

Zero Emission Vehicles: Emerging Technologies for Trucks and Goods Movement



*Clean Transportation
Technologies and
SolutionsSM*

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Agenda

- CALSTART Background
- Status of Advanced Technology for Trucks
- National HTUF Process Commercializing Hybrids and High Efficiency Trucks
- Implications for Zero Emission Vehicles in the 710 Corridor



CALSTART

CALSTART is a unique California-based national, non-profit, member-supported organization.

Founded in 1992 as a public-private partnership to help launch and grow a clean transportation industry.

Mission: via programs and services, supporting and expanding the growth of a **clean transportation technologies industry that will:**

- Create high-quality jobs;**
- Clean the air;**
- Reduce dependence on foreign oil; and**
- Reduce global warming emissions**



CALSTART Has Broad Industry/Public Sector Support (*partial list*)





CALSTART: A Strategic Broker for Advanced Transportation

2010

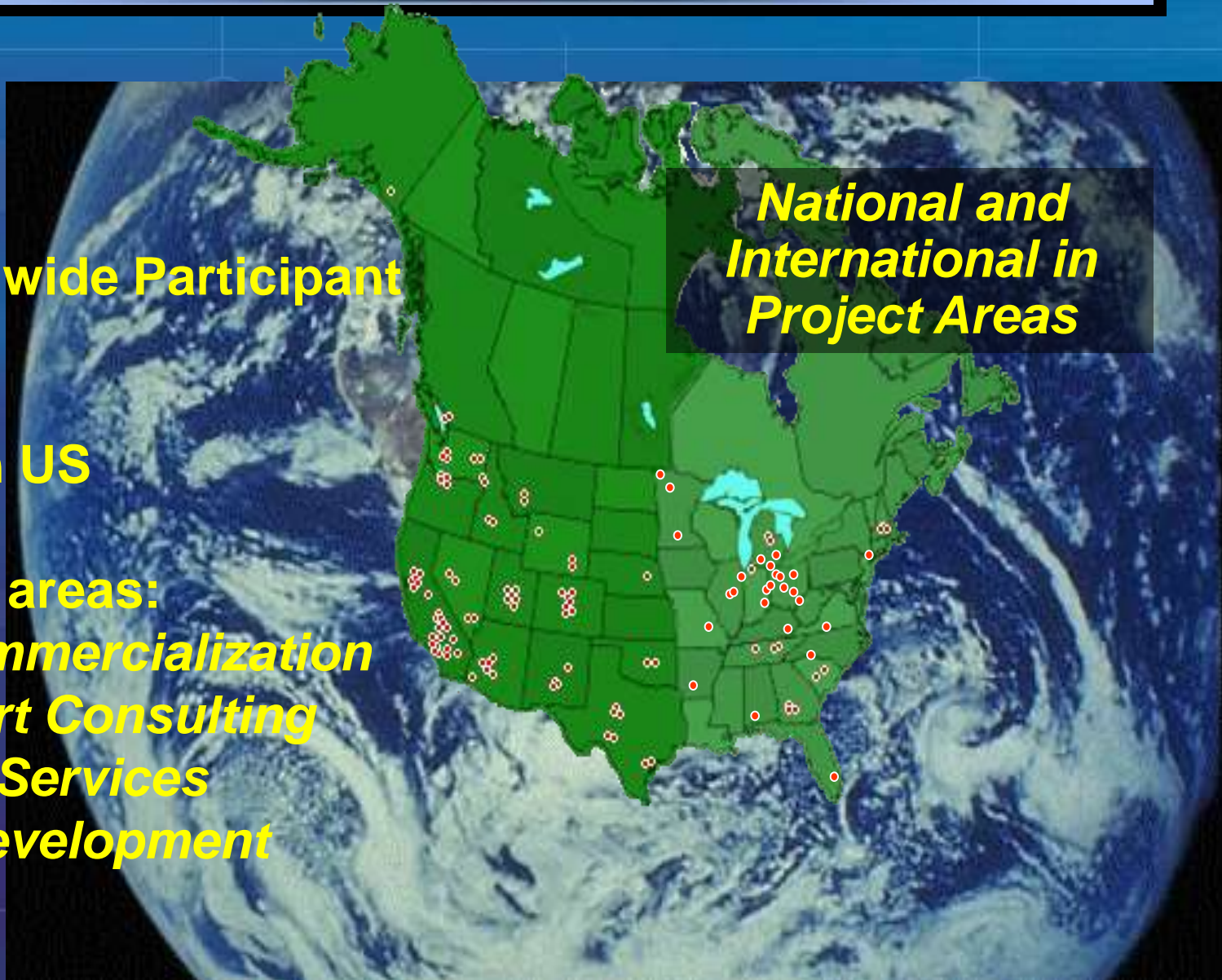
**130+ Worldwide Participant
Network**

3 Offices in US

Four focus areas:

