STATE OF CALIFORNIA
California Environmental Protection Agency
AIR RESOURCES BOARD
ASD/BCGB-337 (NEW 10/2017)

APPROVED AS TO FORM AND LEGALITY
February 21 2020
MICHAEL N. FEUER, City Attorney
By [signature]
Deputy City Attorney

GRANT AGREEMENT COVER SHEET

	GRANT NUMBER G14-LCTI-08 **Amendment No.3**
NAME OF GRANT PROGRAM Multi-Source Facility Demonstration Project	
GRANTEE NAME Los Angeles Harbor Department	
TAXPAYER'S FEDERAL EMPLOYER IDENTIFICATION NUMBER 96-6000735	TOTAL GRANT AMOUNT NOT TO EXCEED $14,510,400.00
FISCAL GRANT TERM FROM: June 1, 2016	TO: ~~June 30, 2020~~ **December 31, 2021**
PROJECT PERFORMANCE PERIOD OF GRANT AGREEMENT FROM: June 1, 2016	TO: ~~June 30, 2020~~ **December 31, 2021**

This legally binding Grant Agreement, including this cover sheet and Exhibits attached hereto and incorporated by reference herein, is made and executed between the State of California, California Air Resources Board (CARB) and Los Angeles Harbor Department (the "Grantee"). The parties mutually agree to amend this Grant Agreement. Amendments are shown as deletions in ~~strikethrough~~ text and as additions in **bold underlined** text. All other terms and conditions remain the same.

Exhibit A – Grant Provisions
Exhibit B – Work Statement, incorporating the following attachments: Attachment I-Budget Summary, Attachment II-Project Milestones and Disbursement Schedule, Attachment III-Project Schedule and Attachment IV-Key Project Personnel
Exhibit C – Grant Solicitation Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments: Multi-Source Facility Demonstration Project Exhibit D – Grant Solicitation
Exhibit D – Grantee Application Package

The purpose of this Amendment No. 3 is reallocate funds to purchase an additional new yard tractor and to extend the grant another 18 months. This Amendment also involves changes to Exhibit B. This Amendment is of no force or effect until signed by both parties. Grantee shall not commence performance until it receives written approval from CARB. The undersigned certify under penalty of perjury that they are duly authorized to bind the parties to this Grant Agreement.

STATE AGENCY NAME California Air Resources Board		GRANTEE'S NAME (PRINT OR TYPE) Los Angeles Harbor Department	
SIGNATURE OF ARB'S AUTHORIZED SIGNATORY:		SIGNATURE OF GRANTEE (AS AUTHORIZED IN RESOLUTION, LETTER OF COMMITMENT, OR LETTER OF DESIGNATION)	
TITLE Administrative Services Branch Chief, CARB	DATE	TITLE	DATE
STATE AGENCY ADDRESS 1001 I Street, Sacramento, CA 95814		GRANTEE'S ADDRESS (INCLUDE STREET, CITY, STATE AND ZIP CODE) 425 S. Palos Verdes Street, San Pedro, CA90731	

CERTIFICATION OF FUNDING

AMOUNT ENCUMBERED BY THIS AGREEMENT $0.00	PROGRAM 3510000L32	PROJECT 3900-LCTI	ACTIVITY	
PRIOR AMOUNT ENCUMBERED FOR THIS AGREEMENT $14,510,400.00	FUND TITLE *Greenhouse Gas Reduction Fund*		FUND NO. 3228	
TOTAL AMOUNT ENCUMBERED TO DATE $14,510,400.00	(OPTIONAL USE)	FISCAL SUPPLIER ID 0000151160	CHAPTER 25	STATUTE 2014
APPR REF 101	ACCOUNT/ALT ACCOUNT 5432000	REPORTING STRUCTURE 39006100	SERVICE LOCATION 57207	FISCAL YEAR (ENY) 2014/15

I hereby certify that the California Air Resources Board Budget Office acknowledges that budgeted funds are available for the period and purpose of the expenditure stated above.

SIGNATURE OF CALIFORNIA AIR RESOURCES BOARD BUDGET OFFICE: [signature]	DATE 1/10/20

I hereby certify that the California Air Resources Board Legal Office has reviewed this Grant Agreement.

SIGNATURE OF CALIFORNIA AIR RESOURCES BOARD LEGAL OFFICE: [signature]	DATE 1/15/20

TRANSMITTAL 1

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Exhibit A

Grant Provisions

1. GRANT PARTIES and CONTACT INFORMATION

1.1 The parties agree to comply with the requirements and conditions contained herein, as well as all commitments identified in the Fiscal Year 2014-15 Grant Solicitation Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments: Multi-Source Facility Demonstration Project (Exhibit C) and Grantee Application Package (Exhibit D).

1.2 The California Climate Investments logo and name serves to bring under a single brand the many investments whose funding comes from the Greenhouse Gas Reduction Fund (GGRF). The logo represents a consolidated and coordinated initiative by the State to address climate change by reducing greenhouse gases, while also investing in disadvantaged communities and achieving many other co-benefits. The Grantee agrees to acknowledge the California Climate Investments program as a funding source from CARB's Low Carbon Transportation program whenever projects funded, in whole or in part by this Agreement, are publicized in any news media, websites, brochures, publications, audiovisuals, or other types of promotional material. The acknowledgement must read as follows: 'This publication (or project) was supported by the "California Climate Investments" (CCI) program. Guidelines for the usage of the CCI logo can be found at www.arb.ca.gov/ccifundingguidelines'.

CALIFORNIA CLIMATE INVESTMENTS

1.3 **Grant Summary and Amendments (if applicable)**

Project Title: Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments Multi-Source Facility Demonstration Project: Port of Los Angeles Green Omni Terminal Project

Funding Amount: [1]$14,510,400

Match Amount: $ 12,092,000

[1] Senate Bill 852 – Budget Act of 2014 (Committee on Budget, Chapter 25)

1.4 **Grant Parties and Contact Information**

a. This grant is from the California Air Resources Board (hereinafter referred to as CARB) to the Los Angeles Harbor Department (hereinafter referred to as Grantee).

b. The CARB Project Liaison is Darren Nguyen. Correspondence regarding this project shall be directed to:

Darren Nguyen
Air Resources Board
Mobile Source Control Division
Post Office Box 2815
Sacramento, California 95812
Phone: (916) 324-6745
E-mail: Darren.Nguyen@arb.ca.gov

c. The Grantee Liaison is Teresa Pisano. Correspondence regarding this project shall be directed to:

Teresa Pisano
Environmental Specialist III
LA Harbor Department
425 South Palos Verdes Street
San Pedro, California 90731
Phone: 310-732-7057
Email: tpisano@portla.org

2 TIME PERIOD

2.1 Performance of work or other expenses billable to CARB under this grant may commence after signing and awarding of this grant. Performance on this grant ends once the Grantee has submitted the final report or if the grant is terminated, whichever is earlier.

2.2 Upon completion of the project, the Grantee shall submit a draft Final Report to the Project Liaison no later than ~~March 2, 2020~~ [2]**March 2, 2021** (see Section 6 Reporting).

2.3 Final request for payment shall be received by CARB no later than ~~March 2, 2020~~ **March 2, 2021** (see Section 4 Grant Disbursements).

2.4 The CARB Executive Officer retains the authority to terminate or reduce the dollar amount of this grant if by **March 31, 2017**, 50 percent of project funding

[2] Assembly Bill 74 – Budget Act of 2019 (Ting, Chapter 23)

has not been expended by the Grantee. In the event of such termination, Section 7 of these provisions shall apply.

3. SCOPE OF WORK

The Green Omni Terminal project will incorporate zero and near-zero emissions vehicles and cargo handling equipment to move goods from ships through the terminal to clean truck transportation to their final destinations, while providing the terminal operations with solar power generation and battery storage. The electrified cargo handling equipment includes ~~four~~ **five** yard tractors, three 21-ton forklifts, and two on-road drayage trucks. An at-berth vessel emissions control system (ShoreKat) will be integrated into the project to address the largest source of greenhouse gas and priority pollutant emissions at the terminal. A one megawatt rooftop solar photovoltaic array will be added to the terminal to supplement current power usage and to help meet 100% of the electricity demands for terminal operations.

Additional Scope of Work detail is in Exhibit B and Exhibit D Grantee Application Package Attachment 3.

3.1 General Responsibilities.

3.1.1. CARB is responsible for the following:

a. Participation in regular meetings with Grantee to discuss project refinements and guide the administration of the project.

b. Reviewing and approving project deliverables and milestones associated with reimbursement provided by Grantee, such as permitting, infrastructure design and construction, vehicle and cargo handling equipment procurement, ShoreKat emissions treatment system design and fabrication, equipment demonstration, data collection and analysis.

c. Review and approve all grant disbursement requests (Form MSCD/ISB-90) and distribute funds to Grantee.

d. Provide project oversight in conjunction with Grantee.

e. Ensure compliance with applicable requirements of:

i. Fiscal Year 2014-2015 Funding Plan for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments (FY 2014-15 Funding Plan)

ii. Fiscal Year 2014-15 Grant Solicitation Advanced Technology Freight Demonstration: Multi-Source Facility Demonstration Project

3.1.2. Grantee's responsibilities include all CEQA requirements, project development, project administration, project reporting, including but not limited to the following tasks:

a. All CEQA requirements must be completed prior to the execution of the grant agreement.

b. Grantee's key project personnel will participate in an initial meeting with CARB staff before work on the project begins. The purpose of the initial meeting will be to discuss the overall plan, details for performing the tasks, the project schedule, and any issues that may need to be addressed. Grantee's key personnel will also participate in meetings to discuss progress to be held at least quarterly beginning three months after the initial meeting. Additional meetings may be scheduled at the sole discretion of the CARB Project Liaison.

c. Grantee must submit numbered status reports accompanying grant disbursement requests to CARB at least every three months, but may submit on a monthly basis if necessary for more frequent invoicing with prior CARB approval. These reports must be approved by CARB and must contain the following, at a minimum, in either Microsoft Word or PDF, as a single electronic file:
   i. Project Status Report number, title of project, name of Grantee, date of submission, and project grant number.
   ii. Summary of work completed since last progress report, noting progress toward completion of tasks and milestones identified in the work plan.
   iii. Statement of work expected to be completed by the next progress report.
   iv. Notification of problems encountered and an assessment of their effects on the project's outcomes.
   v. Data collected from vehicles and equipment since the last data reporting, as deemed necessary by CARB or its designated third-party data analysis provider.
   vi. Itemized invoice showing all costs for which reimbursement is being requested.
   vii. Discussion of the project's adherence to the project timeline.

d. A final report is required at the end of the project and must include:
   i. A description of the project's goals and objectives, methods, results of the demonstration, and future application of the technology.
   ii. An update on the commercialization prospects.

e. Infrastructure design and construction will be done by Burns and McDonnell, which includes the following elements:
   i. Burns and McDonnell will work with the Grantee to acquire necessary permits for construction of the infrastructure.
   ii. Burns and McDonnell will develop designs for the integration of solar, battery storage and charging infrastructure at the terminal.
   iii. Burns and McDonnell will manage the installation of energy generation, storage, and charging infrastructure.
   iv. Burns and McDonnell will provide the sequences of operation for the electrical monitoring and controls system.

f. Cargo handling equipment and vehicles will be developed in two phases.
   i. Phase one, TransPower will manufacture and deliver two drayage trucks, two yard tractors, and one 21-ton forklift. BYD will manufacture and deliver two yard tractors.
   ii. Phase two, TransPower will manufacture the second two 21-ton forklifts.

g. Clean Air Engineering Maritime will manufacture the new ShoreKat emissions treatment system followed by delivery of the system, at-berth assembly, and commissioning. Emission testing will be conducted to validate system performance.

h. The demonstration phase will show how multiple zero and near-zero equipment can operate together. The ShoreKat emissions treatment system will be connected to at-berth vessels. The electric drayage trucks and cargo handling equipment will be placed into operation alongside baseline diesel equipment operating continuously for an 8-hour shift for a period of two years.

i. During the two year demonstration period, data will be collected from baseline and electrified vehicles and equipment for hours of use, energy storage, vehicle performance, type of operation and application, vehicle and equipment maintenance, and general feedback on operator acceptance. All vehicles and equipment will be equipped with a health activity monitoring system as part of the chassis module control. The vehicles will also have data loggers with data logging performed by the third-party CARB contractor for a period of two years. Note that when this grant agreement is signed by the parties, CARB will not have yet entered into a contract with the third-party CARB contractor. Therefore, Grantee must be flexible in scheduling the vehicles and equipment for testing. All data collected will be included in the final report.

4. FISCAL ADMINISTRATION

Budget

4.1 The maximum amount of this grant is $14,510,400. Under no circumstances will CARB reimburse the Grantee for more than this amount. A written Grant Agreement amendment is required whenever there is a change to lower the amount of this grant.

4.2 The budget for this project is shown in Exhibit B, Attachment I.

4.3 The total funding may only be reallocated in the event that the Grantee requests less administrative funding than the amount stated in the budget.

4.4 No grant funds may be used to purchase equipment or computers that would be required to be returned to the State at the completion of this project.

Grant Disbursements

4.5 Requests for payment shall be made with the Grant Disbursement Request Form (Form MSCD/ISB-90) and conform to the instructions identified in the Fiscal Year 2014-15 Air Quality Improvement Program and Low Carbon Transportation GGRF Investments Multi-Source Facility Demonstration Solicitation (Solicitation). Grant payments shall be made only for reasonable costs incurred by the Grantee and only when the Grantee has submitted a Grant Disbursement Request Form, milestones stipulated in Exhibit B, Attachment II and the instructions found in the Solicitation have been accomplished, documentation of accomplishment has been provided to CARB in the form of the Status Report, and any associated deliverables (if applicable) have been provided to CARB. CARB will have sole discretion to accelerate the timeline for allowable disbursements of administration and project funds identified in Exhibit B, Attachment II (with the exception of the final project administration disbursement), necessary to assure the goals of the project are met.

4.6 Grant payments are subject to CARB's approval of Status Reports and any accompanying deliverables (see Section 6 Reporting). A payment will not be made if the CARB Project Liaison deems that a milestone has not been accomplished or documented, a deliverable meeting specification has not been provided, claimed expenses are not documented, not valid per the budget, or not reasonable, or the Grantee has not m et other terms of the Grant Agreement.

The Chief of the Mobile Source Control Division or designee of CARB may review the Project Liaison's approval or disapproval of a Grant Disbursement Request. No reimbursement will be made for expenses that, in the judgment of the Chief of the Mobile Source Control Division, are not reasonable or do not comply with the Grant Agreement.

4.7 The Grantee shall mail Grant Disbursement Requests to the Project Liaison.

4.8 CARB retains the right to withhold up to ten percent of administrative funds until completion of all work and submission of a Final Report to CARB, as identified in the Solicitation. It is the Grantee's responsibility to submit a Grant Disbursement Request for this final disbursement of funds.

4.9 CARB shall disburse funds in accordance with the California Prompt Payment Act, Government Code, Section 927, et seq.

Oversight and Accountability

4.10 The Grantee shall comply with all oversight responsibilities identified in the Solicitation and this Grant Agreement.

4.11 CARB or its designee reserves the right to audit at any time during the duration of this Grant Agreement the Grantee's costs of performing the grant and to refuse payment of any reimbursable costs or expenses that in the opinion of CARB or its designee are unsubstantiated or unverified. The Grantee shall cooperate with CARB or its designee including, but not limited to, promptly providing all information and documents requested, such as all financial records, documents, and other information pertaining to reimbursable costs, and any matching costs and expenses.

4.12 The Grantee shall retain all financial records referred to above and provide them for examination and audit by the State for three years after final payment under this Grant Agreement.

4.13 The Grantee shall develop and maintain accounting procedures in accordance with Section 9 to track reservation and expenditures by grant award, fiscal year, and of all funding sources.

4.14 The Grantee shall store all records in a secured and safe storage facility that provides fire and natural disaster protection (see Section 9 in the Sample Grant Agreement). Files must be retained during the term of the Grant Agreement plus three years.

4.15 CARB or its designee may recoup funds which were received based upon misinformation or fraud, or for which a Grantee, manufacturer (including truck equipment manufacturer), technology provider, or vehicle purchaser is in significant or continual non-compliance with the terms of this grant or State law. CARB also reserves the right to prohibit any entity from participating in the Advanced Technology Demonstration Projects due to non-compliance with project requirements, in which event the parties agree that this Grant Agreement may be modified in order to modify the scope, budget or schedule to accommodate the change.

5. PROJECT MONITORING

Meetings

5.1 Initial meeting: A meeting will be held between key project personnel and CARB staff before work on the project begins. The purpose of the first meeting will be to discuss the overall plan, details of performing the tasks, the project schedule, and any issues that may need to be resolved.

Review meetings: Meetings to discuss progress must be held at least quarterly beginning three months after the initial meeting. Additional meetings may be scheduled at the sole discretion of the Project Liaison. Such meetings may be conducted by phone, if deemed appropriate by the Project Liaison.

Technical Monitoring

5.2 Any changes in the scope or schedule for the project shall require the prior written approval of the CARB Project Liaison.

5.3 The Grantee shall notify the CARB Project Liaison and Grant Coordinator in writing immediately after any circumstances arise (technical, economic, or otherwise), which might place completion of the project in jeopardy. The Grantee shall also make such notification if there is a change in key project personnel (see Exhibit B, Attachment IV).

5.4 The Grantee shall notify the Project Liaison if the project technology will pursue official verification/certification during the term of this agreement and all documentation in support of the verification/certification must be submitted to the Project Liaison concurrently with the verification/certification submittal.

5.5 In addition to Status Reports (see Section 6 Reporting); the Grantee shall provide information requested by the Project Liaison that is needed to assess progress in completing tasks and meeting the objectives of the project.

5.6 Any change in budget allocations, re-definition of deliverables, or extension of the project schedule must be requested in writing to the CARB Project Liaison and approved by CARB in writing, in its sole discretion.

6. REPORTING

Status Reports

6.1 The Grantee shall submit Status Reports at a minimum of three-month intervals. The Status Reports shall be provided in a format agreed upon between the CARB Project Liaison and the Grantee and meet the requirements of the Solicitation.

6.2 Every Grant Disbursement Request Form (Form MSCD/ISB-90) shall be accompanied by a Status Report that documents the completion of a milestone specified in Exhibit B, Attachment II.

6.3 If the project is behind schedule, the Status Reports must contain an explanation of reasons and how the Grantee plans to resume the schedule.

Final Report

6.4 When the project is complete, the Grantee shall submit a draft Final Report. The draft Final Report must be submitted to CARB in an appropriate format agreed upon between the CARB Project Liaison and the Grantee. The Final Report must meet the requirements of the Solicitation. Upon approval of the draft Final Report by the Project Liaison, the Grantee shall provide a written copy of the final version, plus an electronic file.

7. TERMINATION AND SUSPENSION OF PAYMENTS

7.1 CARB reserves the right to terminate this Grant Agreement upon thirty days' written notice to the Grantee, if CARB determines that the project has not progressed satisfactorily during any previous three months and the Grantee and CARB have been unable to agree on modifications to the project. In case of early termination, the Grantee will submit a Grant Disbursement Request Form, a Status Report covering activities up to, and including, the termination date and comply with the requirements in Sections 4 and 6 of these provisions. Upon receipt of the Grant Disbursement Request Form, Status Report, a final payment will be made to the Grantee. This payment shall be for all CARB-approved, actually incurred costs that are justified in conformance with this Grant Agreement. However, the total amount paid shall not exceed the total grant amount.

7.2 CARB reserves the right to issue a written grant suspension order in the event that a dispute should arise. The grant suspension order will be in effect until the dispute has been resolved or the Grant Agreement has been terminated. If the Grantee chooses to continue work on the project after receiving a grant suspension order, the Grantee will not be reimbursed for any expenditure incurred during the suspension in the event CARB terminates the Grant Agreement. If CARB rescinds the suspension order and does not terminate the Grant Agreement, CARB will reimburse the Grantee for any expenses incurred during the suspension that are determined reimbursable in accordance with the terms of the Grant Agreement.

8. CONTINGENCY PROVISION

8.1 In the event this Grant Agreement is terminated for whatever reason, the CARB Executive Officer or designee reserves the right in his or her sole discretion to award a grant to the next highest scored applicant, and if an agreement cannot be reached, to the next applicant(s) until an agreement is reached. If CARB is unable to award a grant under these circumstances, CARB may award a grant to other projects.

9. PROJECT RECORDS

Grantee Record

9.1 As further described in Section 9.3, project records includes but is not limited to Grantee, financial, and other records. All project records must be retained for a period of three (3) years after the term of this Grant Agreement. All project records are subject to audit pursuant to Section 10.27 of this Grant Agreement. At the end of the third year after the term of this Grant Agreement, CARB will make a written request for all project records, and the Grantee shall submit all project records to CARB in response to that request.

9.2 The Grantee shall retain a file for the Multi-Source Facility Demonstration Project containing:

a. Original executed copy of the Multi-Source Facility Demonstration Project Grant Agreement and Grant Agreement Amendments (if applicable).
b. Copies of Grant Disbursement Request Forms.
c. Documentation of earned interest generation and expenditure.

Financial Record

9.3 Without limitation of the requirement to maintain project accounts in accordance with generally accepted accounting principles, the Grantee shall:

a. Establish an official file for the Multi-Source Facility Demonstration Project which shall adequately document all significant actions relative to the project.
b. Establish separate accounts which will adequately and accurately depict all amounts received and expended on the Multi-Source Facility Demonstration Project.
c. Establish separate accounts which will adequately and accurately depict all income received which is attributable to the Multi-Source Facility Demonstration Project, including cash and in-kind match.
d. Establish an accounting system which will adequately depict final total costs of the Multi-Source Facility Demonstration Project, including both direct and indirect costs.

10. GENERAL PROVISIONS

10.1 **Amendment:** No amendment or variation of the terms of this Grant Agreement shall be valid unless made in writing, signed by the parties and approved as required. No oral understanding or agreement not incorporated in the Grant Agreement is binding on any of the parties.

10.2 **Assignment:** This Grant Agreement is not assignable by the Grantee, either in whole or in part, without the consent of CARB.

10.3 **Compliance with laws, regulations, etc.:** The Grantee agrees that it will, at all times, comply with and require its contractors and subcontractors to comply with all applicable federal and State laws, rules, guidelines, regulations, and requirements.

10.4 **Computer software:** The Grantee certifies that it has appropriate systems and controls in place to ensure that State funds will not be used in the performance of this Grant Agreement for the acquisition, operation or maintenance of computer software in violation of copyright laws.

10.5 **Conflict of interest:** The Grantee certifies that it is in compliance with applicable State and/or federal conflict of interest laws.

10.6 **Damages for breach affecting tax exempt status:** In the event that any breach of any of the provisions of this Grant Agreement by the Grantee shall result in the loss of tax exempt status for any State bonds, the Grantee shall immediately reimburse the State in an amount equal to any damages paid by or loss incurred by the State due to such breach.

10.7 **Disputes:** The Grantee shall continue with the responsibilities under this Grant Agreement during any dispute, unless CARB has issued a written grant suspension order pursuant to Section 7. Grantee staff or management may work in good faith with CARB staff or management to resolve any disagreements or conflicts arising from implementation of this Grant Agreement. However, any disagreements that cannot be resolved at the management level within 30 days of when the issue is first raised with CARB staff shall be subject to resolution by the CARB Executive Officer, or his designated representative. Nothing contained in this paragraph is intended to limit any rights or remedies that the parties may have under law.

10.8 **Environmental justice:** In the performance of this Grant Agreement, the Grantee shall conduct its programs, policies, and activities that substantially affect human health or the environment in a manner that ensures the fair treatment of people of all races, cultures, and income levels, including minority populations and low-income population of the State.

10.9 **Fiscal management systems and accounting standards:** The Grantee agrees that, at a minimum, its fiscal control and accounting procedures will be sufficient to permit tracing of grant funds to a level of expenditure adequate to establish that such funds have not been used in violation of State law or this Grant Agreement. Unless otherwise prohibited by State or local law, the Grantee further agrees that it will maintain separate Project accounts in accordance with generally accepted accounting principles.

10.10 **Force majeure:** Neither CARB nor the Grantee shall be liable for or deemed to be in default for any delay or failure in performance under this Grant Agreement or interruption of services resulting, directly or indirectly, from acts of God, enemy or hostile governmental action, civil commotion, strikes, lockouts, labor disputes, fire or other casualty, etc.

10.11 **Governing law and venue:** This grant is governed by and shall be interpreted in accordance with the laws of the State of California. CARB and the Grantee hereby agree that any action arising out of this Grant Agreement shall be filed and maintained in the Superior Court in and for the County of Sacramento, California, or in the United States District Court in and for the Eastern District of California. The Grantee hereby waives any existing sovereign immunity for the purposes of this Grant Agreement.

10.12 **Indemnification:** The Grantee agrees to indemnify, defend and hold harmless the State and the Board and its officers, employees, agents, representatives, and successors-in-interest against any and all liability, loss, and expense, including reasonable attorneys' fees, from any and all claims for injury or damages arising out of the performance by the Grantee, and out of the operation of equipment that is purchased with funds from this Grant Agreement.

10.13 **Grantee's responsibility for work:** The Grantee shall be responsible for work and for persons or entities engaged in work, including, but not limited to, contractors, subcontractors, suppliers, and providers of services. The Grantee shall be responsible for any and all disputes arising out of its contract for work on the Project, including but not limited to payment disputes with contractors, subcontractors, sand providers of services. The State will not mediate disputes between the Grantee and any other entity concerning responsibility for performance of work.

10.14 **Independent actor:** The Grantee, and its agents and employees, if any, in their performance of this Grant Agreement, shall act in an independent capacity and not as officers, employees or agents of CARB.

10.15 **Nondiscrimination:** During the performance of this Grant Agreement, the Grantee and its contractors shall not unlawfully discriminate against, harass, or allow harassment against any employee or applicant for employment because of sex, race, religion, color, national origin, ancestry, disability, sexual orientation, medical condition, marital status, age (over 40) or allow denial of family-care leave, medical-care leave, or pregnancy-disability leave. The Grantee and its contractors shall ensure that the evaluation and treatment of their employees and applicants for employment are free of such discrimination and harassment.

10.16 **No third party rights:** The parties to this Grant Agreement do not create rights in, or grant remedies to, any third party as a beneficiary of this Grant Agreement, or of any duty, covenant, obligation or undertaking established herein.

10.17 **Prevailing wages and labor compliance:** If applicable, the Grantee agrees to be bound by all the provisions of State Labor Code Section 1771 regarding prevailing wages. If applicable, the Grantee shall monitor all agreements subject to reimbursement from this Grant Agreement to ensure that the prevailing wage provisions of State Labor Code Section 1771 are being met.

10.18 **Professionals:** For projects involving installation or construction services, the Grantee agrees that only licensed professionals will be used to perform services under this Grant Agreement where such services are called for and licensed professionals are required for those services under State law.

10.19 **Severability:** If a court of competent jurisdiction holds any provision of this Grant Agreement to be illegal, unenforceable or invalid in whole or in part for any reason, the validity and enforceability of the remaining provisions, or portions of those provisions, will not be affected.

10.20 **Termination:** CARB may terminate this Grant Agreement by written notice at any time prior to completion of projects funded by this Grant Agreement, upon violation by the Grantee of any material provision after such violation has been called to the attention of the Grantee and after failure of the Grantee to bring itself into compliance with the provisions of this Grant Agreement.

10.21 **Timeliness:** Time is of the essence in this Grant Agreement. Grantee shall proceed with and complete the Project in a reasonably expeditious manner.

10.22 **Waiver of Rights:** Any waiver of rights with respect to a default or other matter arising under the Grant Agreement at any time by either party shall not be considered a waiver of rights with respect to any other default or matter. Any rights and remedies of the State provided for in this Grant Agreement are in addition to any other rights and remedies provided by law.

10.23 **Availability of funds:** CARB's obligations under this Grant Agreement are contingent upon the availability of funds. In the event funds are not available, the State shall have no liability to pay any funds whatsoever to the Grantee or to furnish any other considerations under this Grant Agreement.

10.24 **Confidentiality:** The parties agree that each party is a California public agency subject to the California Public Records Act ("Act") and each party is obligated to comply with the Act in effectuating the terms of this Grant Agreement. The parties agree that records which are designated as confidential by CARB, may not be disclosed by the Grantee if such non-disclosure is authorized by the Act. In the event that Grantee submits any confidential information or data to CARB pursuant to this Grant Agreement it may be shared with other divisions within the CARB.

10.25 **Personally Identifiable Information:** Information or data that personally identifies an individual or individuals is confidential in accordance with California Civil Code Section 1798, et seq. and other relevant State or Federal statutes and regulations. The parties agree that to the extent each is required, each shall comply with California Civil Code Section 1798 et seq.

10.26 **Ownership:** All information or data received or generated by the Grantee under this agreement shall become the property of CARB. Except to the extent the Grantee shall be required to comply with the California Public Records Act, information or data received or generated under this agreement shall not be released without CARB's approval.

10.27 **Audit:** Grantee agrees that CARB, the Department of General Services, Department of Finance, the Bureau of State Audits, or their designated representative shall have the right to review and copy any records and supporting documentation pertaining to the performance of this Grant Agreement and all State funds received. Grantee agrees to maintain such records for possible audit for a minimum of three (3) years after the term of this Grant Agreement, unless a longer period of records retention is stipulated. Grantee agrees to allow the auditor(s) access to such records during normal business hours and to allow interviews of any employees who might reasonably have information related to such records. Further, Grantee agrees to include similar right of the State audit records and interview staff in any agreement related to performance of this Agreement.

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EXHIBIT B

Work Statement

Budget Summary (Attachment I)
Project Milestones and Disbursement Schedule (Attachment II)
Project Schedule (Attachment III)
Key Project Personnel (Attachment IV)

EXHIBIT B, Attachment I

Budget Summary

Grantee: **Los Angeles Harbor Department** **Grant No.: G14-LCTI-08**
Amendment ~~2~~ 3

Project: Port of Los Angeles Green Omni Terminal

Total Costs & Funding

Costs	Grant	Applicant Match Funding		Total
		Cash	In-Kind	
1. Demonstration Technology Funds	$13,784,880	$5,547,000	$6,545,000	$25,876,880
2. Administrative Funds[1]	$725,520	$0	$0	$725,520
Total	$14,510,400[2]	$5,547,000	$6,545,000	$26,602,400

[1]Administrative funds may not exceed 10% of the total project cost and only 5% of CARB-awarded funds may be used for administrative purposes.
[2]Total grant funds is $540,000 less than requested amount due to elements of the project not eligible for funding under the solicitation.

Additional budget details are in Exhibit D, Grantee Application Package Attachment 5.

Disbursement of Funds:

Demonstration Technology Funding
The Grantee shall receive funds in accordance with the 2014-15 Grant Solicitation for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund (GGRF) Investments: Multi-Source Facility Demonstration Project.

Project Administration
The Grantee shall receive project administration funding in accordance with the 2014-15 Grant Solicitation for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund (GGRF) Investments: Multi-Source Facility Demonstration Project.

