

Overview of Transportation Research



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Center for Transportation Research
Argonne National Laboratory
July 2013

An aerial photograph of the Argonne National Laboratory campus. The image shows a large, sprawling complex of multi-story brick and concrete buildings, interspersed with green lawns, parking lots, and winding roads. In the upper right, a prominent circular structure, likely a stadium or arena, is visible. The overall scene is a mix of urban infrastructure and natural greenery.

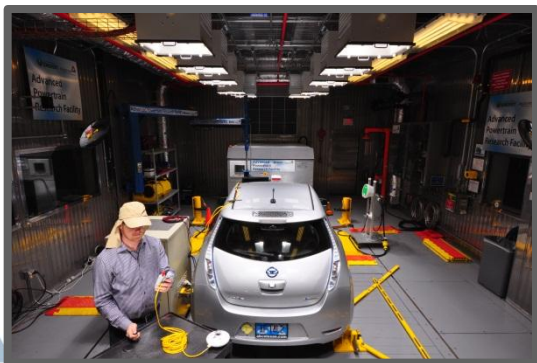
Argonne National Laboratory: A multipurpose national laboratory

The challenge: To do world-class fundamental science and engineering that provides solutions to the national challenges

DOE Energy Efficiency and Renewable Energy - Vehicle Technologies Program Office

Decrease petroleum dependency and Reduce greenhouse gases

Develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum. The long-term aim is to develop technologies that will provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment



Argonne's Center for Transportation Research

Unique Facilities and Depth of Expertise



Basic & Applied Combustion Research



APS – x-rays
Transportation Hutch



Materials Research - Battery electrodes
- Fuel cell catalysts
- Tribology



Autonomie
GREET **High Performance Computing**

Modeling and Simulation



Advanced Powertrain Research Facility

Testing and Validation

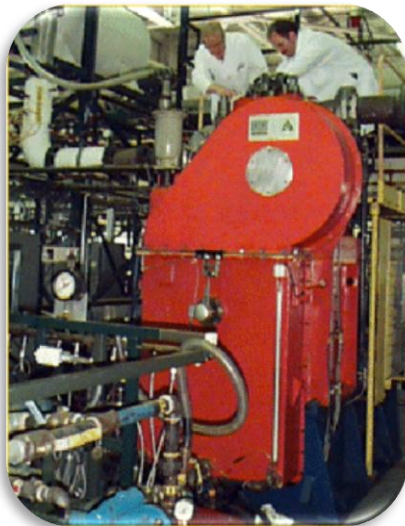
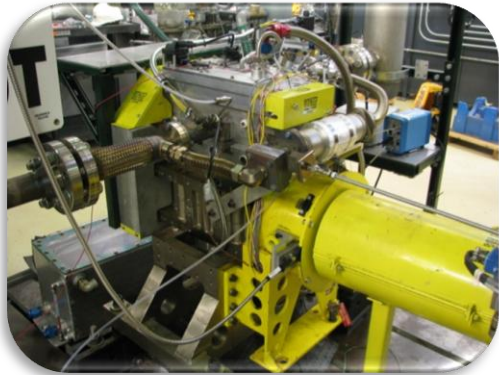


Fuel Cell and Battery Testing



Student Competitions

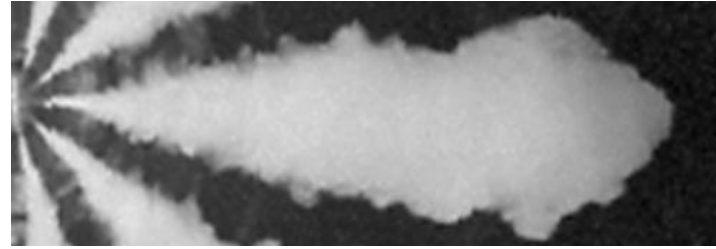
Engine Research - Increasing Engine Efficiency Automotive to Locomotive Size



