

# *Overview of Argonne's Transportation Research Program*

*Jim Miller, Ph.D.*

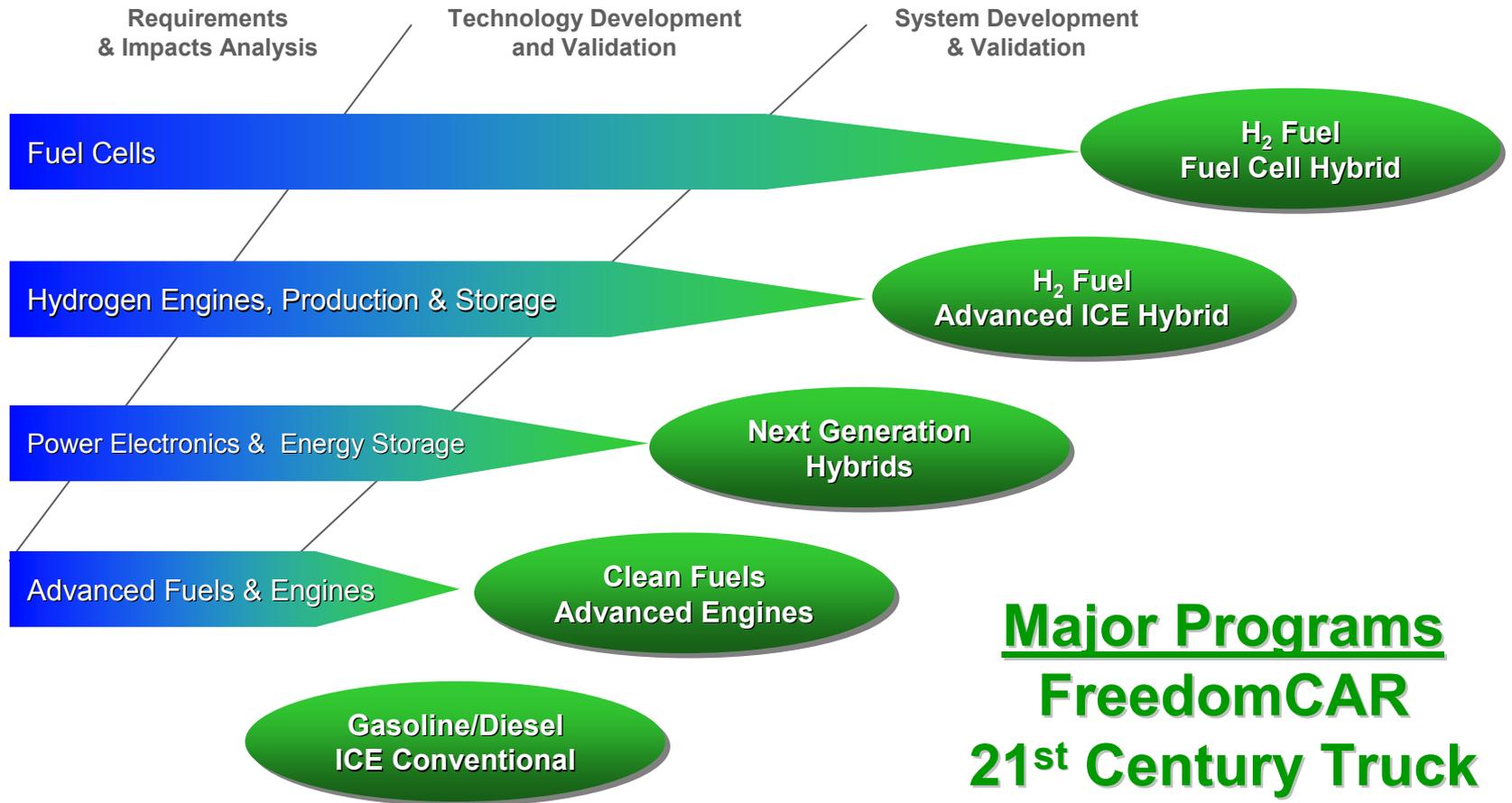
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# Argonne's Transportation R&D Covers Both Near-Term and Long-Term Technologies