Project Milestones and Brief Task Descriptions with Disbursements Schedule

Grantee: Los Angeles Harbor Department **Grant No.: G14-LCTI-08**
Amendment ~~2~~ 3

Project: Port of Los Angeles Green Omni Terminal

Milestone	Task Description	Project Funding	
		Project Funds	Administrative Funds
1.0	**Administration & Project Management**	n/a	n/a
1.1	Conduct Kick Off Meeting	$0	$0
1.2	Recurring Milestone: Monthly Project Update Meetings & Reports	$0	$625,500
1.3	Final Report*	$0	$100,020
2.0	**Infrastructure Design & Construction**	n/a	n/a
2.1	Permitting	$10,080	$0
2.2	Infrastructure Design	$90,000	$0
2.3	Infrastructure Construction	$0	$0
2.3.1	Solar PV Installation	$0	$0
2.3.1.1	Solar PV Electrical Service Equipment Procurement	$540,000	$0

2.3.1.2	Solar PV Electrical Service Installation	$638,400	$0
2.3.1.3	Solar PV Array Installation	$0	$0
2.3.2	Battery Storage System	$0	$0
2.3.2.1	Battery Storage System Manufacture and Delivery	$1,313,000	$0
2.3.2.2	Battery Storage System Infrastructure Procurement	$378,800	$0
2.3.2.3	Battery Storage System Installation	$695,255	$0
2.3.3	Charging Equipment	$320,000	$0
2.3.4	Energy Management/Microgrid Control System	$0	$0
2.3.4.1	System Procurement	$560,000	$0
2.3.4.2	System Installation	$575,400	$0
2.3.5	Wharf Crane Drive Upgrades	$0	$0
2.4	Testing and Commissioning	$60,000	$0
3.0	**Vehicles & Cargo Handling Equipment**	n/a	n/a
3.1	Design Adaptation to Forklifts	$0	$0
3.1.1	Performance Analysis	$200,000	$0

3.1.2	Drive System Design	$600,000	$0
3.2	Drayage Truck and Yard Tractor Procurement	$0	$0
3.2.1	Determination of Final Vehicle Specifications	$100,000	$0
3.2.2	Vehicle Purchases	$450,000	$0
3.3	Subsystem Assembly	$0	$0
3.3.1	Order Externally-Sourced Components – Phase 1	$900,000	$0
3.3.2	Subsystem Assembly – Phase 1 Vehicles	$500,000	$0
3.3.3	Order Externally-Sourced Components – Phase 2	$200,000	$0
3.3.4	Subsystem Assembly – Phase 2 Vehicles	$150,000	$0
3.4	Vehicle Integration and Commissioning	$0	$0
3.4.1	Phase 1 Vehicle Integration – TransPower Drayage Truck, Yard Tractor, and First Forklift; and BYD 2 Yard Tractors	$0	$0
3.4.1.1	TransPower Vehicle Integration – Drayage Truck, Yard Tractor, and First Forklift	$600,000	$0
3.4.1.2	BYD Delivery of 2 Yard Tractors	$600,000	$0
3.4.2	Phase 1 Vehicle Commissioning	$200,000	$0

3.4.3	Phase 2 Vehicle Integration – Two Forklifts	$100,000	$0
3.4.4	Phase 2 Vehicle Commissioning	$50,000	$0
3.5	Vehicle Deployment	$0	$0
3.5.1	Vehicle Delivery – First Two 21-ton Forklifts	$0	$0
3.5.1.1	Vehicle Delivery- Third 21-ton Forklift	$0	$0
3.5.2	Personnel Training	$134,745	$0
3.6	**Kalmar Delivery of Yard Tractor**	**$397,939**	**$0**
4.0	**ShoreKat Emissions Treatment System**	n/a	n/a
4.1	Design, Fabrication, and Delivery	$0	$0
4.1.1	Design	$70,000	$0
4.1.2	Emission Control System Procurement	$985,327	$0
4.1.3	Infrastructure Equipment Procurement	$553,305	$0
4.1.4	Crane/Extraction System Procurement	$1,329,621	$0
4.1.5	ShoreKat Delivery	$64,706	$0

4.2	Equipment Installation and Commissioning	<u>**$0**</u> ~~$499,102~~	$0
<u>**4.2.1**</u>	<u>**Core Emissions Treatment System Equipment Installation and Commissioning**</u>	<u>**$299,102**</u>	<u>**$0**</u>
<u>**4.2.2**</u>	<u>**Carbon Treatment System 1 Equipment Installation and Commissioning**</u>	<u>**$0**</u>	<u>**$0**</u>
4.3	Performance Verification and Emissions Testing	<u>**$0**</u> ~~$197,939~~	$0
5.0	**Equipment Demonstration**	n/a	n/a
5.1	Microgrid, Energy Management System, Efficiency Retrofits	$0	$0
5.2	Vehicles and Equipment	$0	$0
5.2.1	Phase 1 Vehicles and Equipment	$0	$0
5.2.2	Phase 2 Cargo Handling Equipment	$0	$0
5.3	ShoreKat Demonstration	$0	$0
6.0	**Data Collection and Analysis**	$0	$0
6.1	Field Data Collection	$0	$0
6.2	Laboratory Data Collection	$119,200	$0
6.3	Data Analysis	$0	$0

Subtotal of Project Funds and Administrative Funds	**$13,784,880**	**$725,520**
Grant Total Funding Amount	**$14,510,400**	

*CARB will not reimburse for the Final Report until approval of the Final Report

EXHIBIT B, Attachment III

Project Schedule

Grantee: Los Angeles Harbor Department **Grant No.: G14-LCTI-08**
Amendment 2 3

Project: Port of Los Angeles Green Omni Terminal

Detailed Scope of Work and Schedule

Work Task	Start Date	Completion Date
Task 1 – Administration and Project Management	June 1, 2016	March 15, 2020
1.1 Kick-off Meeting - The project team will meet with CARB and third-party data analysis provider to discuss the work plan, details of task performance, schedule, and resolution of issues.	June 1, 2016	June 1, 2016
1.2 Monthly Project Update Meetings and Reports - The Harbor Department will coordinate monthly project update meetings to discuss progress with the project team. The meetings will follow a defined agenda that will cover project status update, difficulties encountered, upcoming deliverables, pending disbursement requests, and schedule of the next update meeting.	June 1, 2016	March 15, 2020
1.3 Final Report - At the completion of the project, the Harbor Department will submit a final report to CARB that describes the project's goals and objectives, methods, results of the demonstration, future application of the technologies, commercialization prospects, and data analysis.	February 1, 2020	March 2, 2020
Task 1 Deliverables: Monthly Agenda, Monthly Project Status Reports, Disbursement Requests, Final Report	June 1, 2016	March 15, 2020
Task 2 – Design and Construction of Infrastructure	June 1, 2016	July 31, 2018
2.1 Permitting - Burns & McDonnell will work with the Harbor Department to acquire permits necessary for construction of infrastructure at the Pasha terminal, including an Engineers Permit, Parallel Cogeneration Interconnection Agreement, PV Interconnection	June 1, 2016	October 31, 2016

Agreement, City of Los Angeles Department of Building and Safety Permits, and will have worked with the Harbor Department to obtain CEQA approval before execution of grant agreement.		
2.2 Infrastructure Design - Burns & McDonnell will develop designs for the integration of solar, battery storage, and charging infrastructure at the terminal. An assessment of the existing infrastructure determined that the substation on the terminal has a dedicated transformer and switchboard that is more than sufficient to handle the demonstration project's proposed load.	July 1, 2016	December 31, 2016
2.3 Infrastructure Construction - Burns & McDonnell will manage the installation of energy generation, storage, and charging infrastructure along with efficiency upgrades and system integration for the following components: Solar PV installation, battery storage system, charging equipment, energy management and microgrid control system, and wharf crane drive upgrades. The infrastructure integration is for grant approved equipment only.	January 1, 2017	July 31, 2018
2.3.1 Solar PV Installation - Following the retrofit and reroofing of the Berth 181 Warehouse by the Harbor Department, PermaCity will install a 1.03 MW (DC) solar PV system on the rooftop. The PV system will be connected to a 1500kVA pad-mounted transformer at the existing building, which will feed to a 3000A switchboard with two breakers – 1200A for the new PV and 400A for the existing building. A single 5kV feeder will be run from the warehouse to the existing substation.	April 1, 2018	July 31, 2018
2.3.1.1 Solar PV Electrical Service Equipment Procurement – Burns & McDonnell will procure the 1500kVA pad-mounted transformer, 3000A switchboard with two breakers – 1200A for the new PV and 400A for the existing building, and 5kV feeder	February 1, 2018	June 19, 2018
2.3.1.2 Solar PV Electrical Service Installation – Burns & McDonnell will install the electrical service equipment to support PV system	April 19, 2018	July 5, 2018
2.3.1.3 Solar PV Array Installation – PermaCity will install a 1.03 MW (DC) solar PV system on the rooftop	April 5, 2018	July 27, 2018
2.3.2 Battery Storage System - BYD will manufacture two battery storage systems (BSS) to Pasha within 7 months of project kickoff. The BSS will include	June 1, 2016	March 31, 2017

batteries, power conversion system (PCS), container, and supporting systems. The BSSs are housed in 40-foot containers, which will be positioned adjacent to the existing substation. Burns & McDonnell will procure and construct the required infrastructure to connect the BSS to the terminal's substation and incorporate the BSS into the terminal's microgrid. Each unit will be rated for 500kW/1.3MWh and will be fed from the reefer switchboard using new, 800A breakers. To prevent sheet-flow runoff from entering the BSS, containers will be mounted on a pad designed by Burns & McDonnell. Each BSS will also need to be connected to a new power meter in the 4160V switchgear in order to perform peak shaving functions. A #4/0 ground ring shall be supplied around the pad and bonded to opposite corners of each shipping container.		
2.3.2.1 Battery Storage System Manufacture and Delivery – BYD will manufacture and deliver two BSSs.	September 1, 2016	February 15, 2017
2.3.2.2 Battery Storage System Infrastructure Procurement – Burns & McDonnell will procure the required infrastructure to connect the BSS to the terminal's substation and incorporate the BSS into the terminal's microgrid.	August 1, 2016	September 30, 2017
2.3.2.3 Battery Storage System Installation – Burns & McDonnell will install the two BSSs and integrate them into the terminal microgrid.	November 1, 2017	March 31, 2018
2.3.3 Charging Equipment - TransPower will provide seven charging units and BYD will provide two charging units for proposed vehicles and equipment. Both systems will connect to standardized electrical infrastructure. The TransPower system consists of a 75kVA transformer, EV support equipment, and cable to connect to the on-board inverter charger unit. BYD will install a 200kW charger that uses 480V 3-phase supply and 240A input current charger charging equipment.	September 1, 2016	March 31, 2018
2.3.4 Energy Management/Microgrid Control System - The microgrid control system is a single, NEMA 4X, stainless steel enclosure with redundant programmable controllers, internal UPS, and a touch-screen HMI. This enclosure will be located adjacent to the batteries (outside of the substation fence line). It will communicate to each of the EVs (for charge control), the batteries, and the new power meter in the 4160V switchgear.	October 1, 2016	March 31, 2018

2.3.4.1 System Procurement – Burns & McDonnell will procure the microgrid control system components.	October 1, 2016	September 30, 2017
2.3.4.2 System Installation – Burns & McDonnell will install the microgrid control system.	November 1, 2017	March 31, 2018
2.4 Testing and Commissioning - Burns & McDonnell will provide the desired sequences of operation for the electrical monitoring and controls system. This will include both grid-tied as well as islanded operation of the system. Once all of the equipment is fully operational, Burns & McDonnell will lead the commissioning effort of the overall system being installed under this project. This will include operation for peak shaving and islanded operation. The commissioning procedures and results will be documented in a final commissioning report to be included in the reports to be submitted to CARB.	August 1, 2018	August 30, 2018
Task 2 Deliverables: As-Built Drawings, Testing and Commissioning Report	June 1, 2016	August 30, 2018
Task 3 – Vehicles and Cargo Handling Equipment - Cargo handling equipment and vehicles will be developed in two phases. During Phase 1, TransPower will manufacture and deliver the two drayage trucks, two yard tractors, and one 21-ton forklift; and BYD will manufacture and deliver two yard tractors. In Phase 2, TransPower will manufacture the two additional 21-ton forklifts to build on the lessons learned during the manufacturing and commissioning of the Phase 1 forklift. BYD will deliver its two yard tractors within 6 months of receiving an order. Charging infrastructure will arrive in early 2018, well before the arrival of vehicles. The following tasks provide details on the delivery process of TransPower vehicles and equipment	October 1, 2016	September 28, 2018
3.1 Design Adaptation to Forklift - Pasha will provide TransPower with three Kalmar 21-ton forklifts for conversion from diesel engines to battery electric drives. TransPower will use propulsion systems that are similar to the ElecTruck™ drives installed in drayage trucks and yard tractors to power this equipment. This will include a design effort to lay out how the drive systems will be installed into the Kalmar equipment. The first forklift design will be completed in Phase 1, and the second two forklift designs will be	October 1, 2016	June 30, 2018

completed in Phase 2.		
3.1.1 Performance Analysis – TransPower will evaluate the performance of diesel forklifts.	October 1, 2016	December 31, 2016
3.1.2 Drive System Design - TransPower will use propulsion systems that are similar to the ElecTruck™ drives installed in drayage trucks and yard tractors to power this equipment. This will include a design effort to lay out how the drive systems will be installed into the Kalmar equipment.	October 1, 2016	January 31, 2017
3.2 Drayage Truck and Yard Tractor Procurement - TransPower will take possession of the base drayage trucks from Navistar and base yard tractors from Cargotec. The base vehicles can take up to 3-4 months to receive from issuance of purchase order, so they will be ordered following project kick off.	October 1, 2016	January 31, 2017
3.2.1 Determination of Final Vehicle Specifications – TransPower will minimize technical risks by using the existing TransPower drayage truck and yard tractor integration concepts. The design improvement process offers the option of customizing vehicles to any unique operating requirements TransPower might encounter at a given location.	October 1, 2016	June 30, 2018
3.2.2 Vehicle Purchase – TransPower will receive the base trucks from Navistar and base yard tractors from Cargotec.	December 1, 2016	January 31, 2017
3.3 Subsystem Assembly - The first step in this process is to order major externally-sourced drive system components. Most purchased components are already elements of TransPower's standard drive system bill of material and can be procured efficiently from known suppliers. Once components are acquired or, when appropriate, manufactured in-house, TransPower will assemble the major subsystems. These are the Motive Drive Subsystem, Power Control and Accessory Subsystem, and Energy Storage Subsystem.	October 1, 2016	August 31, 2018
3.3.1 Order Externally-Sourced Components – TransPower will order externally-sourced subsystem components for Phase 1 Vehicles. Most purchased components are already elements of their standard drive system bill of material and can be procured efficiently from known suppliers.	October 1, 2016	November 30, 2016
3.3.2 Subsystem Assembly – Once components are acquired or, when appropriate, manufactured in-house for Phase 1 Vehicles, TransPower will assemble the	November 1, 2016	March 31, 2018

major subsystems. These are the Motive Drive Subsystem, Power Control and Accessory Subsystem, and Energy Storage Subsystem.		
3.3.3 Order Externally-Sourced Components – TransPower will order externally-sourced subsystem components for Phase 2 Vehicles. Most purchased components are already elements of their standard drive system bill of material and can be procured efficiently from known suppliers.	October 1, 2016	June 30, 2018
3.3.4 Subsystem Assembly – Once components are acquired or, when appropriate, manufactured in-house for Phase 2 Vehicles, TransPower will assemble the major subsystems. These are the Motive Drive Subsystem, Power Control and Accessory Subsystem, and Energy Storage Subsystem.	February 1, 2017	July 31, 2018
3.4 Vehicle Integration and Commissioning - TransPower will install subsystems into the demonstration vehicles in two phases, as previously described in Task 3. During commissioning, TransPower will test all drive system components on the integrated vehicle and then test the entire system to ensure it functions properly. TransPower will then undertake a series of drive tests to validate the basic functionality and safety of the system and to optimize vehicle controls.	February 1, 2017	August 31, 2018
3.4.1.1 TransPower Phase 1 Vehicle Integration – TransPower will install power control and accessory subsystems (PCAS) and inverter charger units (ICU) into the Drayage Trucks, Yard Tractors, and first Forklift.	February 1, 2017	June 30, 2018
3.4.1.2 BYD Vehicle Delivery – BYD will design, manufacturer and deliver 2 electric yard tractors	June 1, 2016	December 31, 2017
3.4.2 Phase 1 Vehicle Commissioning – TransPower will test all drive system components on the integrated vehicle and then test the entire system to assure it functions properly. They will then undertake a series of drive tests to validate the basic functionality and safety of the system, and to optimize vehicle controls.	March 1, 2018	July 31, 2018
3.4.3 Phase 2 Vehicle Integration – TransPower will install power control and accessory subsystems (PCAS) and inverter charger units (ICU) into the two additional 21-ton Forklifts.	April 2, 2018	~~August 31, 2018~~ **November 2019**
3.4.4 Phase 2 Vehicle Commissioning - TransPower will test all drive system components on the integrated vehicle and then test the entire system to ensure it	July 1, 2018	September 30, 2018

functions properly. They will then undertake a series of drive tests to validate the basic functionality and safety of the system and to optimize vehicle controls.		
3.5 Vehicle Deployment - Upon delivery and deployment of vehicles at Pasha, charging infrastructure will be tested, and training of Pasha operational and maintenance crews will begin. BYD and TransPower will provide on-site and classroom training up to 40 hours for drivers of all the vehicles, as well as a printed and digital set of operator training manuals.	January 1, 2018	September 30, 2018
3.5.1 Vehicle Delivery – TransPower will deliver two Forklifts.	June 30, 2018	September 30, 2018
3.5.1.1 Vehicle Delivery – TransPower will deliver third Forklift.	January 1, 2018	September 30, 2018
3.5.2 Personnel Training - BYD and TransPower will provide on-site and classroom training up to 40 hours for drivers of all the vehicles, as well as a printed and digital set of operator training manuals.	July 1, 2017	September 30, 2018
3.6 Yard Tractor Delivery – Kalmar will deliver one battery electric yard tractor	**January 31, 2020**	**May 29, 2020**
Task 3 Deliverables: Updated Design Package, Invoices for Vehicle Purchases, Photographs of Assembled Subsystems, operator training manual, and Vehicle Commissioning Report.	October 31, 2016	September 30, 2018
Task 4 – ShoreKat Emissions Treatment System - CAEM will manufacture the new ShoreKat system over a 20-week period followed by a 4-week period for delivery, at-berth assembly, and commissioning. Emission testing will be conducted over a month period to validate system performance.	October 1, 2016	~~January 1, 2018~~ **March 15, 2020**
4.1 Design, Fabrication, and Delivery - System design will include the packaging of the technology used in METS into a system that can be operated from and moved along a pier. Primary design considerations are the ability of the system to operate as a self-contained unit for a minimum duration that is equivalent to one vessel call. The system will also be enhanced to accommodate a wide variety of auxiliary engine stacks. Additional design improvements will include NO_x removal efficiency, improved energy efficiency, non-methane VOC and SO_2 reduction~~, and CO_2 capture~~. The primary focus of fabrication will be to greatly reduce construction time and level of effort in the field and reduce shipping costs from the factory. This will be	October 1, 2016	February 28, 2018

accomplished by focusing on a modular type of design that incorporates many elements into a single integrated component. The goal is to shift labor delivered in the field to being delivered at the factory. Engineering designs will be completed; the as-built design package, emission control system, infrastructure equipment, and crane/extraction system will be procured; and equipment will be shipped to Pasha.		
4.1.1 Design – CAEM will design the ShoreKat emissions control system and submit designs.	October 1, 2016	November 30, 2016
4.1.2 Emission Control System Procurement – CAEM will procure raw material for filter housings and steel filter elements controls.	October 1, 2016	November 30, 2016
4.1.3 Infrastructure Equipment Procurement – CAEM will procure the primary fan, ECS duct system, duct heater, system power generators, and system compressor.	October 1, 2016	November 30, 2016
4.1.4 Crane/Extraction System Procurement – CAEM will procure the boom tower system and ductwork for capture system.	October 1, 2016	November 30, 2016
4.1.5 ShoreKat Delivery – CAEM will ship the system to Pasha for inservicing.	August 1, 2016	March 16, 2018
4.2 Equipment Installation and Commissioning – The ShoreKat's modular design will facilitate a shipping and delivery approach that is greatly simplified over what was required for the METS-1 system. This approach will eliminate field construction and will convert those activities to a short assembly process. This approach will also allow full functional testing at the factory, greatly reducing troubleshooting in the field during startup. The focus of commissioning activities will be operator training and system performance evaluations. Deliverables for this task are a list of equipment and commissioning report.	April 2, 2018	April 27, 2018
4.2.1 Core Emissions Treatment System Equipment Installation and Commissioning at the Pasha Terminal	**September 1, 2018**	**May 31, 2019**
4.2.2 Carbon Treatment System 1 Delivery, assembly, and Commissioning	**June 1, 2019**	**September 30, 2019**
4.3 Performance Verification and Emissions Testing - ShoreKat will incorporate onboard monitoring systems to determine the removal efficiency of NO_x and corresponding ammonia slip. The system will also have the ability to determine CO_2 capture on a continuous	April 30, 2018	~~May 31, 2018~~ **March 15, 2020**

basis and fuel consumption. The performance demonstration period is expected to last four to six weeks. During that time, the system will collect continuous particulate efficiency data. An independent source test company will be contracted to perform emission testing to validate all of the onboard measurements and to demonstrate SO_2 and non-methane VOC treatment efficiency. Deliverable is the emissions testing results.		
Task 4 Deliverables: As-Built Design Package, Documentation of Procured Equipment, Delivery of ShoreKat, Commissioning Report, and Emission Testing Report	October 1, 2016	January 31, 2020
Task 5 – Demonstration - The demonstration phase will show how multiple zero and near-zero equipment can operate together to sustainably move break bulk and container cargo through the terminal to clean truck transportation. Following successful commissioning and deployment of equipment and training of staff on operation and maintenance, a two-year demonstration will begin. The four electric yard trucks, one 21-ton forklift, two on-road drayage trucks, and cargo handling equipment will be placed in operation alongside baseline diesel equipment. Once at berth, vessels will be connected to the ShoreKat treatment system to reduce emissions **(ShoreKat treatment system demonstration will end in March 2020).** Efficient wharf cranes, powered by solar energy, will offload vessels where electrified forklifts will move cargo to staging areas, yard tractors, drayage trucks, or rail for transport. It is anticipated that equipment will be capable of operating continuously for an 8-hour shift.	January 1, 2018	January 31, 2020
5.1 Microgrid, Energy Efficiency Retrofits - Burns & McDonnell will demonstrate energy efficiency and resiliency gained through the microgrid and energy management control systems. This will include peak shaving and islanded operation.	September 1, 2018	January 31, 2020
5.2 Vehicles and Equipment - The four electric yard tractors, three 21-ton forklifts, two on-road drayage trucks, will be placed in operation alongside baseline diesel equipment to demonstrate the operational viability and cost-effectiveness of operating multiple zero emission vehicles and equipment at one facility.	January 1, 2018	January 31, 2020
5.2.1 Phase 1 Vehicles and Equipment - Class 8 drayage trucks, yard tractors, and forklift will be placed in service during Phase 1. Electric drayage trucks will	June 1, 2017	January 31, 2020

primarily be used to move cargo and personnel within the Port complex. Additional demonstrations will include longer hauls to distribution and processing facilities.		
5.2.2 Phase 2 Cargo Handling Equipment - The two additional 21-ton forklifts will be placed in service during Phase 2.	April 1, 2018	January 31, 2020
5.3 ShoreKat Demonstration - Following emission testing, the ShoreKat system will continue to be used throughout the project demonstration period to test the long-term operation and maintenance of the system at the terminal. Pasha is an ideal terminal for testing this system because the vessels calling on the terminal are not equipped with alternative maritime power infrastructure.	April 1, 2018	January 31, 2020
Task 5 Deliverables: Monthly Status Reports on Equipment In-Service and Operation	July 1, 2017	January 31, 2020
Task 6 – Data Collections and Analysis - During demonstration, data will be collected from baseline and electrified vehicles and equipment for hours of use, energy usage, vehicle performance variables, type of operation/application, vehicle/equipment maintenance, as well as general feedback on operator acceptance.	January 1, 2018	January 31, 2020
6.1 Field Data Collection - EVs and equipment 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. All real-time and historical data will be available in chart form and as a download for analysis by the Harbor Department, PASHA, CARB, and CARB's chosen third party analysis company. Furthermore, the HAMS has the ability to coordinate the charging profile of all of the vehicles to smooth power demand. An algorithm will determine when to start/stop charging based on commands from the web server. Lastly, the HAMS has GPS capability, so it can identify where trucks are at any given time and also provide telematics information related to when the trucks are operating in disadvantaged communities. Demonstration and baseline vehicles will be equipped with CARB-specified	January 1, 2018	January 31, 2020

data loggers to support collection of CARB-required data, in addition to the HAMS system.		
6.2 Laboratory Data Collection - UCR CE-CERT will evaluate representative EVs at their Heavy-Duty Chassis Dynamometer facility in Riverside, CA. Laboratory testing will include a BYD electric yard tractor, a TransPower drayage truck, and a 21-ton forklift. Dynamometer testing will evaluate power, energy efficiency, and fuel economy. These measurements will be made using a series of power consumption measurements over the range of cycles seen at Pasha and other Port terminals. The data will be collected for both integrated cycles and on a second-by-second basis.	September 1, 2018	September 30, 2018
6.3 Data Analysis - Data analysis will be accomplished by an independent third party that CARB selects. It is understood that all types of data to be collected will be determined in CARB's sole discretion, in consultation with the project team.	January 1, 2018	January 31, 2020
Task 6 Deliverables: Electronic data in the format required by CARB, Data Analysis Report will be included in the Final Report.	January 1, 2018	January 31, 2020

EXHIBIT B, Attachment IV

Key Project Personnel

Grantee: Los Angeles Harbor Department **Grant No.: G14-LCTI-08**
Amendment ~~2~~ 3

Project: Port of Los Angeles Green Omni Terminal

Name	Position	Duties
Christopher Cannon	Director, Environmental Management Division	Provides overall leadership and executive oversight for the project
Teresa Pisano	Environmental Specialist III	Oversees grant administrative duties and coordination with CARB throughout the project.
Shaouki Aboulhosn	Harbor Engineer	Reviews infrastructure designs and construction specifications to determine compliance with City and Harbor Department building and operational needs.
Tim DeMoss	Marine Environmental Supervisor	Oversees and coordinates technology demonstration partners' participation in the project.
	Pasha Stevedoring & Terminals – End User Facility	
David VanWaardenburg	Vice President	Oversees equipment operators and maintenance personnel in the use of demonstration vehicles and equipment
	Burns and McDonnell Engineering Company - Subcontractor	
Matthew Wartian	Regional Global Practice Manager	Provides overall management of the project and subcontractors

	LADWP – Technical Advisor	
~~Marvin Moon~~ **Scott Briasco**	~~Director of Power Engineering~~ **Power Engineering Manager**	Provides utility advice on smart grid energy optimization scenarios
	SCAQMD – Technical Advisor	
Matt Miyasato	Deputy Executive Officer	Development and commercialization of clean air technologies advisor
	UCLA Luskin Center for Innovation – Technical Advisor	
J.R. DeShazo	Professor	Sustainable energy management, policy and economics advisor
	UC Riverside Center for Environment Research and Technology – Technical Advisor	
Wayne Miller	Associate Director	Vehicle performance testing and data collection and analysis advisor
	Coalition for Clean Air – Community Relations Advisor	
Joseph Lyou	President & CEO	Disadvantaged Community relations advisor
	BYD Motors – Technology Demonstrator	
Jack Symington	Project Manager	Oversees demonstration of OEM battery-electric drayage trucks, bus, and battery storage system
	Clean Air Engineering Maritime – Technology Demonstrator	

Nick Tonsich	Principal	Oversees implementation of the ShoreKat emissions treatment system
	PermaCity Construction Corp. – Technology Demonstrator	
John Mason	Commercial Sales Manager	Leads the installation of the 1 megawatt solar photovoltaic system
	Transportation Power, Inc. – Technology Demonstrator	
Mike Simon	President & CEO	Assists TransPower project manager in project planning and financial administration, review and approve major supplier agreements, and lead outreach and commercialization activities

NOTE: Changes in Key Project Personnel may be made if approved by CARB in writing. Changes in Key Project Personnel do not require a written grant amendment.

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EXHIBIT C

2014-2015 GRANT SOLICITATION

Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund (GGRF) Investments

Advanced Technology Freight Demonstrations: Multi-Source Facility Demonstration Project

Mobile Source Control Division
California Air Resources Board
June 23, 2015

California Environmental Protection Agency

Air Resources Board

APPENDIX C

AIR QUALITY IMPROVEMENT PROGRAM (AQIP) AND LOW CARBON TRANSPORTATION GREENHOUSE GAS REDUCTION FUND (GGRF) INVESTMENTS

MULTI-SOURCE FACILITY DEMONSTRATION PROJECT

HYDROGEN REFUELING STATION REQUIREMENTS

I. MINIMUM TECHNICAL REQUIREMENTS

To be eligible under this Solicitation, applications that include proposed hydrogen refueling stations to be funded as part of the project must, at a minimum, meet each of the following minimum technical requirements. ARB will only process applications for infrastructure projects where the project is proposed to be sited where similar infrastructure already exists (e.g., installing a hydrogen refueling station at an existing fueling station or industrial facility).

A. Hydrogen Quality

Hydrogen dispensed at the station(s) shall meet the requirements in the Society of Automotive Engineers (SAE) International J2719: 2011, "Hydrogen Fuel Quality for Fuel Cell Vehicles" (www.sae.org). The hydrogen refueling stations must undergo and pass the hydrogen purity test to become considered to be operational and tested every 6 months and when the hydrogen lines are potentially exposed to contamination due to maintenance or other activity.

B. Fueling Protocols

The station(s)/dispenser(s) shall meet the appropriate SAE International Technical Information Report (TIR) for the vehicles or equipment being fueled (e.g., J2601/2 and/or J2601/3) (www.sae.org).

C. Fire and Safety Awareness, Prioritization, and Adherence

To the extent practicable and with consideration of local ordinances, applicants should use the following as a guideline for hydrogen refueling station design:

- National Fire Protection Association (NFPA) 2: Hydrogen Technologies Code: 2011, http://www.nfpa.org

D. Dispenser Pressure

Each hydrogen refueling station shall dispense fuel at a minimum of 350 bar and follow the appropriate SAE International fueling protocol (e.g., J2601/2 for on-road hydrogen vehicles and J2601/3 for off-road hydrogen vehicles).

E. Hydrogen Dispensing

The Applicant must demonstrate the ability to dispense hydrogen per "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices" as adopted by the 97th National Conference on Weights and Measures 2012, U.S. Department of Commerce, National Institute of Standards and Technology (NIST), Handbook 44: 2013.