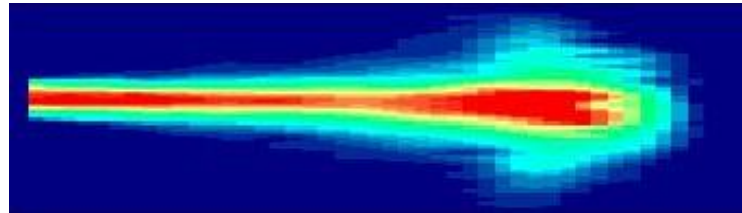
- **State of the art engine test facilities**
 - 7 engine dynamometer cells
 - Multi-fuel capability
 - Several emissions benches
 - FTIRs, Micro-Soot sensor
 - High-speed data acquisition systems
- **Diverse skill sets**
 - Engineers with backgrounds in mechanical engineering, electronics, physics ...
 - 3-D CFD modeling performed in house
 - Highly trained technicians
- **Diverse funding sources**
 - DOE funded projects
 - CRADA agreements
 - WFO/TSA projects

X-Ray Measurements of Fuel Injection and Sprays

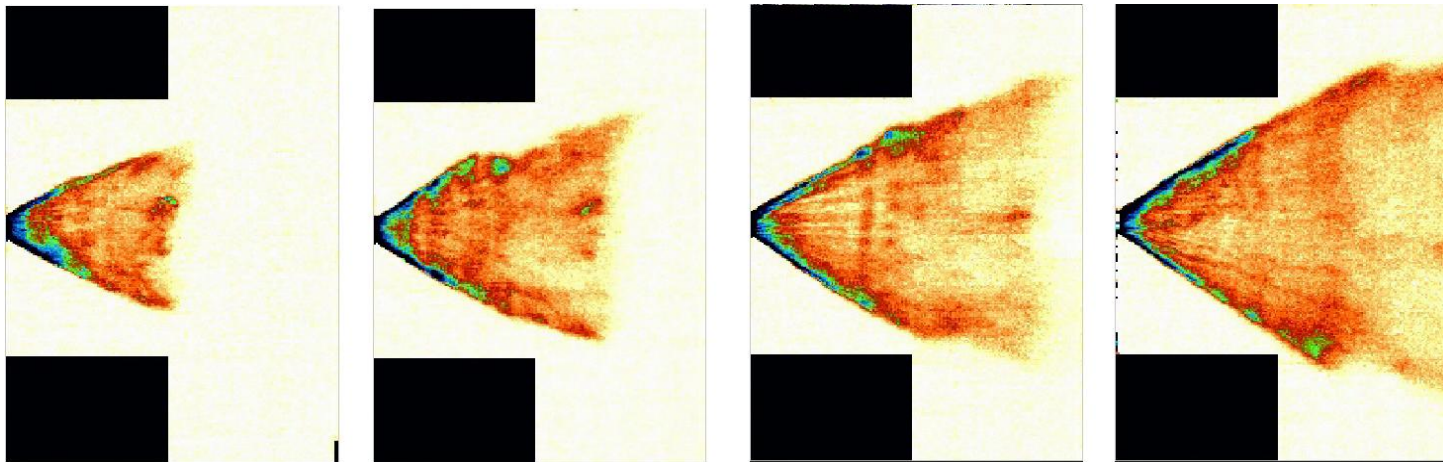
- Achieving high engine efficiency with low emissions requires a detailed understanding of fuel/air mixing
- Precise, quantitative measurements of fuel injection are required
- X-ray imaging gives time-resolved measurements of the fuel distribution



Visible Light Imaging



X-ray Imaging

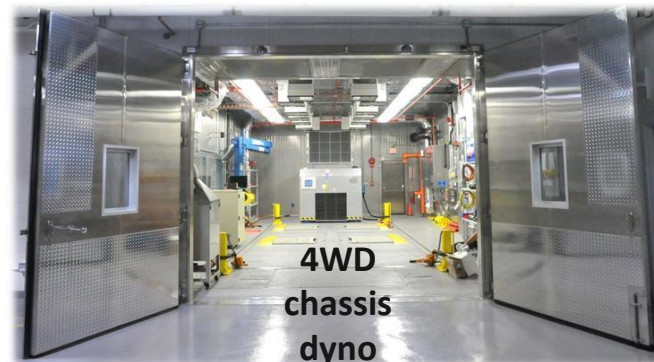


X-ray images showing the time evolution of a gasoline injection

Argonne is the U.S. Department of Energy's Principal Lab to Evaluate Electric Drive Vehicle Technology

Electric Drive testing experience:

- 2-wheel drive and 4-wheel drive vehicle dynamometers
- State-of-the-art environmental chamber for vehicle tests ranging from 90° F (32° C) to 20° F (-7° C)
- Research of unique vehicles from conventional technology to alternative fuels and electric drive
 - E.g., Alcohols, biodiesel, hydrogen, CNG, LPG
- Extensive benchmarking of the latest advanced technology vehicles, e.g. EVs/PHEVs/FCEVs/ HEVs
- Developed HEV and EV test procedures and instrumentation used as the industry-standard