# Argonne Has a Leading R&D Role in Several Transportation Fields

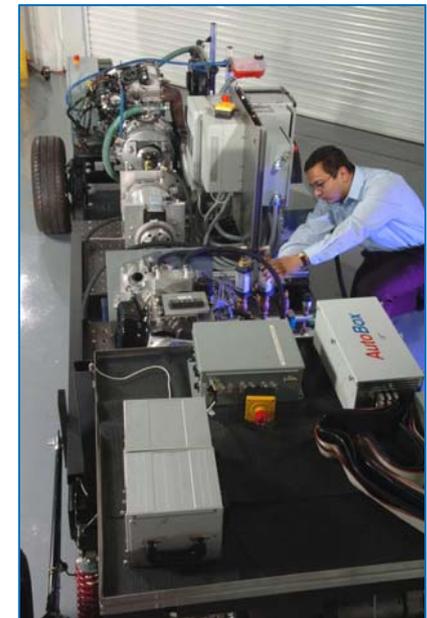
- **Hybrid vehicle systems, incl PHEVs**
  - Modeling
  - Benchmarking and evaluation
  - Component integration
- **Emissions control**
  - In-cylinder combustion
  - Bio-fuels
  - Laser-ignition for natural gas engines
- **Batteries**
- **Fuel cells**
- **Vehicle recycling**
- **Applied materials research**
  - Tribology
  - Nanofluids
- **High-performance computing**
- **Analysis and assessments**



4-wheel drive dynamometer for hybrid vehicle evaluation



Hydrogen Engine Test Stand



MATT HIL

Mobile Automotive Technology Testbed Hardware-In-the-Loop



# Argonne Is DOE's Principal Lab to Evaluate Hybrid Vehicle Technology

## ■ ANL's HEV Systems Activities:

- Modeling (PSAT)
- Hardware-In-the-Loop (HIL)
- Testing (APRF)

## ■ PSAT modeling simulates:

- Several hundred drivetrain configurations
- Fuel consumption and performance
- Powertrain transient phases

## ■ HIL evaluates components in an emulated vehicle system:

- Combination of computer models with real hardware
- Cost-effective approach for technology evaluation
- No need to build a prototype

## ■ Hybrid testing experience:

- >100 HEVs in DOE competitions
- Extensive Toyota Prius and Honda Insight tests
- Developed HEV procedures and instrumentation



■ R&D-100 Award Winner

# *MATT HIL: “We don’t make vehicles; we make vehicles better.”*

**MATT Mobile Automotive Technology Testbed  
HIL Hardware-In-the-Loop**

- MATT Chassis has individual component bedplates
  - Easy component swaps
- One single electric machine that can emulate any smaller size machine
  - Different level of hybridization
- ANL developed control software PSAT-Pro
  - PSAT companion for prototyping
  - Control of the components of the powertrain (emulated or real) in real-time