***Tech Commercialization
Fleet, Port Consulting
Industry Services
Policy Development***

***National and
International in
Project Areas***





Truck World is Changing

- Significant improvement in emissions – but big increase in cost
 - Idle reduction an additional pressure
- Large push to improve fuel efficiency because of fuel price shocks (but without increasing emissions)
- Carbon (global warming) emissions of rising importance because of large fuel use in trucks
 - One efficient truck can cut 24X more fuel than a car
- Ports and California driving force for rapidly upgrading trucks (on emissions but not efficiency)
- Has led to a blossoming of new lower-emitting, higher-efficiency technology and fuels – some entering early production NOW



HTUF 2009



Hybrid Vehicles – A First Step

- A hybrid is any vehicle that uses more than one source of stored energy to drive or do work
- Hybrids add complexity – normally made up of two systems working together
 - Twin energy storage and drive systems; power management; control software
- Can add significant efficiency to vehicle performance
 - Very good in driving cycles with stop and go, delivery, high idling times
- Several hybrid “flavors”
 - hybrid electric (batteries) and hybrid hydraulic (hydraulic pressure accumulators) are most common systems and ways to store extra energy
 - parallel and series most common designs for operation
 - Plug-in hybrids have larger batteries, can partially recharge off electric grid



Industry Transformation: Hybrid Trucks Now Entering Market

10 years behind cars but industry is real, momentum growing – 8 years ago there were no hybrid trucks before CALSTART's HTUF process



Development

Test prototypes
and systems

Pre-Production

Field pilot
assessments
(10-50 vehicles)

Production Intent

Assembly line
builds up to 100+

Early Production

Initial commercial
volumes – still high
incremental cost

R&D Support

Purchase Incentives

Pre-Production Deployment Support (HTUF)

TOOLS:



Regional Heavy and Line Haul Advanced Trucks



- Kenworth, Peterbilt, Navistar and Freightliner all have Class 8 regional haul hybrid tractors
 - All developing next generation advanced Class 8 – including electric and hybrid configurations
- Mack showcased advanced hybrid line haul Class 8 (full 80,000 lb GVWR); next stages add more electrification; Peterbilt has several in demonstration



Hybrid Tractors Emerging for Regional Heavy Applications



- Kenworth unveils Class 7/8 hybrid tractor: 54,500 lbs GCVW
- Peterbilt has similar model – also continuing to test larger Class 8 heavy-duty OTR tractor
- Navistar unveils Class 7/8 hybrid tractor targeting beverage trailer applications
- Freightliner announces will pilot build a hybrid tractor Dec 08



*Above: Kenworth Class 8 tractor;
Below: Navistar Class 7/8 tractor*



Left: Freightliner Class 7/8 tractor pilot; right, Peterbilt Class 7/8 tractor





Wal-Mart Class 8 Demo

- ArvinMeritor – Navistar deliver unique dual-mode hybrid design for testing
- Electric drive at lower speeds (up to 48 mph), blended mode at higher speeds
- Can greatly reduce fuel use, cut idle and give zero emission at ports, urban driving
- Wal-Mart testing this truck and several Peterbilt-Eaton trucks in line-haul and regional heavy haul applications
- Wal-Mart committed to doubling its fleet fuel efficiency by 2015





Series Hybrid and All Electric Trucks Emerging

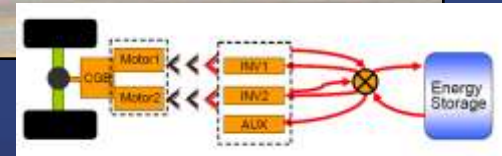
- Oshkosh HEMMT military heavy transport and support truck
- Series hybrid electric drive system with ultracap energy buffer
- Capacity “PHETT”
- Plug-in, series hybrid design
- Balqon all-electric port trucks
- Up to 40-60 miles range
- Freightliner Custom Chassis and Enova electric parcel truck (in testing)
- Smith “Newton” electric truck (in early production)
- Navistar/Modec electric truck (in early production Q1 2010)





All Electric Heavy Transit Buses (comparable systems to heavy trucks)

- LA Metro and ISE Corporation all-electric bus (Zero-emission Bus), Summer 2009
 - Supported by the California Air Resources Board (CARB), the South Coast Air Quality Management District (SCAQMD) and LACMTA
 - 45-foot bus expected range - 150 miles before recharging
- Foothill Transit Plans Revenue Operations for all-electric, rapid-recharge bus
 - 30 mile range
 - On-route charging
 - Composite bus, all conventional subsystems off-the-shelf



