/day).

Speeding up Timetable for Reduction in US Oil Consumption

- Possible scenario for beginning of significant impact (e.g. 2 million barrel/day reduction)



- Gasoline consumption could be reduced by 800 billion gallons before hydrogen fuel cell vehicles make a significant impact.
- 20 billion barrel reduction in oil consumption

Summary

- Plasma furnace technology is beginning to be used commercially to destroy waste and produce hydrogen and other useful products.

- Use of plasma hydrogen technology to treat diesel exhaust shows promise for meeting strict 2010 EPA requirements.

- High efficiency gasoline engines using plasma technology could significantly reduce CO_2 greenhouse gases and dependence on foreign oil.