1. Name and contact information.

Name: BYD Motors in partnership with drayage fleets
Contact Information: Andy Swanton, BYD, (213)-458-6918 andy.swanton@byd.com

2. Descriptive (under ten-word) project title.

Title: Zero-Emission Drayage Trucks for California Ports

3. Location of project (e.g., Interstate-XX, _________ County, post mile ______ to _______ or Port of _______, ________ Road, _______ longitude, _______ latitude).

This project has up to 5 locations.

- California Cartage (Cal Cartage): 2401 E Pacific Coast Highway, Wilmington, CA
- TTSI: 801 Reeves Ave, San Pedro, CA 90731
- GSC Logistics (GSC): 555 Maritime St, Oakland, CA
- California Multimodal (CMI): 375 Maritime St, Oakland, CA
- Central Valley Agriculture (CVA): 1404 Middle Harbor Rd, Oakland, CA

4. Concise two paragraph executive summary of project.

According to the South Coast Air Quality Management District, Heavy Duty Diesel Trucks are responsible for 49 tons/day or 15% of overall nitrogen oxide emissions in the Southern California region. BYD is currently developing electric Class 8 vehicles for a range of vocational markets, including refuse trucks, drayage trucks, concrete mixers, and yard trucks that will significantly reduce emissions and improve public health. BYD currently has a battery electric drayage truck prototype with 175 kWh of battery capacity and a range of 86 miles. Starting January 1st, 2016 BYD will introduce new battery cells that will increase battery capacity to 188 kWh and extend the driving range to 92 miles. This range does not meet all drayage duty cycles, but can satisfy a number of highly trafficked routes surrounding the ports of Los Angeles, Long Beach, and Oakland. There are currently 12,893 drayage trucks that visit the Ports of Los Angeles and Long Beach and 6,500 that visit the Port of Oakland.

This project would demonstrate a significant sample size of 100% zero emission drayage trucks with the leading drayage operators in California. BYD has commitments from the two largest drayage operators that visit the Ports of Los Angeles and Long Beach, Cal Cartage and TTSI, as well as the top drayage operators that visit the Port of Oakland, GSC, CMI, and CVA. Each truck will provide benefits to disadvantaged communities and successful demonstration will accelerate the adoption and commercialization of battery electric drayage and Class 8 trucks. All trucks will be built at BYD's facilities in Lancaster, California and will be delivered to the technology demonstrators with manufacturer's warranties. The California Air Resources Board and the California Energy Commission will support this project by monitoring and synthesizing the performance of the all vehicles via data loggers and real-time telematics. Project outcomes and data will ultimately be utilized to help inform the marketplace and pave the way for widespread commercialization of the tested vehicles.

Comments: This proposal is similar to a project submitted by the South Coast Air Quality Management District for 26 BYD drayage trucks in response to the California Air Resources Board's 2015 Drayage Solicitation. Results from that solicitation have not yet been released. Even if the project is awarded, this proposal provides an opportunity to scale the project and add trucks and fleets. We are extremely open to working with ARB should it be determined that modifications to size, scope, and cost of the proposal would be appropriate.

5. Detailed description of how the pilot project idea components will incorporate advanced technologies, alternative fuels, freight and fuel infrastructure, and local economic development; and advance goals of improving freight efficiency, transitioning to zero-emission technologies, and increasing competitiveness of California's freight system.

Technology

The trucks in this project are innovative because for the very first time an original equipment manufacturer will be manufacturing every major electric propulsion component. One of the current hurdles with electric technology is ensuring that each of the electric components communicates seamlessly with the other components. The discharge from the batteries needs to be closely controlled to ensure that power is delivered promptly and reliably to the traction motors. Otherwise, operators will experience irregular propulsion and even scenarios where a truck will not respond to the throttle. These scenarios result in frustration among operators and safety hazards. BYD manufactures each critical component:

- Batteries: BYD purpose built their iron phosphate battery for vehicle electrification and the technology has three distinct advantages relative to competitive technologies: (1) They are long-lasting and retain 70% charge after 10,000 cycles compared to other lithium ion batteries that rapidly degrade after 2,000 cycles or 5-6 years of regular use; (2) They are extremely safe as the chemical reaction is not exothermic (ie no heat is released) and no oxygen is released; and (3) They are environmentally-friendly as the primary components are iron, which is the most common element on earth by mass, and phosphate, which is naturally occurring.
- BMS System: The batteries will be monitored, diagnosed, and controlled by BYD's proprietary battery management system (BMS), which closely monitors the voltage, temperature, and charge and discharge rates from each individual cell, module, and pack.
- Inverters: BYD also manufactures the inverters responsible for converting AC power from the grid to DC on board the vehicle to charge the batteries and for inverting the DC power from the batteries to AC to power the traction motors. BYD's inverters are bi-directional, which means that vehicle owners can discharge any excess power back to the grid or any other load source whenever they choose. This power can therefore serve as a backup generator to keep critical services running or perform peaking services for utilities.
- Traction Motors: The traction motors used in each vehicle were developed by BYD and are already in use in various vehicle types. These motors are permanent magnet (neodymium) synchronous motors (PMSM) and consist of a stator and rotor assembly.
- Chargers: BYD utilizes 3-phase AC charging because it is a reliable solution that is also cost effective. No transformers are required and the AC power that is delivered to the vehicle is converted to DC power to charge the batteries with the on-board inverter.

All BYD trucks will be equipped with a health activity monitoring system (HAMS) as part of the chassis module control. This device is provided by I/O Controls, who will ensure that the data is available. The HAMS provides the ability to monitor all performance parameters in real-time from a cloud-based server, including fuel efficiency (miles/kWh), Strength of Charge (SOC), mileage/odometer readings, runtime, idle time, battery temperature, speed, and charging current/voltage. Interagency partners like the California Air Resources Board and the California Energy Commission will have direct access to real-time and historical data for each vehicle throughout their useful life.

Drayage Trucks

BYD's drayage truck model is the T9. All truck deliveries will have 188 kWh of battery capacity, providing 92 miles of range between charges. The three axle truck will have 180 kW longitudinally mounted motors in each of the rear axles. Each of these motors has a maximum torque of 1,106 lb-ft or 2,212 lb-ft total, and a maximum speed of 5,000 RPM. The T9 is designed to match or exceed the performance of diesel and CNG trucks across each key performance specification. BYD also anticipates meaningful maintenance and fuel savings. BYD testing suggests average maintenance cost per mile for the T9 will be $0.15/mile compared to $0.28/mile for diesel yard trucks. Fuel efficiency for the T9A is 0.35 miles/kWh compared to 5.00 miles/gallon for diesel. Assuming 80 miles/day and 6 operating days per week, the T9 will generate $13,700 in annual savings.

Emission Reductions

The vehicles in this demonstration will have meaningful impacts on emission reductions, with the following emission reductions per vehicle.

Metric	Results	Unit
Metric ton CO2e / year	43	metric tons CO2e / year
Ton NOx / year	0.019	tons NOx / year
Ton ROG / year	0.0010	tons ROG / year
Ton PM10 / year	0.0008	tons PM10/ year
WER / year	0.036	tons criteria pollutants / year

Each of the fleet operators will be using the trucks to transport freight from one or multiple of the following ports: Port of Los Angeles, Port of Long Beach, and Port of Oakland. Each of these ports has a physical address with a zip code that is a top 25% disadvantaged community. Furthermore, each truck will be transporting containers on fixed routes through disadvantaged communities. Lastly, four of the five technology demonstrators have physical addresses in disadvantaged communities and the trucks will be domiciled there.

	Cal Cartage	TTSI	GSC	CMI	CVA
Step 1 – Located Within					
Physical Address in DAC	YES	YES		YES	YES
Domiciled in DAC	YES	YES		YES	YES
Fixed Routes Primarily in DAC	YES	YES	YES	YES	YES
Step 2 – Provides Benefits To					
Physical Address in a Zip Code	YES	YES	YES	YES	YES
Serve Freight Hub with Zip Code in DAC	YES	YES	YES	YES	YES

Economic Benefits

BYD is committed to supporting all product development and manufacturing for the North American market from their offices in California. They are currently building local engineering and product development support for their North American product lines, which will be located in Downtown Los Angeles along with the Sales, Finance, and Human Resources teams. All manufacturing will be completed at one of BYD's existing facilities in Lancaster, or in one of the many facilities that BYD intends to build in Lancaster. Therefore, the trucks in this demonstration project, as well as those that stem from this project, will provide direct economic benefits to California in the form of job creation and economic growth.

6. Estimated cost for implementation and existing funding commitments (include any funding limitations or constraints) by stakeholder and amount.