Hydraulic Hybrids Coming of Age

- Several pre-production and near production models shown: Eaton, Bosch Rexroth, Parker
- Parallel and Series architecture
- FCCC – Parker series parcel strip chassis showed impressive integration, potential fuel savings





New NG Engines, Trucks Available



California Air Resources Board (CARB) and U.S. Environmental Protection Agency (EPA) certified Westport's High Pressure Direct Injection (HPDI) technology adapted to the 2007 Cummins ISX heavy-duty engine

- Kenworth expands to LNG vehicles with T800 LBG trucks
 - Mfg at Renton WA in 2009
 - Trucks to feature Cummins ISX, Westport's HPDI fuel systems
- Freightliner producing CNG version of its Business Class M2 106 truck
 - To contain Cummins Westport 8.9 -liter L Gas Plus engine
- Mack bring natural gas refuse truck back to market
 - Use Cummins Westport ISL G natural gas engine





Dairy Biogas-to-Biomethane For Vehicle Fuel Project

- **Funded by EPA & CARB**
- **Project team includes CALSTART, Western United Dairymen, Sustainable Conservation, UC Davis**
- **Dairy partners – Hilarides Dairy, Hilmar Cheese**
- **Goal: Upgrade biogas to biomethane & dispense at dairy for use in dairy's fleet**
- **4 vehicles being tested for emissions & performance**





Hybrid Truck Users Forum (HTUF)

- **User-driven process** to commercialize medium- and heavy-duty hybrid trucks
- Joint **CALSTART-U.S. Army** program (RDECOM-TARDEC-NAC)
 - Also supported by Hewlett Foundation, support from DOE, DOT
- HTUF focuses on commercializing hybrid trucks with **dual-use** benefits
 - Speed commercialization and reduce overall costs by creating common fleet requirements, joint purchase commitments, increasing volumes

All Major Truck Makers and System Suppliers involved (partial list)





HTUF Forums & WGs: A Market Development & Transformation Process

- HTUF Forums are North America's primary hybrid and high efficiency truck industry meetings
- The HTUF process has sped market introduction by 2-5 years (5 years according to fleets)
- The Forums uniquely bring together the full range of key stakeholders in one place:
 - fleet vehicle users (commercial and military)
 - vehicle manufacturers
 - suppliers and technology developers
 - regulators
 - researchers
 - NGOs
- The Forums provide the clearest window on industry status and reality; technology developments; field-test data and real-world performance evaluations; hands-on experience via ride-and-drives; and developing the action agenda for the industry.





Hybrid, High Efficiency Low Emission Trucks and Buses:

- REAL; AND IN FIRST PRODUCTION
- EXPANDING IN TYPE AND APPLICATION
- PURCHASE INCENTIVES EMERGING
- **NEXT GENERATION** CAPABILITIES ARE BUILDING ON FOUNDATION OF HYBRID, NATURAL GAS, MILITARY AND TRANSIT CAPABILITIES
- ULTRA-LOW CARBON AND NEAR/ZERO EMISSION MEDIUM- AND HEAVY-DUTY TRUCKS TECHNICALLY ACHIEVABLE
- **CHALLENGE IS DEVELOPING MARKET**