# ***ANL Is DOE's Designated Lead in R&D for Promising Plug-In Hybrid Vehicles***

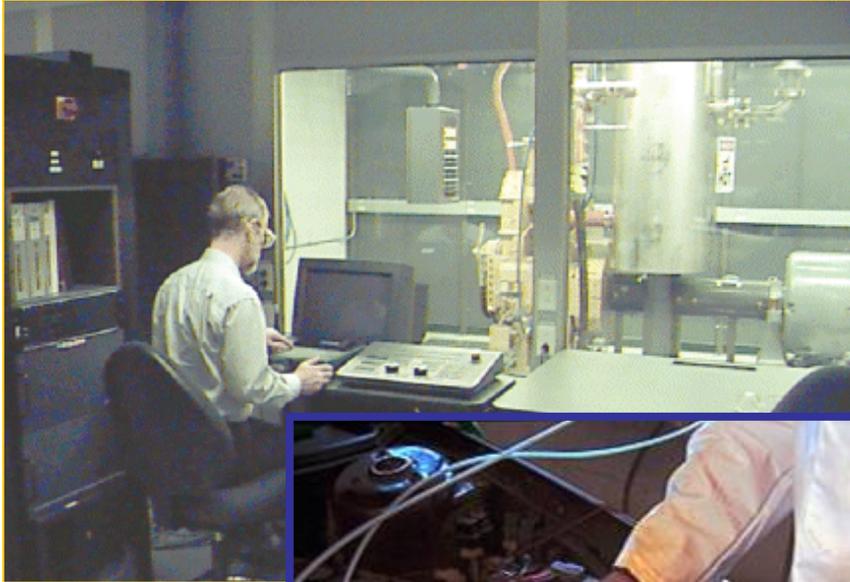
- Displace energy sources for transportation: from oil to grid electricity
- Majority of daily trips are short
- Technical barriers
  - *batteries, batteries, batteries*
    - safety
    - cycle life
    - calendar life
    - cost
  - *vehicle and control systems integration*
  - *benchmarking and protocols*



***P-HEVs are hybrid vehicles with larger batteries that can deplete during electric mode of operation and recharge from the grid***



# *Engine Emissions Can Be Controlled by Selective Modification of Intake Air*

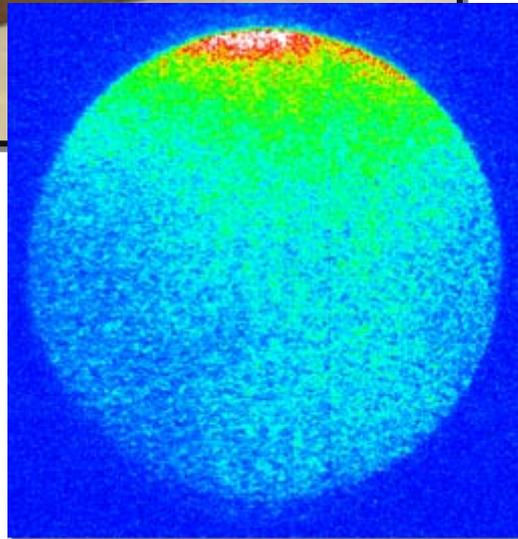
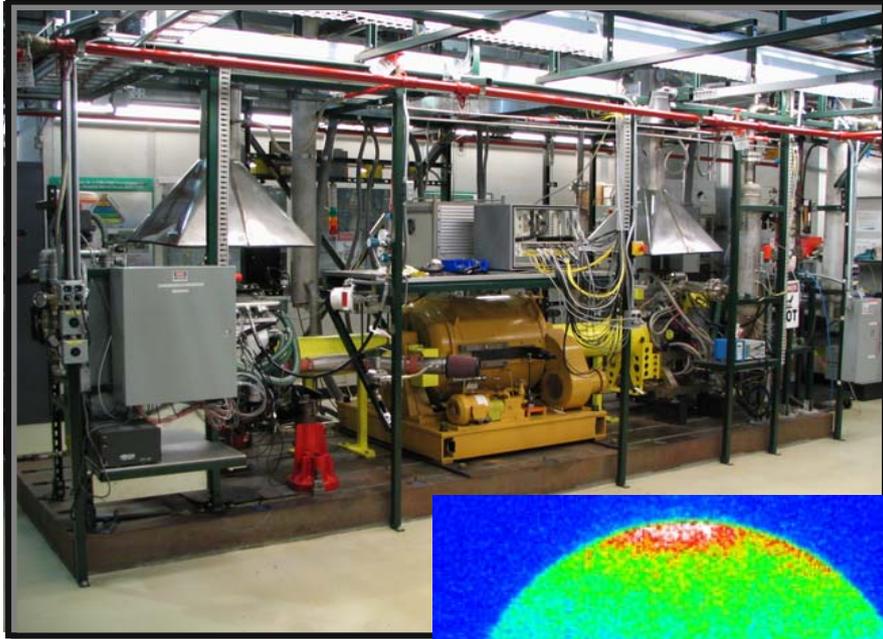