This project is requesting funding for 20 drayage trucks, which will be distributed among the five fleet demonstrators; however, this project can be scaled up or down pending input and feedback from the Governor's Office. The table below shows the maximum number of vehicles that each fleet partner would be willing to demonstrate and the proposed allocation for 20 vehicles.

	Cal Cartage	**TTSI**	**GSC**	**CMI**	**CVA**
Maximum Number of Trucks	50	20	15	10	15
Recommended Distribution for 20 Truck Deployment	9	4	3	2	2

The price of each truck is $300,000. BYD has four different AC chargers that could be used to charge the vehicles, with 40 kW, 80 kW, 100 kW, and 200 kW options. Each of these chargers operates at 480 V 3-phase AC power. The price increases for each charger from $2,500 for the 40 kW charger up to $30,000 for the 200 kW charger. If awarded, the project team will need to assess the power supply to each facility to determine if infrastructure upgrades are needed to support the chargers. There are two infrastructure costs associated with upgrading power supply: costs to the utility provider to upgrade service; and costs incurred by the fleet to upgrade their facilities. The first step is sending the utilities scaled plans of the facility with the proposed charger site, a peak demand chart, and a charging profile. The utilities will then perform a site evaluation and a $10,000 engineering evaluation to determine if any upgrades are required, including transformer upgrades, trenching, or line extensions. If upgrades are necessary the costs are paid for by the utility under tariff allowance programs, Rule 15 and Rule 16, provided the customer uses the increased power from the upgrades. If the customer does not use the power, then the upgrades will be billed to the customer in future billing periods. Once the power supply to the meter has been upgraded the facilities may incur costs to upgrade panels, breakers, and switchgear, install underground wiring conduits, and install the chargers. A general rule of thumb is $70 per amp for these costs.

With these costs in mind there is an inherent tradeoff between the charging speed and the cost to provide the necessary power. A 200 kW charger installation would cost $30,000 for the charger in addition to 240 amps of power and therefore a 300 amp circuit breaker at a cost of $21,000 per charger, or $51,000 total. This high rate of charge would also lead to increased demand chargers from the utility providers. On the other hand a 40 kW charger is $2,500 for the equipment and would require 48 amps with a 75 amp circuit breaker at a cost of approximately $5,000, or $7,500 total. Furthermore, with a lower power demand it is possible that the existing facility would not require utility and facility upgrades. For these reasons the project team recommends using 40 kW chargers, which will provide a full charge in less than 5 hours. These trucks will primarily be charged overnight, so the lower rate of charge will not present operational difficulties.

This project is requesting $6,150,000 in total funding to support facility upgrades and EVSE installation, as well as all vehicles and chargers. The fleets will pay for all operational costs for fuel, driver salaries, maintenance, and annual registrations, as well as the utility engineering fees. Budget is presented below.

Fleets Annual Cost	**Number**	**Price**	**Total**	**Cash Match Labor/Capital**
Fuel Cost – Annual			$199,223	$199,223
Driver Cost – Annual			$2,496,000	$2,496,000
Maintenance Cost – Annual			$80,000	$80,000
Total Registration Cost to Fleets - Annual			$70,440	$70,440
Direct Costs	**Number**	**Price**	**Total**	**Cash Match Labor/Capital**
Utility Engineering Cost	5	$10,000	$50,000	$50,000
Facility Upgrades	20	$5,000	$100,000	
40 kW AC Chargers	20	$2,500	$50,000	
Drayage Trucks	20	$300,000	$6,000,000	
Total			$9,045,663	**Split**
Cash Match			$2,895,663	32%
Project Request			$6,150,000	68%

7. Timeline.

BYD is committed to delivering all 20 vehicles 6 months from the date that the project contract is executed. BYD has experience delivering new vehicles within 6 months, most recently fulfilling an order of 20 street sweepers for the City of Beijing within that timeframe. A draft project schedule is included below.

Task 1 Project Kickoff: **Deliverable Due Date: January 8, 2016**

Task 2 Product Testing and Registration – complete FMVSS testing, update DOT NHTSA registration, acquire World Manufacturer Identifier (WMI), EPA and CARB Certifications (BYD)**: Deliverable Due Date: June 1, 2016**

Task 3 Electric Vehicle Supply Equipment (EVSE) Installation (Fleets and Utility Providers): **Deliverable Due Date: July 1, 2016**

Task 4 Delivery of All Trucks (BYD): **Deliverable Due Date: July 1, 2016**

Task 5 Product Registration including Federal Highway Use Tax (HUT), California DMV, CARB Drayage Registry, eModal transponder, Port Drayage Registry, and radio-frequency identification (RFID) tags and Fleet Integration (Fleets)**: Deliverable Due Date: August 1, 2016**

Each vehicle will be assembled at BYD's facilities in Lancaster, California, and will be warranted by BYD with the following terms.