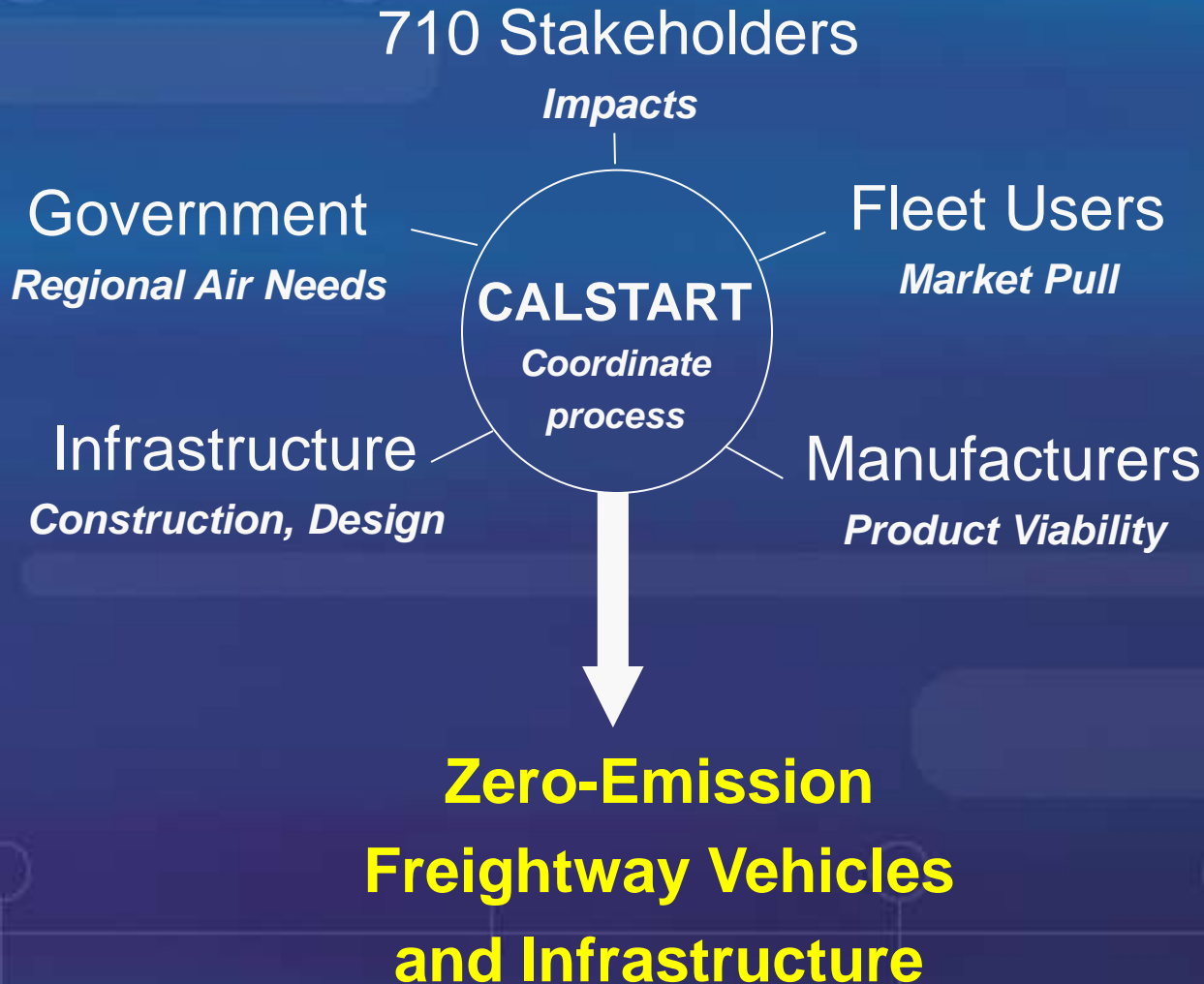
710 Clean Freightway

- Moving Freight with Zero Emissions
- CALSTART would be willing to partner with Metro (and others) to examine how to launch a process to commercialize zero-emission freight movement vehicles and infrastructure and is willing to assist
- Assist with forming and participating in a future, long-term public-private program with partners and stakeholders serving, using and living along the I-710 corridor
- Goal: develop, validate and commercialize market-sustainable, zero-emission goods movement vehicles - and supporting infrastructure – to service the I-710 freight corridor (and additional uses)



Proposed Market Transformation Process

Builds on Proven Structure, Industry Relationships





710 Clean Freightway: Possible Process

CALSTART suggests the following process and possible stages that could be the basis of market and technology commercialization, and could be followed and engaged at the appropriate time:

Stage 1 Outline core technical and market barriers/opportunities and share findings with partners on project

- I-710 Project in formative stages – first 1-2 years
- Assemble partners and building relationships around the concepts and technical challenges
- Proof of capability demonstrations

Stage 2 Develop user groups to identify requirements for the vehicle. Validate capabilities and requirements with OEMs and technology suppliers. Pre-production deployments.

- I-710 Project moving to planning – following 2 years
- User groups and monitoring groups.
- Funding partners



710 Clean Freightway: Possible Process

Stage 3 Prototypes from several OEMs put into test use for data collection, analysis and data sharing through user group forums

- Simultaneous development of the economic sustainability requirements and business case confirmation, to ensure market viability
- I-710 Project in planning and design stages, moving to construction preparation – following 2 years
- Process of rapid, iterative production design improvement, sharing results. Development of the business case through similar user group model.

Stage 4 Deploy pre-production vehicles based on previous improvement steps. Validate vehicles in real-world use.

- Work with public partners, governments, and regulators to implement market sustainability tools.
- I-710 Project construction underway, to completion – following 5+ years
- Phased-in production of vehicles meeting Freightway goals as 710 build-out can support; inducements for early actions.



Summary

- Advanced low-emitting, high-efficiency technology now emerging in trucks and in early production
- Technology shows real pathways to achieve near-zero and zero-emission operations
- Targeted, fast-track market transformation processes have been proven and demonstrated
- Such approaches can be useful for the 710 corridor

Clean Transportation Technologies and Solutions SM

www.calstart.org



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