- In-cylinder combustion control complements aftertreatment and fuel modifications
- Membrane separates air into oxygen-rich and nitrogen-rich streams for use in engine
- Argonne has half a dozen patents on engine air composition
- Argonne's unique engine research has directly led to industrial collaboration
  - GM ElectroMotive Division
  - Caterpillar
  - Mack Truck
  - Degussa

**R&D-100 Award**



# Argonne's Engineers See into the Future of Hydrogen Internal Combustion Engines



- Designated hydrogen engine test cell
  - Single-cylinder research engine
  - Four-cylinder production-based engine
- Experiments with hydrogen port-injection and direct-injection
- Optical access allows imaging of hydrogen combustion

Image of hydrogen combustion (OH\* chemiluminescence intensity)

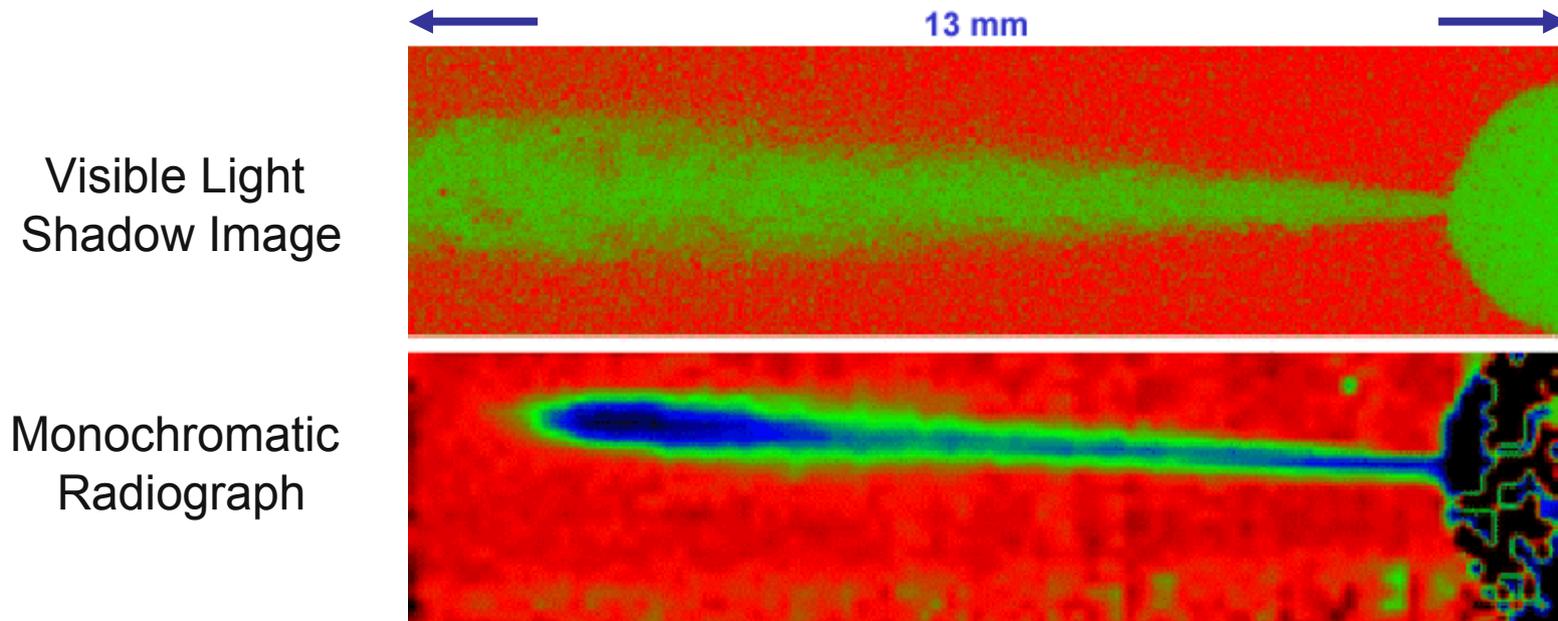


# Argonne's Fuel Research Provides Needed Data for Success of Future Biofuels

- Argonne conducted the first US tests of SunDiesel (developed by Choren)
  - Derived from wood chips
  - Significant interest in Germany
- Characteristics
  - Clear and odor-free
  - Low aromatics, negligible sulfur
