1. Name and contact information.

Name: BYD Motors in partnership with the City of Los Angeles, Bureau of Sanitation (LABOS)
Contact Information: Andy Swanton, BYD, (213)-458-6918 andy.swanton@byd.com

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

Title: Zero-Emission Refuse Trucks for Los Angeles

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

West Valley Yard, 8840 Vanalden Ave, Northridge, CA, 91324

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. This project will demonstrate 5 electric trucks for residential refuse collection in Los Angeles. Each truck will have 188 kWh of battery capacity, which will provide power for all lifting and compaction, as well as range of approximately 80 miles. This range will satisfy approximately 50% of the routes in Los Angeles. The LABOS performs collection for all residents and apartments with less than 4 units, and operate 750 trucks. There are approximately 8,000 additional refuse trucks in California.

Refuse trucks are excellent heavy duty vehicles to electrify because the routes are defined and short, traditional vehicles burn unnecessary fuel while the vehicles idle for lifting, and the zero emission benefits will have real public health impacts as the trucks travel in residential areas. BYD and the LABOS have agreed to conduct a pilot project to demonstrate 1 truck in Los Angeles that would begin around April, 2016. However, the LABOS would prefer to demonstrate multiple vehicles because a larger sample size will be more meaningful and will accelerate the widespread adoption of electric trucks into their fleet. The cab, chassis, and powertrain will be assembled at BYD's facilities in Lancaster, California and will be delivered to the body manufacturer, AMREP, who is the current manufacturer of refuse truck bodies for LABOS. The trucks will be warranted by BYD. 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: 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.

Refuse Trucks

BYD's refuse truck is part of the T9 platform, which is the same platform for drayage trucks and concrete mixers. All truck deliveries will have 188 kWh of battery capacity, providing 80 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

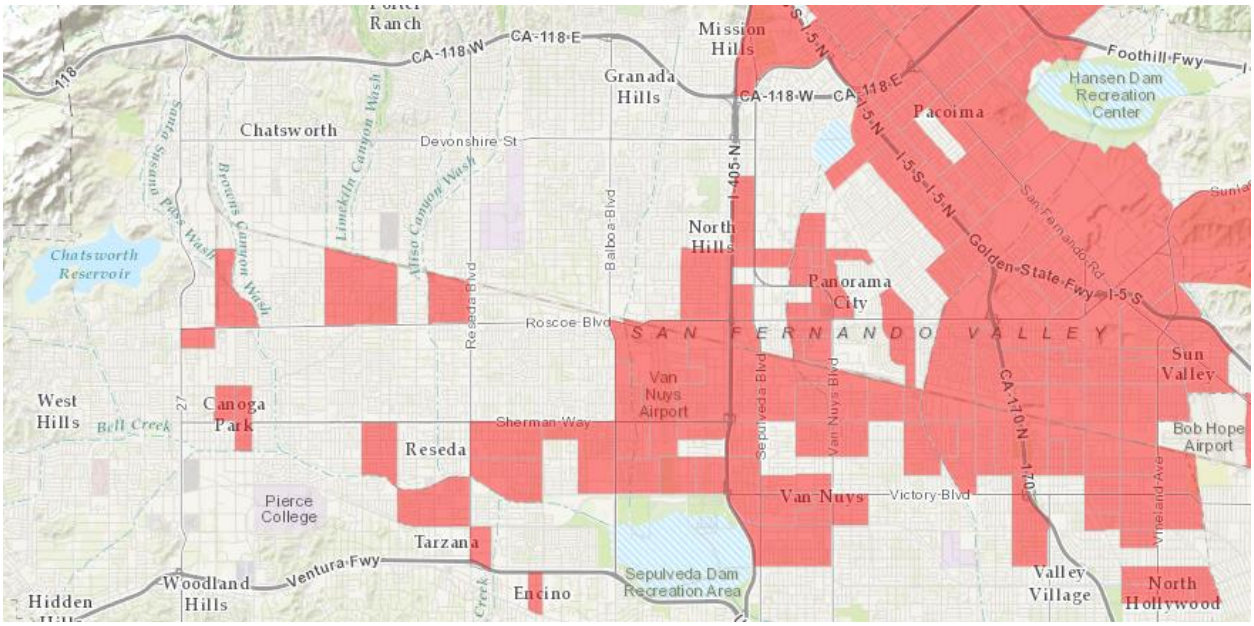
maximum speed of 5,000 RPM. The T9 is designed to match or exceed the performance of diesel and CNG trucks across each key performance specification. BYD also anticipates meaningful maintenance and fuel savings. BYD testing suggests average maintenance cost per mile for the T9 will be $0.15/mile compared 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 truck will be located at the West Valley Yard, which is one of six refuse collection yards in the City of Los Angeles. Collection routes will primarily the San Fernando Valley, which includes many disadvantaged communities as shown in the figure below.