Dynamometer Vehicle Benchmark Testing Approach

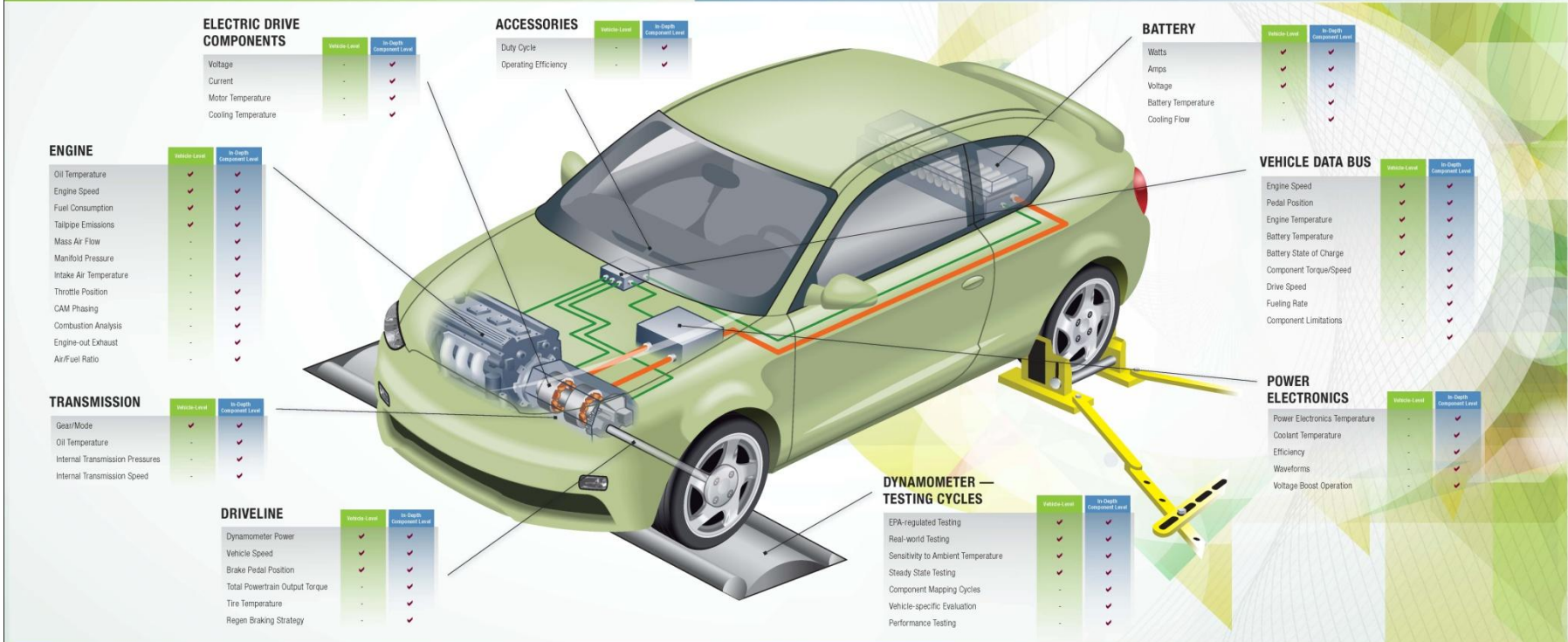
Advanced Vehicle and Component Research at Argonne's APRF

VEHICLE-LEVEL BENCHMARK RESEARCH

Vehicle-Level Benchmark Research is the initial testing performed on a wide variety of vehicles at Argonne's Advanced Powertrain Research Facility (APRF). Engineers use the facility's two-wheel drive and four-wheel drive dynamometers and state-of-the-art instrumentation to reveal important information on performance, fuel economy, energy consumption and emissions output. This data, which seeks to broadly understand a specific vehicle, is critical to evaluating the progress and viability of current and future transportation technologies.

