

HELPING FLEETS NAVIGATE MEDIUM- AND HEAVY-DUTY TECHNOLOGY CHOICES

How Argonne's Analysis/Simulation Tools, HD
Dynamometer, and XIL Capabilities Support
Affordability, Readiness, and Lower-Risk Deployment



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Argonne National Laboratory is a
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managed by UChicago Argonne, LLC.



MD/HD FREIGHT FACES AFFORDABILITY SQUEEZE

Small efficiency gains scale into large economic value across the freight system



**55.5M
tons/day**

U.S. freight moved each day



\$51B+/day

Value of freight moved daily



**+50%
by 2050**

Projected freight growth

- **Trucks are central to the U.S. economy** and remain the dominant freight mode.
- Average operating cost is about **\$2.26 per mile**.
- Fuel cost is about **48¢/mile**; non-fuel costs are about **\$1.78/mile**.
- In trucking, **pennies per mile** become **millions of dollars** across fleets.



***Affordability in trucking is measured in cents per mile —
and cents per mile become millions of dollars across fleets and supply chains.***

FLEET TECHNOLOGY DECISIONS ARE BECOMING MORE COMPLEX

Fleets need trusted insight before committing capital to vehicles, infrastructure, and operations



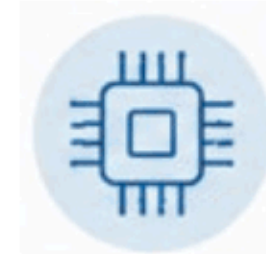
What technology fits my duty cycle?

Diesel, RNG/CNG, propane, hydrogen, hybrid, battery-electric



What will it cost over life?

Vehicle, energy, maintenance, incentives, residual value, infrastructure



What infrastructure must change?

Depot upgrades, fueling / charging access, utility coordination, workforce readiness



How ready is it for my operation?

Range, payload, uptime, reliability, service network, parts and support

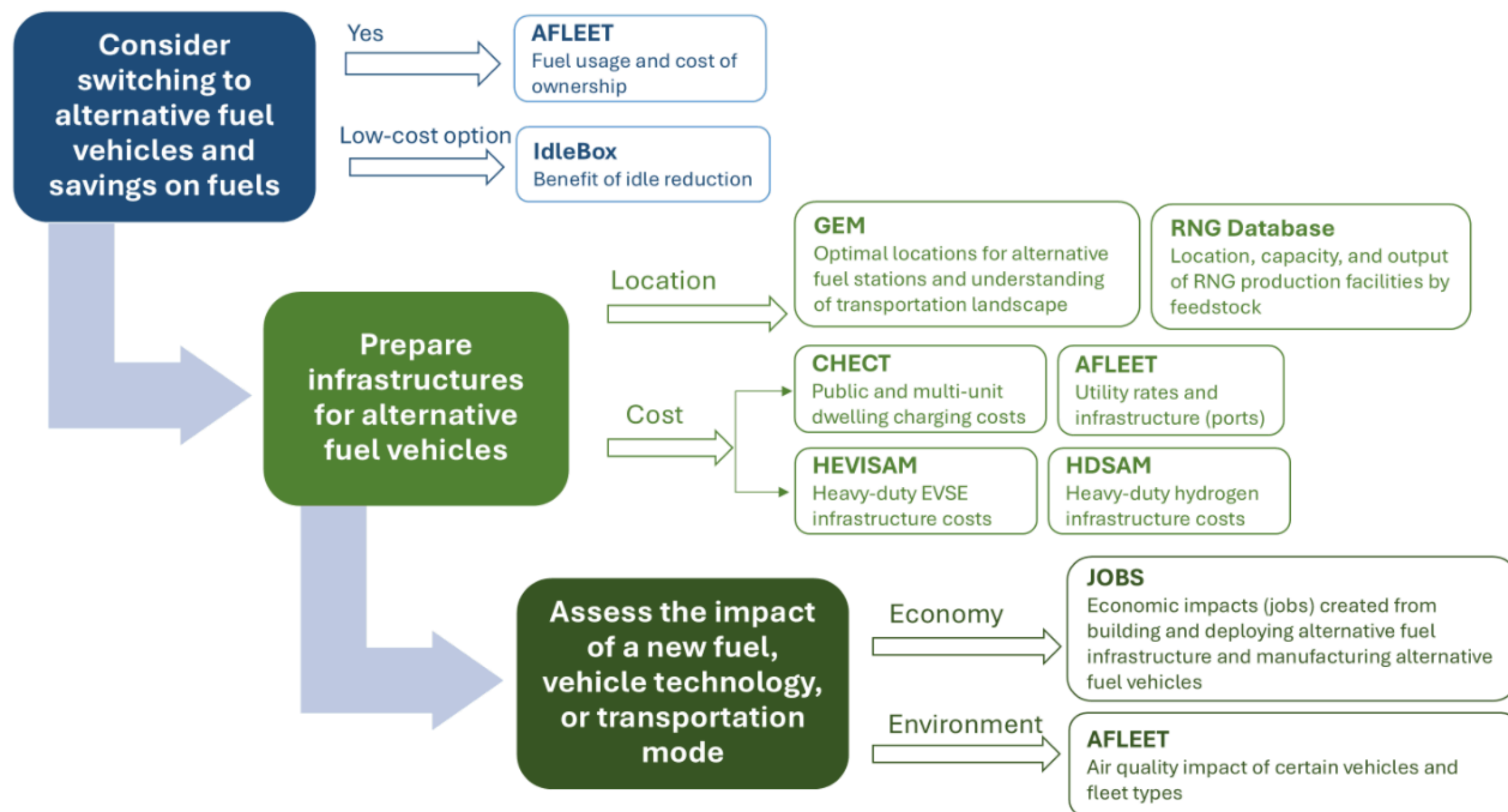
- **Technology selection is a fleet planning decision** – not a one-size-fits-all answer.
- **Clean Cities coalitions need credible, comparable information** across vehicle and fuel options.
- The goal is to reduce uncertainty **before procurement and infrastructure investments.**