- Engine, dyno, and on-road tests
  - THC, CO, PM and NOx emissions were significantly lower than conventional diesel fuel
  - Total CO2 emission rate was 10% lower than the base fuel - less fuel mass consumed
- Dissemination of results
  - DOE and other government agencies
  - US Postal Service, BMW
  - Universities



# APS X-Rays of Diesel Fuel Spray Provide Startling Clarity Compared to Lasers

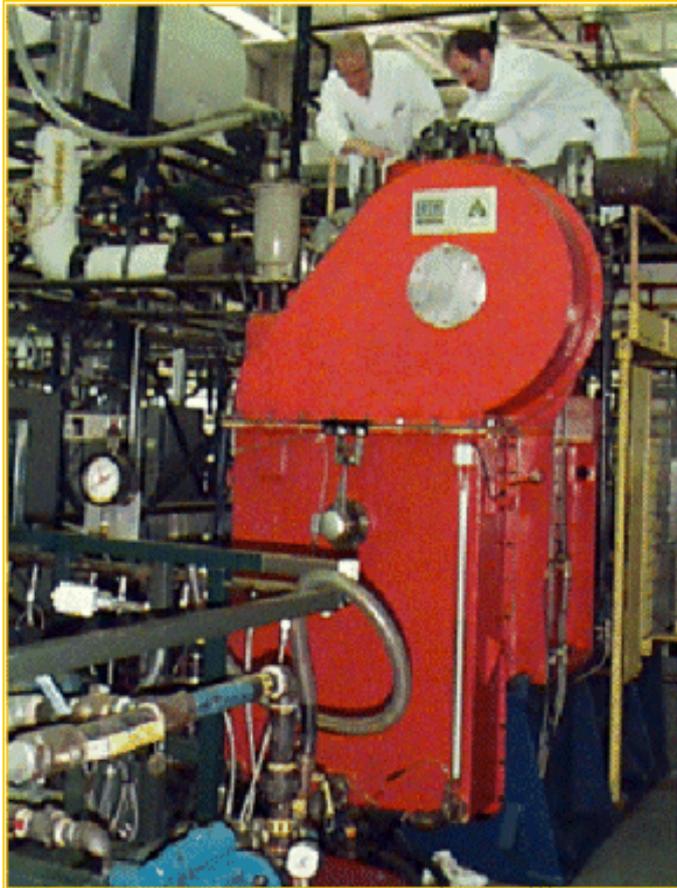


- X-rays penetrate the mist surrounding the spray core and reveal a more realistic image of the spray plume structure.
- **More than 99% of the fuel mass** is concentrated in the spray core, which takes a volume less than 10% of that shown by visible light images.

2001 Discover Award Finalist



# Engine Research Ranges from Automotive to Locomotive Size



## ■ ElectroMotive Diesel

- Formerly GM ElectroMotive Division
- Interest sparked by ANL emission control technology
- Major investment at ANL
  - *\$7M in facilities*
    - 4-stroke engine
    - 2-stroke engine
  - *Annual operating budget: \$800K - \$1M*
- 10 years of successful collaboration