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. The bodies will be configured at AMREP's headquarters and largest facility

in Ontario, California. 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 5 refuse trucks. The price of each truck is $500,000 with the following breakdown: $300,000 for the electric cab, chassis, and powertrain from BYD; and $200,000 for the body of the refuse truck with all hydraulics and lifting and compaction mechanisms from AMREP. 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. To minimize costs and because the vehicles have the ability to charge overnight, BYD recommends using 40 kW chargers, which utilize 480 V 3-phase AC power and 48 amps.

There are two infrastructure costs associated with upgrading power supply: costs to the utility provider, Los Angeles Department of Water and Power (LADWP), to upgrade service; and costs incurred by the fleet to upgrade their facilities. The first step is sending LADWP scaled plans of the facility with the proposed charger site, a peak demand chart, and a charging profile. LADWP 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 LABOS uses the increased power from the upgrades. If LABOS does not use the power, then the chargers will be billed to the customer in future billing periods. Once the power supply to the meter has been upgraded the facility 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 or approximately $5,000 for each 40 kW charger.

This project is requesting $1,537,500 in total funding to support facility upgrades and EVSE installation, as well as all vehicles and chargers. LABOS will pay for all operational costs for fuel, driver salaries, maintenance, and vehicle registrations, as well as the LADWP engineering fees. Budget is presented below with all operational costs shown as annual expenses.

Annual Operating Costs	**Number**	**Price**	**Total**	**Cash Match Labor/Capital**
Fuel Cost – Annual			$31,129	$31,129
Driver Cost – Annual			$520,000	$520,000
Maintenance Cost – Annual			$20,000	$20,000
Total Registration Cost to Fleets - Annual			$16,375	$16,375
Direct Costs	**Number**	**Price**	**Total**	**Cash Match Labor/Capital**
Utility Engineering Cost	1	$10,000	$10,000	$10,000
Facility Upgrades	5	$5,000	$25,000	
40 kW AC Chargers	5	$2,500	$12,500	
Refuse Trucks	5	$300,000	$1,500,000	
Total			$2,135,004	**Split**
Cash Match			$597,504	28%

Project Request			$1,537,500	72%

7. Timeline.

BYD is committed to delivering all 5 vehicles 8 months from the date that the project contract is executed. 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 (LABOS and LADWP): **Deliverable Due Date: September 1, 2016**

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

Task 5 Product Registration including Federal Highway Use Tax (HUT) and California DMV and Fleet Integration of Trucks (LABOS)**: Deliverable Due Date: October 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

LABOS will incorporate the electric vehicles into their fleet and will operate them in the same conditions and environment as the current CNG, LNG, and 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 refuse 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 diesel and alternative fuel counterparts. And all vehicles in this project will face the daily wear-and-tear inherent to refuse collection 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 refuse 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 refuse trucks by other fleets. Because the utilization of electric vehicles is a new operational model for refuse collection departments and private operators, 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 refuse 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 among both government-operated fleets that typically operate urban collection, as well as corporations like Waste Management and Republic Services that service commercial customers in urban areas and generally all collection in suburban areas.

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 all Class 8 applications, including regional food, beverage, and goods delivery, drayage trucks, and concrete mixers. Each of these markets are great opportunities 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, Californian drayage operators like California Cartage LLC, Total Transportation Services Inc, and GSC Logistics have expressed interest in drayage trucks, and concrete companies like Oldcastle and Cemex have expressed interest in concrete trucks. A successful demonstration of Class 8 refuse 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 $500,000 to approximately $350,000 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 project budget, timeline, and emissions reductions with BYD and LABOS.

- 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 electric utility provider at this location, the Los Angeles Department of Water and Power, and have their understanding and support.

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

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

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

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

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.

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.