IN-DEPTH VEHICLE AND COMPONENT-LEVEL RESEARCH

In-Depth Vehicle and Component-Level Research takes vehicle evaluation a step further with invasive instrumentation and extensive testing to reveal even more significant data and insight. By outfitting vehicles with equipment such as torque sensors, power analyzers and thermocouples, researchers attain a more complete vehicle assessment, including detailed component mapping and operating strategy evaluation. As compared to the standard Vehicle-Level Benchmark Research, this in-depth approach provides more comprehensive data, component characterization and understanding of the powertrain system operation. The schematic below illustrates the varying levels of data provided by the two types of vehicle evaluation.



RESEARCH FINDINGS

An Energy Efficiency Analysis to gain understanding of the engine on/off strategy, battery usage and management, shifting algorithms, emissions and fuel consumption trade-offs, accessory load management, real-world performance, thermal waste heat utilization, and component efficiencies.

RESULTS APPLICATION

Working with the U.S. Department of Energy (DOE) and the automotive industry, Argonne's vehicle research is used to:

- Support DOE in evaluating current and future technologies, and developing transportation goals and policies for petroleum displacement
- Aid in the development and optimization of advanced technologies to expand commercial applications
- Demonstrate alternative fuel benefits and promote energy diversity
- Provide unbiased research results for many stakeholders



Argonne Develops Advanced Battery Technologies for Electric-Drive Vehicles



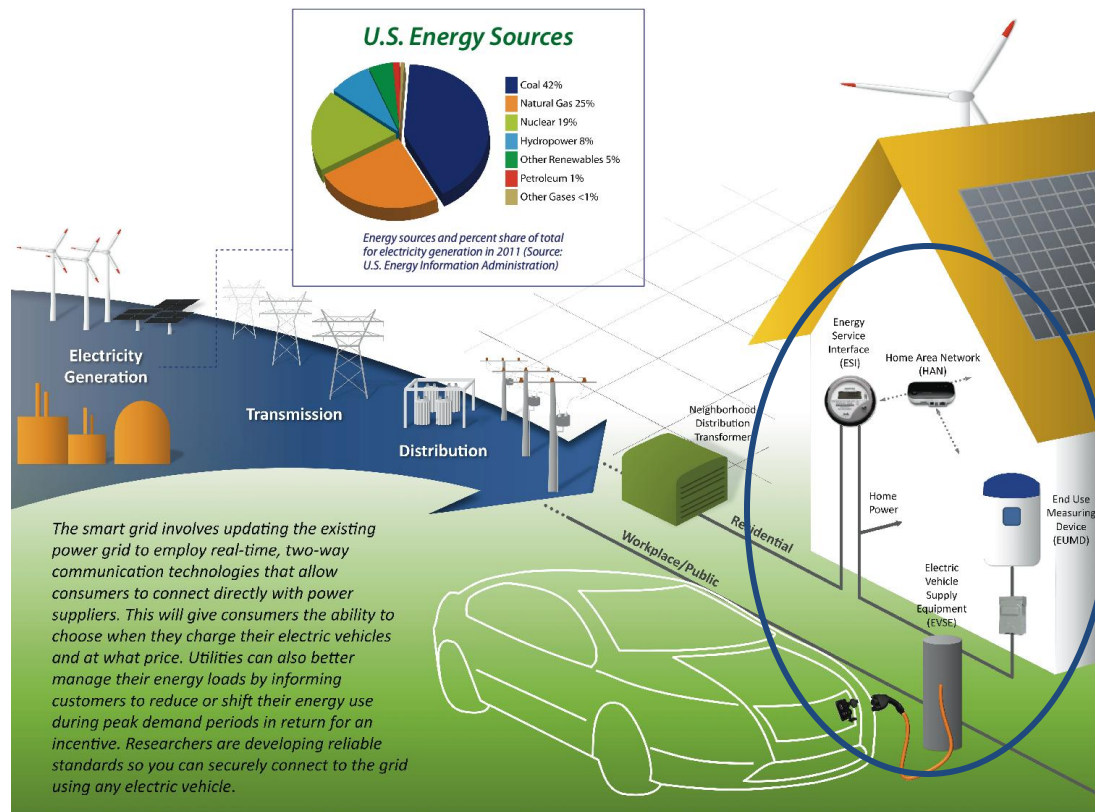
Argonne is leading the nation in developing revolutionary energy storage systems that enable electric-drive vehicles and greening of the energy grid through:

- Advancing electrochemical storage beyond lithium-ion batteries to other systems with new material discoveries (Energy Frontier Research Center)
- Developing and demonstrating energy storage prototype, manufacturing, and recycling processes and technologies
- Developing large energy storage and power management systems that improve grid reliability and efficiency, and enable steady power supply from renewable sources
- Optimizing efficiency, performance, and emissions of electric-drive powertrains