Category	Warranty Contents	Period (Whichever Comes First)
I	High Voltage Battery	8 Years or 250,000 miles
II	Low Voltage Battery	3 Years
III	Powertrain: Traction Drive Motor, High Voltage Electronics Controller Assembly, BMS Module Assembly	5 Years or 100,000 miles
Other	Bumper to Bumper: Remaining Parts of Complete Vehicle	2 Years or 30,000 miles

The technology demonstrators will incorporate the electric vehicles into their fleet and will operate them in the same conditions and environment as the current diesel vehicles through the end of their useful life, which is anticipated to be 8 years.

8. Means for measuring progress toward meeting goals over time.

Each vehicle in this demonstration will have a data logger for assessing historical and real-time performance. BYD will provide the technology demonstrators, interagency partners, and any other parties with access to the data for analysis and evaluation.

The successful conclusion of this project will help move the dial forward for widespread market adoption of electric drayage trucks in California. First, the project will prove the viability of the trucks. All vehicles in this project will operate in real-world conditions and will have to meet the duty cycles of their conventional counterparts. And all vehicles in this project will face the daily wear-and-tear inherent to drayage environments. A successful outcome of the proposed project will demonstrate that the tested vehicles are in fact viable and capable of meeting the demands placed upon them.

Second, the project will prove that the long-term economics of the proposed vehicles are sound. Electric vehicles typically have higher upfront costs compared to their diesel counterparts. However, because of the reduced long-term operational costs, electric vehicles can be the more economical option for end users over the life of the vehicle. It is critical to build the business case for electric vehicles by showing that these savings actually materialize after the vehicles have operated under real world conditions. This project will build the business case data point by data point. The final results of the project can then be used to educate the marketplace to view drayage trucks as a smart and economical investment—a critically important outcome for achieving widespread market adoption.

Third, the project will establish a real-world utilization model for battery electric drayage trucks by other fleets. Because the utilization of electric vehicles is a new operational model for drayage fleets, part of what must be done to achieve widespread market adoption is to demonstrate a workable utilization model that can then be copied by potential purchasers in the broader marketplace. This project seeks to do just that. By demonstrating zero emission battery electric drayage trucks on real-world routes, the project will serve as a template for other end users to learn from, mimic, and modify to their individual needs. Long after the project has successfully concluded, this project will serve as an example that helps guide the decision-making of other end users interested in procuring the tested technologies. The end result will be even greater market commercialization.

Lastly, a successful demonstration will have benefits for other vocational truck markets. BYD's 3-axle T9 platform uses the same cab, chassis, and powertrain that will be used for other Class 8 trucks, namely regional food, beverage, and goods delivery, refuse trucks, and concrete mixers. Each of these markets is a great opportunity for vehicle electrification because they typically have defined, short routes. Companies like Coca-Cola, Sysco, and UPS have already expressed interest in electric Class 8 trucks for regional deliveries, Cities like Los Angeles, Sacramento, and New York City have expressed interest in refuse trucks, and concrete companies like Oldcastle and Cemex have expressed interest in concrete trucks. A successful demonstration of Class 8 drayage trucks will advance the market for each of these truck configurations. Furthermore, a sizable production quantity will reduce the cost of similar Class 8 trucks. If BYD is able to meet its sales and production targets then a combination of battery cost reduction, manufacturing scale, and writing off engineering costs will reduce the price from $300,000 to approximately $150,000 in 5 years.

9. Description of the potential roles each of the interagency partners could provide to support the project's implementation.

The interagency partners would provide administrative oversight throughout the project, namely the California Air Resources Board (CARB) and the California Energy Commission (CEC). Critical functions include:

- Project Kickoff: reviewing and finalizing truck allocations, project budget, timeline, and emissions reductions with BYD and the fleet demonstrators.
- Monthly Progress Meetings: web conference with project partners during product development, site facility upgrades and EVSE installation, delivery, and vehicle deployment.
- Data Monitoring and Synthesis: ongoing assessment of performance indicators like odometer readings, fuel economy, and vehicle downtime.
- Report Writing: distilling learnings from the project and publishing results for review by industry stakeholders, operators, and advocates.