Hydrogen dispenser performance specifications must satisfy NIST Handbook 44: 2013, unless superseded by California Department of Agriculture (CDFA), Division of Measurement Standards Rulemaking: California Code of Regulations (CCR) 3.39 "Hydrogen Gas-Measuring Devices -- Tentative Code" (as proposed for replacement through public review processes).

F. Hydrogen Technologies Code

The station/dispenser(s) shall be capable of meeting or exceeding the National Fire Protection Association (NFPA) 2: Hydrogen Technologies Code: 2011, www.nfpa.org.

G. Station Design Requirements

Hydrogen refueling stations must be designed to allow the hydrogen refueling station to accept delivery of hydrogen fuel from a mobile refueler or hydrogen tube trailer if on-site hydrogen production goes off-line. The applicant must provide a detailed plan, equipment list, and performance specifications to show they are able to obtain and contract an effective station bid from an experienced supplier.

H. Renewable Hydrogen

Applications must demonstrate compliance with the minimum Renewable Hydrogen Requirements (Section II of this Appendix). This compliance may contain all stations for which the applicant has received State funding in addition to any funded under this Solicitation.

II. RENEWABLE HYDROGEN REQUIREMENTS

Applications that include funding for proposed hydrogen refueling stations must provide a plan for dispensing at least 33% renewable hydrogen. This plan must describe how each station or portfolio of stations in the application expects to dispense at least 33% renewable hydrogen on a per kilogram basis over the applicant's portfolio of State-funded stations (this can include previously State-funded agreements).

A. Eligible Renewable Feedstocks

Eligible renewable feedstocks include:

- Biomethane or biogas such as: biomass, digester gas, landfill gas, sewer gas, or municipal solid waste gas.
- Other feedstocks may be eligible if the Application demonstrates that the proposed feedstock is sustainably produced, reduces greenhouse gas emissions compared to the petroleum baseline, and achieves the ARFVTP sustainability goals contained in 20 CCR 3101.5.

B. Eligible Renewable Electricity Sources

Eligible renewable electricity sources include facilities that use the following:

- Fuel cells using renewable fuels
- Geothermal
- Small hydroelectric (30 megawatts or less)
- Ocean wave
- Ocean thermal
- Tidal current
- Photovoltaic (PV)
- Solar Thermal
- Wind
- Biomass digester gas
- Municipal solid waste conversion (non-combustion thermal process)
- Landfill gas
- Renewable Energy Certificates (RECs)

C. Required Information

Applications must include information about the source of the feedstock(s) and/or process electricity (i.e., electrical power used to run a system); how the feedstocks will be processed into fuel; and how the fuel will be transported, stored, and ultimately dispensed at the proposed station(s). If the primary process energy for hydrogen production is electricity (e.g., for electrolysis), applicants must describe a direct source of eligible renewable electricity or source of renewable energy certificates (RECs) that are registered and verifiable through Western Renewable Energy Generation Information System (WREGIS) or an equivalent tracking and verification system. Further information about WREGIS can be found at: www.wecc.biz/WREGIS.

For each station, applicants must submit the following information: Year, name of pathway, amount of hydrogen dispensed annually per station (in kilograms), biogas/renewable feedstock (in standard cubic feet), and renewable electricity (in kilowatt hours), assumptions and calculations on an energy equivalent basis that demonstrate that on a "well to wheel" evaluation that the required percent of the energy used to produce, deliver, dispense and use hydrogen was from renewable feedstock. Applicants should use the energy economy ratio (EER) value of 2.5 (relative to gasoline) from the Low Carbon Fuel Standard (LCFS) regulation to account for the fuel cell vehicle efficiency. For further information, see: www.arb.ca.gov/fuels/lcfs/lcfs.htm.

D. Renewable Electricity Requirements

Applicants planning to use renewable electricity for system power must describe how they intend to use new renewable electricity capacity with the electricity either going directly to the hydrogen production system or connected to the grid (within the Western Electricity Coordinating Council --- WECC). Applicants planning to use renewable electricity for system power must describe how the electricity will be dedicated and used for the hydrogen production. Alternatively, applicants purchasing and utilizing eligible renewable electricity credits must describe how the credits will be dedicated and used for the hydrogen production.

E. Biogas Requirements

Applicants planning to use biogas for system power must describe how they will either produce or purchase biogas (certified as renewable) that will be delivered directly to their hydrogen production facility or injected into a pipeline system. If the purchased biogas will be injected into a natural gas pipeline distribution system, applicants must show that a physical pathway exists by providing documentation that proves that the purchased biogas could be transported from the injection point to the hydrogen plant (that supplies the hydrogen for the applicant's stations).

F. Utilization of Previously Funded Stations

Hydrogen refueling stations previously funded by the State may be included in the portfolio of stations to meet the renewable hydrogen requirement. The ARB award recipient may utilize the amount of renewable hydrogen from these previously funded stations.

G. Contingency Plans if not all Proposed Stations Recommended for Funding

Applicants must account for the possibility that not every proposed station will be recommended for funding. Therefore, applicants must describe whether and how their renewable hydrogen plan would change depending on the number and location of stations ultimately awarded. Applicants should include information about whether and how costs will change depending on the portfolio of stations ultimately awarded grant funding. For example, the applicant shall specify whether different technologies or more expensive equipment would be used depending on the combination of stations awarded.

H. Verification

The ARB will verify whether the renewable hydrogen requirement is met.

I. SB 1505 Disclaimer

The 33% Renewable Hydrogen Content requirement is a condition to participate in this Solicitation. This is separate and distinct from ARB's sole authority to regulate the renewable hydrogen content requirements for hydrogen refueling stations under Health and Safety Code, Section 43869 (commonly referred to as Senate Bill 1505 or SB 1505). Fulfilling the 33% Renewable Hydrogen Content requirement in this Solicitation does not guaranty or warranty in any way that hydrogen refueling stations funded under this Solicitation will meet any standards or regulations that ARB may adopt in the future for hydrogen refueling stations pursuant to the authority in SB 1505. The applicant will be solely responsible for complying with such standards and regulations as applicable, including funding its compliance with them.

J. Greenhouse Gas Requirements

Applicants must use "well to wheel" calculation methodology for the greenhouse gas emission calculations that include the feedstock of the hydrogen, the production of the hydrogen, and the use of the hydrogen." See Appendix D for the emission reduction and cost-effectiveness methodology.

APPENDIX D

AIR QUALITY IMPROVEMENT PROGRAM (AQIP) AND LOW CARBON TRANSPORTATION GREENHOUSE GAS REDUCTION FUND (GGRF) INVESTMENTS

MULTI-SOURCE FACILITY DEMONSTRATION PROJECT

METHODOLOGY FOR DETERMINING EMISSION REDUCTIONS AND COST-EFFECTIVENESS

The methodology below must be used to calculate the emission reductions and cost-effectiveness of projects proposed by this Solicitation. All calculations and assumptions made must be shown clearly and in their entirety in the application (Appendix A, Attachment 4).

All calculations will use diesel fuel usage of the baseline vehicle or equipment as a basis for the greenhouse gas (GHG) and criteria pollutant emission calculations. This technique may not adequacy capture the emission profiles of all proposed applications however, this technique is used to allow all submitted applications to be scored on a level playing field.

GHG emission calculations are based on life cycle analysis (well-to-wheel). Criteria pollutant and PM emission calculations are based on exhaust emissions (tank-to-wheel). The GHG emission factors below are excerpted from the 2015 Low Carbon Fuel Standard (LCFS) regulatory documents. Please note that while the LCFS fuel carbon intensity values may change during the Solicitation period, project applicants must use the values listed in this appendix. The remaining emission factors and methodology below are from the Board approved 2011 Carl Moyer Program Guidelines (Moyer Guidelines) Appendices C, D, and G, as amended in July 2014 and updated in December 2014. Language has been modified where necessary for the purposes of this Solicitation. The complete Moyer Guidelines, including all of its appendices, can be found at http://www.arb.ca.gov/msprog/moyer/guidelines/current.htm.

If a proposed project is for an application that uses a baseline diesel engine of 24 hp or lower, for the purpose of this solicitation and to calculate the needed emission reductions and cost effectiveness, use the relevant Carl Moyer tables for a 25 hp baseline diesel engine.

Any examples provided here are for reference only and do not imply additional demonstration project types or categories, nor do Carl Moyer Program funding amounts limit the amount of funding that may be available for demonstration projects. Criteria pollutant and PM Table numbers are kept the same as those in the current Moyer Guidelines.

Emission Factors for GHG: 2015 Proposed Re-Adoption of LCFS

- Table MSF App D1: Fuel Energy Density[1]

Fuel (units)	*Energy Density*
CARBOB (gal)	119.53 (MJ/gal)
CaRFG (gal)	115.63 (MJ/gal)
Diesel fuel (gal)	134.47 (MJ/gal)
CNG (scf)	0.98 (MJ/scf)
LNG (gal)	78.83 (MJ/gal)
Electricity (KWh)	3.60 (MJ/KWh)
Hydrogen (kg)	120.00 (MJ/kg)
Denatured Ethanol (gal)	81.51 (MJ/gal)
FAME Biodiesel (gal)	126.13 (MJ/gal)
Renewable Diesel (gal)	129.65 (MJ/gal)

[1] Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Proposed Re-Adoption of the Low Carbon Fuel Standard, December 2014 (http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf)

- Table MSF App D2: Fuel Carbon Intensity Values[2]

Fuel		Pathway Identifier	Carbon Intensity Values (gCO_2e/MJ)
Baseline Fuels	CARBOB – based on the average crude oil supplied to California refineries and average California refinery efficiencies	CBOB001	100.53
	ULSD – based on the average crude oil supplied to California refineries and average California refinery efficiencies	ULSD001	102.76
	CaRFG (calculated)	--	99.11
Natural Gas	North American NG – CNG	CNG002	79.46
	North American NG – LNG (90% liquefaction eff.)	LNG002	86.57
Biomethane	Landfill Gas – CNG	CNG003	19.21
	Landfill Gas – LNG (90% liquefaction eff.)	LNG007	26.35
	Dairy and feedlot waste CNG	CNG004	30.13
Biodiesel	Soybean Biodiesel	BIOD001	22.73
	Tallow Biodiesel	BIOD008	32.83
	UCO Biodiesel	BIOD004	19.87
	Canola Biodiesel	BIOD006	35.73
	Corn Oil Biodiesel (from Wet DGS)	BIOD021	28.68
Renewable Diesel	Soybean RD	RNWD001	22.01
	Tallow RD	RNWD002	31.22
	UCO RD	--	18.21
	Canola RD	--	30.39
	Corn Oil RD (from Wet DGS)	--	28.49
Ethanol	Sugarcane Base Case; no credit	ETHS001	41.43
	Sugarcane; mechanized harvest and power export	ETHS002	31.09
	Sugarcane; mechanized harvest (harvest only)	--	32.17
	Sugarcane; power export only	ETHS003	40.35
	Sorghum Ethanol; 100% natural gas	ETHG001	67.29

[2] Direct values (without energy efficiency ratio adjustments). Source: California Air Resources Board, CA-GREET 1.8b versus 2.0 CI Comparison Table, April 1, 2015; http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040115_pathway_ci_comparison.pdf.

	Fuel	Pathway Identifier	Carbon Intensity Values (gCO_2e/MJ)
	Corn Ethanol; 100% natural gas	ETHC004	60.29
Hydrogen	Hydrogen Gas; compressed H_2 from central reforming of NG; liquefaction and re-gasification	HYGN001	151.01
	Hydrogen Gas; liquid H_2 from central reforming of NG	HYGN002	143.51
	Hydrogen Gas; compressed H_2 from central reforming of NG (no liquefaction and re-gasification steps)	HYGN003	105.65
	Hydrogen Gas; compressed H_2 from on-site reforming of NG	HYGN004	105.13
	Hydrogen Gas; compressed H_2 from on-site reforming with renewable feedstocks (2/3 NA-NG and 1/3 biomethane)	HYGN005	89.84
Electricity	Average California Electricity	ELC001	105.16
Anaerobic Digestion	Biomethane CNG derived from the high solids anaerobic digestion (HSAD) of food and green wastes	CNG005	-34.70
	Biomethane CNG from anaerobic digestion of wastewater sludge at a small-to-medium-sized wastewater treatment plant	CNG021	30.98
	Biomethane CNG from anaerobic digestion of wastewater sludge at a medium-to-large-sized wastewater treatment plant	CNG020	7.80

- Table MSF App D3: EER Values for Fuels Used in Light- Medium- and Heavy-Duty Applications[3]

Fuels Used as a Diesel Replacement for Heavy-Duty and Off-Road Applications	
Fuel/Vehicle Combinations	**EER Value Relative to Diesel**
Diesel Fuel or Biomass Based Diesel Blends	1.0
CNG or LNG/Any Vehicles (Spark-Ignition Engines)	0.9
CNG/LNG /Any Vehicle (Compression-Ignition Engines)	1.0
Electricity / Battery Electric or Plug-in Hybrid Electric Truck	2.7
Electricity / Fixed Guideway, Heavy Rail	4.6
Electricity / Fixed Guideway, Light Rail	3.3
Electricity / Trolley Bus, Cable Car, Street Car	3.1
Electricity/Forklifts or Equipment	3.8
H_2 / Fuel Cell Vehicle	1.9

[3] Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Proposed Re-Adoption of the Low Carbon Fuel Standard, December 2014 (http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf). For gasoline as a fuel replacement, see Table III-3, page III-22.

Cost-Effectiveness and Emission Reduction Formulas for Calculations of GHG Emissions[4]

A. Well-to-Wheel GHG Emission Calculations

Formula 1: Liquid / Natural Gas and Hydrogen Fueled Vehicles

$$GHG\ EF = carbon\ intensity * \frac{fuel\ energy\ density}{efficiency} * \frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}$$

$$= \frac{gram\ CO2e}{MJ} * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

Where GHG EF is the Greenhouse Gas Emission Factor

Formula 2: Electric Vehicles

$$GHG\ EF = \frac{metric\ ton\ CO2e}{year} = carbon\ intensity * unit\ conversion * efficiency$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{3.60\ MJ}{kWh}\right) * \left(\frac{X\ kWh}{year}\right) * \frac{1\ metric\ ton}{1{,}000{,}000\ grams}$$

B. Conversion from Diesel Fuel Usage to Electricity / Hydrogen / CNG Usage

Formula 3:

$$= \left(\frac{X\ gal\ Diesel}{yr}\right)\left(ED\ \frac{MJ}{1\ gal\ diesel}\right) * \left(ED\ \frac{NF\ unit}{MJ}\right) * \left(\frac{1}{EER}\right)$$

Where:
X is the number of gallons diesel fuel used as a basis for the conversion;
NF is the new fuel that is proposed to be used as a diesel replacement;
ED is the Energy Density of the replacement fuel (see Table MSF App D1: Fuel Energy Density); and
Unit is the units associated with the replacement fuel:

Electricity:	kWh
Hydrogen:	kg
CNG:	scf

[4] GHG emissions are measured in "CO_2 equivalent", which means the number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas.

C. GHG Emission Reduction Calculation

Using the results from determining the GHG emissions that are associated with the base case and the advanced technology and taking their difference gives the estimated emission reductions that are associated with the proposed project.

Base case vehicles or equipment for the purpose of this solicitation are the cleanest vehicle or equipment that is commercially available at the time the application for funding is submitted.

Formula 4:

Project GHG ER_{annual} = GHG EF_{base} - GHG $EF_{adv\ tech}$

Where:

- GHG ER_{annual} is the annual GHG emission reductions that are associated with the proposed project.
- GHG EF_{base} is the GHG emission factor associated with the base case vehicle or equipment that the advanced technology vehicle or equipment is compared too.
- GHG $ER_{adv\ tech}$ is the GHG emission factor that is associated with the proposed technology.

D. Cost-Effectiveness Calculations for GHG

The cost-effectiveness of a project is determined by dividing the annualized cost of the potential project by the annual emission reductions that will be achieved by the project as shown in Formula 5 below.

Formula 5:

$$Cost\ Effectiveness\ \left(\frac{\$}{metric\ ton}\right) = \left(\frac{\left(\frac{CRF * (\$Advanced\ Technology\ Vehicle - \$Baseline\ Diesel\ Vehicle)}{year}\right)}{\left(\frac{metric\ ton\ emissions\ reduced}{year}\right)}\right)$$

For the purposes of this Solicitation:

Capital Recover Factor = CRF

CRF_2 = 0.515 per Moyer Table G-3b (2-year life)

CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

E. Composite Carbon Intensity Calculations

Formula 6 below is to use to determine a composite Carbon Intensity value for use in the calculations if two of the same fuel types are to be blended for use in the propose vehicle or equipment. Using values from Table MSF App D2: Fuel Carbon Intensity Values above as inputs:

Formula 6:

$$CI_{composite} = (Fraction\ of\ total\ fuel * (CI\ fuel\ 1)) + (fraction\ of\ total\ fuel * (CI\ Fuel\ 2))$$

Where CI is the Carbon Intensity of the fuel.

Cost-Effectiveness and Emission Reduction Calculations for Criteria Pollutant and Particulate Matter Emissions (from the Moyer Guidelines)

Only the relevant language from the Moyer Guidelines is included below. Language has been modified where necessary for the purposes of this Solicitation. Tables that contain emission factors and necessary inputs follow at the end of this section. Updates to the below tables may have been made since the release of this solicitation. Only use the information included in the below tables for criteria and toxic emission reduction and cost effectiveness calculations.

Baseline vehicles or equipment for the purpose of this solicitation are the cleanest vehicle or equipment that is commercially available at the time the application for funding is submitted.

1. Calculating Cost-Effectiveness

The cost-effectiveness of a project is determined by dividing the annualized cost of the potential project by the annual weighted surplus emission reductions that will be achieved by the project as shown in Formula C-1 below.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

$$\textit{Cost-Effectiveness (\$/ton)} = \frac{\textit{Annualized Cost (\$/year(yr))}}{\textit{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Descriptions on how to calculate annual emission reductions and annualized cost are provided in the following sections.

2. Determining the Annualized Cost

Annualized cost is the amortization of the one-time incentive grant amount for the life of the project to yield an estimated annual cost. The annualized cost is calculated by multiplying the incremental cost by the capital recovery factor (CRF) from Table G-3. [NOTE: For the purposes of this Solicitation, the CRF is 0.106, which assumes a 10-year life.] The resulting annualized cost is used to complete Formula C-1 above to determine the cost-effectiveness of surplus emission reductions.

Formula C-2: Annualized Cost ($)

*Annualized Cost = CRF * incremental cost ($)*

CRF_2 = 0.515 per Moyer Table G-3b (2 year life)
CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

3. Calculating the Incremental Cost

Formula C-3: Incremental Cost ($)

Incremental Cost = Cost of New Technology ($) – Cost of Baseline Diesel Technology ($)

4. Calculating the Annual Weighted Surplus Emission Reductions

Annual weighted emission reductions are estimated by taking the sum of the project's annual surplus pollutant reductions following Formula C-5 below. This will allow projects that reduce one, two, or all three of the covered pollutants to be evaluated.. While oxides of nitrogen (NOx) and reactive organic gases (ROG) emissions are given equal weight, emissions of particulate matter (PM) carry a greater weight in the calculation.

Formula C-5: Annual Weighted Surplus Emission Reductions (tons/yr)

Weighted Emission Reductions =

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM reductions (tons/yr)]*

The result of Formula C-5 is used to complete Formula C-1 to determine the cost-effectiveness of surplus emission reductions.

In order to determine the annual surplus emission reductions by pollutant, emission reduction calculations need to be completed for each pollutant (NOx, ROG, and PM), for the baseline technology and the reduced technology, totaling up to 4 calculations:

Baseline Technology	Reduced Technology
1. Annual emissions of NOx	4. Annual emissions of NOx
2. Annual emissions of ROG	5. Annual emissions of ROG
3. Annual emissions of PM	6. Annual emissions of PM

These calculations are completed for each pollutant by multiplying the engine emission factor or converted emission standard (found in Appendix D) by the annual activity level and by other adjustment factors as specified for the calculation methodologies presented.

5. Calculating Annual Emission Reductions Based on Usage

(A) Calculating Annual Emissions Based on Fuel Consumption

When annual fuel consumption is used for determining emission reductions, the equipment activity level must be based on annual fuel usage within California provided by the applicant.

A fuel consumption rate factor must be used to convert emissions given in g/bhp-hr to units of grams of emissions per gallon of fuel used (g/gal). The fuel consumption rate factor is a number that combines the effects of engine efficiency and the energy content of the fuel used in that engine into an approximation of the amount of work output by an engine for each unit of fuel consumed. The fuel consumption rate factor is found in Table D-24 later in this appendix. Formulas C-8 and C-9 below are the formulas for calculating annual emissions based on annual fuel consumed.

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

Annual Emission Reductions =

*Emission Factor or Converted Emission Standard (g/bhp-hr) * fuel consumption rate factor (bhp-hr/gallon (gal)) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

Formula C-9: Estimated Annual Emissions based on Fuel using Emission Factors (tons/yr)

Annual Emission Reductions =

*Emission Factor (g/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

(B) Calculating Annual Emissions Based on Annual Miles Traveled

Calculations based on annual miles traveled are used for on-road projects only.

Calculations Using Emission Factors: There is no conversion since the emission factors for on-road projects provided are given in units of g/mile. Formula C-10 describes the method for calculating pollutant emissions based on emission factors and miles traveled.

Formula C-10: Estimated Annual Emissions based on Mileage using Emission Factors (tons/yr)

Annual Emission Reductions =

*Emission Factor (g/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g*

Calculating Annual Emissions Based on Converted Standards: The unit conversion factors found in Tables D-5 and D-6 (Appendix D) are used to convert the units of the converted emission standard (g/bhp-hr) to g/mile. Formula C-11 describes the method for calculating pollutant emissions using converted emission standards.

Formula C-11: Estimated Annual Emissions based on Mileage using Converted Emission Standards (tons/yr)

Annual Emission Reductions =

*Converted Emission Standard (g/bhp-hr) * Unit Conversion (bhp-hr/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200 g*

List of Criteria Pollutant Cost Effectiveness Formulas

For an easy reference, the necessary formulas to calculate the cost-effectiveness of surplus emission reductions for a project funded through the Carl Moyer Program are provided below.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton):

$$\text{Cost-Effectiveness (\$/ton)} = \frac{\text{Annualized Cost (\$/year(yr))}}{\text{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Formula C-2: Annualized Cost ($)

*Annualized Cost = 0.106 * incremental cost ($)*

Formula C-3: Incremental Cost ($)

Incremental Cost = Cost of New Technology ($) – Cost of Baseline Diesel Technology ($)

Formula C-5: Annual Weighted Surplus Emission Reductions

Weighted Emission Reductions =

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM reductions (tons/yr)]*

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

Annual Emission Reductions =

*Emission Factor or Converted Emission Standard (g/bhp-hr) * fuel consumption rate factor (bhp-hr/gallon (gal)) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

Formula C-9: Estimated Annual Emissions based on Fuel using Emission Factors (tons/yr)

Annual Emission Reductions =

*Emission Factor (g/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

Formula C-10: Estimated Annual Emissions based on Mileage using Emission Factors (tons/yr)

Annual Emission Reductions =

*Emission Factor (g/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g*

Formula C-11: Estimated Annual Emissions based on Mileage using Converted Emission Standards (tons/yr)

Annual Emission Reductions =

*Converted Emission Standard (g/bhp-hr) * Unit Conversion (bhp-hr/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g*

ON-ROAD TRUCK TABLES

Table D-1
Diesel Heavy-Duty Engines
Converted Emission Standards for Fuel Based Usage Calculations

EO Certification Standards g/bhp-hr		NOx	ROG[(a)]	PM10
		g/gal[(b)(c)(d)]		
6.0 NOx	0.60 PM10	103.23	5.33	7.992
5.0 NOx	0.25 PM10	86.03	4.44	3.330
5.0 NOx	0.10 PM10	86.03	4.44	1.332
4.0 NOx	0.10 PM10	68.82	3.55	1.332
2.5 NOx + NMHC	0.10 PM10	40.86	2.11	1.332
1.8 NOx + NMHC	0.01 PM10	29.42	1.52	0.148
1.5 NOx + NMHC	0.01 PM10	24.52	1.27	0.148
1.2 NOx + NMHC	0.01 PM10	19.61	1.01	0.148
0.84 NOx + NMHC	0.01 PM10	13.73	0.71	0.148
0.50 NOx	0.01 PM10	8.60	0.44	0.148
0.20 NOX	0.01 PM10	3.44	0.18	0.148

a - ROG = HC * 1.26639.
b - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.
c - Fuel based factors are for engines less than 750 horsepower only.
d - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables D-25 and D-26, respectively.

Table D-2
Alternative Fuel Heavy-Duty Engines
Converted Emission Standards for Fuel Based Usage Calculations

EO Certification Standards g/bhp-hr		NOx	ROG[(a)]	PM10
		g/gal[(b)(c)(d)]		
6.0 NOx	0.60 PM10	111.00	35.14	11.100
5.0 NOx	0.25 PM10	92.50	29.29	4.625
5.0 NOx	0.10 PM10	92.50	29.29	1.850
4.0 NOx	0.10 PM10	74.00	23.43	1.850
2.5 NOx + NMHC	0.10 PM10	37.00	11.71	1.850
1.8 NOx + NMHC	0.01 PM10	26.64	8.43	0.185
1.5 NOx + NMHC	0.01 PM10	22.20	7.03	0.185
1.2 NOx + NMHC	0.01 PM10	17.76	5.62	0.185
0.84 NOx + NMHC	0.01 PM10	12.43	3.94	0.185
0.50 NOx	0.01 PM10	9.25	2.93	0.185
0.20 NOX	0.01 PM10	3.70	1.17	0.185

a - ROG = HC * 1.26639.

b - Fuel based emissions factors were calculated using fuel consumption rate factors from Table D-24.

c - Fuel based factors are for engines less than 750 horsepower only.

d - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values listed in Table D-25.

Table D-3
Heavy-Duty Vehicles
14,001-33,000 pounds (lbs) Gross Vehicle Weight Rating (GVWR)
Emission Factors for Mileage Based Calculations (g/mile)[a]

Model Year	Diesel[b]		
	NOx	ROG[c]	PM10
Pre-1987	14.52	0.75	0.69
1987-1990	14.31	0.59	0.75
1991-1993	10.70	0.26	0.41
1994-1997	10.51	0.20	0.23
1998-2002	10.33	0.20	0.25
2003-2006	6.84	0.13	0.16
2007-2009	4.01	0.11	0.02
2007-2009 (0.50 g/bhp-hr NOx or Cleaner)[d]	1.73	0.10	0.017
2010+	0.74	0.09	0.02

a - EMFAC 2011 Zero-Mile Based Emission Factors.
b - Emission factors incorporate the ultra low-sulfur diesel fuel correction factors listed in Table D-26.
c - ROG = HC * 1.26639.
d - Use interpolated values assuming 1.2 g/bhp-hr NOx Standards for 2007-2009 Model Year Grouping and 0.2 g/bhp-hr NOx Standards for 2010+ Model Years.

Table D-4
Heavy-Duty Vehicles
Over 33,000 lbs GVWR
Emission Factors for Mileage Based Calculations (g/mile)[a]

Model Year	Diesel[b]		
	NOx	ROG[c]	PM10
Pre-1987	21.37	1.09	1.25
1987-1990	21.07	0.86	1.35
1991-1993	18.24	0.56	0.56
1994-1997	17.92	0.42	0.37
1998-2002	17.61	0.43	0.40
2003-2006	11.64	0.27	0.25
2007-2009	6.62	0.23	0.03
2007-2009 (0.50 g/bhp-hr NOx or Cleaner)[d]	2.88	0.20	0.028
2010+	1.27	0.19	0.03

a - EMFAC 2011 Zero-Mile Based Emission Factors.

b - Emission factors incorporate the ultra low-sulfur diesel fuel correction factors listed in Table D-26.

c - ROG = HC * 1.26639.

d - Use interpolated values assuming 1.2 g/bhp-hr NOx Standards for 2007-2009 Model Year Grouping and 0.2 g/bhp-hr NOx Standards for 2010+ Model Years.

OFF-ROAD PROJECTS AND NON-MOBILE AGRICULTURAL PROJECTS

Table D-10
Off-Road Diesel Engines Default Load Factors

Category	Equipment Type	Load Factor
Airport Ground Support	Aircraft Tug	0.54
	Air Conditioner	0.75
	Air Start Unit	0.90
	Baggage Tug	0.37
	Belt Loader	0.34
	Bobtail	0.37
	Cargo Loader	0.34
	Cargo Tractor	0.36
	Forklift	0.20
	Ground Power Unit	0.75
	Lift	0.34
	Passenger Stand	0.40
	Service Truck	0.20
	Other GSE	0.34
Agricultural (Mobile, Portable or Stationary)	Agricultural Mowers	0.43
	Agricultural Tractors	0.70
	Balers	0.58
	Combines/Choppers	0.70
	Chippers/Stump Grinders	0.73
	Generator Sets	0.74
	Hydro Power Units	0.48
	Irrigation Pump	0.65
	Shredders	0.40
	Sprayers	0.50
	Swathers	0.55
	Tillers	0.78
	Other Agricultural	0.51
Construction	Air Compressors	0.48
	Bore/Drill Rigs	0.50
	Cement & Mortar Mixers	0.56
	Concrete/Industrial Saws	0.73
	Concrete/Trash Pump	0.74
	Cranes	0.29
	Crawler Tractors	0.43
	Crushing/Process Equipment	0.78
	Excavators	0.38
	Graders	0.41

Table D-10
Off-Road Diesel Engines Default Load Factors
(Continued)

Category	Equipment Type	Load Factor
Construction	Off-Highway Tractors	0.44
	Off-Highway Trucks	0.38
	Pavers	0.42
	Other Paving	0.36
	Pressure Washer	0.30
	Rollers	0.38
	Rough Terrain Forklifts	0.40
	Rubber Tired Dozers	0.40
	Rubber Tired Loaders	0.36
	Scrapers	0.48
	Signal Boards	0.78
	Skid Steer Loaders	0.37
	Surfacing Equipment	0.30
	Tractors/Loaders/Backhoes	0.37
	Trenchers	0.50
	Welders	0.45
	Other Construction Equipment	0.42
Industrial	Aerial Lifts	0.31
	Forklifts	0.20
	Sweepers/Scrubbers	0.46
	Other General Industrial	0.34
	Other Material Handling	0.40
Logging	Fellers/Bunchers	0.71
	Skidders	0.74
Oil Drilling	Drill Rig	0.50
	Lift (Drilling)	0.60
	Swivel	0.60
	Workover Rig (Mobile)	0.50
	Other Workover Equipment	0.60
Cargo Handling	Container Handling Equipment	0.59
	Cranes	0.43
	Excavators	0.57
	Forklifts	0.30
	Other Cargo Handling Equipment	0.51
	Sweeper/Scrubber	0.68
	Tractors/Loaders/Backhoes	0.55
	Yard Trucks	0.65
Other	All	0.43

Table D-11
Uncontrolled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25 – 49	pre-1988	6.51	2.21	0.547
	1988 +	6.42	2.17	0.547
50 – 119	pre-1988	12.09	1.73	0.605
	1988 +	8.14	1.19	0.497
120+	pre-1970	13.02	1.59	0.554
	1970 – 1979	11.16	1.20	0.396
	1980 – 1987	10.23	1.06	0.396
	1988 +	7.60	0.82	0.274

Table D-12
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)[(a)]

Horsepower	Tier	NOx	ROG	PM10
25-49	1	5.26	1.74	0.480
	2	4.63	0.29	0.280
	4 Interim	4.55	0.12	0.128
	4 Final	2.75	0.12	0.008
50-74	1	6.54	1.19	0.552
	2	4.75	0.23	0.192
	3[(b)]	2.74	0.12	0.192
	4 Interim	2.74	0.12	0.112
	4 Final	2.74	0.12	0.008
75-99	1	6.54	1.19	0.552
	2	4.75	0.23	0.192
	3	2.74	0.12	0.192
	4 Phase-Out	2.74	0.12	0.008
	4 Phase-In/ Alternate NOx	2.14	0.11	0.008
	4 Final	0.26	0.06	0.008
100-174	1	6.54	0.82	0.274
	2	4.17	0.19	0.128
	3	2.32	0.12	0.112
	4 Phase-Out	2.32	0.12	0.008
	4 Phase-In/ Alternate NOx	2.15	0.06	0.008
	4 Final	0.26	0.06	0.008
175-299	1	5.93	0.38	0.108
	2	4.15	0.12	0.088
	3	2.32	0.12	0.088
	4 Phase-Out	2.32	0.12	0.008
	4 Phase-In/ Alternate NOx	1.29	0.08	0.008
	4 Final	0.26	0.06	0.008

Table D-12
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)[a]
(Continued)

Horsepower	Tier	NOx	ROG	PM10
300-750	1	5.93	0.38	0.108
	2	3.79	0.12	0.088
	3	2.32	0.12	0.088
	4 Phase-Out	2.32	0.12	0.008
	4 Phase-In/ Alternate NOx	1.29	0.08	0.008
	4 Final	0.26	0.06	0.008
751+	1	5.93	0.38	0.108
	2	3.79	0.12	0.088
	4 Interim	2.24	0.12	0.048
	4 Final	2.24	0.06	0.016

Note: Engines that are participating in the "Tier 4 Early Introduction Incentive for Engine Manufacturers" program per California Code of Regulations, Title 13, section 2423(b)(6) are eligible for funding provided the engines are certified to the final Tier 4 emission standards. The ARB Executive Order indicates engines certified under this provision. The emission rates for these engines used to determine cost-effectiveness shall be equivalent to the emission factors associated with Tier 3 engines.