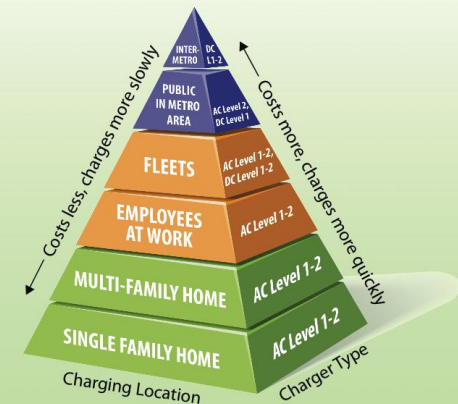
Interoperability: Vehicle - EVSE - Home - Utility



HOW YOU WILL CONNECT TO THE SMART GRID



Electric Vehicle Charging Options



Cars charge most often where they are parked most often.

Types of Chargers

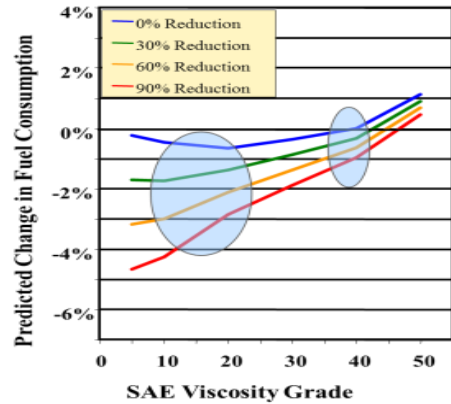
Level	Volts	Amps	kW
AC-1	120	20	2.4
AC-2	240	<80	<19.2
DC-1	<450	<80	<36
DC-2	<600	<400	<240



Tribology, Friction and Wear

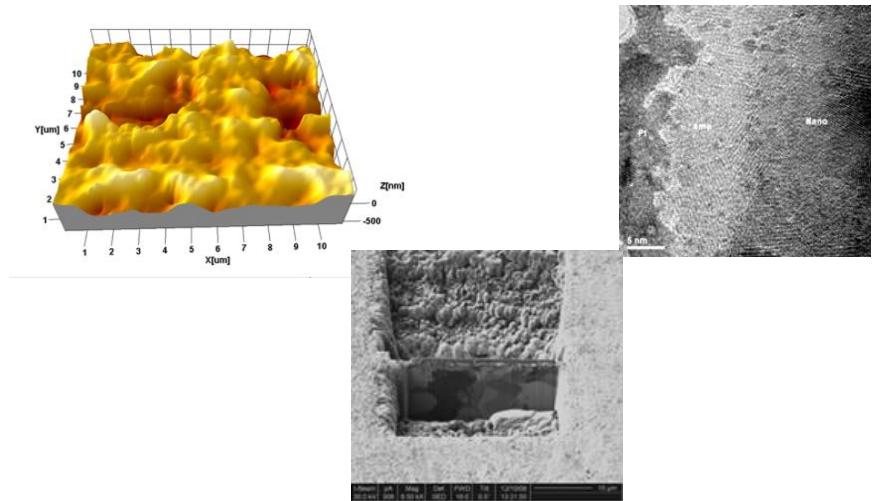
Modeling Impact of Friction on Fuel Economy