Affordability starts with matching the right technology to the right route, fleet size, and operational need.

ARGONNE'S TECHNOECONOMIC TOOLS

Aim for user friendliness on widely accepted & consistent platforms and to answer questions below



LEGEND

- **AFLEET:** Alternative Fuel Life-Cycle Environmental and Economic Transportation Tool
- **GEM:** Geospatial Energy Mapper
- **RNG:** Renewable Natural Gas
- **CHECT:** Charging Hub and Economic Costing Tool
- **HEVISAM:** Heavy-duty Electric Vehicle Infrastructure Scenario Analysis Model
- **HDSAM:** Hydrogen Delivery Scenario Analysis Model
- **JOBS:** No underlying acronym

ARGONNE'S SYSTEM APPROACH FOR TRANSPORTATION TECHNOLOGY EVALUATION



HARDWARE & FACILITIES



4WD Light Duty Chassis Dynamometer & Thermal Chamber



4WD Heavy Duty Chassis Dynamometer



Argonne's Controlled Roadway



Heavy Duty Engine Dynamometer



Phone-based DAQ portable data collection



APACK-V high-resolution multi-sensor on-road DAQ

and more...



SIMULATION TOOLS

Vehicle energy consumption (on-road, off-road)



AUTONOMIE

Techno-economic & environmental assessment



TECHSCAPE

Multi-level transportation system simulation



POLARIS



ROAD RUNNER

Road & multi-vehicle simulator



SV TRIP

Speed/drive cycle generation from GIS



AERONOMIE

Aircraft flight & energy simulator (planes, UAV, eVTOL)

HOW ARGONNE HELPS IMPROVE AFFORDABILITY

Analysis/Simulation tools + HD testing + XIL insights support lower-risk MD/HD technology decisions



COMPARE OPTIONS

- Screen vehicle and fuel pathways
- Estimate TCO, energy use, and emissions
- Match technologies to vocation, duty cycle, and infrastructure needs



GENERATE EVIDENCE

- Use controlled Class 1-8 testing to produce trusted data
- Quantify energy and performance under real-world cycles
- Validate models for fleet and corridor analysis



PLAN WITH CONFIDENCE

- Understand readiness, infrastructure, and operational risks
- Evaluate future impacts of connectivity and automation
- Inform procurement, pilots, and scaling decisions



Argonne connects fleet-facing decision tools with experimental validation — helping stakeholders understand what to buy, when to deploy, and how to reduce risk.