BYD has engaged the utility providers, Los Angeles Department of Water and Power, Southern California Edison, and the Port of Oakland, and has their understanding and support for these projects.

Additional information may be attached. Please note that any information provided is considered public.

Charger Specs

Charger	40 kW
Price	$2,500
Charging Mode	AC
Input Voltage	480V 3-phase
Operating Voltage Range	432V-528V 3-phase
Input Current	48A
Input Power	40kW
Frequency	60Hz
Output Voltage	432V-528V 3-phase
Output Current	48A
Output Power	40kW
Charging Coupler Type	IEC62196-2

Length	15.75in
Width	7.87in
Height	27.17in
Number of Coupler(s)	1
Charging Cable Length	118.11in
Mounting Method	Wall-mounted
Short-circuit Protection	✓
Overheat Protection	✓
Lightning Protection	✓
Certification	TUV
Reference Standard	IEC61851/IEC62196
Enclosure Protection	IP55
Operating Temperature	-22 to +122 deg F
Surrounding Humidity	5-95%
LED Indicators	Power, Connect, Charging, Complete, Error
LED Screen	SOC, Est Time to 100% SOC, ID, Charging Volume, Error

Idea summaries and any supporting materials should be provided via email to freight@arb.ca.gov by ***5:00 pm November 30, 2015.*** *All ideas will be reviewed by the State agencies and a list of preliminary pilot projects for consideration will be presented for public comment at regional workshops planned for January 2016.*

MOST RELIABLE

Battery Electric Class 8 Truck

120,000 lb GCWR, Long Range

T9

The 100% Battery Electric Class 8 Truck
Affordable, Dependable, & Environmentally Friendly

BYD's Class 8 truck utilizes the first battery that was purpose-built for vehicle electrification. Our proprietary iron phosphate technology is the core of BYD's delivery truck, enabling 86 miles of range with gradual battery degradation. This truck is designed to fit seamlessly into your fleet without changing the way you do business.

Our 120,000 lb GCWR Class 8 Truck is manufactured at BYD's Lancaster, CA Facility, and is compliant with FMVSS and CMVSS.

- ✔ Environmentally friendly: no heavy metals or toxic electrolytes
- ✔ Regenerative braking extends battery life and reduces brake component wear
- ✔ High-efficiency, longitudinal mounted motors that are integrated with the drive axle
- ✔ Vehicle-to-Grid system that allows the truck to deliver power back to the grid, to a load, or to another vehicle

Build Your Dreams

WHAT SETS BYD APART

LONG RANGE
BYD's breakthrough battery technology enables 86 miles of range

FUEL SAVINGS
$9,100 annual savings assuming 70 miles per day and 6 days per week.

LONG-LASTING
BYD's batteries will still have 70% strength of charge after 10,000 cycles or 27 years if cycled every day.

MAINTENANCE SAVINGS
$2,800 annual savings assuming 70 miles per day and 6 days per week. Lower maintenance on propulsion system, fewer fluids to change, less brake wear, and fewer moving parts.

ECO-FRIENDLY
Zero emission. Our iron-phosphate chemistry contains no heavy metals and the electrolyte is non-toxic.

SAFE
No propensity to combust: no oxygen released, thermal balancing, and no cell swelling. Proprietary Battery Management System (BMS) assists with balancing and charging safety.

VEHICLE		120,000 lbs GCWR
Dimensions	Length	25.4 ft
	Width	97.3 in
	Height	118.9 in
	Wheelbase	177.2 in
	Curb Weight	27,205 lbs
	GCWR	120,000 lbs
Performance	Top Speed	56 mph
	Max Gradeability	20%
	Range	86 miles
	Turning Radius	30.8 ft
	Approach/ Departure Angle	27° / 30°
Chassis	Suspension	Leaf Spring
	Brakes	Pneumatic Drum , ABS, Regenerative Braking
	Tires	11R 22.5
Powertrain	Motor Type	AC Permanent Magnet Synchronous Motor
	Max Power	483 hp
	Max Torque	2,212 lb-ft
	Battery Type	Iron-Phosphate
	Battery Capacity	350 kWh
	Charging Capacity	100 kW
	Charging Voltage	480 V
	Charging Time	3.5 hrs

Note:
1. All information based on the latest data available at the time of printing. Final specs subject to change at production.
2. Initial capacity shown. Numbers may decrease with time and use.
3. Battery age and outside ambient temperature affect charging times.