- Viscosity, asperity friction, surface finish...
- Drive cycle

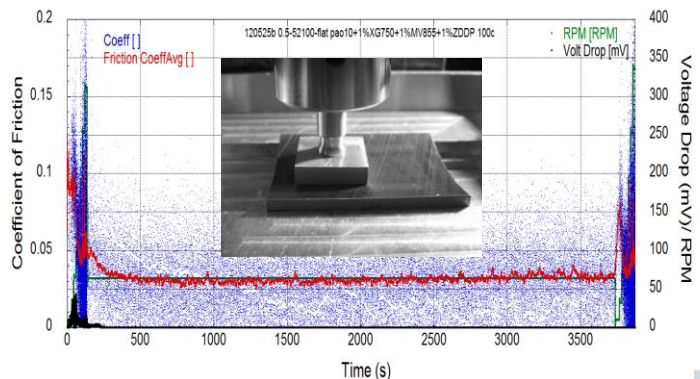


Characterization of Tribological Surface

- Structure, Composition, Chemistry

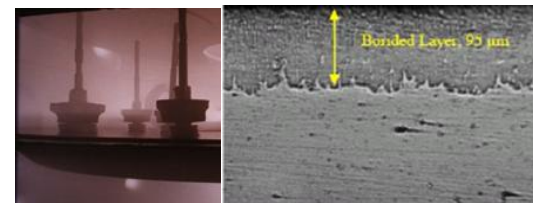


Lab Scale Testing of Materials, Coatings and Lubricants



Technology Development

- DLC, Superhard NanoComposite coating, Ultrafast Boriding
- NanoAdditives

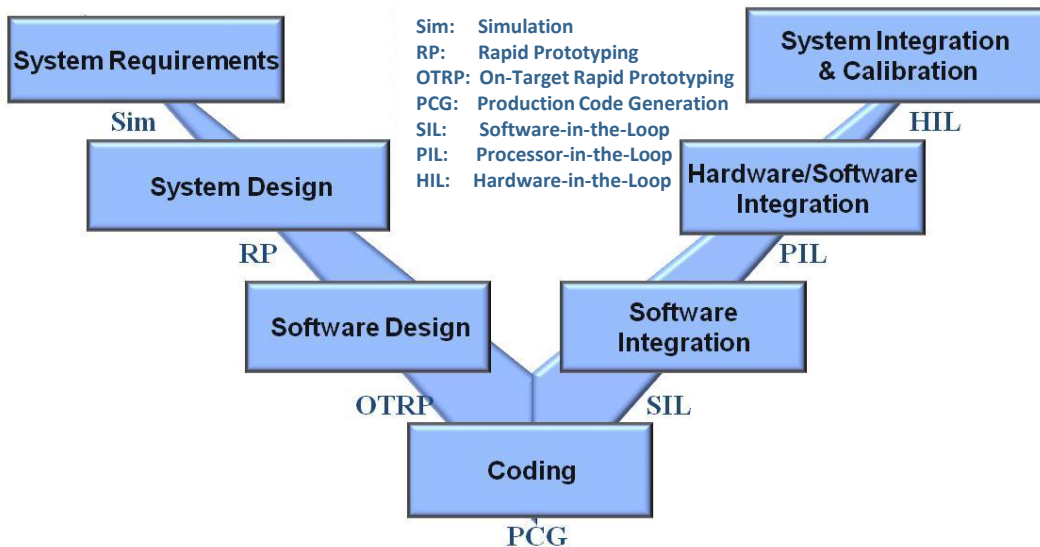


Macromolecular



AUTONOMIE - Model Based Design Approach to Accelerate the Vehicle Development Process

Model Based Design Process



Solution:

AUTONOMIE developed for fuel consumption analysis, control development, virtual powertrain evaluation with application from the concept phase to production mode for OEMs and researchers

Problem:

- Heavy reliance on hardware leads to high cost and longer development time
- Integration of new technologies in a system lowers true benefit

Result:

Wasted Opportunities, Time, and Resources (People & Budget)



Argonne's GREET Model

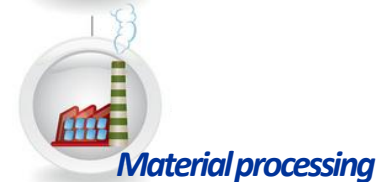
GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation)
Model is known as the gold standard for life-cycle analysis

The GREET Suite includes:

- Fuel cycle (GREET1)
- Manufacturing cycle (GREET2)