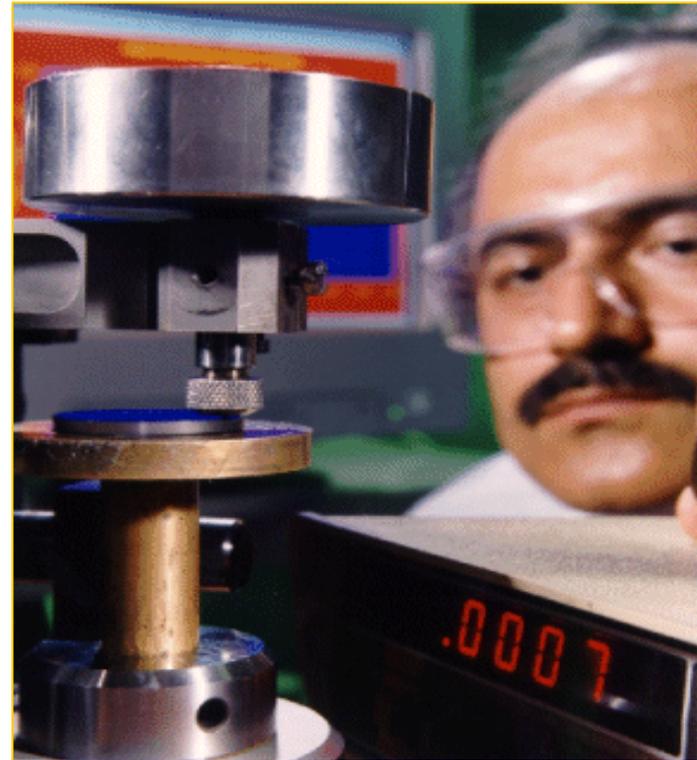
## ■ Argonne's Engine Research Facility allows researchers to

- Analyze basic design
- Improve performance and reliability
- Increase fuel efficiency
- Reduce exhaust emissions
  - *Meet new EPA emissions standards*



# *Transportation Applications Are Many for Near-Frictionless Carbon Coatings*

- **Sliding/rolling/rotating components**
  - fuel injectors
  - transmissions
  - turbochargers, etc.
- **Excellent adhesion to:**
  - metals
  - ceramics
  - Plastics
- **Industrial interest**
  - 3500 inquiries
  - 80 non-disclosure agreements
  - 30 work-for-other projects
  - commercial scale-up next objective

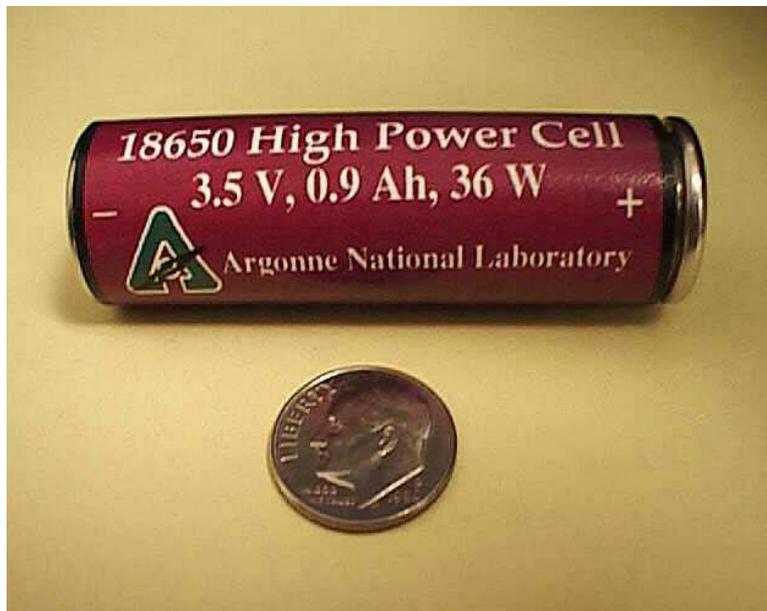


**R&D-100 Award**



# Argonne Develops Advanced Battery Technologies for Hybrid Electric Vehicles (HEVs)

- Argonne leads DOE's lithium-ion research program, focused on:
  - extending battery life
  - improving safety
  - reducing battery cost
- R&D-100 Award in 2005