ADVANCED MOBILITY TECHNOLOGY LABORATORY

MD/HD CHASSIS DYNAMOMETER TEST CELL

TEST CELL FEATURES

- ✓ **CFR40** (Part 1066) compliant
- ✓ Testing range **Class 3-8 trucks** (up to 82,000 lbs)
- ✓ **100-280" Wheelbase** Range
- ✓ **4x2 Dyno rolls**
 - 72" fixed roll (rear): 800 hp, 2.5 mph/s @ 150k
 - 50" movable roll (front): 600 hp, 1mph/s @150k
- ✓ **Tandem/4WD/2WD** axle config
- ✓ Drive on/off axle load: 20,000k lb
- ✓ Controlled acceleration rate: 0-5 mph/s @ 82k lbs
- ✓ **Supports industry-standard drive cycles**, EPA HD, CARB, GHG and vocational profiles

SPECIAL INSTRUMENTATION

- ✓ High precision power analyzers for detailed energy measurements
- ✓ Vehicle Network / Diagnostic decoding and recording for full data capture
- ✓ Integrated facilities supporting research- focused vehicle instrumentation
- ✓ Direct Fuel Flow metering
- ✓ Flexible, Modular DAQ for integrating independent sensors and datasets
- ✓ Custom robotic driver with adaptive learning
- ✓ Energy centric analytics and reporting to support system-level insights



ARGONNE MD/HD CHASSIS DYNO: VEHICLE-LEVEL ENERGY CHARACTERIZATION

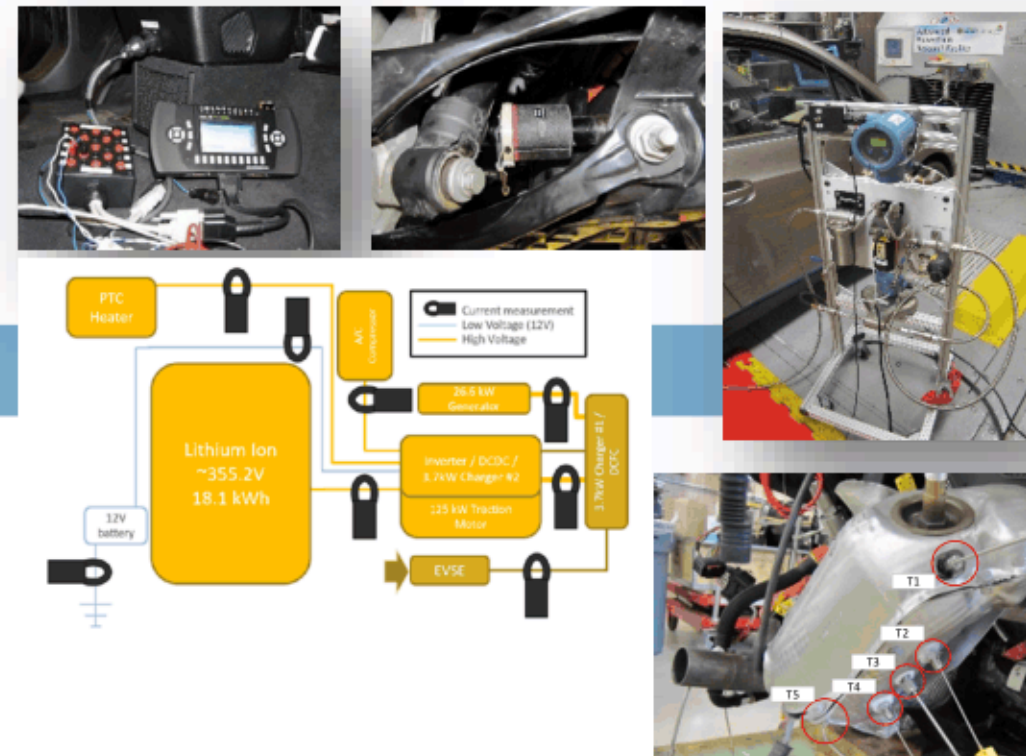
High-Fidelity Testing for Energy Performance and Insight Generation

- **Real-world operation is complex** : diverse duty cycles + variable payloads + uncontrolled environments → **difficult to isolate what drives energy use**

Controlled Testing Environment



In-Depth Instrumentation and Data Capture



Actionable Energy Insights



Energy Breakdown

Sensitivity to
design choices

Model Validation
Data

Partners can evaluate vehicles, systems, and technologies under controlled conditions and develop insights for design, validation, and deployment