For equipment with baseline engines certified under the flexibility provisions per California Code of Regulations, Title 13, section 2423(d), baseline emission rates shall be determined by using the previous applicable emission standard or Tier for that engine model year and horsepower rating. The ARB Executive Order indicates engines certified under this provision.

a - Emission factors were converted using the ultra low-sulfur diesel fuel correction factors listed in Table D-27.
b - Alternate compliance option.

Table D-13
Off-Road LSI Equipment Default Load Factors

Category	Equipment Type	Load Factor
Agriculture (Mobile, Portable or Stationary)	Agricultural Tractors	0.62
	Balers	0.55
	Combines/Choppers	0.74
	Chipper/Stump Grinder	0.78
	Generator Sets	0.68
	Sprayers	0.50
	Swathers	0.52
	Pumps	0.65
	Other Agricultural Equipment	0.55
Airport Ground Support	A/C Tug	0.80
	Baggage Tug	0.55
	Belt Loader	0.50
	Bobtail	0.55
	Cargo Loader	0.50
	Forklift	0.30
	Ground Power Unit	0.75
	Lift	0.50
	Passenger Stand	0.59
	Other GSE	0.50
Construction	Air Compressors	0.56
	Asphalt Pavers	0.66
	Bore/Drill Rigs	0.79
	Concrete/Industrial Saws	0.78
	Concrete/Trash Pump	0.69
	Cranes	0.47
	Gas Compressor	0.85
	Paving Equipment	0.59
	Pressure Washer	0.85
	Rollers	0.62
	Rough Terrain Forklifts	0.63
	Rubber Tired Loaders	0.54
	Skid Steer Loaders	0.58
	Tractors/Loaders/Backhoes	0.48

Table D-13
Off-Road LSI Equipment Default Load Factors
(Continued)

Category	Equipment Type	Load Factor
Construction	Trenchers	0.66
	Welders	0.51
	Other Construction	0.48
Industrial	Aerial Lifts	0.46
	Forklifts	0.30
	Sweepers/Scrubbers	0.71
	Other Industrial	0.54

Table D-14
Off-Road LSI Engines
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Model Year	NOx	ROG	PM10
25 – 49	Gasoline	Uncontrolled – pre-2004	8.01	3.81	0.060
		Controlled 2001-2006	1.33	0.72	0.060
		Controlled 2007-2009[a]	0.89	0.48	0.060
		Controlled 2010+	0.27	0.14	0.060
	Alt Fuel	Uncontrolled – pre-2004	13.00	0.90	0.060
		Controlled 2001-2006	1.95	0.09	0.060
		Controlled 2007-2009[a]	1.30	0.06	0.060
		Controlled 2010+	0.39	0.02	0.060
50 – 120	Gasoline	Uncontrolled – pre-2004	11.84	2.66	0.060
		Controlled 2001-2006	1.78	0.26	0.060
		Controlled 2007-2009[a]	1.19	0.18	0.060
		Controlled 2010+	0.36	0.05	0.060
	Alt Fuel	Uncontrolled – pre-2004	10.51	1.02	0.060
		Controlled 2001-2006	1.58	0.11	0.060
		Controlled 2007-2009[a]	1.05	0.07	0.060
		Controlled 2010+	0.32	0.02	0.060
>120	Gasoline	Uncontrolled – pre-2004	12.94	1.63	0.060
		Controlled 2001-2006	1.94	0.16	0.060
		Controlled 2007-2009[a]	1.29	0.11	0.060
		Controlled 2010+	0.39	0.03	0.060
	Alt Fuel	Uncontrolled – pre-2004	10.51	0.90	0.060
		Controlled 2001-2006	1.58	0.09	0.060
		Controlled 2007-2009[a]	1.05	0.06	0.060
		Controlled 2010+	0.32	0.02	0.060

a - Emission factors for federally certified engines used in preempt equipment.

Table D-15
Emission Factors for Off-Road LSI Engine Retrofits
Verified to Absolute Emission Number (g/bhp-hr)

Manufacturers of LSI retrofit systems may verify to a percent emission reduction or absolute emissions. If a retrofit system is verified to a percent reduction, the emission factors will be that verified percent of the appropriate emissions factors in Table D-14. If a retrofit system is verified to an absolute emission number, use the following table for the emission factors.

Fuel	Verified Value	NOx	ROG	PM10
Gasoline	3.0 g/bhp-hr	1.78	0.26	0.060
	2.5 g/bhp-hr	1.48	0.22	0.060
	2.0 g/bhp-hr	1.19	0.18	0.060
	1.5 g/bhp-hr	0.89	0.13	0.060
	1.0 g/bhp-hr	0.59	0.09	0.060
	0.6 g/bhp-hr	0.36	0.05	0.060
	0.5 g/bhp-hr	0.30	0.04	0.060
Alt Fuel	3.0 g/bhp-hr	1.58	0.10	0.060
	2.5 g/bhp-hr	1.32	0.09	0.060
	2.0 g/bhp-hr	1.05	0.07	0.060
	1.5 g/bhp-hr	0.79	0.05	0.060
	1.0 g/bhp-hr	0.53	0.03	0.060
	0.6 g/bhp-hr	0.32	0.02	0.060
	0.5 g/bhp-hr	0.26	0.02	0.060

Table D-16
Off-Road LSI Engines Certified to Optional Standards
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Optional Standard	NOx	ROG	PM10
25-50	Gasoline	1.50	0.67	0.36	0.060
		1.00	0.44	0.24	0.060
		0.60	0.27	0.14	0.060
		0.40	0.18	0.10	0.060
		0.20	0.09	0.05	0.060
		0.10	0.04	0.02	0.060
	Alt Fuel	1.50	0.98	0.05	0.060
		1.00	0.65	0.03	0.060
		0.60	0.39	0.02	0.060
		0.40	0.26	0.01	0.060
		0.20	0.13	0.01	0.060
		0.10	0.07	0.00	0.060
50-120	Gasoline	1.50	0.89	0.13	0.060
		1.00	0.59	0.09	0.060
		0.60	0.36	0.05	0.060
		0.40	0.24	0.04	0.060
		0.20	0.12	0.02	0.060
		0.10	0.06	0.01	0.060
	Alt Fuel	1.50	0.79	0.05	0.060
		1.00	0.53	0.03	0.060
		0.60	0.32	0.02	0.060
		0.40	0.21	0.01	0.060
		0.20	0.11	0.01	0.060
		0.10	0.05	0.00	0.060
>120	Gasoline	1.50	0.97	0.08	0.060
		1.00	0.65	0.05	0.060
		0.60	0.39	0.03	0.060
		0.40	0.26	0.02	0.060
		0.20	0.13	0.01	0.060
		0.10	0.06	0.01	0.060
	Alt Fuel	1.50	0.79	0.05	0.060
		1.00	0.53	0.03	0.060
		0.60	0.32	0.02	0.060
		0.40	0.21	0.01	0.060
		0.20	0.11	0.01	0.060
		0.10	0.05	0.00	0.060

LOCOMOTIVES

Table D-17a
Locomotive Emission Factors (g/bhp-hr)
Based on 1998 Federal Standards

Engine Model Year	Type	NOx[(a)]	ROG[(b)]	PM10[(a)]
Pre-1973	Line-haul and Passenger	12.22	0.51	0.275
	Switcher	16.36	1.06	0.378
1973-2001 Tier 0	Line-haul and Passenger	8.93	1.05	0.516
	Switcher	13.16	2.21	0.619
2002-2004 Tier 1	Line-haul and Passenger	6.96	0.58	0.387
	Switcher	10.34	1.26	0.464
2005-2011 Tier 2	Line-haul and Passenger	5.17	0.32	0.172
	Switcher	7.61	0.63	0.206

These factors are to be used for the project baseline emissions if the baseline locomotive is certified or required to be certified to the 1998 federal locomotive remanufacture standards, and for the reduced emission locomotive if the project locomotive is remanufactured to these 1998 standards. Factors are based upon Regulatory Impact Analysis: Final United States Environmental Protection Agency (U.S. EPA) Locomotive Regulation (2008).
a - NOx and PM10 emission factors have been adjusted by a factor of 0.94 and 0.86, respectively, to account for use of California ultra-low sulfur diesel fuel.
b - ROG = HC * 1.053

Table D-17b
Locomotive Emission Factors (g/bhp-hr)
Based on 2008 Federal Standards

Engine Model Year	Type	NOx[(a)]	ROG[(b)]	PM10[(a)]
1973-2001 Tier 0+	Line-haul and Passenger	6.96	0.58	0.189
	Switcher	11.09	2.21	0.224
2002-2004 Tier 1+	Line-haul and Passenger	6.96	0.58	0.189
	Switcher	10.34	1.26	0.224
2005-2011 Tier 2+	Line-haul and Passenger	5.17	0.32	0.086
	Switcher	7.61	0.63	0.112
2011-2014 Tier 3	Line-haul and Passenger	5.17	0.32	0.086
	Switcher	4.70	0.63	0.086
2015 Tier 4	Line-haul and Passenger	1.22	0.15	0.026
	Switcher	1.22	0.15	0.026

These factors are to be used for the project baseline emissions if the baseline locomotive is certified or required to be certified to the new (2008) federal locomotive remanufacture standards, and for the reduced emission locomotive if the project locomotive is remanufactured to the new standards or meets Tier 3 standards. Factors are based upon Regulatory Impact Analysis: Final U.S. EPA Locomotive Regulation (2008).

a - NOx and PM10 emission factors have been adjusted by a factor of 0.94 and 0.86, respectively, to account for use of California ultra-low sulfur diesel fuel.

b - ROG = HC * 1.053

Table D-18
Locomotive Idle-Limiting Device Emission Reduction Factors

Type	Factor
Switchers	0.90
Line-Haul	0.97
Passenger	0.97

Note: Factors based on assumption Idle Limiting Device (ILD) reduces locomotive engine idling by 50 percent. Multiply total baseline emissions by this factor to determine reduced emissions with ILD.

Table D-19a
Uncontrolled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25-50	All	7.57	1.32	0.520
51-120	pre-1997	14.27	1.04	0.575
	1997+	9.70	0.71	0.524
121-250	pre-1971	15.36	0.95	0.527
	1971-1978	14.27	0.79	0.451
	1979-1983	13.17	0.72	0.376
	1984+	12.07	0.68	0.376
251+	pre-1971	15.36	0.91	0.506
	1971-1978	14.27	0.76	0.431
	1979-1983	13.17	0.68	0.363
	1984-1994	12.07	0.65	0.363
251-750	1995+	8.97	0.49	0.260
751+	1995+	12.07	0.60	0.363

Table D-19b
Controlled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)

Horsepower	Tier	NOx	ROG	PM10
25-50	1	6.93	1.30	0.580
	2	5.04	1.30	0.240
	3	5.04	1.30	0.176
51-120	1	6.93	0.71	0.524
	2	5.04	0.71	0.240
	3	5.04	0.71	0.176
121-175	1	8.97	0.49	0.290
	2	4.84	0.49	0.176
	3	3.60	0.49	0.077
176-750	1	8.97	0.49	0.290
	2	4.84	0.49	0.120
	3	3.87	0.49	0.068
751-1900	1	8.97	0.49	0.290
	2	5.24	0.49	0.160
	3	3.87	0.49	0.068
1901 +	1	8.97	0.49	0.290
	2	5.24	0.49	0.160
	3	4.14	0.49	0.085

Table D-20a
Uncontrolled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25-50	all	6.42	1.58	0.460
51-120	pre-1997	12.09	1.23	0.508
	1997+	8.14	0.85	0.417
121-250	pre-1971	13.02	1.13	0.466
	1971-1978	12.09	0.94	0.399
	1979-1983	11.16	0.86	0.333
	1984-1995	10.23	0.82	0.333
	1996+	7.75	0.59	0.255
251-750	pre-1971	13.02	1.08	0.448
	1971-1978	12.09	0.90	0.381
	1979-1983	11.16	0.81	0.321
	1984-1994	10.23	0.77	0.321
	1995+	7.60	0.58	0.230
751 +	pre-1971	13.02	1.08	0.448
	1971-1978	12.09	0.90	0.381
	1979-1986	11.16	0.81	0.321
	1987-1998	10.23	0.72	0.321
	1999+	7.75	0.58	0.255

Table D-20b
Controlled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)

Horsepower	Tier	NOx	ROG	PM10
25-50	1	6.54	1.54	0.511
	2	5.04	1.54	0.240
	3	5.04	1.54	0.176
51-120	1	6.93	0.85	0.464
	2	5.04	0.85	0.240
	3	5.04	0.85	0.176
121-175	1	6.93	0.58	0.255
	2	4.84	0.58	0.176
	3	3.60	0.58	0.077
176-750	1	6.93	0.58	0.255
	2	4.84	0.58	0.120
	3	3.78	0.58	0.068
751-1900	1	6.93	0.58	0.255
	2	5.24	0.58	0.160
	3	3.87	0.58	0.068
1901 +	1	6.93	0.58	0.255
	2	5.24	0.58	0.160
	3	4.14	0.58	0.085

Table D-21
Harbor Craft Load Factors

Vessel Type	Propulsion Engine	Auxiliary Engine
Charter Fishing	0.52	0.43
Commercial Fishing	0.27	
Ferry/Excursion	0.42	
Pilot	0.51	
Tow	0.68	
Work	0.45	
Other	0.52	
Barge/Dredge	0.45	0.65
Crew & Supply	0.38	0.32
Tug	0.50	0.31

Table D-22
Shore Power
Default Emission Rates (Grams per kilowatt-hour (g/kWh))

Pollutant	Emission Rate
NOx	13.9
ROG	0.49
PM10 (marine gas oil fuel with 0.11- 0.5 % sulfur content)	0.38
PM10 (marine gas oil fuel with <= 0.10 % sulfur content)	0.25

Table D-23
Shore Power
Default Power Requirements

Ship Category	Ship Size / Type Default (Twenty-foot Equivalent Unit (TEU))	Power Requirement (kW)
Container Vessel	<1,000	1,000
	1,000 – 1,999	1,300
	2,000 – 2,999	1,600
	3,000 – 3,999	1,900
	4,000 – 4,999	2,200
	5,000 – 5,999	2,300
	6,000 – 6,999	2,500
	7,000 – 7,999	2,900
	8,000 – 9,999	3,300
	10,000 – 12,000	3,700
Passenger Vessel	No Default Value – Use Actual Power Requirement[(a)]	
Reefer	Break Bulk	1,300
	Fully containerized	3,300

a - The average power requirement for passenger vessels is 7,400 kW (ARB Oceangoing Vessel Survey, 2005).

ALL ENGINES

Table D-24
Fuel Consumption Rate Factors (bhp-hr/gal)

Category	Horsepower/Application	Fuel Consumption Rate
Non-Mobile Agricultural Engines	ALL	17.5
Locomotive	Line Haul and Passenger (Class I/II)	20.8
	Line Haul and Passenger (Class III)	18.2
	Switcher	15.2
Other	< 750 hp	18.5
	≥ 750 hp	20.8

Example Calculations

Example Calculations are provided to illustrate all the permutations that staff expects may be included in an application for funding. Example calculations are included for four scenarios providing the values that are needed for a complete application, those required values are:

- GHG annual emission reductions from each proposed vehicle or piece of equipment
- Criteria pollutant and toxic air contaminant annual pollutant emissions reductions for each propose vehicle
- GHG cost effectiveness for a two year life during the time of the proposed project field demonstration
- GHG cost effectiveness for a 10 year life, two years after the end of the proposed demonstration project, assuming the technology is commercialized and available in the marketplace.
- Criteria pollutant and toxic air contaminant cost effectiveness for a two year life during the time of the proposed project field demonstration
- Criteria pollutant and toxic air contaminant cost effectiveness for a 10 year life, two years after the end of the proposed demonstration project, assuming the technology is commercialized and available to the marketplace.

GHG emission reductions are calculated in a well-to-wheel format and the criteria and toxic air contaminant pollutant emission reductions calculations are determined under a tank-to-wheel scenario. The example calculations contained in this appendix are illustrations of:

1. **Fuel Cell Yard Truck**
   - This example demonstrates a project that proposes to utilize a hydrogen fuel cell propulsion system in a yard truck application. The hydrogen refueling system that will be used for the demonstration is considered part of the match for the project and therefore does not need to comply with SB 1505 requirements, which call for 1/3 of hydrogen to be from renewable sources.

2. **Fuel Cell Transportation Refrigeration Unit:**
   - This example shows a project that proposes to utilize a hydrogen fuel cell as the power source for a transportation refrigeration unit. The hydrogen refueling station is proposed to be funded by the AQIP/GGRF grant and therefore must utilize renewable hydrogen as required by SB 1505.

3. **Battery-Electric Heavy Lift Forklift:**
   - This example shows a project that proposes to use grid power to recharge on-board battery packs contained in a heavy-lift forklift.

4. **Range Extending Battery-Dominant Regional Haul Truck**
   - This example shows the use of an internal combustion engine being used as a range extender for a battery-dominant on-road truck. The truck will use both grid charging and on-board natural gas for the range extending engine. The natural gas in this example will have a 15% renewable content.

All of the following examples use diesel fuel usage of the baseline vehicle or equipment as a basis for the GHG and criteria pollutant emission calculations. This technique may not adequately capture the emission profiles of all proposed applications however; this technique is used to allow all submitted applications to be scored on a level playing field.

If a proposed project is for an application that uses a baseline diesel engine of 24 hp or lower, for the purpose of this solicitation and to calculate the needed emission reductions and cost effectiveness, use the relevant Carl Moyer tables for a 25 hp baseline diesel engine.

Example 1: Use of hydrogen fuel cell in a yard truck application

Potential GHG emission reductions are determined on a well-to-wheel basis, while criteria pollutant emission reductions are determined using a tank-to-wheel analysis. This example assumes that a fuel cell yard truck will have the same energy requirements as a diesel counterpart and will be used the same number of hours. Further, it is assumed that this project will use hydrogen that is produced from natural gas and compressed for use in the project.

Baseline vehicle:

- 2010 diesel fueled yard truck with 2010 on-road engine
- Usage 1.6 gal per hour, 1500 hours of operation a year
- Yard truck cost at demonstration: $100,000
- Yard truck cost two years after demonstration: $100,000

Advanced Technology:

- Hydrogen Fuel Cell Yard Truck
- Yard truck cost at demonstration: $750,000
- Yard truck cost two years after demonstration: $500,000

Variables Used in Calculation:

Carbon Intensity

From Table MSF App D2: Fuel Carbon Intensity Values

CI = Carbon Intensity

$CI_{diesel} = \frac{102.76\ g\ CO2e}{MJ}$ Table Pathway Identifier ULSD001

From Table MSF App D2: Fuel Carbon Intensity Values

$CI_{hydrogen} = \frac{105.65\ g\ CO2e}{MJ}$ Pathway Identifier HYGN003

Energy Density

From Table MSF App D1: Fuel Energy Density

ED = Energy Density

$ED_{diesel} = \frac{134.47\ MJ}{gal\ diesel}$ $ED_{hydrogen} = \frac{120.00\ MJ}{kg\ H2}$

Energy Efficiency Ratio

From Table MSF App D3: EER Values for Fuels Used in Light- Medium- and Heavy-Duty Applications

EER = Energy Efficiency Ratio (unit less)

$EER_{hydrogen} = 1.9$

Step 1: Calculate the baseline yard trucks annual fuel usage:

$$\frac{gal\ diesel}{year} = \left(\frac{1.6\ gallons}{hour}\right) * \left(\frac{1500\ hours}{year}\right) = \frac{2400\ gallons\ diesel}{year}$$

Step 2: Convert the diesel used per year from the baseline yard truck to the amount of hydrogen needed to do the same work. Using Formula 3 and the variable identified above.

Formula 3:

$$= \left(\frac{X\ gal\ Diesel}{yr}\right) * \left(ED\ \frac{MJ}{1\ gal\ diesel}\right) * \left(ED\ \frac{NF\ unit}{MJ}\right) * \left(\frac{1}{EER}\right)$$

Where:
X is the number of gallons diesel fuel used annually as a basis for the conversion;
NF is the new fuel that is proposed to be used as a diesel replacement;
ED is the Energy Density of the replacement fuel see Table MSF App D1: Fuel Energy Density; and
Unit is the units associated with the replacement fuel:

Electricity: kWh
Hydrogen: kg
CNG: scf

$$\frac{kg\ H2}{year} = \left(\frac{2400 gal\ diesel}{year}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{1\ kg\ H2}{120.00\ MJ}\right) * \left(\frac{1}{1.9}\right) = 1415\ \frac{kg\ H2}{year}$$

Step 3: Determine the GHG emissions that are attributed to the base case yard truck. Using Formula 1 and the variables identified above.

Formula 1:

$$GHG\ EF = carbon\ intensity * \frac{fuel\ energy\ density}{efficiency} * \frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

$$GHG\ EF_{base} = \left(\frac{102.76\ g\ CO2e}{MJ}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{2400\ gal}{year}\right) * \left(\frac{1\ metric\ ton}{1{,}000{,}000\ grams}\right) = 33\ \frac{metric\ tons\ CO2e}{year}$$

Step 4: Determine the GHG emissions that are attributed to the advanced technology fuel cell yard truck. Using the result from Step 2, the variables identified above as inputs into Formula 1.

$$GHG\ EF_{adv\ tech} = \left(\frac{105.65\ g\ CO2e}{MJ}\right) * \left(\frac{120.00\ MJ}{kg\ H2}\right) * \left(\frac{1415\ kg\ H2}{year}\right) * \left(\frac{1\ metric\ ton}{1{,}000{,}000\ grams}\right) = 18\ \frac{metric\ tons\ CO2e}{year}$$

Step 5: Determine the annual GHG emission reductions that are associated with the proposed project. Using Formula 4 above populated by results from Step 3 and Step 4 from the above example to give the annual GHG emission benefit from the proposed project.

Formula 4:

$$Project\ GHG\ ER_{annual} = GHG\ EF_{base} - GHG\ EF_{adv\ tech}$$

$$Project\ GHG\ ER_{annual} = \left(\frac{33\ metric\ tons\ CO2e}{year}\right) - \left(\frac{18\ metric\ tons\ CO2e}{year}\right) = 15\ \frac{metric\ tons\ CO2e}{year}$$

Step 6: Determine the annual criteria and toxic pollutant emission reductions that are associated with the proposed project. Since the base case diesel yard truck is using a 2010 on-road engine, inputs from Table D-1 and the result of Step1 above will be used to populate Formula C-9. There are not any tank-to-wheel criteria or toxic emissions associated with the use of the advanced technology yard truck, therefore all the emissions associated with the base case diesel yard truck are considered to be the criteria and toxic emission reductions for the proposed project.

For a 2010 on-road engine with Certification Standard of 0.20 g NOx/bhp-hr, Table D-1 gives emissions per gallon of diesel consumed. Therefore:

$$NOx = 3.44\ \frac{g\ NOx}{gal\ diesel}\ ;\ ROG = 0.18\ \frac{g\ ROG}{gal\ diesel}\ ;\ PM10 = 0.148\ \frac{g\ PM\ 10}{gal}$$

Using Formula C-9:

Formula C-9: Estimated Annual Emissions based on Fuel using Emission Factors (tons/yr). All the emission reductions are taking place in CA.

Annual Emission Reductions =

*Emission Factor (g/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

Annual ER is the calculated annual emission reductions

$$\text{Annual ER}_{NOx} = \left(\frac{3.44\ g\ NOx}{gal\ diesel}\right) * \left(\frac{2400 gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) = 0.0091 \frac{tons\ NOx}{year}$$

$$\text{Annual ER}_{ROG} = \left(\frac{0.18\ g\ ROG}{gal\ diesel}\right) * \left(\frac{2400\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) = 0.00048\ \frac{tons\ ROG}{year}$$

$$\text{Annual ER}_{PM10} = \left(\frac{0.148\ g\ PM}{gal\ diesel}\right) * \left(\frac{2400 gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) = 0.00039 \frac{tons\ PM}{year}$$

Step 7: Determine the weighted annual surplus emission reductions that are associated with the proposed project. Using the results from Step 6 above along with the realization that the proposed fuel cell yard truck will not produce any criteria pollutant emissions in a tank-to-wheel scenario populate Formula C-5.

Formula C-5: Annual Weighted Surplus Emission Reductions (tons/yr)

Weighted Emission Reductions =

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM reductions (tons/yr)]*

Therefore using the results from Step 6 above and Formula C-5:

WER is the Weighted Emission Reductions

$$\text{WER} = \left(0.0091 \frac{tons\ NOx}{year}\right) + \left(0.00048\ \frac{tons\ ROG}{year}\right) + 20 * \left(0.00039 \frac{tons\ PM}{year}\right) = 0.017 \frac{tons}{year}$$

Therefore, WER = $0.0017\ \frac{tons\ criteria\ pollutants\ reduced}{year}$

Step 8: Determine the incremental cost of the proposed technology using Formula C-3 and the vehicle costs for the base case yard truck and the fuel cell yard truck given at the start of this example. Cost effectiveness is to be calculated for two scenarios; for two years during the demonstration and for 10 years, two years after the completion of the demonstration project.

Baseline vehicle:

- Yard truck cost at demonstration: $100,000
- Yard truck Cost two years after demonstration: $100,000

Advanced Technology:

- Yard truck cost at demonstration: $750,000
- Yard truck cost two years after demonstration: $500,000

Formula C-3: Incremental Cost ($)

Incremental Cost = Cost of New Technology ($) – Cost of Baseline Diesel Technology ($)

$\text{Incremental Cost}_{2\ \text{years}}$ = $750,000 - $100,000 = $650,000

$\text{Incremental Cost}_{10\ \text{years}}$ = $500,000 - $100,000 = $400,000

Step 9: Determine the GHG emission reduction cost effectiveness for the proposed project using the results from Step 5, Step 8 and Formula 5.

Formula 5:

Where CRF is the Capital Recover Factor

$$Cost\ Effectiveness\left(\frac{\$}{metric\ ton}\right) = \left(\frac{\left(\frac{CRF * (\$Advanced\ Technology\ Vehicle - \$Baseline\ Diesel\ Vehicle)}{year}\right)}{\left(\frac{metric\ ton\ emissions\ reduced}{year}\right)}\right)$$

For the purposes of this Solicitation:

CRF_2 = 0.515 per Moyer Table G-3b (2-year life)

CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

Therefore:

GHG C/E is the GHG Cost Effectiveness

$$\text{GHG C/E}_{2\ \text{years}} = \left(\frac{\frac{(0.515 * \$650,000)}{year}}{\frac{15\ metric\ tons\ CO2e}{year}}\right) = \frac{\$22,317}{metric\ ton\ CO2e\ reduced}$$

$$\text{GHG C/E}_{10\text{ years}} = \left(\frac{\left(\frac{(0.111*\$400{,}000)}{year}\right)}{\frac{15\ metric\ tons\ CO2e}{year}}\right) = \frac{\$2{,}960}{metric\ tons\ CO2e\ reduced}$$

Step 10: Determine the criteria pollutant cost effectiveness for the proposed technology. Use the results from Step 7 and Step 8 to populate Formula C-1.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

$$\textit{Cost-Effectiveness (\$/ton)} = \frac{\textit{Annualized Cost (\$/year(yr))}}{\textit{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Where C/E is cost effectiveness

CRF_2 = 0.515 per Moyer Table G-3b (2-year life)

CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

$$\text{Criteria Pollutant C/E}_{2\text{ years}} = \left(\frac{\frac{(0.515*\$650{,}000)}{year}}{\frac{0.017\ tons\ WER}{year}}\right) = \frac{\$20\ million}{ton\ criteria\ pollutants\ reduced}$$

$$\text{Criteria Pollutant C/E}_{10\text{ years}} = \left(\frac{\frac{(0.111*\$400{,}000)}{year}}{\frac{0.017\ tons\ WER}{year}}\right) = \frac{\$2.6\ million}{ton\ criteria\ pollutants\ reduced}$$

Example 2: Fuel Cell Transportation Refrigeration Unit (TRU)

Potential GHG emission reductions are determined on a well-to-wheel basis, while criteria pollutant emission reductions are determined using a tank-to-wheel analysis. This example assumes that a TRU will have the same energy requirements as a diesel counterpart and will be used the same number of hours. The initial chill down of the trailer, TRU operations and any needed standby power are provided by the fuel cell. Further, it is assumed that this project will use hydrogen that is SB 1505 compliant and therefore has a 1/3 renewable component.