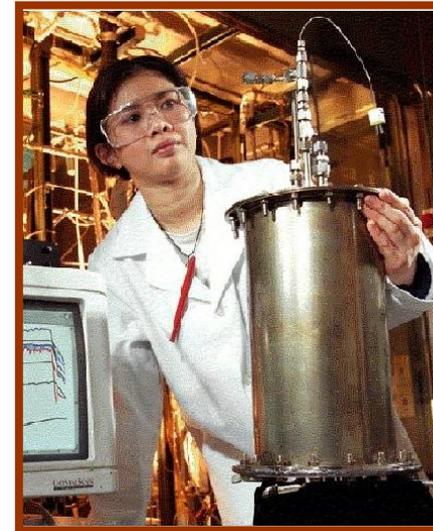
- Battery Test Facility provides independent evaluation of development technologies under a wide range of test conditions



Argonne Has Evaluated More than 4,000 Cells and Batteries since 1976

# *Argonne Develops Fuel Cell Technologies*

- **Low-cost fuel cell catalysts, to reduce or replace platinum needed**
- **Carbon nanotubes as new electrode structures**
- **Fuel processors that extract hydrogen from conventional and alternative fuels**
- **Fuel Cell Test Facility for testing automotive-size fuel cells**



**Fuel reformer**



**Fuel cell test facility**



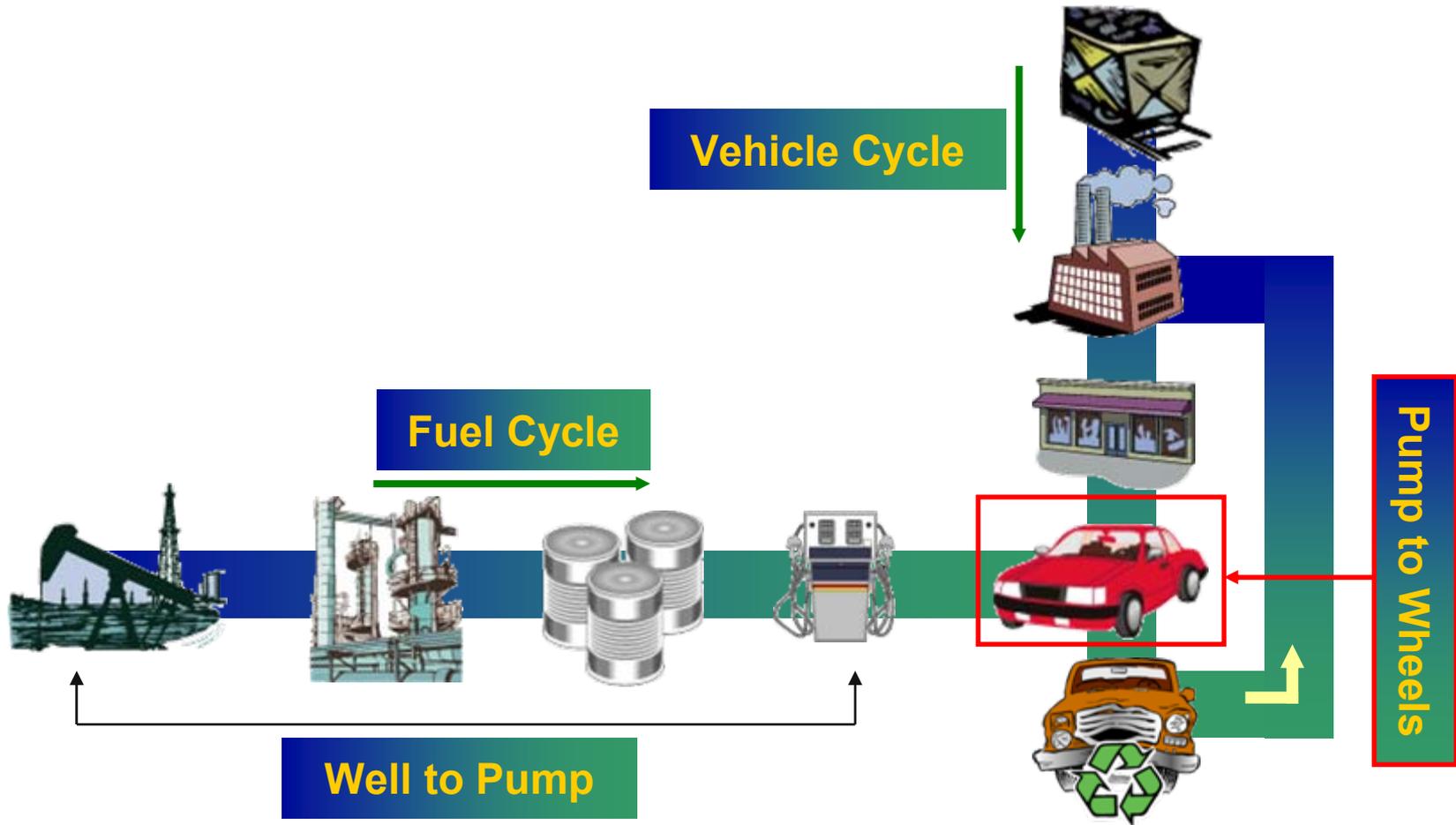
# Cost-Effective Recovery of Auto Shredder Residue Developed at ANL



