What is CalHEAT?

- State center for research, development, demonstration and commercialization of advanced, efficient truck technologies and systems
- Initial funding by California Energy Commission
- Operated by CALSTART, a CA-based non-profit

Purpose of CalHEAT

- To drive and coordinate accelerated research, development and demonstration of cleaner, more efficient medium- and heavy-duty vehicles (M-HDVs)
- Enable commercialization of M-HDVs that enable State of California to meet its climate protection, air pollution, and energy security goals
CalHEAT Research and Market Transformation Roadmap

- Pathways for staged technology/market milestones to 2020
- Identifies needed actions to achieve milestones:
  - R&D
  - Demonstrations
  - Incentives and policies
- Leverage technology developments across platforms
- Roadmap is based on expected structure of market, applicability, ability to implement and benefits of technologies and approaches based on research
- Roadmap charts course of what’s needed to meet 2020 goals (given California’s multiple needed) as well as drive solutions needed beyond 2020
CO2 Reduction from Roadmap

CO₂e Contributions by Truck Category

- Tractors - Short Haul/ Regional
- Tractors - OTR
- Class 3 - 8 Work Trucks - Work Site Support
- Class 3 - 8 Work Trucks - Urban
- Class 3 - 8 Work Trucks - Rural/ Intracity
- Class 2b/3 vans/ pickups
- BAU
- AB-32 and EO-B-16-2012 - CO2e
Technical Advisory Group
- Direct Technical inputs into the Transformation Roadmap
- Technical and Industry Experts
  HTUF - OEMS - Fleets

Advisory Council
- Assist with strategic direction with a focus on the Transformation Roadmap
- Govt Agencies, Visionaries, NGO’s and Industry Associations.

Steering Committee
- Provide guidance, review and potentially contribute to the Annual Research Plan
- Demonstration and Funding Partners
# 6 Truck Categories – Based on Tech Applicability

## Class 7/8 Tractors

### Over the Road
- Younger Trucks; High Annual VMT
- Mostly higher average speed, highway driving

### Short Haul/Regional
- Between cities; Drayage; Day Cabs
- Includes second use trucks; trucks with smaller engines

## Class 3-8 Vocational Work Trucks

### Urban
- Cargo, freight, delivery collection
- Lower VMT; Lower Average speed; Lots of stop start

### Rural/Intracity
- Cargo, freight, delivery collection
- Higher VMT; Higher Avg speed; Combined urban/ highway

### Work site support
- Utility trucks, construction, etc.
- Lots of idle time; Lots of PTO use

## Class 2B/3

### Pickups/Vans
- Commercial use; Automotive OEMs & volumes
Relative NOx by Truck Category

Area of circle: NOx    x axis: truck population in CA    y axis: avg. annual VMT
## Where We Are: Truck Categories, 2010 Populations and CO2e Emissions

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Truck Population</th>
<th>% Population</th>
<th>Average VMT (MMT/yr)</th>
<th>CO2e (MMT)</th>
<th>% CO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractors - OTR</td>
<td>175,000</td>
<td>12%</td>
<td>85,000</td>
<td>12.9</td>
<td>38%</td>
</tr>
<tr>
<td>Tractors - Short Haul/ Regional</td>
<td>111,000</td>
<td>8%</td>
<td>55,000</td>
<td>6.3</td>
<td>18%</td>
</tr>
<tr>
<td>Class 3 - 8 Work - Urban</td>
<td>253,000</td>
<td>17%</td>
<td>25,000</td>
<td>3.6</td>
<td>11%</td>
</tr>
<tr>
<td>Class 3 - 8 Work - Rural/ Intracity</td>
<td>295,000</td>
<td>20%</td>
<td>35,000</td>
<td>6.1</td>
<td>18%</td>
</tr>
<tr>
<td>Class 3 - 8 Work - Work Site</td>
<td>77,000</td>
<td>5%</td>
<td>13,000</td>
<td>0.8</td>
<td>2%</td>
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<tr>
<td>Class 2b/3 vans/pickups</td>
<td>531,000</td>
<td>36%</td>
<td>21,000</td>
<td>4.2</td>
<td>12%</td>
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<tr>
<td>Unknown</td>
<td>15,000</td>
<td>1%</td>
<td>8,192</td>
<td>0.1</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>1,457,000</td>
<td>100%</td>
<td>34,255</td>
<td>34.0</td>
<td>100%</td>
</tr>
</tbody>
</table>
CalHEAT’s Tech Strategy Focus

Advanced Electrification: opportunities range from accessories to hybridization to full vehicle electrification

Hybridization opportunities exist in many segments, but not actively supported by current rule

Zero emission and plug-in tech has a role to play if driven by policy and investments

Engine and Driveline: opportunities include better diesel engines, alt fuels, and driveline improvements (Plus the need to provide Near Zero Emissions)

Advanced Engines, Combustion Cycles and Power Plants, including opposed pistons, camless and low NOx turbine engines.