Baseline TRU:

- Off-Road diesel engine: Tier-4 final certification, 24 hp
- Diesel usage: 0.8 gal per hour, 40 hours per week, 1664 gal per year
- TRU cost at demonstration: $26,000
- TRU cost two years after demonstration: $26,000

Advanced Technology:

- Hydrogen fuel cell TRU
- TRU cost at demonstration: $45,000
- TRU cost two years after demonstration: $40,000

Variables Used in Calculation:

Carbon Intensity

From Table MSF App D2: Fuel Carbon Intensity Values

CI = Carbon Intensity

$CI_{diesel} = \frac{102.76\ g\ CO2e}{MJ}$ Table Pathway Identifier ULSD001

From Table MSF App D2: Fuel Carbon Intensity Values

$CI_{hydrogen} = \frac{89.94\ g\ CO2e}{MJ}$ Pathway Identifier HYGN005

Energy Density

From Table MSF App D1: Fuel Energy Density

ED = Energy Density

$ED_{diesel} = \frac{134.47\ MJ}{gal\ diesel}$ $ED_{hydrogen} = \frac{120.00\ MJ}{kg\ H2}$

Energy Efficiency Ratio

From Table MSF App D3: EER Values for Fuels Used in Light- Medium- and Heavy-Duty Applications

EER = Energy Efficiency Ratio (unit less)

$EER_{hydrogen}$ = 1.9

Step 1: Convert the diesel used per year to the amount of hydrogen needed to do the same work. Using Formula 3 and the variable identified above.

Formula 3:

$$= \left(\frac{X\ gal\ Diesel}{yr}\right)\left(ED\ \frac{MJ}{1\ gal\ diesel}\right) * \left(ED\frac{NF\ unit}{MJ}\right) * \left(\frac{1}{EER}\right)$$

Where:
X is the number of gallons diesel fuel used as a basis for the conversion;
NF is the new fuel that is proposed to be used as a diesel replacement;
ED is the Energy Density of the replacement fuel see Table MSF App D1: Fuel Energy Density; and
Unit is the units associated with the replacement fuel:

Electricity: kWh
Hydrogen: kg
CNG: scf

$$\frac{kg\ H2}{year} = \left(\frac{1664\ gal\ diesel}{year}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{1\ kg\ H2}{120.00\ MJ}\right) * \left(\frac{1}{1.9}\right) = 981\ \frac{kg\ H2}{year}$$

Step 2: Determine the GHG emissions that are attributed to the base case diesel fueled TRU. Using Formula 1 and the variables identified above.

Formula 1:

$$GHG\ EF = carbon\ intensity * \frac{fuel\ energy\ density}{efficiency} * \frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

$$GHG\ EF_{base} = \left(\frac{102.76\ g\ CO2e}{MJ}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{1664\ gal}{year}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right) = 23\ \frac{metric\ tonc\ CO2e}{year}$$

Step 3: Determine the GHG emissions that are attributed to the advanced technology TRU. Using Formula 1, the result from Step 1 and the variables identified above.

$$GHG\ EF_{adv\ tech} = \left(\frac{89.94\ g\ CO2e}{MJ}\right) * \left(\frac{120.00\ MJ}{kg\ H2}\right) * \left(\frac{981\ kg\ H2}{year}\right) * \left(\frac{1\ metric\ ton}{1{,}000{,}000\ grams}\right) = 11\ \frac{metric\ tons\ CO2e}{year}$$

Step 4: Determine the GHG emission reductions that are associated with the proposed project. Using Formula 4, populated by results from Step 2 and Step 3 to give the GHG emission benefit from the proposed project.

Formula 4:

$$Project\ GHG\ ER_{annual} = GHG\ EF_{base} - GHG\ EF_{adv\ tech}$$

$$Project\ GHG\ ER_{annual} = \left(\frac{23\ metric\ tons\ CO2e}{year}\right) - \left(\frac{11\ metric\ tons\ CO2e}{year}\right) = 12\ \frac{metric\ tons\ CO2e}{year}$$

Step 5: Determine the annual criteria pollutant emission reductions that are associated with the proposed project. The base case TRU is using a 24 hp, diesel engine that is certified to the Tier-4 final emissions standard, therefore, using emission values from Table D-12 and fuel consumption rate factors from Table D-24, the result of Step1 above to populate Formula C-8. The fuel cell TRU will be used 100% of the time in California. There are no criteria pollutant emissions associated with the use of the fuel cell TRU in a tank to wheel analysis.

For a Tier-4 final off-road engine at 24 hp, Table D-12 gives criteria pollutant emissions per bhp-hr, but only for diesel engines above 25 hp, for this calculation use the emission factor for a 25 hp diesel engine. The conversion factor from Table D-24, for the relevant engine power rating, allows for the conversion from gram per bhp-hr to gram per gallon of fuel consumed. Therefore:

$$NOx = 2.75\ \frac{g\ NOx}{bhp-hr}\ ;\ ROG = 0.12\ \frac{g\ ROG}{bhp-hr}\ ;\ PM10 = 0.008\ \frac{g\ PM\ 10}{bhp-hr}$$

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

Annual Emission Reductions =

*Emission Factor or Converted Emission Standard (g/bhp-hr) * fuel consumption rate factor (bhp-hr/gallon (gal)) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

Annual ER is the annual emission reductions for a particular pollutant.

$$Annual\ ER_{NOx} = \left(\frac{2.75g\ NOx}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{1664\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

Annual $ER_{NOx} = 0.093 \frac{tons\ NOx}{year}$

Annual $ER_{ROG} = \left(\frac{0.12\ g\ ROG}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{1664\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$

Annual $ER_{ROG} = 0.0041 \frac{tons\ ROG}{year}$

Annual $ER_{PM} = \left(\frac{0.008\ g\ PM}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{1664 gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$

Annual $ER_{PM} = 0.00027 \frac{tons\ PM}{year}$

Step 6: Determine the weighted annual surplus emission reductions that are associated with the proposed project. Using the results from Step 5 above along with the realization that the proposed fuel cell TRU will not produce any criteria pollutant emissions in a tank-to-wheel scenario populate Formula C-5.

Formula C-5: Annual Weighted Surplus Emission Reductions (tons/yr)

WER is the Weighted Emission Reductions

Weighted Emission Reductions =

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM reductions (tons/yr)]*

Therefore, using the results from Step 6 above and Formula C-5:

$$WER = \left(0.093 \frac{tons\ NOx}{year}\right) + \left(0.0041 \frac{tons\ ROG}{year}\right) * 20 \left(0.00027 \frac{tons\ PM}{year}\right) = 0.10 \frac{tons}{year}$$

Therefore, $WER = 0.10 \frac{tons\ criteria\ pollutants\ reduced}{year}$

Step 7: Determine the incremental cost of the proposed technology using Formula C-3, the equipment costs for the base case TRU and the fuel cell TRU given at the start of this example. Cost effectiveness is to be calculated for two scenarios; for two years during the demonstration and for 10 years, two years after the completion of the demonstration project.

Baseline Equipment:

- TRU cost at demonstration: $26,000
- TRU cost two years after demonstration: $26,000

Advanced Technology:

- TRU cost at demonstration: $45,000
- TRU cost two years after demonstration: $40,000

Formula C-3: Incremental Cost ($)

Incremental Cost = Cost of New Technology ($) – Cost of Baseline Diesel Technology ($)

$\text{Incremental Cost}_{2\ years}$ = $45,000 - $26,000 = $19,000

$\text{Incremental Cost}_{10\ years}$ = $40,000 - $26,000 = $14,000

Step 8: Determine the GHG emission reduction cost effectiveness for the proposed project using the results from Step 4, Step 7 and Formula 5

Formula 5:

$$Cost\ Effectiveness\ \left(\frac{\$}{metric\ ton}\right) = \left(\frac{\left(\frac{CRF * (\$Advanced\ Technology\ Vehicle - \$Baseline\ Diesel\ Vehicle)}{year}\right)}{\left(\frac{metric\ ton\ emissions\ reduced}{year}\right)}\right)$$

For the purposes of this Solicitation:

CRF is the Capital Recover Factor for a specific useful life.

CRF_2 = 0.515 per Moyer Table G-3b (2-year life)

CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

Therefore:

GHG C/E is the GHG Cost Effectiveness

$$\text{GHG C/E}_{2\ years} = \left(\frac{\frac{(0.515*\$19,000)}{year}}{\frac{12\ metric\ tons\ CO2e}{year}}\right) = \frac{\$815}{metric\ tons\ CO2e\ reduced}$$

$$\text{GHG C/E}_{10\ years} = \left(\frac{\left(\frac{(0.111*\$14,000)}{year}\right)}{\frac{12\ metric\ tons\ CO2e}{year}}\right) = \frac{\$130}{metric\ tons\ CO2e\ reduced}$$

Step 9: Determine the criteria pollutant cost effectiveness for the proposed technology. Use the results from Step 6 and Step 7 to populate Formula C-1.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton):

$$\textit{Cost-Effectiveness (\$/ton)} = \frac{\textit{Annualized Cost (\$/year(yr))}}{\textit{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

$$\text{Criteria Pollutant C/E}_{2\text{ years}} = ((\frac{\frac{(0.515*\$19{,}000)}{year}}{\frac{0.10\ tons\ WER}{year}}) = \frac{\$97{,}850}{tons\ criteria\ pollutants\ reduced}$$

$$\text{Criteria Pollutant C/E}_{10\text{ years}} = ((\frac{\frac{(0.111*\$14{,}000)}{year}}{\frac{0.10\ tons\ WER}{year}}) = \frac{\$15{,}540}{tons\ criteria\ pollutants\ reduced}$$

Example 3: Battery Electric Heavy Lift Forklift

Potential GHG emission reductions are determined on a well-to-wheel basis, while criteria pollutant emission reductions are determined using a tank-to-wheel analysis. This example assumes that a heavy-lift forklift will have the same energy requirements as a diesel counterpart and will be used the same number of hours. Electricity to charge the proposed forklift will come from the electrical grid.

Baseline Diesel Forklift:

- Off-Road diesel engine: Tier-4 initial certification, 110 hp
- 19,000 lbs. lift capacity
- Diesel usage: 13 gallons per week, 676 gal per year
- Forklift cost at demonstration: $40,000
- Forklift cost two years after demonstration: $40,000

Advanced Technology:

- Battery-electric forklift
- Forklift cost at demonstration: $75,000
- Forklift cost two years after demonstration: $65,000

Variables Used in Calculation:

Carbon Intensity

From Table MSF App D2: Fuel Carbon Intensity Values

CI = Carbon Intensity

$CI_{diesel} = \frac{102.76\ g\ CO2e}{MJ}$ Table Pathway Identifier ULSD001

From Table MSF App D2: Fuel Carbon Intensity Values

$CI_{electricity} = \frac{105.16\ g\ CO2e}{MJ}$ Pathway Identifier ELC001

Energy Density

From Table MSF App D1: Fuel Energy Density

ED = Energy Density

$ED_{diesel} = \frac{134.47\ MJ}{gal\ diesel}$ $ED_{electricity} = \frac{3.60\ MJ}{Kw\text{-}hr}$

Energy Efficiency Ratio

From Table MSF App D3: EER Values for Fuels Used in Light- Medium- and Heavy-Duty Applications

EER = Energy Efficiency Ratio (unit less)

$EER_{electricity}$ = 3.8

Step 1: Convert the diesel used per year to the amount of electricity needed to do the same work. Using Formula 3 and the variable identified above.

Formula 3:

$$= \left(\frac{X\ gal\ Diesel}{yr}\right)\left(ED\ \frac{MJ}{1\ gal\ diesel}\right) * \left(ED\frac{NF\ unit}{MJ}\right) * \left(\frac{1}{EER}\right)$$

Where:
X is the number of gallons diesel fuel used as a basis for the conversion;
NF is the new fuel that is proposed to be used as a diesel replacement;
ED is the Energy Density of the replacement fuel see Table MSF App D1: Fuel Energy Density; and
Unit is the units associated with the replacement fuel:

Electricity: kWh
Hydrogen: kg
CNG: scf

$$\frac{Kw\text{-}hr}{year} = \left(\frac{676\ gal\ diesel}{year}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{1\ Kw\text{-}hr}{3.60MJ}\right) * \left(\frac{1}{3.8}\right) = 6{,}645\ \frac{Kw\text{-}hr}{year}$$

Step 2: Determine the GHG emissions that are attributed to the base case diesel fueled heavy-lift forklift. Using Formula 1 and the variables identified above.

Formula 1:

$$GHG\ EF = carbon\ intensity * \frac{fuel\ energy\ density}{efficiency} * \frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

$$GHG\ EF_{base} = \left(\frac{102.76\ g\ CO2e}{MJ}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{676\ gal}{year}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right) = 9.3\ \frac{metric\ tons\ CO2e}{year}$$

Step 3: Determine the GHG emissions that are attributed to the advanced technology forklift. Using Formula 2, the result from Step 1 and the variables identified above.

Formula 2:

$$GHG\ EF = \frac{metric\ ton\ CO2e}{year} = carbon\ intensity * unit\ conversion * efficiency$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{3.60\ MJ}{kWh}\right) * \left(\frac{X\ kWh}{year}\right) * \frac{1\ metric\ ton}{1{,}000{,}000\ grams}$$

$$GHG\ EF_{adv\ tech} = \left(\frac{105.16\ g\ CO2e}{MJ}\right) * \left(\frac{3.60\ MJ}{kWh}\right) * \left(\frac{6645\ Kw\text{-}hr}{year}\right) * \left(\frac{1\ metric\ ton}{1{,}000{,}000\ grams}\right)$$

$$GHG\ EF_{adv\ tech} = 2.5\ \frac{metric\ tons\ CO2e}{year}$$

Step 4: Determine the GHG emission reductions that are associated with the proposed project. Using Formula 4, populated by results from Step 2 and Step 3 above to give the GHG emission benefit from the proposed project.

Formula 4:

$$Project\ GHG\ ER_{annual} = GHG\ EF_{base} - GHG\ EF_{adv\ tech}$$

$$Project\ GHG\ ER_{annual} = \left(\frac{9.3\ metric\ tons\ CO2e}{year}\right) - \left(\frac{2.5\ metric\ tons\ CO2e}{year}\right) = 6.8\ \frac{metric\ tons\ CO2e}{year}$$

Step 5: Determine the annual criteria pollutant emission reductions that are associated with the proposed project. The base case diesel fueled forklift is using a 110 hp diesel engine that is certified to the Tier-4 initial emissions standard, therefore, using emission values from Table D-12 and fuel consumption rate factors from Table D-24, the result of Step1 above to populate Formula C-8. The forklift will be used 100% of the time in California. There are no criteria pollutant emissions associated with the use of the battery-electric forklift in a tank to wheel analysis.

For a Tier-4 initial off-road engine at 110 hp, Table D-12 gives criteria pollutant emissions per bhp-hr, the conversion factor from Table D-24, or the relevant sized engine, allows for the conversion from gram per bhp-hr to gram per gallon of fuel consumed. Therefore:

$$NOx = 2.14\ \frac{g\ NOx}{bhp\text{-}hr}\ ;\ ROG = 0.11\ \frac{g\ ROG}{bhp\text{-}hr}\ ;\ PM10 = 0.008\ \frac{g\ PM\ 10}{bhp\text{-}hr}$$

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

Annual Emission Reductions =

*Emission Factor or Converted Emission Standard (g/bhp-hr) * fuel consumption rate factor (bhp-hr/gallon (gal)) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

$$\text{Annual } ER_{NOx} = \left(\frac{2.14g\ NOx}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{676\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

$$\text{Annual } ER_{NOx} = 0.030\ \frac{tons\ NOx}{year}$$

$$\text{Annual } ER_{ROG} = \left(\frac{0.11\ g\ ROG}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{676\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

$$\text{Annual } ER_{ROG} = 0.0015\ \frac{tons\ ROG}{year}$$

$$\text{Annual } ER_{PM10} = \left(\frac{0.008\ g\ PM\ 10}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{676\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

$$\text{Annual } ER_{PM10} = 0.00011\ \frac{tons\ PM}{year}$$

Step 6: Determine the weighted annual surplus emission reductions that are associated with the proposed project. Using the results from Step 5 above along with the realization that the proposed battery-electric forklift will not produce any criteria pollutant emissions in a tank-to-wheel scenario, populate Formula C-5.

Formula C-5: Annual Weighted Surplus Emission Reductions (tons/yr)

WER is the Weighted Emission Reductions

Weighted Emission Reductions =

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM reductions (tons/yr)]*

Therefore, using the results from Step 6 above and Formula C-5:

$$WER = \left(0.030\frac{tons\ NOx}{year}\right) + \left(0.0015\ \frac{tons\ ROG}{year}\right) * 20\left(0.00011\frac{tons\ NOx}{year}\right) = 0.034\ \frac{tons}{year}$$

$$\text{Therefore, } WER = 0.034\ \frac{tons\ criteria\ pollutants\ reduced}{year}$$

Step 7: Determine the incremental cost of the proposed technology using Formula C-3 and the equipment costs for the base case diesel fueled forklift and the battery-electric heavy lift forklift given at the start of this example. Cost effectiveness is to be calculated for two scenarios; for two years during the demonstration and for 10 years, two years after the completion of the demonstration project.

Baseline Equipment:

- Forklift cost at Demonstration: $40,000
- Forklift cost two years after demonstration: $40,000

Advanced Technology:

- Forklift cost at demonstration: $75,000
- Forklift cost two years after demonstration: $65,000

Formula C-3: Incremental Cost ($)

Incremental Cost = Cost of New Technology ($)–Cost of Baseline Diesel Technology ($)

$\text{Incremental Cost}_{2\ years}$ = $75,000 - $40,000 = $35,000

$\text{Incremental Cost}_{10\ years}$ = $65,000 - $40,000 = $25,000

Step 8: Determine the GHG emission reduction cost effectiveness for the proposed project using the results from Step 4, Step 7 and Formula 5

Formula 5:

CRF is the Capitol Recovery Factor

$$Cost\ Effectiveness\ \left(\frac{\$}{metric\ ton}\right) = \left(\frac{\frac{CRF * (\$Advanced\ Technology\ Vehicle - \$Baseline\ Diesel\ Vehicle)}{year}}{\left(\frac{metric\ ton\ emissions\ reduced}{year}\right)}\right)$$

For the purposes of this Solicitation:

CRF_2 = 0.515 per Moyer Table G-3b (2-year life)

CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

Therefore:

GHG C/E is the GHG Cost Effectiveness

$$\text{GHG C/E}_{2\ years} = \left(\frac{\frac{(0.515*\$35{,}000)}{year}}{\frac{6.8\ metric\ tons\ CO2e}{year}}\right) = \frac{\$2651}{metric\ tons\ CO2e\ reduced}$$

$$\text{GHG C/E}_{10\ years} = \left(\frac{\left(\frac{(0.111*\$25{,}000)}{year}\right)}{\frac{6.8\ metric\ tons\ CO2e}{year}}\right) = \frac{\$408}{metric\ tons\ CO2e\ reduced}$$

Step 9: Determine the criteria pollutant cost effectiveness for the proposed technology. Use the results from Step 6 and Step 7 to populate Formula C-1.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

$$\textit{Cost-Effectiveness (\$/ton)} = \frac{\textit{Annualized Cost (\$/year(yr))}}{\textit{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

$$\text{Criteria Pollutant C/E}_{2\ years} = \left(\left(\frac{\frac{(0.515*\$35{,}000)}{year}}{\frac{0.034\ tons\ WER}{year}}\right) = \frac{\$530{,}000}{tons\ criteria\ pollutants\ reduced}\right.$$

$$\text{Criteria Pollutant C/E}_{10\ years} = \left(\left(\frac{\frac{(0.111*\$25{,}000)}{year}}{\frac{0.034\ tons\ WER}{year}}\right) = \frac{\$81{,}600}{tons\ criteria\ pollutants\ reduced}\right.$$

Example 4: Battery-Electric Regional Haul On-Road Truck with Internal Combustion Range Extender

Potential GHG emission reductions are determined on a well-to-wheel basis, while criteria pollutant emission reductions are determined using a tank-to-wheel analysis. This example assumes that an internal combustion range extending battery-electric on-road heavy-duty truck will have the same energy requirements as a diesel counterpart and will be used the same number of miles. Further, it is assumed that this project will use electricity for on-board battery charging and on-board CNG for the range extending internal combustion engine. It is assumed that 2/3rds of the advanced technology vehicle's energy needs will come from the on-board battery pack and that 1/3 of the trucks energy needs will come from the on-board range extending engine. The CNG will be 85% pipeline and 15% renewable from high solids anaerobic digestion of food and green wastes.

This example demonstrates the use of two fuel types in one advanced technology application with one of those fuel types, CNG, having a composite Carbon Intensity that is not directly given in Table MSF App D2: Fuel Carbon Intensity Values, but rather needs to be calculated.

Baseline On-Road Truck:

- 2010 on-road heavy duty diesel emission standard compliant engine
- Fuel usage is 7 miles per gallon at 150 miles per day for 210 days a year
- On-road truck cost at Demonstration: $100,000
- On-road truck cost two years after demonstration: $100,000

Advanced Technology:

- CNG range extending battery dominant on-road truck
- CNG range extending engine meet the 2010 heavy-duty diesel emission standard of 0.20 gram NOx per bhp-hr
- Truck cost at demonstration: $750,000
- Truck cost two years after demonstration: $550,000

Variables Used in Calculation:

Carbon Intensity

From Table MSF App D2: Fuel Carbon Intensity Values

CI = Carbon Intensity

$CI_{diesel} = \frac{102.76\ g\ CO2e}{MJ}$ Table Pathway Identifier ULSD001

From Table MSF App D2: Fuel Carbon Intensity Values

$CI_{electricity} = \frac{105.16\ g\ CO2e}{MJ}$ Pathway Identifier ELC001

$CI_{pipeline\ cng} = \frac{79.46\ g\ CO2e}{MJ}$ Pathway Identifier CNG002

$CI_{renewable\ cng} = \frac{-34.70\ g\ CO2e}{MJ}$ Pathway Identifier CNG0005

Energy Density

From Table MSF App D1: Fuel Energy Density

ED = Energy Density

$ED_{diesel} = \frac{134.47\ MJ}{gal\ diesel}$ $ED_{electricity} = \frac{3.60\ MJ}{Kw-hr}$ $ED_{cng} = \frac{0.98\ MJ}{scf}$

Energy Efficiency Ratio

From •Table MSF App D3: EER Values for Fuels Used in Light- Medium- and Heavy-Duty Applications

EER = Energy Efficiency Ratio (unit less)

The EER for electricity in use on electric, battery electric or hybrid electric trucks are selected and the EER for CNG in spark ignition engines. Those EER values are show below:

$EER_{electricity} = 2.7$ $EER_{cng} = 0.9$

Conversion for CNG Standard Cubic Feet (scf) to Diesel Gallon Equivalent (DGE)

For the purpose of this solicitation assume:

1 DGE = 139.30 scf CNG[5]

Step 1: Calculate the baseline on-road trucks annual fuel usage:

$$\frac{gal\ diesel}{year} = \left(\frac{1 gallon}{7\ miles}\right) * \left(\frac{150\ miles}{yearday}\right)\left(\frac{210\ days}{year}\right) = \frac{4500\ gallons\ diesel}{year}$$

Step 2: Convert the diesel used per year to the amount of electricity and CNG needed to do the same work. Using Formula 3, the variable identified above and the realization

[5] CNG scf to DGE conversion Source: U.S. Department of Energy Alternative Fuels Data Center http://www.afdc.energy.gov/fuels/equivalency_methodology.html

that 2/3 of the energy needs of the truck will come from electricity and 1/3 of the energy needs will come from CNG. .

Formula 3:

$$= \left(\frac{X\ gal\ Diesel}{yr}\right)\left(ED\ \frac{MJ}{1\ gal\ diesel}\right) * \left(ED\ \frac{NF\ unit}{MJ}\right) * \left(\frac{1}{EER}\right)$$

Where:

X is the number of gallons diesel fuel used as a basis for the conversion;

NF is the new fuel that is proposed to be used as a diesel replacement;

ED is the Energy Density of the replacement fuel see Table MSF App D1: Fuel Energy Density; and

Unit is the units associated with the replacement fuel:

Electricity: kWh

Hydrogen: kg

CNG: scf

First calculate the number of kilowatt hours needed to supply the power needs for 2/3rds of the diesel.

Electric need = $0.67 * 4500\ gallons$ = 3015 gallons diesel

CNG need = $0.33 * 4500\ gallons$= 1485 gallons diesel

$$Electricity = \left(\frac{3015\ gal\ diesel}{year}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{1\ Kw{-}hr}{3.60MJ}\right)*\left(\frac{1}{2.7}\right) = 41{,}711\ \frac{Kw{-}hr}{year}$$

$$CNG = \left(\frac{1485\ gal\ diesel}{year}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{1\ scf}{0.98MJ}\right)*\left(\frac{1}{0.9}\right) = 226{,}404\ \frac{scf}{year}$$

Step 3: Determine the GHG emissions that are attributed to the base case diesel fueled on-road truck. Using Formula 1 and the variables identified above.

Formula 1:

$$GHG\ EF = carbon\ intensity * \frac{fuel\ energy\ density}{efficiency} * \frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right)$$

$$GHG\ EF_{base} = \left(\frac{102.76\ g\ CO2e}{MJ}\right) * \left(\frac{134.47\ MJ}{gal\ diesel}\right) * \left(\frac{4500\ gal}{year}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right) = 62\ \frac{metric\ tons\ CO2e}{year}$$

Step 4: Determine the composite Carbon Intensity value for the CNG blend that is proposed to be used in this project. The proposal for this project will use 85% pipeline CNG and 15% renewable CNG from anaerobic digestion of food and green waste. Use Formula 6 for this calculation.

Formula 6:

$$CI_{composite} = (Fraction\ of\ total\ fuel * (CI\ fuel\ 1)) + (fraction\ of\ total\ fuel * (CI\ Fuel\ 2))$$

$$CI_{cng\ composite} = (\frac{2}{3} * (\frac{79.46\ g\ CO2e}{MJ})) + (\frac{1}{3} * (\frac{-34.70\ g\ CO2e}{MJ})) = \frac{41.79\ g\ CO2e}{MJ}$$

Use this result for the Carbon Intensity calculations using CNG.

Step 5: Determine the well-to-wheel GHG emissions that are attributed to the advanced technology on-road truck. This calculation will need to be performed for each of the two fuel types that will be used in the proposed advanced technology on-road truck. Using Formula 1 and Formula 2, the result from Step 2, the composite CI value determined in Step 4 and the variables identified above, calculate the GHG emissions associated with the advanced technology on-road truck. .

Formula 1: Liquid / Natural Gas and Hydrogen Fueled Vehicles

$$GHG\ EF = carbon\ intensity * \frac{fuel\ energy\ density}{efficiency} * \frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}$$

$$= (\frac{gram\ CO2e}{MJ}) * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * (\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams})$$

Formula 2: Electric Vehicles

$$GHG\ EF = \frac{metric\ ton\ CO2e}{year} = carbon\ intensity * unit\ conversion * efficiency$$

$$= \left(\frac{gram\ CO2e}{MJ}\right) * \left(\frac{3.60\ MJ}{kWh}\right) * \left(\frac{X\ kWh}{year}\right) * \frac{1\ metric\ ton}{1{,}000{,}000\ grams}$$

$$= (\frac{gram\ CO2e}{MJ}) * \left(\frac{MJ}{gal}\ or\ \frac{MJ}{kg}\ or\ \frac{MJ}{scf}\right) * \left(\frac{gal}{day}\ or\ \frac{kg}{day}\ or\ \frac{scf}{day}\right) * (\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams})$$

Formula 2 will be used for the electric portion of the energy requirements.

$$GHG\ EF_{adv\ tech\ electricity} = \left(\frac{105.16\ g\ CO2e}{MJ}\right) * \left(\frac{3.60\ MJ}{kWh}\right) * \left(\frac{41{,}711\ kWh}{year}\right) * \frac{1\ metric\ ton}{1{,}000{,}000\ grams}$$

$GHG\ EF_{adv\ tech\ electricity} = 15.8 \frac{metric\ tons\ CO2e}{year}$

Formula 1 will be used for the CNG energy portion of the energy requirements

$GHG\ EF_{adv\ tech\ CNG} = \left(\frac{41.79\ g\ CO2e}{MJ}\right) * \left(\frac{0.98\ MJ}{scf}\right) * \left(\frac{226{,}404\ scf}{year}\right) * \left(\frac{1\ metric\ ton\ CO2e}{1{,}000{,}000\ grams}\right) =$

$GHG\ EF_{adv\ tech\ CNG} = 9.3 \frac{metric\ tons\ CO2e}{year}$

Sum the GHG emissions from the electricity and the CNG to get the total GHG emissions from the advanced technology truck.

$GHG\ EF_{adv\ tech} = 15.8 \frac{metric\ tons\ CO2e}{year} + 9.3 \frac{metric\ tons\ CO2e}{year} = 25 \frac{metric\ tons\ CO2e}{year}$

Step 6: Determine the annual GHG emission reductions that are associated with the proposed project. Using Formula 4 above populated by results from Step 4 and Step 5 from the above example to give the annual GHG emission benefit from the proposed project.

Formula 4:

$Project\ GHG\ ER_{annual} = GHG\ EF_{base} - GHG\ EF_{adv\ tech}$

$Project\ GHG\ ER_{annual} = \left(\frac{62\ metric\ tons\ CO2e}{year}\right) - \left(\frac{25\ metric\ tons\ CO2e}{year}\right) = 37 \frac{metric\ tons\ CO2e}{year}$

Step 7: Determine the annual criteria pollutant emission reductions that are associated with the proposed project. The base case diesel on-road truck meeting 2010 emission standard, therefore, using emission values from Table D-12 and fuel consumption rate factors from Table D-24, the result of Step1 above to populate Formula C-8. The trucks will be used 100% of the time in California. There are criteria pollutant emissions associated with the use of the advanced technology truck and therefore those emissions need to be considered.

For an on-road 2010 emission standard diesel heavy duty truck Table D-12 gives criteria pollutant emissions per bhp-hr, the conversion factor, for the relevant engine hp from Table D-24 allows for the conversion from gram per bhp-hr to gram per gallon of fuel consumed. Therefore:

$NOx = 2.32 \frac{g\ NOx}{bhp-hr}$; $ROG = 0.12 \frac{g\ ROG}{bhp-hr}$; $PM10 = 0.008 \frac{g\ PM\ 10}{bhp-hr}$

Formula C-8: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

Annual Emission Reductions =

*Emission Factor or Converted Emission Standard (g/bhp-hr) * fuel consumption rate factor (bhp-hr/gallon (gal)) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

$$\text{Annual Em}_{NOx} = \left(\frac{2.32g\ NOx}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{4500\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

$$\text{Annual Em}_{NOx} = 0.21\ \frac{tons\ NOs}{year}$$

$$\text{Annual Em}_{ROG} = \left(\frac{0.12\ g\ ROG}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{4500\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

$$\text{Annual Em}_{ROG} = 0.011\ \frac{tons\ ROG}{year}$$

$$\text{Annual Em}_{PM10} = \left(\frac{0.008\ g\ PM\ 10}{bhp-hr}\right) * \left(\frac{18.5\ bhp-hr}{gal\ diesel}\right) * \left(\frac{4500\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) =$$

$$\text{Annual ER}_{PM10} = 0.00073\ \frac{tons\ PM}{year}$$

Step 8: Calculate the criteria pollutant emissions that are associated with the advanced technology on-road truck. Since the proposed heavy-duty on-road range extending battery dominant truck has criteria pollutant emissions associated with its operation those emissions need to be determined and subtracted from the emissions from the base case diesel truck calculated in Step 7 above. Using inputs from Table D-2 with the understanding that the CNG range extending engine is an on-road engine certified to the 2010 emission standard for NOx at 0.20 g per bhp-hr and DGE is diesel gallons equivalent. Therefore, Table D-2 gives:

$NOx = 3.70 \frac{g\ NOx}{DGE}$ $ROG = 1.17 \frac{g\ NOx}{DGE}$ $PM = 0.185 \frac{g\ PM}{DGE}$

To calculate the DGE for the CNG sourced emissions from the advanced technology truck, for the purpose of this solicitation use the conversion factor of 139.30 scf of CNG per DGE and the output from Step 2 above, therefore:

$$DGE = \left(\frac{1\ DGE}{139.30\ scf}\right) * \left(226{,}404\ \frac{scf}{year}\right) = 1{,}625\ DGE$$

Using Formula C-9 with the criteria pollutant emission levels identified above and the DGE that was calculate above as inputs.