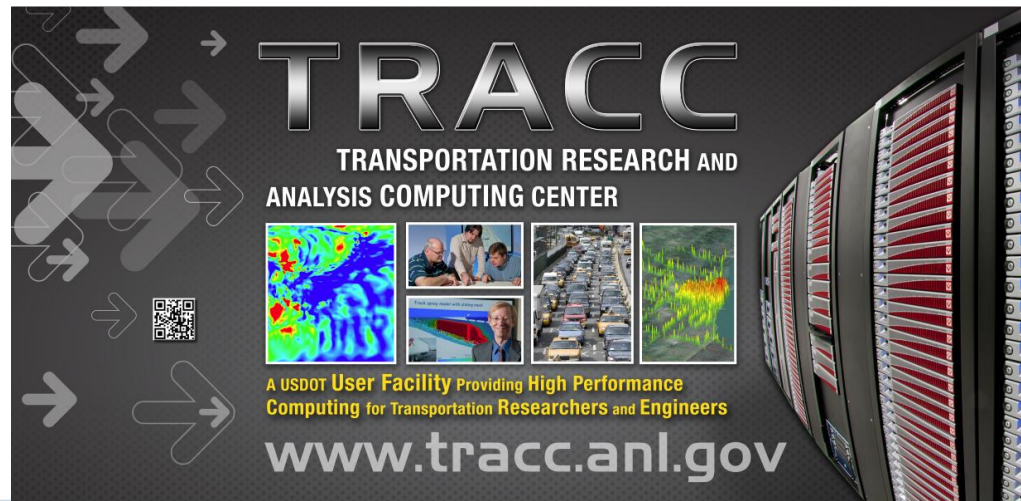


VEHICLE CYCLE
(GREET2)



TRACC - A National User Facility to Meet Advanced Computation Needs

- U.S. DOT and U.S. DOE transportation research programs are moving to simulation-based design and analysis for improvements in efficiency, economics, and safety
 - Requires higher fidelity analysis in areas such as crashworthiness, aerodynamics, combustion, thermal management, weather modeling, and traffic simulation
 - Requires access to state-of-the-art computational and visualization facilities
- Argonne expertise in high-performance computing and transportation system analysis provides the basis for a national HPC user facility and a focal point for computational research for transportation applications



The graphic features the TRACC logo in large, metallic letters, with the full name 'TRANSPORTATION RESEARCH AND ANALYSIS COMPUTING CENTER' below it. To the left, there are several grey arrows pointing right. In the center, there is a QR code and a grid of four small images: a colorful simulation, two people working at a computer, a highway with cars, and a 3D model of a car. Below the images, the text reads 'A USDOT User Facility Providing High Performance Computing for Transportation Researchers and Engineers'. At the bottom, the website 'www.tracc.anl.gov' is displayed. The right side of the graphic shows a perspective view of server racks in a data center.

TRACC
TRANSPORTATION RESEARCH AND
ANALYSIS COMPUTING CENTER

A USDOT User Facility Providing High Performance
Computing for Transportation Researchers and Engineers

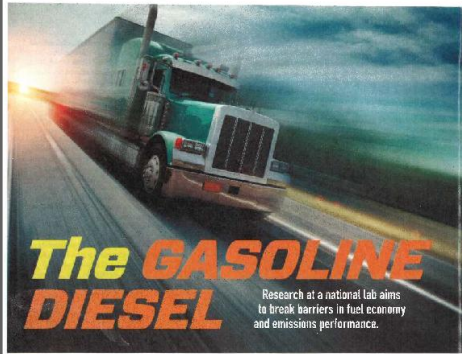
www.tracc.anl.gov

DOE Advanced Vehicle Technology Competitions (AVTC)



- Since 1987, DOE has sponsored AVTCs in partnership with the domestic auto industry to simulate the development of advanced propulsion and alternative fuel technologies and provide the training ground for the next generation of automotive engineers
- Advanced Vehicle Technology Competition:
 - Managed by Argonne National Laboratory and have involved more than 15,000 students from more than 600 educational institutions
 - Challenge students to design and build advanced vehicles with the goal of increasing energy efficiency and minimizing the environmental impact of personal transportation
 - Provide real-world, systems-level engineering challenges for students using industry-leading engineering tools, components and hardware and mimic the auto industry's vehicle development process

Examples of Ways Argonne Transfers Research Results



The GASOLINE DIESEL

Research at a national lab aims to break barriers in fuel economy and emissions performance.

BY STEVE CHITT

A common topic I often hear discussed around the coffee maker or water cooler is the seeming lack of progress in fuel economy among cars sold in the United States. Conspiracy theories abound. So do apparent solutions, such as "If we all drove vehicles based on [fill in the technology—diesel, hybrid, electric], we wouldn't have this problem."

I'm not a conspiracy theorist, and I'm certain Americans will not scrap their 260 million vehicles—and the infrastructure that supports them—overnight.

Yet when it comes to fuel economy in conventional spark-ignition and diesel engines, we seem to be treading water. Why?