Natural Gas engines can be optimized to increase efficiency and provide low NOx emissions, and can be expanded to additional segments
Technology Strategies

Advanced Electrification
- Hybrid-electric
- Electrified accessories
- Full electric powertrains
- Electrified Power take-off (PTO)
- Plug-in hybrid-electric
- External power to electric powertrain for ZEV Corridors
- AF/Hybrid Combinations

Engine and Driveline Efficiency
- Hydraulic hybrid
- Optimized engines for alternative fuel (AF)
- Energy recovery
- Engine efficiency improvements
- Alternative power plants and combustion cycles
- Transmission and driveline improvements

Chassis, Body, and Roadway Systems
- Light weighting
- Aerodynamics
- Lower rolling resistance
- Intelligent vehicle technologies, e.g. forecasting, adapting
- Corridors and platooning
- Longer, heavier single trucks
Stage 1 economic goal: Lifetime ROI
Stage 1 performance goals may include:
- Demonstrate hybrid functionality
- Commercially available
- Fuel economy improvement of 20 to 30%

Stage 1 technical characteristics may include:
No engine off at idle, no electric accessories

Stage 2 builds off Stage 1...
Stage 2 economic goal: ROI 5 years w/o incentives
Stretch goal: ROI 2-4 years
Stage 2 technical characteristics may include:
- Engine off at idle
- Electric accessories (may not show up until Stage 3)
- Improved design and integration
  (most important)
- Fuel economy gain of 30-50% (can be sacrificed for low cost system)
- Alternatively a simpler, light hybrid approach with strong ROI
- Capable of meeting CA OBD

Stage 3 builds off Stage 2...
Stage 3 economic goal: ROI 3-5 years
Stage 3 technical characteristics may include:
- Optimized engine system and integration
- Increase energy storage to 5 kWh; design to take advantage of greater energy storage; better regen; greater idle capacity
- CARB OBD compliant
- Much larger electric motors (>65 kW), especially for series architecture; reduced cost motors

Stage 4 builds off Stage 3...
Stage 4 economic goal: ROI 2-4 years
Stage 4 technical characteristics may include:
- Emergence of OTR hybrid-electric trucks as ROI decreases further and payback is within initial ownership of OTR tractors
- Enhanced performance from further enlarged energy storage capacity

Stage 2 Action Items (draft list):
- SAE standardization of OBD interfaces (J1939)
- Pre-commercial demonstration support to hybrid driveline developers to improve design & integration (3 x $4m per platform direct); requires ARB OBD compliance
- Create pull for e-accessories through requirements of solicitations
- Deployment Incentive support for Stage 2 hybrids; start when Stage 2 hybrids are commercially available (3yrs, lower per-vehicle incentive than today)

Stage 3 Action Items (draft list):
- R&D prototype project for hybrid-specific optimized engines and combustion cycles for hybrid applications Integrate battery, electric motor and power electronics advancements from other pathways (lower cost, improved performance)

Stage 4 Action Items (draft list):
- Pre-commercial demonstration funding for the more-electric OTR hybrid truck
Technology Adoption Rates

**Short-haul Tractors**
- Population trends from 2010 to 2050, showing different adoption rates for different technologies.

**OTR Tractors**
- Population trends from 2010 to 2050, showing different adoption rates for different technologies.

**Class 2b & 3 Vans & Trucks**
- Population trends from 2010 to 2050, showing different adoption rates for different technologies.

**Class 3-8 Worksite**
- Population trends from 2010 to 2050, showing different adoption rates for different technologies.

**Class 3-8 Urban**
- Population trends from 2010 to 2050, showing different adoption rates for different technologies.

**Class 3-8 Rural**
- Population trends from 2010 to 2050, showing different adoption rates for different technologies.

Legend:
- Baseline
- New Combustion
- Fuel Cells
- Hydraulic
- HEV
- xEV
CalHEAT uses five types of actions to accelerate technology solutions in the market:

- **Studies**: Includes business case or technology feasibility studies.
- **R&D**: Research and Development is a component or systems development activity for drivetrain systems and software.
- **Pilot Demo**: A pilot demonstration is the full integration into a truck of a newly developed component or system to evaluate performance.
- **Precomm. Demos**: Pre-commercial demonstrations involve 1 to 50 trucks to evaluate performance in the field. Further system refinement precedes commercial production.
- **Deploy. Incentives**: Incentives for early deployment (when a supplier sells a commercial product in the marketplace).

Public investment is needed at all stages to accelerate tech development & deployment.

Nearly $500 million needed just for market launch of these advanced technologies; Full fleet turnover will require additional funding.
More Funding Needed for Clean Freight Tech

THE PROBLEM

• Need to rapidly develop/deploy advanced tech
• Cleaning up legacy fleet is not enough
• Existing programs are set to expire

THE SOLUTION

• Pass SB 11 / AB 8
  – Extend AB 118 advanced tech $$
  – Extend Moyer/923 funds for fleet turnover
• Cap and Trade Revenues ?
  – Additional funding for market transformation

Primary Authors of Incentives Reauthorization Bills

Senator Pavley
Assembly Member Perea
Questions/Discussion