Formula C-9: Estimated Annual Emissions based on Fuel using Emission Factors (tons/yr) (all of the emission reductions are taking place in CA)

Annual Emission Reductions =

*Emission Factor (g/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

ADV Tech Em is the Advanced Technology Criteria pollutant emission factor for the identified criteria pollutant.

ADV Tech Em $_{NOx}$ = $\left(\frac{3.70\ g\ NOx}{gal\ diesel}\right) * \left(\frac{1625\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) = 0.0066 \frac{tons\ NOx}{year}$

ADV Tech Em $_{ROG}$ = $(\frac{1.17\ g\ ROG}{gal\ diesel}) * \left(\frac{1625\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) = 0.0021\ \frac{tons\ ROG}{year}$

ADV Tech Em $_{PM10}$ = $\left(\frac{0.185\ g\ NOx}{gal\ diesel}\right) * \left(\frac{1625\ gal\ diesel}{year}\right) * (1) * \left(\frac{1\ ton}{907{,}200\ g}\right) = 0.00033 \frac{tons\ PM}{year}$

Step 10: Calculate the criteria emission reductions that are associated with the proposed project. The emission reductions that are associated with the use of the advanced technology on-road truck are the criteria pollutant emissions that are associated with the baseline diesel truck, calculated in Step 8 above, minus the criteria pollutant emissions that are associated with the advanced technology truck, calculated` in Step 8 above, as follows:

Project ER = Baseline Emissions – Advanced Technology Emissions

Project ER$_{NOX}$ = $(0.21 \frac{tons\ NOs}{year}) - \left(0.0066 \frac{tons\ NOx}{year}\right) = 0.20 \frac{tons\ NOx}{year}$

Project ER$_{ROG}$ = $(0.011\ \frac{tons\ ROG}{year}) - (0.0021\ \frac{tons\ ROG}{year}) = 0.0089\ \frac{tons\ ROG}{year}$

Project ER$_{PM}$ = $(0.00073 \frac{tons\ PM}{year}) - \left(0.00033 \frac{tons\ PM}{year}\right) = 0.00040\ \frac{tons\ PM}{year}$

Step 11: Determine the weighted annual surplus emission reductions that are associated with the proposed project. Using the results from Step 10 above populate Formula C-5.

Formula C-5: Annual Weighted Surplus Emission Reductions (tons/yr)

WER is the Weighted Emission Reductions

Weighted Emission Reductions =

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM reductions (tons/yr)]*

Therefore, using the results from Step 6 above and Formula C-5:

WER = $(0.20 \frac{tons\ NOx}{year}) + \left(0.0089\ \frac{tons\ ROG}{year}\right) * 20 \left(0.00040 \frac{tons\ NOx}{year}\right) = 0.22\ \frac{tons}{year}$

Therefore, WER = $0.22 \frac{tons\ criteria\ pollutants\ reduced}{year}$

Step 12: Determine the incremental cost of the proposed technology using Formula C-3, the vehicle costs for the base case diesel fueled on-road truck and the range extending battery-dominant advanced technology truck given at the start of this example. Cost effectiveness is to be calculated for two scenarios; for two years during the demonstration and for 10 years, two years after the completion of the demonstration project.

Baseline Equipment:

- On-road diesel truck cost at demonstration: $100,000
- On-road diesel truck cost two years after demonstration: $100,000

Advanced Technology:

- Advanced technology truck cost at demonstration: $750,000
- Advanced technology truck cost two years after demonstration: $550,000

Formula C-3: Incremental Cost ($)

Incremental Cost = Cost of New Technology ($) – Cost of Baseline Diesel Technology ($)

Incremental $Cost_{2\ years}$ = $750,000 - $100,000 = $650,000

Incremental $Cost_{10\ years}$ = $550,000 - $100,000 = $450,000

Step 13: Determine the GHG emission reduction cost effectiveness for the proposed project using the results from Step 5, Step 11 and Formula 5

Formula 5:

$$Cost\ Effectiveness\ \left(\frac{\$}{metric\ ton}\right) = \left(\frac{CRF * \left(\frac{\$Advanced\ Technology\ Vehicle - \$Baseline\ Diesel\ Vehicle}{year}\right)}{\left(\frac{metric\ ton\ emissions\ reduced}{year}\right)}\right)$$

For the purposes of this Solicitation:

CFR is the Capital Recover Factor for a specific useful life

CRF_2 = 0.515 per Moyer Table G-3b (2-year life)

CRF_{10} = 0.111 per Moyer Table G-3b (10-year life)

Therefore,

GHG C/E is the GHG Cost Effectiveness

$$\text{GHG C/E}_{2\ years} = \left(\frac{\frac{(0.515*\$650{,}000)}{year}}{\frac{37\ metric\ tons\ CO2e}{year}}\right) = \frac{\$9047}{metric\ tons\ CO2e\ reduced}$$

$$\text{GHG C/E}_{10\ years} = \left(\frac{\left(\frac{(0.111*\$450{,}000)}{year}\right)}{\frac{37\ metric\ tons\ CO2e}{year}}\right) = \frac{\$1350}{metric\ tons\ CO2e\ reduced}$$

Step 14: Determine the criteria pollutant cost effectiveness for the proposed technology. Use the results from Step 11 and Step 12 to populate Formula C-1.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

$$\textit{Cost-Effectiveness (\$/ton)} = \frac{\textit{Annualized Cost (\$/year(yr))}}{\textit{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

$$\text{Criteria Pollutant C/E}_{2\ years} = \left(\left(\frac{\frac{(0.515*\$650{,}000)}{year}}{\frac{0.22\ tons\ WER}{year}}\right) = \frac{\$\ 1.5\ million}{tons\ criteria\ pollutants\ reduced}\right.$$

$$\text{Criteria Pollutant C/E}_{10\ years} = \left(\left(\frac{\frac{(0.111*\$450{,}000)}{year}}{\frac{0.22\ tons\ WER}{year}}\right) = \frac{\$227{,}000}{tons\ criteria\ pollutants\ reduced}\right.$$

APPENDIX E

AIR QUALITY IMPROVEMENT PROGRAM (AQIP) AND LOW CARBON TRANSPORTATION GREENHOUSE GAS REDUCTION FUND (GGRF) INVESTMENTS

MULTI-SOURCE FACILITY DEMONSTRATION PROJECT

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) COMPLIANCE AND PERMITTING REQUIREMENTS

Each proposed infrastructure installation (e.g., electric vehicle supply equipment or hydrogen refueling station) may be subject to California Environmental Quality Act (CEQA) compliance, as well as permitting and other requirements. Such proposals must adhere to the requirements specified in this Appendix.

I. CEQA COMPLIANCE INFORMATION

Applicants must complete a CEQA Worksheet (Appendix A, Attachment 9) for each proposed infrastructure installation. The Air Resources Board (ARB or Board) must ensure that the appropriate level of environmental review under CEQA is complete prior to approval. Thus, no grant can be approved, nor can any grant be executed, until the Lead Agency has determined that the project is exempt from CEQA requirements, or the CEQA requirements have been satisfied.

As part of its application, the Applicant shall provide a detailed description of the project and all of its components, as well as any direct physical changes and reasonably foreseeable indirect changes to the surrounding environment. In order to minimize or avoid adverse environmental impacts,, ARB will only accept applications for proposed projects to be sited where similar infrastructure already exists (e.g., installing electric vehicle supply equipment where electrical infrastructure already exists, or installing a hydrogen refueling station at an existing fueling station or industrial facility).

The Applicant must provide the following information as it pertains to the proposed project:

A. **Proposed Station Location:** The Applicant must provide the specific address or equivalent location information for the proposed station, equipment, fill system(s), and/or dispensing unit(s).

B. **Permits:** The Applicant must identify the permits necessary for the project with the proposal narrative.

C. **Project Impacts:** The Applicant must describe the direct physical changes and reasonably foreseeable indirect changes to the surrounding environment that may result from the project. Please see Section 3 of Attachment 9 to Appendix A.

D. **CEQA Lead Agency:** The lead agency will be identified using the following process.

1. Where the proposed project would require a discretionary approval from another permitting agency, the Applicant must identify the CEQA lead agency in the application and include documentation demonstrating that contact has been made with the lead agency with jurisdiction over the project for purposes of complying with CEQA. The documentation may be in the form of a letter from the lead agency or a CEQA application to the lead agency that is stamped as received by the local agency.

2. If ARB is the only agency with discretionary approval over the proposed project, then ARB will act as the lead agency and will work with the Applicant to satisfy CEQA requirements.

3. Regardless of which agency is the lead agency for a proposed project, the Applicant shall be responsible for all costs associated with preparation of environmental review documents. The Applicant may also be required to retain a consultant to perform an initial study or other environmental studies. The ARB ***WILL NOT*** reimburse any Applicant for these costs.

E. CEQA Compliance Where the Proposed Project Would require a Discretionary Approval From Another Permitting Agency (i.e., another permitting agency serves as the Lead Agency):

1. **Exempt Projects:** If the lead agency has exempted the proposed project or if the lead agency determines that the proposed project is not a "project" for purposes of CEQA, the Applicant must submit proof of such a determination to ARB by December 1, 2015. Additionally, the Applicant must provide information on why the project meets the applicable statutory or categorical exemption. The Applicant shall provide facts that support the lead agency's conclusion. For example, for a Class One Categorical Exemption (California Code of Regulations (CCR), Title 14 § 15301), the Applicant should provide documentation showing that the project is located at an existing facility that involves negligible or no expansion of an existing use.
    i. Ministerial or "Common Sense" Exemptions: If the lead agency exempts a proposed project under the "ministerial" or "common sense" exemptions (CCR, Title 14, § 15268 and § 15061, subd. (b)(3), respectively), the Applicant shall provide details on whether the project meets some other statutory or categorical exemption. For example, the Applicant should not simply state that a 100% renewable hydrogen project is exempt under the common sense exemption.

2. **Non-Exempt Projects Requiring a Negative Declaration or Environmental Impact Report (EIR):** If the lead agency has not exempted the project, the Applicant shall explain whether the lead agency is expected to prepare an initial study and negative declaration or EIR, and the expected date of completion. The Applicant must submit proof that the lead agency has completed environmental review of its project and adopted a Negative Declaration, Mitigated Negative Declaration or Environmental Impact Report by December 1, 2015.
3. If an Applicant fails to timely submit the required CEQA documentation by December 1, 2015, as described above, ARB its sole discretion may cancel the proposed grant and make a selection to the next-highest scoring project, and so on, until an agreement is reached, or exercise its right, in its sole discretion, throughout this process, no not award a grant. ARB reserves the right, in its sole discretion, to cancel this solicitation, re-solicit for a Grantee, or to direct funding to another project in the Funding Plan.
4. In accordance with CEQA requirements, ARB will review each project application and consider the facts and circumstances of each project application (including the project's reasonably foreseeable direct and indirect impacts) before determining whether the lead agency's CEQA review findings and documentation are adequate.

F. **CEQA Compliance Where the Proposed Project Would Not Require a Discretionary Approval From Another Permitting Agency:** If ARB is the only agency with discretionary approval over the proposed project, then ARB will act as the lead agency and will work with the Applicant to satisfy CEQA requirements. In accordance with CEQA requirements, ARB will review each project application, and consider the facts and circumstances of each project application (including the project's reasonably foreseeable direct and indirect impacts) before determining the level of required environmental review.

G. **Other Relevant CEQA Information:** The Applicant shall submit any other relevant CEQA documentation or information that will assist ARB in confirming CEQA compliance.

Within a proposal, the applicant is encouraged to fully document efforts completed or underway to achieve CEQA compliance. This includes, but is not limited to, CEQA compliance documentation, completed or schedule pre-application meetings with the local CEQA lead agency, or documentation of contact with CEQA lead agency.

NOTE REGARDING ENCUMBRANCE DEADLINES AND DISCLAIMER: The funds under this solicitation have strict encumbrance deadlines. The lead agency (which may be ARB if no other local discretionary approval is required) must complete environmental review under CEQA and approve each grant prior to the applicable encumbrance deadline. Thus, if a project cannot complete CEQA review in time to meet the applicable encumbrance deadline, **ARB reserves the right to cancel the**

proposed grant and recommend funding the next highest scoring project that can meet the encumbrance deadline, regardless of the Applicant's diligence in submitting CEQA information and materials. Further, ARB is not liable for any costs incurred during environmental review or as a result of cancelling the proposed grant.

II. PERMITTING

The Applicant must include information in their narrative that describes their plans to obtain permits for each proposed infrastructure installation. The Governor's Office of Business and Economic Development is available to provide permitting assistance. Contact information is available below:

Mr. Tyson Eckerle
Zero-Emission Vehicle Infrastructure Project Manager
Office of Business and Economic Development
1400 Tenth Street, 2nd Floor
Sacramento, CA 95814
Phone: 916-322-0563
Fax: 916-322-0693
Email: tyson.eckerle@gov.ca.gov

III. PHOTOGRAPHIC EVIDENCE OF THE STATION LAYOUT

The Application must provide photographic images with both date and time stamps of all intended locations. The images must show the station ingress and egress.

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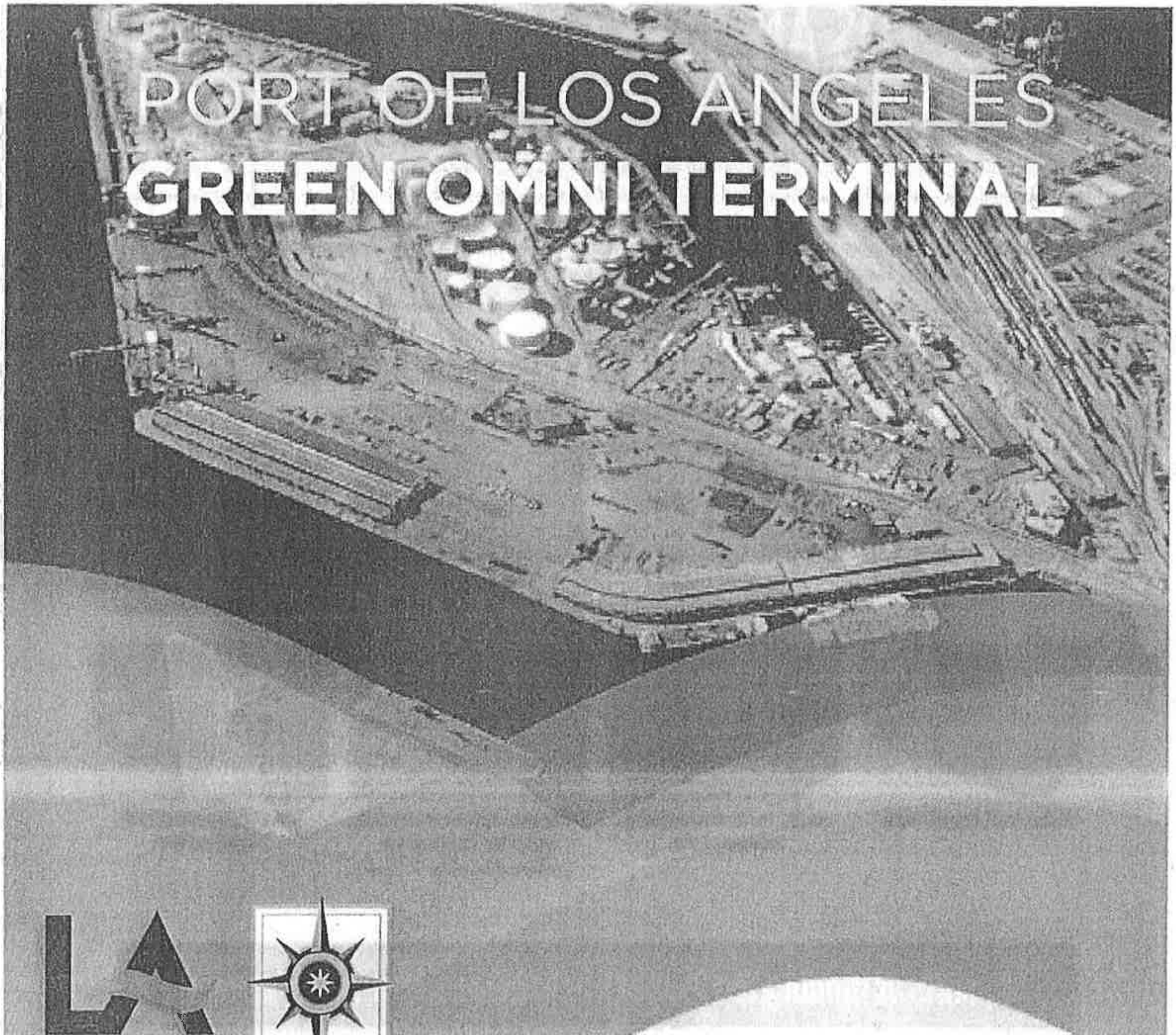
EXHIBIT D

GRANTEE APPLICATION PACKAGE

PORT OF LOS ANGELES
GREEN OMNI TERMINAL



THE PORT OF LOS ANGELES

PST

Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund (GGRF) Investments

MULTI-SOURCE FACILITY DEMONSTRATION PROJECT APPLICATION

SEPTEMBER 24, 2015

PORT OF LOS ANGELES GREEN OMNI TERMINAL

Exporting Green Technologies to the Southern California Region

With a commitment to conducting sustainable terminal operations that reduce overall environmental footprints, while enhancing the surrounding community and the local and national economy, the Los Angeles Harbor Department and Pasha are partnering together to develop a Green Omni Terminal at Pasha's Port of Los Angeles Terminal. The vision of the terminal is to be a solar-powered facility that uses zero and near-zero emissions cargo handling and transportation equipment to sustainably move goods from ships through the terminal to clean transportation to their final destinations.

PROPOSED TECHNOLOGIES CONSIDERED FOR EVALUATION

Electric yard tractors

Electric top handler

21-ton electric forklifts

At-berth ship emission control systems
(reduces CO_2 & harmful emissions)

Electric Class 8 drayage trucks

Electric bus for moving workers between facilities

Integrated 1 MW solar photovoltaic and battery storage system
(terminal functions as a green microgrid)

Standardized bi-directional charging systems

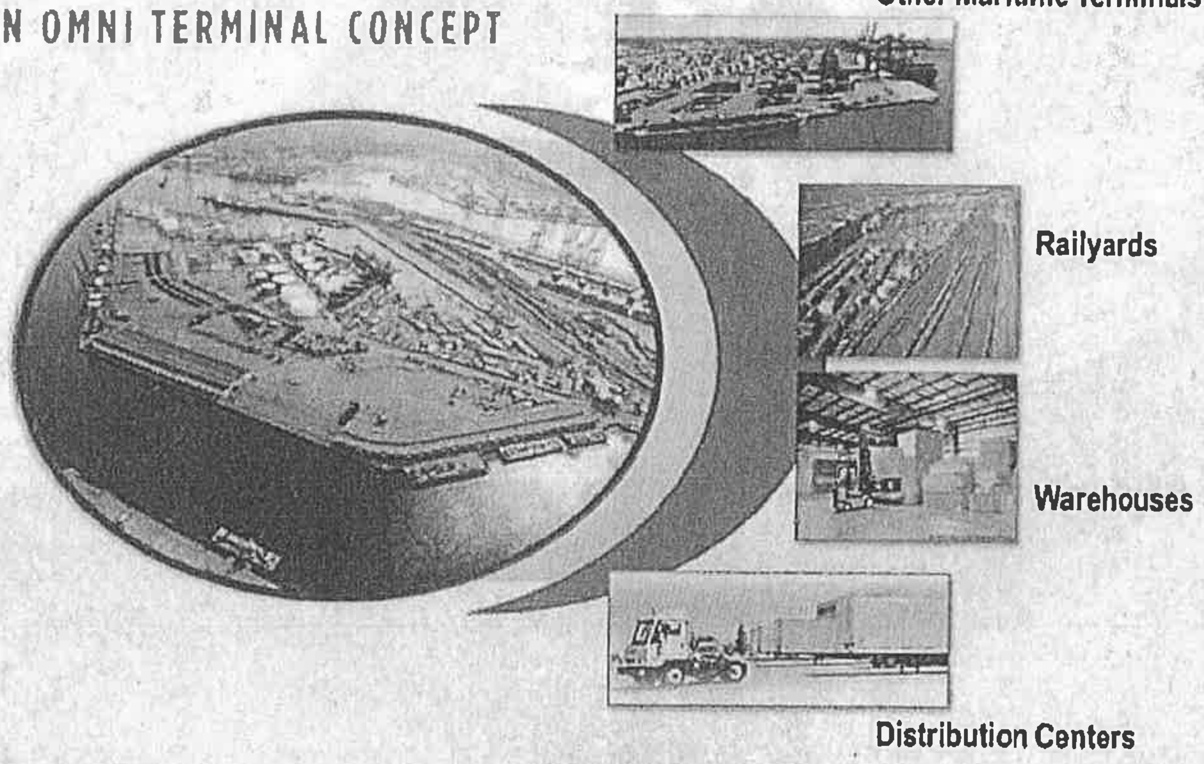
Benefits of funding the Port of Los Angeles Green Omni Terminal

1. Reduces greenhouse gas, diesel particulate matter, and nitrogen oxides emissions in an area not meeting National Ambient Air Quality Standards, within and adjacent to disadvantaged communities.
2. Serves as a catalyst for change at the Pasha Terminal and throughout the region.
3. Allows for future integration of zero and near-zero emission technology, such as on-road trucks providing drayage to and from Pasha.
4. Provides a test facility for technologies that can be scaled to other non-automated goods distribution centers and marine terminals throughout the region.

PORT OF LOS ANGELES GREEN OMNI TERMINAL

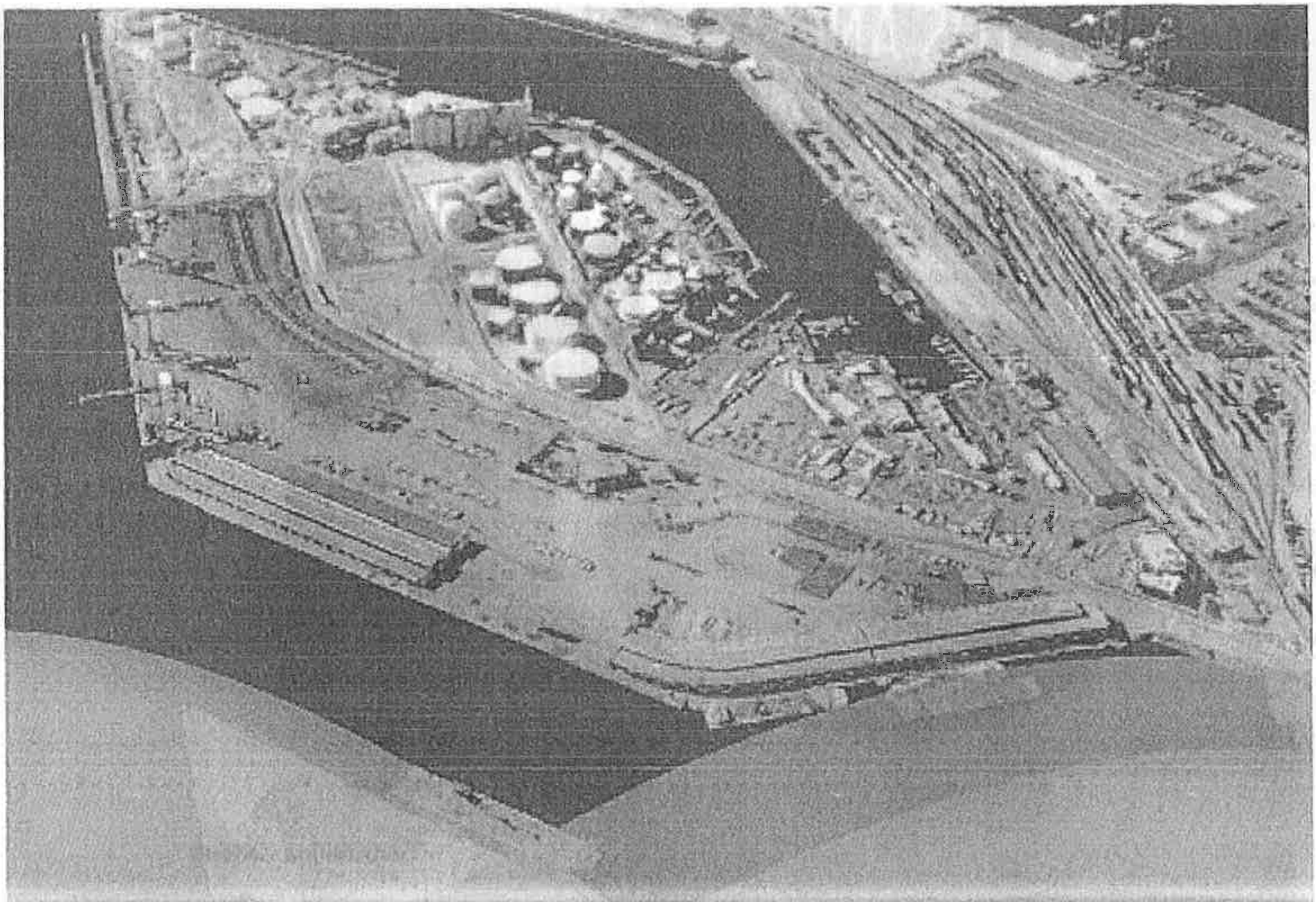
Exporting Green Technologies to the Southern California Region

GREEN OMNI TERMINAL CONCEPT



ARB can achieve its goals by funding the Green Omni Terminal	Demonstration Project Scoring Criteria 1	2	3	4	5	6	7	8	9	10	11
1 **Emission reduction benefits to the Wilmington DAC.** *The project will reduce 3,230.7 tpy of CO2e, 0.623 tpy of PM10, 25.9 tpy of NOx, and 1.44 tpy of ROG emissions in a DAC not meeting NAAQS.*			✓		✓		✓	✓		✓	✓
2 **Multiple zero and near zero-emission technologies demonstrated at one facility.** *Pasha will be a test facility for commercialization of zero and near-zero emission technologies to move high-tonnage break bulk and containerized cargo.*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3 **Economic, environmental, and public health co-benefits.** *The Green Omni Terminal will provide a cost-effective and scalable model for sustainable and low-emission terminal operations for other distribution centers and marine terminals throughout the state, nation, and world.*		✓		✓	✓	✓	✓	✓	✓	✓	✓
4 **Practicality and economic viability of wide-spread adoption of advanced freight technologies at one facility.** *The Green Omni Terminal goes beyond this goal, showing how a sustainable and resilient terminal can integrate electric zero emission equipment into the first seaport terminal microgrid; using renewable power to operate in a disaster event that causes the electric grid to lose power.*	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
5 **Funds technologies on the cusp of commercialization that further the purpose of AB 32.** *This project will help reduce the costs of electric drayage trucks and yard tractors, continuing to increase the commercial viability of zero emission technologies. It will also show applicability of a solar-powered microgrid, with battery storage systems, to enhance operational sustainability and resiliency.*			✓	✓	✓	✓	✓	✓	✓	✓	✓

Scoring Criteria: 1-Applicant Qualifications; 2-Project Team Capabilities and Degree of Industry Collaboration; 3-Project Objectives and Work Plan; 4-Budget, Match Funding, and Financial Capabilities; 5-Potential Emission Reduction Benefits; 6-Cost-Effectiveness; 7-Benefits to Disadvantaged Communities; 8-Technology and Innovation; 9-Potential for Market Penetration and Commercialization of the Technology; 10-Application Completeness; 11-Timeline for Project Completion



THE PORT OF LOS ANGELES

PST

LOS ANGELES HARBOR DEPARTMENT
425 S. PALOS VERDES STREET
SAN PEDRO, CA 90731
CHRISTOPHER CANNON, CHIEF SUSTAINABILITY OFFICER
P: (310) 732-3763; E: CCANNON@PORTLA.ORG

THE PORT
OF LOS ANGELES
425 S. Palos Verdes Street   Post Office Box 151   San Pedro, CA 90733-0151   TEL/TDD 310 SEA-PORT   www.portoflosangeles.org

September 24, 2015

Lisa Williams
California Environmental Protection Agency
Air Resources Board
Mobil Source Control Division
1001 I Street
Sacramento, CA 95814

Dear Ms. Williams:

SUBJECT: THE CITY OF LOS ANGELES HARBOR DEPARTMENT MULTI-SOURCE GRANT APPLICATION FOR THE GREEN OMNI TERMINAL PROJECT

The City of Los Angeles Harbor Department (Harbor Department) is pleased to submit the attached application for a Multi-Source Grant that would support the development and demonstration of a Green Omni Terminal at the Pasha Stevedoring & Terminals (Pasha) Port of Los Angeles facility.

If funded, this project would reduce up to 3,231 tons per year of greenhouse gas emissions, as well as substantial amounts of criteria pollutants. More important, this project can serve as a model for clean energy usage at many types of industrial facilities throughout the State of California - and in more than just a marine setting. By integrating several different zero emission goods movement technologies with a microgrid that includes solar generation, battery storage, and an energy management system to coordinate energy usage, the Pasha terminal will become a more sustainable and resilient facility that can operate independent of the grid for short periods of time, should grid power go down.

The Green Omni Terminal Project will demonstrate zero-emission technologies on the cusp of commercialization to show how a "zero emission" facility that uses electrified conventional cargo handling equipment can operate. Once a ship reaches berth, over 90% of its emissions will be treated by an on-dock marine exhaust treatment system that includes the capability to capture CO_2 emissions. The battery electric yard tractors, 21-ton forklifts, and top handler that will unload, handle, and ultimately transfer the cargo to on-road battery-electric drayage trucks will all generate zero emissions. Even the electric bus moving Pasha personnel between the Pasha parking area, dockside, and between facilities will produce zero emissions. By combining multiple zero and near-zero emission technologies at a single multi-source facility, the Green Omni Terminal will serve as a scalable model that can be replicated at thousands of ports and other types of industrial facilities across the state, nation, and world.