Part of the problem is that there is not just one

SAE International

MECHANICAL EQUIPMENT

Journals and Trade Technical Publications



SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

J1711

REV. PropDft JUN2006


Issued 1999-03
Revised Proposed Draft 2006-06
Superseding J1711 MAR1999

Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles



Newsletters

Mechanical engineering ASME 9/2012



MOVING & SHAKING

A DIFFERENT KIND OF DIESEL

BY STEVE CHITT

SAE International

SAE 2012-01-1011

Impact of Technology on Electric Drive Fuel Consumption and Cost

A. Moawad, N. Kim, A. Rousseau
Argonne National Laboratory

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ABSTRACT

In support of the U.S. Department of Energy's Vehicle Technologies Program, numerous vehicle technology combinations have been simulated using Autonomie. Argonne National Laboratory (Argonne) designed and wrote the Autonomie modeling software to serve as a single tool that could be used to meet the requirements of automotive engineering throughout the development process, from modeling to control, offering the ability to quickly compare the performance and fuel efficiency of numerous powertrain configurations.

For this study, a multitude of vehicle technology combinations were simulated for many different vehicle classes and configurations, which included conventional, power split hybrid electric vehicle (HEV), power split hybrid electric vehicle (PHEV), extended-range EV (E-REV)-capability PHEV, series fuel cell, and battery electric vehicle. In this paper, the results are examined to compare the extent to which each of these technologies reduces fuel consumption and which combination of technologies produces the best trade-off between cost and fuel consumption. The main questions are whether it is cost effective to use advanced technologies, such as PHEVs, and how far we should or could electric vehicles to obtain fuel consumption improvements at reasonable cost. Several timescales are considered—2010, 2015, 2020, 2030, and 2045—to track electric drive evolution through time.

INTRODUCTION

The U.S. Department of Energy (DOE) Vehicle Technologies Program (VTP) is developing more energy-efficient and environmentally friendly highway transportation technologies that will enable America to use less petroleum. The long-term aim is to develop "enabling" technologies that will provide Americans with greater freedom of mobility and energy security, while lowering costs and reducing impacts on the environment. The DOE VTP assumes pre-competitive, high-risk research needed to develop the:

- Component and infrastructure technologies necessary to enable a full range of affordable cars and light trucks.
- Fueling infrastructure to reduce the dependence of the nation's personal transportation system on imported oil and minimize harmful vehicle emissions, without sacrificing freedom of mobility and freedom of vehicle choice.

As part of this ambitious program, numerous technologies are addressed, including engines, energy storage systems, fuel-cell systems, batteries, energy, electric machines, and materials, among others.

The 1993 Government Performance and Results Act (GPRA) holds federal agencies accountable for using resources wisely and achieving program results. GPRA requires agencies to develop plans for what they intend to accomplish, measure how well they are doing, make appropriate decisions on the basis of the information they have gathered, and communicate information about their performance to Congress and to the public. Every year, a report is published [1] to assess the results and benefits of the different programs.

Owing to the large number of component and powertrain technologies considered, the benefits were simulated using Autonomie [2]. Argonne designed Autonomie to serve as a single tool that can be used to meet the requirements of automotive engineering throughout the development process, from modeling to control. Autonomie, a forward-looking model developed using MathWorks tools, offers the ability to quickly compare powertrain configurations and component technologies from a performance and fuel-efficiency point of view.

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Argonne National Laboratory

Transportation Technology R&D Center

Checklist Makes Transition to New Fuels Easier

READ STORY

Alternative Fuels

- Autonomie
- Batteries
- Engine Testing
- HEV/EV
- Hybrid Electric Vehicles
- Hydrogen & Fuel Cells
- Materials
- Modeling, Simulation & Software
- Plug-In Hybrid Electric Vehicles
- PSAT
- Smart Grid
- Student Competitions

Technology Analysis

Press Coverage

- May 18 **WYNN**: Cranking for progress in hybrids
- May 18 **Green Car Congress**: Argonne study identifying fuel consumption penalties for CHG use in light-duty vehicles
- May 18 **State**: Eric Isaacson on the myth of the lone inventor in the garage
- May 17 **Scientific American**: How to Build a Better Lithium Ion Battery
- May 10 **QuintzCast**: BRP to begin testing next generation fuelcell
- Apr 28 **enr.com/stocks**: Battery-powered locomotives

What's New

- View monthly update of [electric drive vehicle safety](#)
- Argonne discovers [new class of battery materials](#)
- Read our new vehicle systems brochure: ["Driving the Future"](#)
- Read Argonne's "Energy to Renew Our World" brochure
- Argonne, LMS [partner in Autonomie](#)
- Remembering [Jules](#)

More press stories

More news