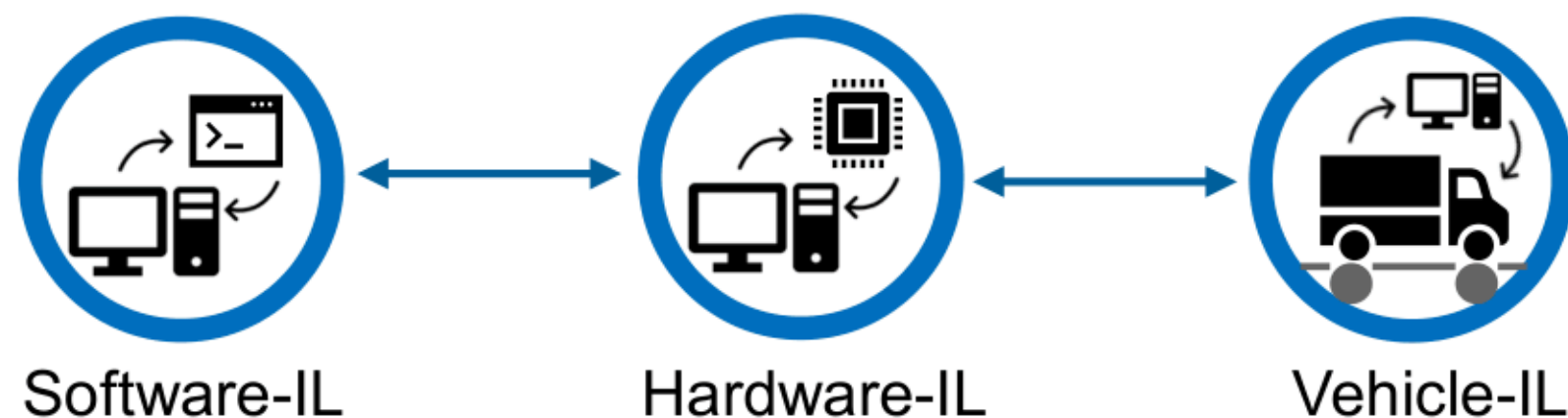
ARGONNE XIL: PROGRESSIVE ASSESSMENT FROM VIRTUAL TO PHYSICAL REALITY

A Comprehensive Functionality & Energy Validation Framework

- **XIL:** real-time closed-loop interface between physical (“X”) and virtual system to verify performance in a controlled, repeatable setting



Progressive Assessment & Validation



Future technology assessment via XIL workflow at Argonne

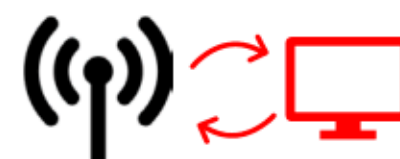
Applications

HDV-IL



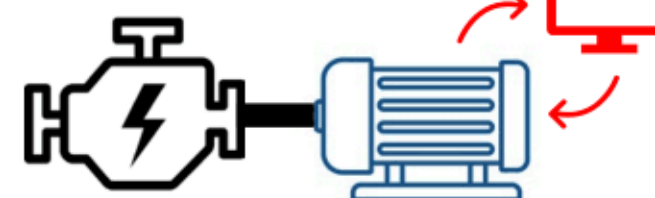
- Validate energy-optimized **CAV control**
- **Physical:** CAV & control deployed in RCP
- **Virtual:** Road & traffic
- Deploying VIL capability to other OEM's facility (dyno)

V2X-IL



- Validate **CDA communication** performance and its energy impacts
- **Physical:** C-V2X communication hardware & a vehicle on dyno
- **Virtual:** Road & other cooperative vehicles

ENGINE-IL



- Validate compatibility of **HD diesel engine in off-road vehicle**
- **Physical:** HD diesel engine
- **Virtual:** Off-road vehicle & duty cycle

UNLOCKING ENERGY INSIGHTS FOR MD/HD VEHICLES

Helping fleets & stakeholders understand technology options before large-scale investment decisions



EXPERIMENTAL ENERGY CHARACTERIZATION

How do current vehicles perform under controlled, repeatable conditions?

- **Quantification of real-world energy consumption** across representative HD cycles
- **Powertrain comparison** under identical repeatable conditions
- **In-depth instrumentation** for operational data capturing
- **Energy flows characterization** across electrified powertrains



MODELING/SIMULATION/ANALYSIS SUPPORT

How can we translate test data into accurate, scalable models?

- **Simulation model development and validation:** high-fidelity models developed from experimental data to support fleet and corridor impact assessment
- **Energy sensitivity studies:** evaluation of the impact of vehicle configuration on energy use (mass, aerodynamics, auxiliaries)



ADVANCED TECHNOLOGIES & XIL INTEGRATION

How do future technologies impact energy performance before deployment?

- **Early assessment of advanced technologies:** Assess energy impact of future technologies (advanced controls, V2X, and next-gen powertrains) from simulation to the vehicle on the dyno
- **XIL-based validation :** simulation, controls, hardware linked in a controlled real-time environment (physical or virtual)

The background is a blue-tinted photograph of an industrial facility, likely a refinery or chemical plant. On the left, there are tall distillation columns and complex piping. In the center, a large storage tank is visible. On the right, a large, cylindrical storage tank with a spiral staircase is prominent. In the foreground, a road or highway stretches towards the facility. The overall scene is industrial and technical.

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