As you will see in our proposal, we have developed an innovative project that addresses all of the Air Resource Board's goals under the Multi-Source Facility Demonstration Project and the Fiscal Year 2014-2015 Funding Plan, including: (i) emissions reduction benefits to the adjacent Wilmington disadvantage community, (ii) demonstration of multiple types of zero and near zero emission equipment and vehicles, (iii) economic, environmental, and public health co-benefits by serving as a cost-effective and scalable model for sustainable and low-emission terminal operations at thousands of distribution centers and marine terminals.

The Harbor Department has assembled a team of industry experts, technology providers, and technical advisors to successfully develop and implement this project. Our team has a track record of cost-effectively implementing grant programs that few can match. The Harbor Department alone is currently implementing $361 million in grant-funded projects.

We are committed to this project, and our team has allocated over $12 million in matching funds to cover 44% of the total project costs. You can be assured that our team offers both the technical and financial capabilities to see this project through to completion. With your support, we can create a Green Omni Terminal that will effectively reduce emissions, demonstrate and help commercialize new technologies, and provide long-lasting benefits to the surrounding community and beyond.

Our proposal is organized to follow the items as they are set forth in the June 23, 2015, Grant Solicitation. If you have any questions, please feel free to contact me at 310-732-3763 or via email at ccannon@portla.org. Thank you for your consideration.

Sincerely,

CHIRSTOPHER CANNON
Chief Sustainability Officer
Director of Environmental Management

CC.TJD:CA:mrx
APP No.: 150915-515

Table of Contents

Exhibits

APPENDIX A

MULTI-SOURCE FACILITY DEMONSTRATION PROJECT APPLICATION

Please print clearly or type all information on this application.

1. AQIP Project: **Port of Los Angeles Green Omni Terminal**		
2. Company Name/Air District/Organization Name/Individual Name: **Los Angeles Harbor Department**		
3. Business Type: **Government Agency**		
4. Contact Name and Title: **Christopher Cannon, Project Director**		
5. Person with Contract Signing Authority (if different from above)/Air Pollution Control Officer (APCO): **Eugene D. Seroka**		
6. Mailing Address and Contact Information: Street: **425 S. Palos Verdes St.**		
City: **San Pedro**	State: **CA**	Zip Code: **90731**
Phone: **(310) 732-3763**	Fax: **(310) 547-4643**	
Email: **CCannon@portla.org**		
☒ I have read and understood the terms and conditions of the Sample Grant Agreement.		

I hereby certify under penalty of perjury that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party or APCO: **Eugene D. Seroka**	Title: **Executive Director**
Signature of Responsible Party or APCO:	Date: **September 24, 2015**

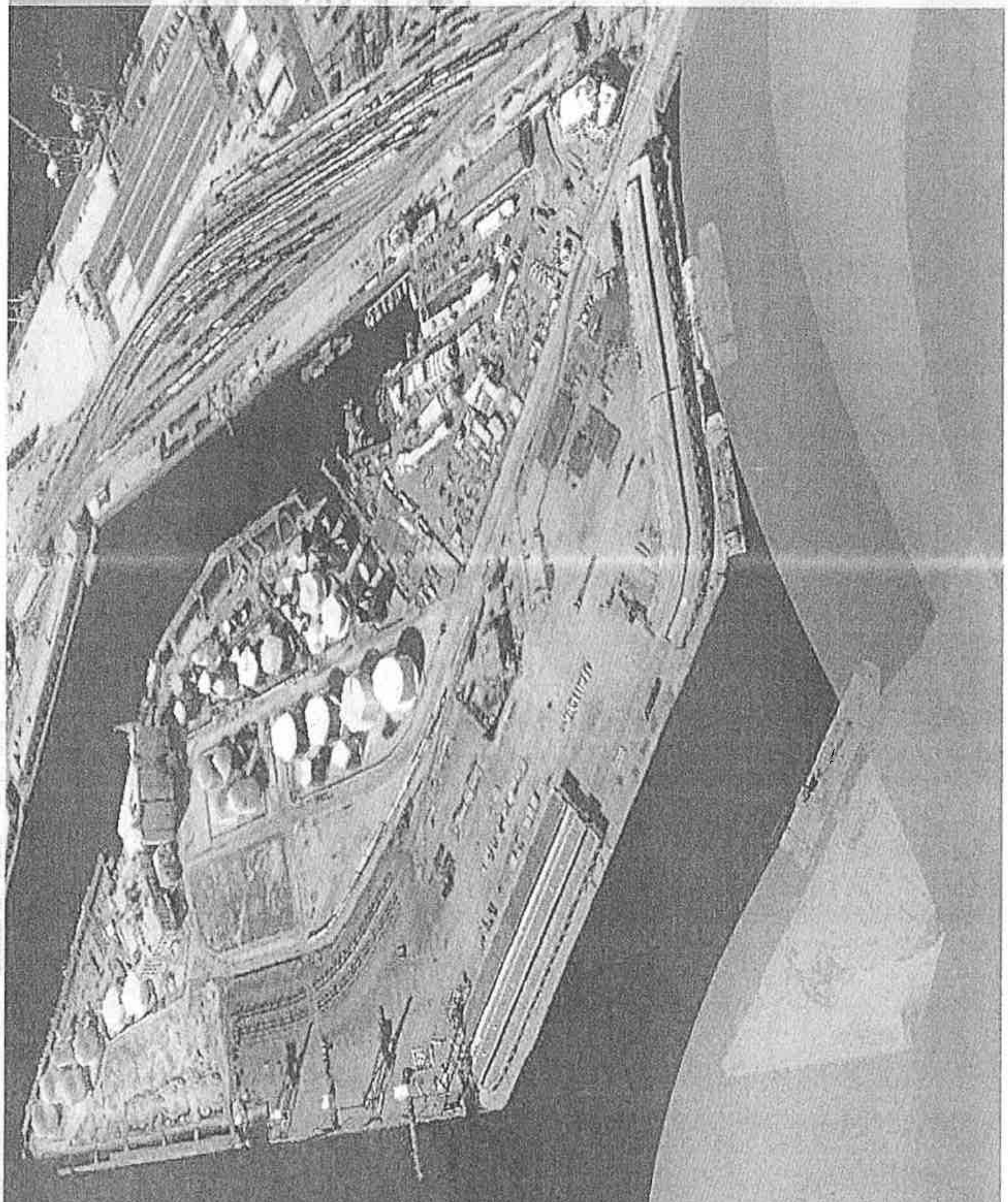
FOR EUGENE SEROKA

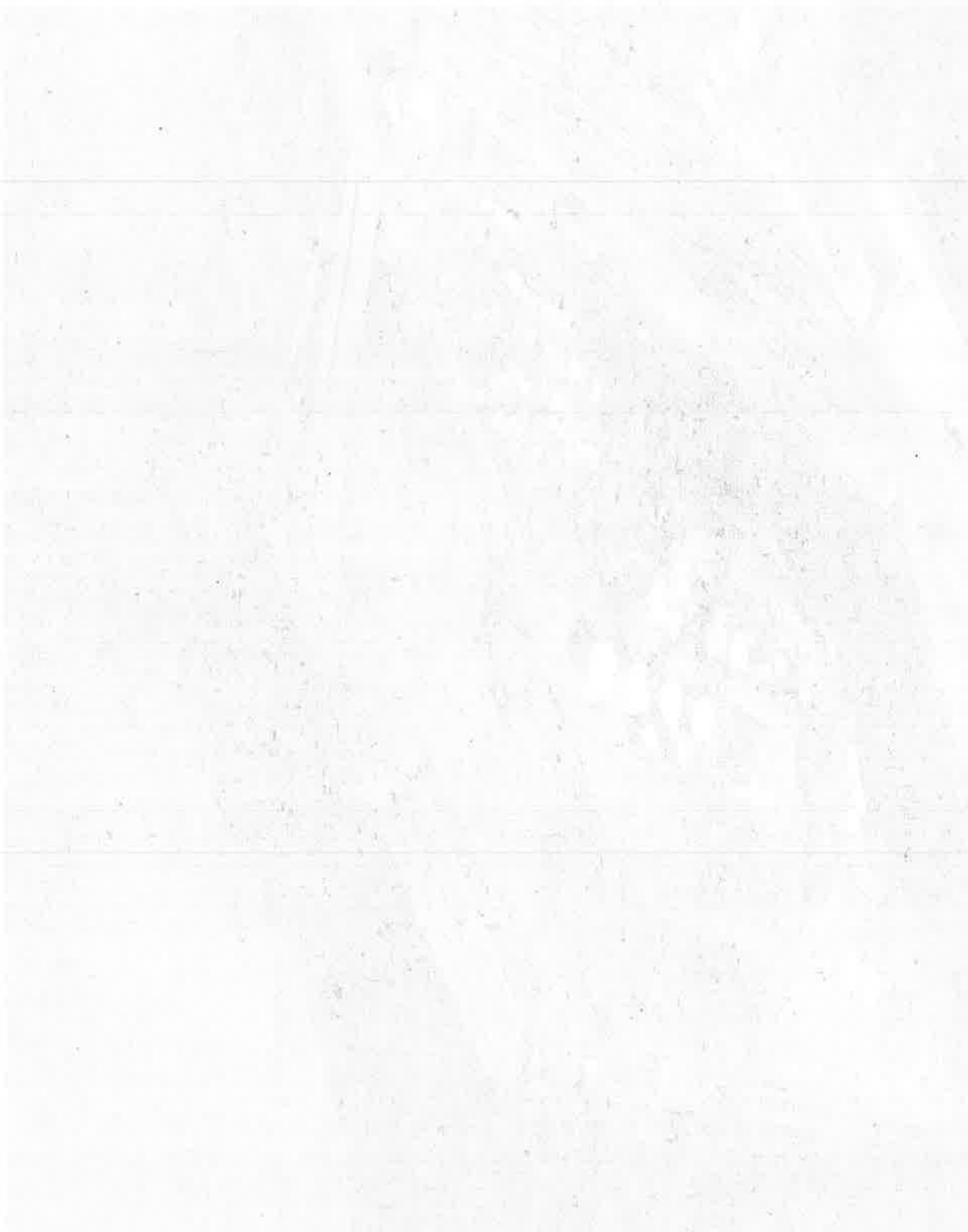
Third Party Certification (if applicable)

I have completed the application, in whole or in part, on behalf of the applicant.

Printed Name of Third Party:	Title:
Signature of Third Party:	Date:
Amount Being Paid for Application Completion in Whole or Part:	Source of Funding to Third Party:

ATTACHMENT 1





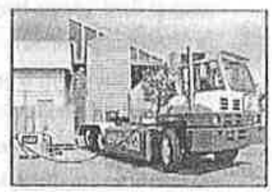
Attachment 1: APPLICANT QUALIFICATIONS

Evaluation Criteria
- ✓ Applicant Qualifications
- ✓ Project Team Capabilities and Industry Collaboration

The City of Los Angeles Harbor Department (Harbor Department or LAHD) has extensive experience developing, implementing, and administering technology demonstrations and projects that require detailed and active project management and coordination with technology providers, equipment and vehicle manufacturers, equipment operators, as well as other project stakeholders. The Ports of Los Angeles and Long Beach's landmark joint Clean Air Action Plan (CAAP) guides the Harbor Department in its commitment to reduce the health risks and air emissions associated with port-related operations, while allowing port development and growth to continue. A key element of the CAAP is its Technology Development Program (TAP), which accelerates the verification and commercial availability of new, clean technologies through evaluation and demonstration to move towards an emissions free port. Active since 2007, the TAP has considered numerous technology proposals covering a broad range of different port sources, ultimately approving 25 projects for TAP funding. To date, 18 TAP projects support or have supported technology development and/or demonstration of on-road drayage truck or off-road cargo handling equipment. Sample TAP projects relevant to this proposed project are summarized below:

TransPower Electric Drayage Pre-Commercial Truck Demonstration – This project develops and demonstrates a zero-emission battery-electric drive system for heavy-duty drayage trucks. TransPower's ElecTruck™ electric propulsion system is being integrated into seven Navistar International ProStar trucks. The TAP project is part of the Zero-Emission Cargo Transport Demonstration which is funded by the U.S. Department of Energy, South Coast Air Quality Management District (SCAQMD), and TransPower.

International Rectifier Plug-In Hybrid Electric Class 8 Truck Conversion –International Rectifier will convert a diesel drayage truck into a plug-in hybrid electric vehicle (PHEV). Once completed, the PHEV will be placed into drayage operations with Mega Fr8 Ways, Inc., a local operator. Performance and durability testing will be conducted to validate operation under various payloads and scenarios.



Foss Maritime Green Assist™ Hybrid Tugboat – In 2009, the Harbor Department contributed to the Foss Maritime Diesel Electric Hybrid Tugboat project. Christened the Carolyn Dorothy, the hybrid tug reduces particulate matter (PM), nitrogen oxide (NO_x) and carbon dioxide (CO_2) by 73%, 51% and 27%, respectively. To date, the Carolyn Dorothy has accumulated more than 8,000 operating hours. The project was funded in part by a $1,000,000 grant from the Air Resource Board's (ARB's) AB 118 Air Quality Investment Program.

In addition to the TAP, the Harbor Department is active outside the TAP to further demonstrate new technologies in port applications. Relevant examples include:

- *Electric Yard Tractor Demonstration Project* – In 2013, the Harbor Department was awarded $1 million from ARB's AB 118 Air Quality Improvement Program to integrate TransPower's electric drive technology into two off-road yard tractors. The two yard tractors are currently being demonstrated by port tenants. The project was completed in May 2015.
- *Cargo Handling Equipment Retrofit* – The Harbor Department was awarded $469,000 from the 2013 Defense Evaluation and Research Agency program to retrofit 14 pieces of cargo handling equipment with diesel particulate filters. Projects are on schedule and reporting is up to date.

Attachment 1: APPLICANT QUALIFICATIONS

> **$361 Million**
>
> *The amount of grant funds that we are successfully managing*

- *Shore Power Program* – In 2012, the Harbor Department was awarded $23.5 million by ARB to co-fund shore power installation. All 10 berths were completed by November 2014.
- *Eco-Crane* – U.S. Environmental Protection Agency (USEPA) awarded a $731,298 Emerging Technologies grant to the Harbor Department to demonstrate the Eco-Crane, a diesel-electric hybrid rubber tire gantry crane.
- *Early Shore Power* – USEPA awarded $1.2 million in June 2010 to supply electricity generated from a Flex-Grid System to container vessels while at berth. The final report was accepted by USEPA.
- *Vehicle Retrofits* – In 2009, USEPA awarded $2 million from the American Recovery and Reinvestment Act to retrofit 27 vehicles including harbor vessels, trucks, sweepers, loaders, cranes, and forklifts. The final report was accepted by USEPA.

The Harbor Department has 27 active cooperative agreements with the Transportation Security Authority and Federal Emergency Management Agency (FEMA) valued at $78 million, as well as 35 other federal and state grants. All government grants active at this time total over $361 million. The Harbor Department is consistent in its quarterly reporting and has successfully completed cooperative agreements with approved final reports submitted on time. In addition, the Harbor Department has a long history of implementing successful government grant partnerships. These include:

- The Air Quality Mitigation Incentive Program (AQMIP), a $29 million program that provided grant funding to port operators to reduce emissions that are surplus to existing regulations or other mandates. A wide range of projects have been implemented under the AQMIP, including marine vessel and cargo handling equipment repowers, truck and non-road equipment replacements, diesel emission reduction retrofits, and a number of innovative research and development projects.
- The Vessel Main Engine Fuel Incentive Program, which provided monetary incentive for the use of low-sulfur marine fuel in vessel main engines prior to state regulation.
- In July 2012, the Harbor Department launched the Environmental Ship Index Program to provide incentives to ships that obtain certain clean ship scores using an international rating system developed through the International Association of Ports and Harbors and World Ports Climate Initiative.
- The Harbor Department successfully manages the Vessel Speed Reduction (VSR) Program, an incentive program for vessels to reduce speeds in the designated VSR zone. In 2014, the compliance rate was 95% at 20 nm and 84% at 40 nm.
- The Harbor Department, as part of CAAP, oversees the Clean Truck Program, which calls for drayage truck owners to replace about 16,000 polluting trucks working at the ports, with the assistance of a port-sponsored grant or loan subsidy. The Harbor Department has contributed close to $70 million in funding to the Clean Truck Program, including grants.

These programs represent a voluntary, collaborative effort between Harbor Department and equipment owners and technology providers that spans decades. In addition, these projects demonstrate the Harbor Department's ability to successfully implement cooperative agreements, manage resources, meet reporting requirements, evaluate projects/initiatives, and document progress. Its extensive history implementing grant projects from both sides (grantor and grantee) uniquely positions the Harbor Department for this proposed project in that it has both managed and implemented technology development and demonstration programs for zero-emission vehicles and equipment.

Attachment 1: APPLICANT QUALIFICATIONS

Staff Information

The Green Omni Terminal Project will be led by senior Harbor Department staff who have administered and managed tens of millions of dollars of grant funded projects.

Name: Christopher Cannon	Hourly rate: $91.21
Phone: (310) 732-3763	Email: CCannon@portla.org
Title: City of Los Angeles Harbor Department Chief Sustainability Officer	
Expected duties: Project Director – Provides overall leadership and executive oversight for the project	

Name: Vahik Haddadian, PE	Hourly rate: $70.20
Phone: (310) 732-3647	Email: VHaddadian@portla.org
Title: Sr. Building Electrical Engineer	
Expected duties: Port Electrical Infrastructure Engineer – Reviews infrastructure designs and construction specifications to determine compliance with City and Harbor Department building and operational standards	

Name: Carter Atkins	Hourly rate: $50.78
Phone: (310) 732-7649	Email: Catkins@portla.org
Title: Environmental Scientist III	
Expected duties: Grant Administrator – Oversees grant administrative duties and coordination with ARB throughout the project	

Name: Tim DeMoss	Hourly rate: $55.21
Phone: (310) 221-4782	Email: TDeMoss@portla.org
Title: Marine Environmental Supervisor	
Expected duties: Technology Demonstration Lead – Oversees and coordinates technology demonstration partners participation in the project	

Attachment 1: APPLICANT QUALIFICATIONS

Subcontractor Information

The Harbor Department, as the Applicant, has partnered with end user facility, Pasha Stevedoring & Terminals (Pasha or PST), to implement the Green Omni Terminal Project. They have assembled the following team of subcontractors and partners to construct the terminal's infrastructure and design, manufacture, and test pre-commercial zero and near-zero emission technologies. Lead personnel for each teaming partner are presented in the following table. Qualification narratives are provided immediately following the table. Résumés of key personnel are provided in Exhibit A, and letters of commitment for subcontractors and partners are provided in Attachment 8.

Pasha Stevedoring & Terminals – End User Facility	
Name: Braxton Craghill	Hourly rate: N/A
Phone: (310) 233-2011	Email: braxton.craghill@psterminals.com
Title: Director of Finance	
Expected duties: Pasha Operations Lead – Oversees equipment operators and maintenance personnel in the use of demonstration vehicles and equipment	
Burns & McDonnell Engineering Company, Inc. - Subcontractor	
Name: Matthew Wartian, PhD	Hourly rate: $218.00
Phone: (858) 320-2945	Email: mwartian@burnsmcd.com
Title: Regional Global Practice Manager, Environmental Studies & Permitting	
Expected duties: Project Manager – Provides overall management of the project and subcontractors	
Los Angeles Department of Water & Power – Technical Advisor	
Name: Marvin Moon	Hourly rate: N/A
Phone: (213) 367-4211	Email: Marvin.Moon@ladwp.com
Title: Director of Power Engineering	
Expected duties: Technical Advisor – Provides utility advice on smart grid energy optimization scenarios	
South Coast Air Quality Management District – Technical Advisor	
Name: Matt Miyasato, PhD	Hourly rate: N/A
Phone: (909) 396-3249	Email: mmiyasato@aqmd.gov
Title: Deputy Executive Officer for Science & Technology Advancement	
Expected duties: Technical Advisor – Development and commercialization of clean air technologies	

Attachment 1: APPLICANT QUALIFICATIONS

UCLA Luskin Center for Innovation – Technical Advisor	
Name: J.R. DeShazo, PhD	Hourly rate: N/A
Phone: (310) 267-5435	Email: deshazo@ucla.edu
Title: Professor of Public Policy and Urban Planning	
Expected duties: Technical Advisor – Sustainable Energy Management, Policy and Economics	
UC Riverside Center for Environmental Research and Technology – Technical Advisor	
Name: Wayne Miller, PhD	Hourly rate: $200.00
Phone: (951) 781-5579	Email: wayne@cert.ucr.edu
Title: Adjunct Professor and Associate Director, CE-CERT	
Expected duties: Technical Advisor – Vehicle performance testing and data collection and analysis	
Coalition for Clean Air – Community Relations Advisor	
Name: Joseph Lyou, PhD	Hourly rate: N/A
Phone: (213) 223-6860	Email: joe@ccair.org
Title: President & CEO	
Expected duties: Disadvantaged Community Relations Advisor	
BYD Motors – Technology Demonstrator	
Name: Andy Swanton	Hourly rate: $250.00
Phone: (213) 748-3980	Email: andy.swanton@byd.com
Title: Director of Business Development	
Expected duties: Technology Demonstrator – Original Equipment Manufacturer of battery-electric drayage trucks, bus, and battery storage system	
Clean Air Engineering – Maritime – Technology Demonstrator	
Name: Nick Tonsich	Hourly rate: N/A
Phone: (310) 241-1208	Email: ntonsich@caemaritime.com
Title: Principal	
Expected duties: Technology Demonstrator – Implementation of the "ShoreCat" emissions treatment system	

Attachment 1: APPLICANT QUALIFICATIONS

Envision Solar – Technology Demonstrator	
Name: David Greenfader	Hourly rate: N/A
Phone: (310) 961-4669	Email: david.greenfader@envisionsolar.com
Title: Vice President Business Development	
Expected duties: Technology Demonstrator – Modular solar-powered electric vehicle (EV) charger	
PermaCity Construction Corp. – Technology Demonstrator	
Name: John Mason	Hourly rate: $150.00
Phone: (323) 692-9264 ext. 205	Email: jmason@permacity.com
Title: Commercial Sales Manager	
Expected duties: Solar Photovoltaic (PV) System Installer – Leads the installation of the 1 megawatt (MW) solar PV system	
Transportation Power, Inc. – Technology Demonstrator	
Name: Mike Simon	Hourly rate: $132.21
Phone: (858) 248-4255	Email: mike@transpowerusa.com
Title: President & CEO	
Expected duties: Commercialization Lead – Assists TransPower project manager in project planning and financial administration, review and approve major supplier agreements, and lead outreach and commercialization activities	

Attachment 1: APPLICANT QUALIFICATIONS

Subcontractor Qualifications Narratives

To develop a solar-powered, sustainable, and resilient Green Omni Terminal, the Harbor Department has partnered with industry leaders in goods movement, energy infrastructure development, zero and near-zero emission technology development and demonstration, academia, and the local community. The following partners, subcontractors, and advisors will support this demonstration project and help realize the overall vision for the terminal.

Evaluation Criteria

- ✓ Project Team Capabilities and Industry Collaboration
- ✓ Technology and Innovation
- ✓ Benefit to a Disadvantaged Community
- ✓ Potential for Market Penetration and Commercialization
- ✓ Potential Emission Reduction Benefits
- ✓ Cost Effectiveness

Pasha Stevedoring & Terminals Qualifications

Pasha Stevedoring & Terminals, LP will serve as the end user facility. The vision for its Port of Los Angeles (Port or POLA) terminal is to become a laboratory for the integration of zero and near-zero emission goods movement technologies into a solar-powered microgrid. In doing so, they will create a Green Omni Terminal that will serve as a scalable, sustainable, and resilient model for terminals, distribution centers, and industrial facilities in California, the United States, and the world.

PST is a division of the Pasha Group, a family-owned diversified global logistics and transportation services company. Their mission is to be a leader in providing customized, cost-effective, and profitable value-added services to the automotive, maritime, and relocation industries by integrating their network of global logistics entities and strategic partners. Pasha's continuing investment in their employees, technology, facilities, and equipment enhances productivity, leading to increased quality and profitability for their customers.

Breakbulk/Container Stevedoring

Pasha's state-of-the-art omni break-bulk and container terminal in the Port has become the preferred terminal for general, project, heavy lift, and specialized cargoes of all shapes and sizes. Two transcontinental railroads and three major interstate highways provide direct access to all regions of the United States, Canada, and Mexico. As terminal operator, Pasha offers a full array of related services, including contract stevedoring, import/export management, and ocean vessel chartering. Pasha also provides third-party container stevedoring services for major carriers.

Pasha provides expert vessel loading and unloading services for the global maritime transportation industry in the Port, accommodating a multitude of commodities and standard ocean-going containers. As the operator of the only true omni cargo terminal in the Port, Pasha serves as an ideal test facility for diverse goods movement.

Braxton Craghill, PE

Braxton Craghill is Pasha's Director of Finance. He is an expert in managing complex logistical operations and marine terminals, and will serve as Pasha's primary point of contact for the grant program. He has successfully obtained and implemented $6 million in grant funds from FEMA to implement security improvements at the terminal. At the time, Pasha was one of the largest recipients of federal grants to a private company in the Port. Braxton will serve as the Facility Operations Lead for the Green Omni Terminal Project.

Burns & McDonnell Qualifications

BURNS McDONNELL. Burns & McDonnell Engineering Company, Inc. will serve as the design-build engineer and will support the Harbor Department in managing the Green Omni Terminal Project. Burns & McDonnell is an internationally recognized engineering, architectural, construction, environmental, and consulting solutions firm. For more than 115 years, Burns & McDonnell has planned, designed, permitted, constructed, and managed projects all over the world with one mission in mind— to "Make Our Clients Successful". The firm has experience in all types of technologies and services required for this project including:

- Facility assessments and audits
- Energy policy, planning, and market trends
- Clean/renewable energy distribution
- Sustainability and climate change
- Energy efficiency and resilience
- Regulatory compliance
- Alternative fuels

The Burns & McDonnell team has completed more than 30 utility and energy master plans and worked on more than 50 large and small facility utility systems, including at seaports. This knowledge and experience provides a solid platform to develop the next generation of infrastructure planning and energy efficiency for the Port.

Case Studies

Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) – Phase I Design-Build

Joint Base Pearl Harbor Hickam, Hawaii

- The team designed and constructed a microgrid to improve energy reliability
- Incorporated existing infrastructure with renewable energy sources including solar, wind and battery storage
- Successfully met an aggressive one-year design-build schedule without significant impact to operations

Net Zero Facility Design & Implementation

Hawaii National Guard Joint Base Pearl Harbor-Hickam, Hawaii

- Evaluated and developed energy conservation measures and renewable energy solutions
- The project team integrated and designed efficient technologies including solar to successfully achieve net-zero energy usage

Team Member Qualifications

Matt Wartian, PhD

Dr. Matt Wartian will be the project manager for the Green Omni Terminal Project and will manage the team's efforts during all phases of work. He has led multi-disciplinary teams to deliver innovative approaches to assess environmental issues in port, harbor, and coastal systems. Matt has managed multi-year and multi-million dollar feasibility and impact assessments for coastal and offshore electrical infrastructure projects. He works with engineering teams to identify energy management and electrical system continuity solutions at California ports and is the project manager for POLA's Energy Management Action Plan and the Port of Oakland's Energy Innovation Study.

Attachment 1: APPLICANT QUALIFICATIONS

Technical Advisors Qualifications

The **Los Angeles Department of Water and Power (LADWP)**, as the local utility servicing the Port, will advise the project team on utility connections and smart grid energy optimization scenarios, such as demand response. Currently the largest municipal water and power utility in the nation, LADWP was established more than 100 years ago to deliver reliable, safe water and electricity to 3.8 million residents and businesses in Los Angeles. LADWP provides its 666,000 water customers and 1.4 million electric customers with quality service at competitive prices.

LADWP is also at the forefront of renewable energy and EV development and commercialization. They are playing an instrumental role in developing infrastructure to prepare Los Angeles and Southern California for the next generation of electric and plug-in hybrid vehicles. And, they are currently working with UCLA and the University of Southern California to research and test EV integration into the electric grid.

Marvin Moon

Marvin Moon will serve as the utility technical advisor. He is the Director of the Power Engineering Division, and is responsible for the design and management of all projects related to the Power System infrastructure for LADWP. This includes projects for generation, substations, transmission, renewable projects, and the distribution system. He is also LADWP's EV Program Manager. He has been recognized as an Innovator by the Electric Power Research Institute, and has twice received the Los Angeles City Productivity Award.

The **South Coast Air Quality Management District (SCAQMD)** will advise the project team on development and commercialization of clean air technologies. SCAQMD is the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Riverside, and San Bernardino counties. This area of 10,743 square miles is home to over 16.8 million people—about half the population of the whole state of California. It is the second most populated urban area in the United States and one of the smoggiest. SCAQMD is committed to undertaking all necessary steps to protect public health from air pollution, with sensitivity to the impacts of its actions on the community and businesses. This is accomplished through a comprehensive program of planning, regulation, compliance assistance, enforcement, monitoring, technology advancement, and public education.

Matt Miyasato, PhD

Dr. Matt Miyasato will serve as a technical advisor to the project. He has an undergraduate degree in Mechanical Engineering, and a Masters and Ph.D. in Engineering, specializing in combustion technologies and air pollution control. Prior to SCAQMD, he worked at Southern California Edison in the Nuclear Engineering Department and at General Electric, where he designed burners and combustion modifications for utility boilers. He also conducted research on combustion phenomena, active control, and laser diagnostics at UC Irvine.

Currently, Dr. Miyasato leads the Demonstration, Implementation, Best Available Control Technologies, and Technology Outreach groups at SCAQMD. He oversees SCAQMD's efforts to develop, demonstrate, and commercialize clean technologies including fuel cells, hydrogen, alternative fueled engines, and NO_x after-treatment, hybrid and plug-in hybrid EVs, and other clean air technologies.

Attachment 1: APPLICANT QUALIFICATIONS

Luskin Center FOR INNOVATION

The **UCLA Luskin Center for Innovation (Luskin Center)** will support the project by evaluating financial costs, as well as greenhouse gas (GHG) and environmental benefits relative to baseline technologies. The Luskin Center will also assess the role that policy incentives and technology cost trends will play in encouraging adoption by other terminal operators, and quantify the GHG, air pollution, and economic development benefits of scaling these technologies to other terminals at POLA and POLB, as well as other ports.

The Luskin Center unites the intellectual capital of UCLA with forward-looking civic leaders to address the most pressing issues confronting the community, nation, and world. They partner with leaders from the public, private, and civil society sectors to advance environmental sustainability in Los Angeles through a mixture of scholarship, research, and community engagement.

J.R. DeShazo, PhD

Dr. J.R. DeShazo is the Director of the Luskin Center for Innovation at the University of California at Los Angeles. He also is a Professor and Vice Chair of the Department of Public Policy in the Luskin School of Public Affairs at UCLA, where he is an expert in economics, public finance, and organizational governance. He holds a Ph.D. in Urban Planning from Harvard University and a M.Sc. in Economics from Oxford University, where he was a Rhodes Scholar. Dr. DeShazo's recent research has focused on local public finance, regulatory reform, climate change policy, and solar energy policy. His work also supports the California Air Resources Board and the Southern California Association in their effort to implement AB 32, the Global Warming Solutions Act, and its complementary SB 375, transportation and land use bill.