- Polyurethane foam and plastics separated from automotive shredder residue.
- Cleaned foam used for carpet padding; licensed to Salyp N.V. (Belgium)
- The high-purity ABS material has been used to make automobile components.
- **2000 R&D 100 Award Winner** (Foam Recovery)
- **2000 Discover Award Finalist** (Plastics Recovery)



# Technology Assessments Include the GREET Model for Total Lifecycle Analysis



Results of Argonne's assessments of new fuels and advanced vehicles have been used by federal and state governments, auto industry, and energy industry in their decisions.

# The Web and Newsletters Are Additional Ways That We Transfer Research Results



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### Recycling Automotive Plastics Is Profitable and Good for the Environment

Recycling is not just good for the environment, it is good for business. Argonne researchers have developed a technology to successfully recover plastic from obsolete automobiles that may add plastic to the list of valuable materials recycled from old cars and trucks.

Current research at Argonne is focused on "mechanical recycling" – recovery of materials such as plastics from shredder residue for re-use in automotive and other applications. The technology being developed at Argonne consists of two major processes. The first is a bulk separation process to separate shredder residue into constituent fractions, followed by the second process, which recovers specific plastics from a polymer concentrate. ([Learn more...](#))

**What's New**

- The latest version of AirCRED allows you to save your data. The online software calculates Clean Cities emissions credits for alternative fuel vehicle fleets. ([More...](#))
- The VISION model, which evaluates alternative assumptions about advanced vehicle and alternative fuel market penetration, has been modified. ([More...](#))

**Highlights**

- GREET 1.7 Beta is available for download. ([More...](#))
- Why do platinum fuel cell catalysts degrade? PEM fuel cells use a platinum catalyst. Over time, performance decreases. We are studying the stability of platinum to determine why. ([More...](#))
- PSAT Demonstration Videos: Find out what [this software](#) is all about. (registration required) ([More...](#))

**Latest Publications**

- TransForum Vol. 5, No. 2, Fall 2005 ([html version](#)) ([623Kb pdf](#))
- Hydrogen Demand, Production, and Cost by Region to 2050 ([1Mb pdf](#))
- Suggestions for a New Vehicle Choice Model Simulating Advanced Vehicles Introduction Decisions (AVID): Structure and Coefficients ([11Mb pdf](#))
- The Debate on Energy and Greenhouse Gas Emissions Impacts of Fuel Ethanol ([2Mb pdf](#))

These documents are available as Adobe Acrobat pdf files [Download Acrobat Reader](#).

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