UNIVERSITY OF CALIFORNIA UCRIVERSIDE

UCR Center for Environmental Research & Technology (CE-CERT) will support the collection and analysis of performance data on zero-emission vehicles relative to baseline vehicles. In recent years, they have assisted the Harbor Department with performance evaluations of zero emission yard tractors and drayage trucks using their heavy duty truck dynamometer. CE-CERT has also completed a number of field studies to characterize vehicle emissions and field activities. They played a central role in validating portable emissions measurement systems (PEMS) used in USEPA's heavy-duty vehicle in-use testing program through the Measurement Allowance Program. As part of this program, CE-CERT conducted in-use testing validation using their Mobile Emissions Laboratory (MEL). The MEL is a self-contained emissions laboratory that is towed by the vehicle being tested. It is capable of collecting and analyzing total vehicle emissions in real driving conditions.

UCR is also a leading research institute in characterizing in-use emissions using PEMS and the MEL. UCR assesses light-duty vehicles, heavy-duty vehicles, construction equipment, ships, port support equipment, trains, and even jet aircraft. They offer a separate PEMS system based on a Horiba PG250 portable multi-gas analyzer for steady state measurements meeting ISO 8178 requirements. This system has been used for testing on ships, generators, and port support equipment. UCR developed protocols to verify emission control technologies for generators, marine vessels, and rubber tire gantry cranes.

Case Studies

Aerodynamic GHG Emissions Reduction Assessment of Non 53-foot Trailers Pulled by Heavy-Duty (HD) Tractors

Air Resources Board

UCR is gathering data to help ARB determine if trailers that are not subject to the Tractor-trailer GHG regulation (exempted trailer) would benefit from using similar aerodynamic technologies. The study will help determine if HD tractors pulling exempted trailers operate at high enough speeds to accrue enough annual vehicle miles traveled (VMT) to benefit from improved aerodynamics. Because of the diversity of possible trailer types, VMT, and fleet operations; the first steps of the study will assess a variety of fleets and their real-world performance.

Collection of Activity Data from On-Road Heavy-Duty Diesel Vehicles

Air Resources Board

UCR is performing a screening analysis to identify which truck types and uses contribute the most NO_x emissions in California. They are outfitting 80 trucks with GPS data loggers, and an additional 20 with ECU and GPS data loggers to reveal activity profiles and analyze if the vehicle certification cycle reflects real world emissions for different types of heavy-duty diesel vehicles and uses.

Wayne Miller, PhD

Dr. Wayne Miller will advise the project on data collection and analysis of battery EV performance and emissions reductions. Dr. Miller joined UCR's CE-CERT lab in December 2000 after a distinguished career with Sunoco and UNOCAL. He has more than 39 years of experience in technology planning, new product commercialization, and working within multi-national relationships. He was a member of several nationally acclaimed studies investigating refinery products and the environment. His research measures gaseous and particulate emissions from a multitude of fuels and sources under real world operating conditions

Disadvantaged Community Advisor Qualifications

COALITION FOR CLEAN AIR

The **Coalition for Clean Air (CCA)** will participate as a disadvantaged community advisor, providing insights on how the project can provide economic, environmental, and community benefits to the Wilmington DAC, as well as the broader region. CCA is California's only statewide nonprofit dedicated exclusively to advocating for healthy air. Their unique collaborative model brings all interested parties together to find cooperative solutions to California's most pressing air quality issues. For over 40 years, they have made significant improvements to California's air by: advocating innovative policy solutions, encouraging new technologies, advising businesses on clean air practices, and educating decision-makers and the public on air pollution solutions. The CCA will help our team engage the local DAC.

Joseph Lyou, PhD

For more than 20 years, Dr. Joseph Lyou has advocated for environmental justice and protection of air quality throughout California. He is currently CCA's President and CEO and a governor's appointee to the SCAQMD Governing Board. Prior to CCA, He also founded the California Environmental Rights Alliance and held management positions with the California League of Conservation Voters and Committee to Bridge the Gap. Dr. Lyou's role will be to confirm that the project team hears and understands community-specific issues and concerns.

Attachment 1: APPLICANT QUALIFICATIONS

Technology Demonstrators Qualifications

BYD Company Limited (BYD) will serve as a technology demonstrator for zero emission vehicles and battery storage stations (BSSs). As an original equipment manufacturer (OEM), BYD will directly support the commercialization of demonstration equipment. BYD has operations in every developed country in the world, and with more than $9 billion in revenue and 180,000 employees worldwide they have the financial resources, technology, and organizational depth to continuously design, refine, and manufacture world class products for the global markets that they serve. A battery company first and foremost—BYD manufactures approximately 25% of the world's rechargeable batteries. Their iron phosphate (Fe) battery was purpose built for vehicle electrification and has already achieved price parity with traditional lithium ion batteries which have reached their technological maturity. In contrast, BYD's Fe technology has gained a 10% increase in energy density year over year.

BYD's expertise in each of the three components of microgrids makes it an ideal partner for the Green Omni Terminal Project. They have already achieved wide-scale commercialization of 100% battery electric transit buses and taxis—more than 50 million operating miles in both categories. BYD has developed BSSs that can store up to 40 megawatt hours (MWh); and solar farms that can produce up to 75 megawatts (MW). Electric trucks are the next focus area for their company and they have 1,000 research and development engineers dedicated to these product lines. BYD manufactures every major component, starting with the batteries and battery management system (BMS), and including the inverters and traction motors. This vertical integration means that all the major components will communicate seamlessly. They will provide high performing and reliable electric trucks that allow Pasha to continue operating their facility in the exact same fashion as with diesel vehicles.

Their approach would make Pasha the gold standard for truck electrification. The project also will have exposure to the highest levels of BYD's organization, ensuring that there will be no shortage of financial and engineering resources to make the project a success. Successful execution on this project will allow BYD to invest in building dedicated manufacturing resources for their truck product lines right here in California.

Andrew Swanton
Andrew is a graduate of both the Massachusetts Institute of Technology and Harvard Business School. He has led engineering design and research & development teams throughout the United States, and across industry sectors. He is experienced in developing and tracking performance metrics, improving product quality, team accountability, and client satisfaction. Andrew is located within 30 minutes form the project site and will provide close coordination with the Harbor Department, Pasha, and the project implementation team.

Clean Air Engineering – Maritime, Inc. (CAEM) will demonstrate a new "ShoreCat" at-berth vessel emissions control system. CAEM is the developer and operator of the Marine Exhaust Treatment System (METS-1). With minimal contact with the ship, METS-1 captures and treats emissions from ocean-going vessels while at berth in port, and is the only ARB-approved alternative control technology to comply with ARB's At-Berth Regulation. The exclusive CAEM/Tri-Mer Corporation (Tri-Mer) emissions treatment unit provides the greenest solution for treating ship exhaust and related equipment sources with minimal environmental impacts. Byproducts of the treatment are completely dry, non-Resource Conservation and Recovery Act and non-hazardous. Additionally, there are no liquid waste disposal issues.

Attachment 1: APPLICANT QUALIFICATIONS

A portion of the funding for the development of the METS-1 was provided in the form of a TAP grant issued by the Port to TraPac, LLC. TraPac in turn contracted with CAEM pursuant to the TAP grant. CAEM subsequently successfully completed various milestones within the provisions of the grant to achieve funding payments. CAEM works closely with Tri-Mer who manufactures the exhaust treatment portion of the METS-1 sytem. Tri-Mer will also be manufacturing the prototype ShoreCat for use in this demonstration project. The ShoreCat will have the ability to treat CO_2 as well as the other constituents treated by METS-1.

Nicholas Tonsich

Nicholas Tonsich is the President of CAEM. He will be responsible for the successful development, implementation, and operation of the ShoreCat treatment system, which is the same role that he provided for METS-1. Mr. Tonsich is an attorney, as well as a Principal in CAEM. Mr. Tonsich is also the owner of Ocean Terminal Services, Inc., a maintenance and repair company that employs 120 International Longshore and Warehouse Union (ILWU) mechanics for repair of terminal equipment and quayside cranes in the Cities of Los Angeles and Long Beach.

Envision Solar (Envision) is a small publicly traded manufacturer based in San Diego, CA. They will provide a modular, grid-independent, and solar-powered EV charging unit for employee and passenger vehicles called EV ARC™ (EV Autonomous Renewable Charger). They invent, design, and manufacture solar products and proprietary technology solutions for EV charging infrastructure, renewable energy production, and disaster preparedness. Envision creates renewable energy platforms for EV charging that integrate simple, commonly available engineered components. The resulting products are built to have the longest life expectancy and meet the energy needs of their customers. Envision's products deliver multiple layers of value including EV charging, renewable and reliable energy production, reduced carbon footprint, and reduced net operating costs.

The EV ARC™ is transportable and delivered ready to use. The EV ARC™ can solve many problems associated with deploying EV charging infrastructure. Deploying traditional charging systems can be complicated due to site layout constraints, invasive infrastructure, and rapidly changing operational needs. The EV ARC™ is entirely self-contained and delivered to the site ready to operate. It requires no foundation, trenching, concrete, electrical, or civil works and can be deployed in minutes. Its high traction ballasted base pad creates a structurally sound platform that supports the rest of the structure. Envision's products qualify for various federal, state, and local incentives, which could reduce final out-of-pocket costs by more than 50%.

David Greenfader

David Greenfader is a multi-lingual executive with more than 20 years of experience in international sales, business development, and human capital in the U.S., Asia, and Latin America. David spearheads strategic sales and business development initiatives across a multitude of channels including a statewide contract with the State of California's Department of General Services to implement the EV ARC™ - the world's first full transportable solar tracking EV charging station. Prior to Envision Solar, David worked in the renewable energy sector, providing business development consulting for companies that feature PV, solar thermal and alternative energy technologies.

Attachment 1: APPLICANT QUALIFICATIONS

PermaCity
the solar evolution

PermaCity will install the 1 MW solar photovoltaic (PV) array on the Berth 181 Warehouse rooftop. PermaCity has more than 12 years of experience developing and installing solar installations in Southern California and across the United States. They have maintained steady growth with more than 42 MW of installed projects, which they have achieved through their commitment to high quality and customer satisfaction. PermaCity will employ its most recent innovation, their patent-pending SolarStrap™ racking system, on the Berth 181 rooftop. The system will be bonded to the new roof, making it stronger, lighter, and more cost-effective than other rooftop racking solutions. On most roofs, the SolarStrap™ is non-penetrative and non-ballasted (the only such design approved in Los Angeles County), eliminating conventional fears and concerns about rooftop integrity associated with roof-top solar infrastructure. They will work hand-in-hand with their roofing contractor to optimize labor efficiency, enhance safety, control quality, and reduce installation time.

Case Studies

CLEAN LA Solar Project

After a highly competitive selection process, LADWP selected PermaCity to install nearly 30 MW of solar on nearly 5 million square feet of rooftop, across the Los Angeles Basin under the CLEAN LA Solar, or feed-in-tariff program. Unlike other solar developers that must go through a public lottery selection process, PermaCity has been pre-approved to build projects under the CLEAN LA program.

Commercial Rooftop Solar Projects

PermaCity installed rooftop solar panels on more than 30 Costco locations since 2007, including the largest solar roof in California. PermaCity also completed the largest rooftop solar installation in Los Angeles and the third largest in California, a 5.1 MW installation for retail clothing giant Forever 21's headquarters and distribution center. This is the first installation in the history of the county that leverages both LADWP's net metering and feed-in-tariff programs. Their other achievements include winning the Los Angeles Business Council's Best Sustainable Retrofit Award in 2011 for their patented solar car canopy designed for Cathay Bank.

John Ortega, Director of Project Management

Mr. John Ortega has Class A and Class B contractor licenses from the State of California and has worked as either a project manager or owner's representative on more than 20 MW of commercial solar electric installations. John brings decades of construction knowledge to this project and he specializes in specification review, contractor selection, specification compliance, project-work coordination and management, coordination with permitting agencies, project implementation and project documentation, equipment purchases, budget planning, estimating, change order management, scheduling, job costing, invoicing, installation, and close-out. John will manage the installation of the solar PV system at Pasha.

TransPower

Transportation Power, Inc. (TransPower) is a California-based corporation that was founded in 2010 to manufacture components for zero-emission heavy-duty vehicles. Over the past five years, TransPower has established itself as an industry leader in adapting zero emission technologies to port vehicles such as drayage trucks, yard tractors, and top handlers—all of which are key elements of this project. They have been actively preparing for this solicitation for the past two years by deploying industry-leading prototypes that have validated the feasibility of using EVs for many port applications. During the Green Omni Terminal Project, TransPower will demonstrate the following pre-commercial zero-emission technologies: battery electric yard tractors, drayage trucks, 21-ton forklifts, and top handler.

Case Studies

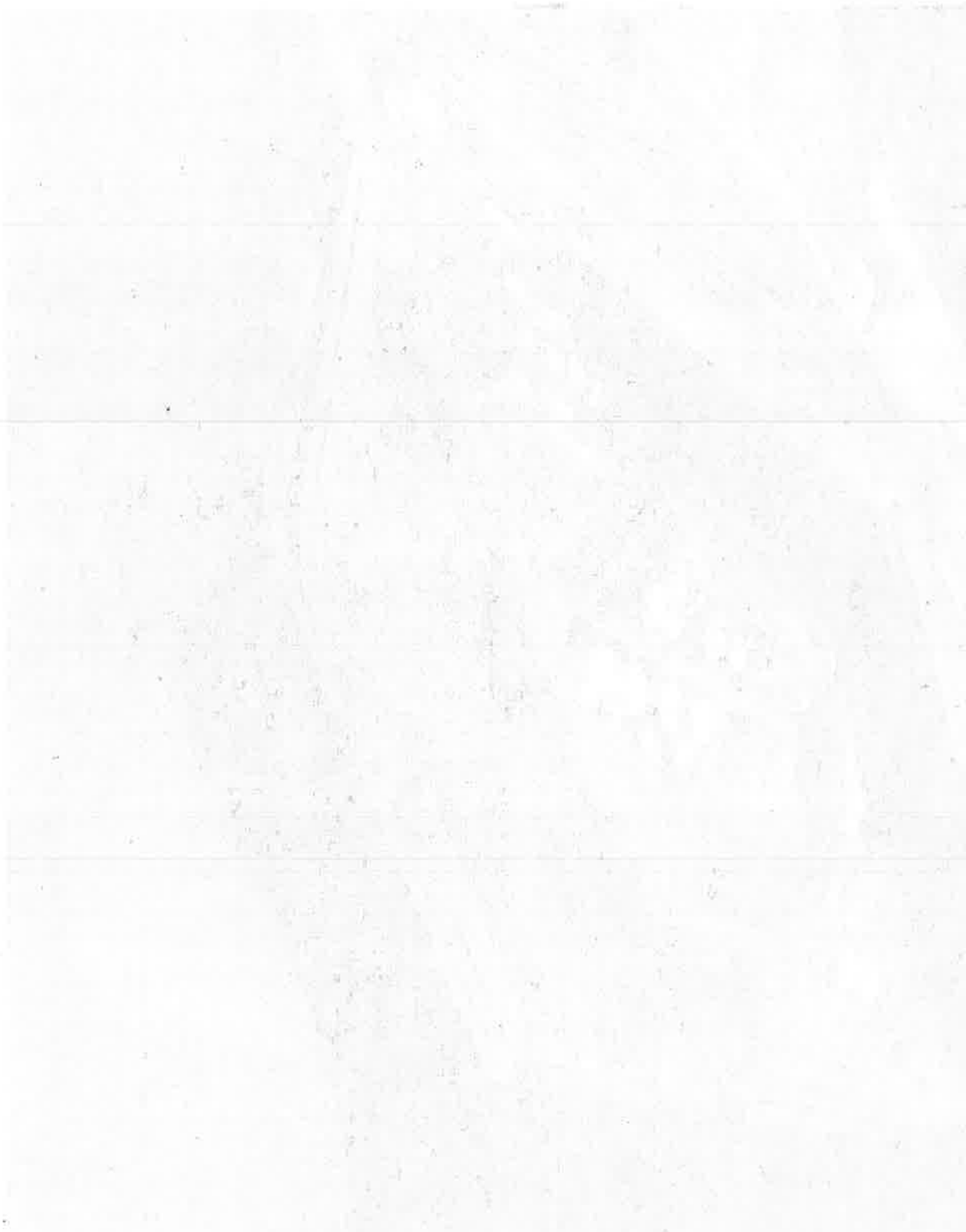
Manufacturing reliable electric port and multi-source vehicles is a task TransPower has addressed effectively in a series of demonstration projects funded by grant projects similar to the Multi-Source Facility (MSF) project. TransPower's initial business was focused on developing an "ElecTruck™" battery-electric drive system for drayage trucks and branched into developing battery-electric yard tractors. TransPower then installed an electric drive system into a top handler at the Port of San Diego. To date, TransPower has secured more than $30 million in funding commitments for Class 8 truck, yard tractor, and cargo handler demonstrations, along with funding for two different school bus models – all from grants similar to the anticipated MSF grant. In fact, development of their current generation yard tractor system was funded in part by an ARB/AQIP grant for "Electric Yard Tractor Development," which the Company successfully completed in 2015. When work is completed on all its current and prior grants, TransPower will have 40 medium and heavy-duty electric, hybrid, and fuel cell demonstration vehicles on California roads, including 28 Class 8 vehicles related to port or multi-source facilities—12 of which are used in actual service.

The technology demonstrator role proposed for TransPower on the Green Omni Terminal Project is identical to the role they have played on most, if not all, of their prior grant programs. Key aspects of their role are to analyze vehicle requirements, design and manufacture advanced technology zero or near-zero emission components that meet these requirements, and provide turn-key integration and support of vehicles using these components. TransPower has established itself as an industry leader in performing this role, particularly for Class 8 EVs that have demanding performance requirements.

Michael Simon, TransPower Program Control Manager

Mike Simon will manage administrative and budgeting activities relating to TransPower tasks, as well as actively participate in the development and execution of commercialization plans. Mr. Simon has 38 years of professional experience with a unique blend of technical and economic expertise, along with a lifelong focus on transportation and energy technologies, which has enabled him to achieve numerous successes in commercialization of new technologies. Mr. Simon is the founder, President, and CEO of TransPower, and under his leadership the company has grown from generating less than $1 million in 2011 to nearly $6 million in revenue in 2015 and more than $12 million in 2016.

ATTACHMENT 2



Attachment 2: PROJECT EXECUTIVE SUMMARY

Applicant: Los Angeles Harbor Department
End User Facility: Pasha Stevedoring & Terminal
Technology Demonstrators: BYD, CAEM, Envision Solar, PermaCity, TransPower
Design-Build Management: Burns & McDonnell
Technical Advisors: LADWP, SCAQMD, UCLA Luskin Center, UCR CE-CERT
Community Advisor: Coalition for Clean Air
Funding Amount: $15,167,200
Funding Match: $12,092,000

The Harbor Department and Pasha are partnering together to develop a Green Omni Terminal at Pasha's POLA Terminal in the Wilmington disadvantaged community (DAC). The vision for the terminal is to incorporate zero and near-zero emissions cargo handling equipment to move goods from ships through the terminal to clean transportation to their final destinations, while making portions of terminal operations more resilient through solar power generation and battery storage.

Near-commercial electrified cargo handling equipment, including yard tractors, 21-ton forklifts, and a top handler will be demonstrated at the terminal along with on-road electric drayage trucks and an electric bus for moving workers between facilities. Electric equipment will be powered by standardized charging infrastructure that can power different manufacturer's equipment. An at-berth vessel emission control system will be integrated into the project to address the largest source of greenhouse gas (GHG) and priority pollutant emissions at the terminal. Lastly, a modular, solar-powered passenger vehicle charging system will be installed in the employee and visitor parking lot to provide solar-powered EV charging.

A 1 MW rooftop solar PV array will be added to the terminal to supplement current power usage and help meet resiliency objectives. The system will be capable of meeting 100% of Pasha's current electricity demands for terminal operations. When combined with a 2.6 MWh battery storage system (BSS) and microgrid/energy management control system, key elements of the facility will be able to remain operational for finite periods of time when islanded from the electrical grid in the event of power outages caused by unforeseen man-made and natural events.

The Harbor Department and Pasha are committed to conducting sustainable terminal operations that reduce their overall environmental footprint, while enhancing the surrounding Wilmington DAC and the local and national economy. The Green Omni Terminal Project will serve as the first step in transitioning the Pasha terminal to a zero emission terminal, while serving as a scalable model that can be replicated at other ports and industrial facilities throughout California, the country, and the world.

By funding the Port of Los Angeles Green Omni Terminal, Cap and Trade funds will:

1. Reduce 3,230.7 tons per year (tpy) of CO_2e, 0.623 tpy of diesel particulate matter (PM_{10}), 25.9 tpy of nitrogen oxides (NO_x), and 1.44 tpy of reactive organic gases (ROG) emissions in a disadvantaged community that is not meeting National Ambient Air Quality Standards.
2. Create a test facility for the commercialization of zero and near-zero emission technologies that can move break bulk and containerized cargo.
3. Demonstrate terminal resiliency, where critical operational elements can operate independent of the grid in the event of a loss of grid power due to natural or man-made events.
4. Serve as a catalyst for change in the San Pedro Bay Port Complex, and provide cost-effective and scalable solutions for thousands of marine terminals and distribution facilities throughout the state, nation, and world.

Attachment 3: PROJECT NARRATIVE AND WORK PLAN

Project Narrative

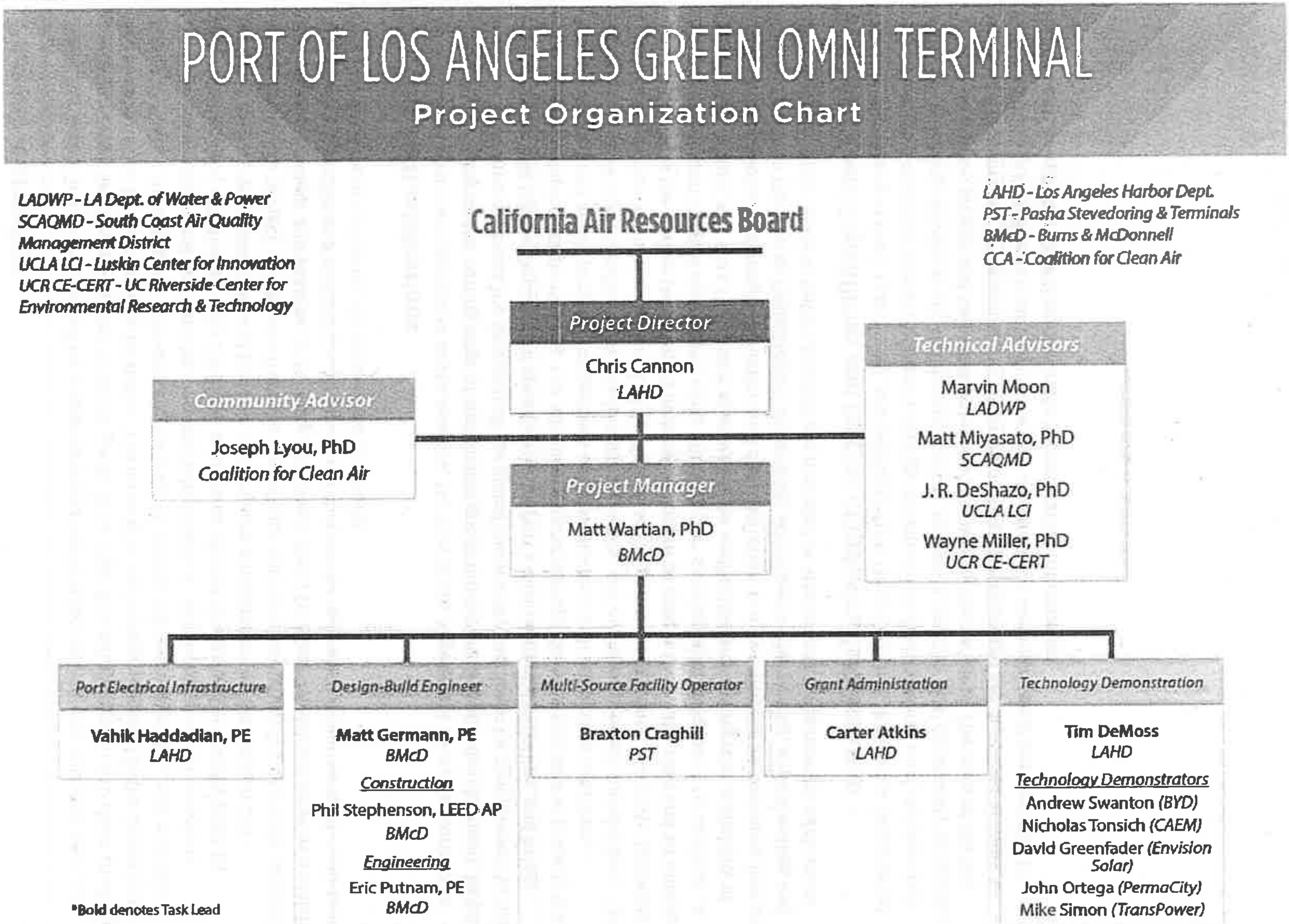
The POLA Green Omni Terminal will be a solar-powered resilient facility that uses zero and near-zero emissions cargo handling equipment to move goods from ships through the terminal to clean truck and rail transportation to their final destinations. The innovative technology proposed in the Green Omni Terminal Project, including the solar-powered microgrid, energy efficiency upgrades, zero emission cargo handling equipment and vehicles, charging infrastructure, and ShoreCat vessel emissions treatment system, will directly help California achieve its climate change and air quality goals by reducing GHG, criteria pollutant, and toxic air contaminant emissions in the Wilmington DAC. Furthermore, the project will demonstrate the operational and commercial viability of a wide range of electrified equipment and vehicles. In so doing, the Green Omni Terminal Project will serve as a scalable model for sustainable and resilient goods movement that can be replicated at thousands of multi-source facilities throughout California, the nation, and the world.

1. Applicant Qualifications

As the busiest container terminal in North America, the Port of Los Angeles has earned a world-class reputation of being on the cutting edge of sustainable goods movement and port development, helping the Port simultaneously meet the demands of the global community and honor its commitment to the environment. The Harbor Department spearheads the Port's environmental initiatives, and brings experience developing, implementing, and administering technology demonstrations and projects that require detailed and active project management and coordination with technology providers, equipment and vehicle manufacturers, equipment operators, and numerous project stakeholders. This experience includes administering over $361 million in active government grants. The Ports' landmark joint CAAP guides the Harbor Department in its commitment to reduce the health risks and air emissions associated with port-related operations, while allowing port development and growth to continue. A key element of the CAAP is its TAP, which accelerates the verification and commercial availability of new, clean technologies through evaluation and demonstration to move towards an emissions free port. Further details on the Harbor Department's experience and expertise developing, implementing, and administering similar demonstration projects are provided in Attachment 1: Applicant Qualifications.

2. Project Team Capabilities and Degree of Industry Collaboration

To develop a solar-powered, sustainable, and resilient Green Omni Terminal, the Harbor Department and Pasha have identified industry leaders in energy infrastructure development, zero and near-zero emission technology development and demonstration, academia, and the local community to support this demonstration project and help realize the overall vision for the terminal. The roles of the key project participants are presented in the following organization chart and are described in Table 1. Further details on the Green Omni Terminal team's qualifications and experience are provided in Attachment 1: Applicant Qualifications under Subcontractor Information.



PORT OF LOS ANGELES GREEN OMNI TERMINAL
Project Organization Chart
LADWP - LA Dept. of Water & Power
SCAQMD - South Coast Air Quality Management District
UCLA LCI - Luskin Center for Innovation
UCR CE-CERT - UC Riverside Center for Environmental Research & Technology
LAHD - Los Angeles Harbor Dept.
PST - Pasha Stevedoring & Terminals
BMcD - Burns & McDonnell
CCA - Coalition for Clean Air
California Air Resources Board
Project Director
Chris Cannon
LAHD
Community Advisor
Joseph Lyou, PhD
Coalition for Clean Air
Technical Advisors
Marvin Moon
LADWP
Matt Miyasato, PhD
SCAQMD
J. R. DeShazo, PhD
UCLA LCI
Wayne Miller, PhD
UCR CE-CERT
Project Manager
Matt Wartian, PhD
BMcD
Port Electrical Infrastructure
Vahik Haddadian, PE
LAHD
Design-Build Engineer
Matt Germann, PE
BMcD
Construction
Phil Stephenson, LEED AP
BMcD
Engineering
Eric Putnam, PE
BMcD
Multi-Source Facility Operator
Braxton Craghill
PST
Grant Administration
Carter Atkins
LAHD
Technology Demonstration
Tim DeMoss
LAHD
Technology Demonstrators
Andrew Swanton (BYD)
Nicholas Tonsich (CAEM)
David Greenfader (Envision Solar)
John Ortega (PermaCity)
Mike Simon (TransPower)
*Bold denotes Task Lead

Attachment 3: PROJECT NARRATIVE AND WORK PLAN

Table 1: Roles of Key Participants

Key Participants	Roles
Harbor Department	Lead Applicant – Project Leadership, Administration, Oversight of Technology Demonstration, Data Collection and Reporting
Pasha	Multi-Source Facility Operator – Equipment and Vehicle Operation
Burns & McDonnell	Project Management, Design-Build Engineer for Energy Infrastructure
LADWP	Technical Advisor – Smart Grid and Utility Integration
South Coast AQMD	Technical Advisor – Zero and Near-Zero Technology Demonstration and Commercialization
UCLA Luskin Center	Technical Advisor – Sustainability Environmental Benefits, Policy and Economics
UCR CE-CERT	Technical Advisor – Data Collection and Analysis for Mobile Sources
Coalition for Clean Air	Disadvantaged Community Advisor
BYD	Technology Provider – Battery Storage System, Charging Equipment, Yard Tractors
Clean Air Engineering - Maritime	Technology Provider – ShoreCat Dockside Marine Emissions Treatment System
Envision Solar	Technology Provider – Modular Solar-Powered Passenger EV Charger
PermaCity	Technology Provider – Rooftop Solar Array
TransPower	Technology Provider – Yard Tractor, Drayage Truck

Qualifications and Capabilities of Key Personnel

The Green Omni Terminal Team is comprised of leaders in port and terminal operations; sustainable, efficient, and resilient energy infrastructure design and construction; and development of zero and near-zero emission cargo handling equipment, vehicles, and emissions treatment systems. The administration and technical qualifications of select key personnel are briefly described as follows. Detailed information is provided in their résumés, which are provided in the Staff and Subcontractor Information sections of Attachment 1.

Los Angeles Harbor Department

Mr. Christopher Cannon (Chief Sustainability Officer) will serve as the Project Director for the Green Omni Terminal Project. Mr. Cannon offers more than 25 years of experience in the environmental services industry, including 20 years as a technical manager of large multi-jurisdictional environmental projects. His experience includes serving as the Director of the Harbor Department's Environmental Management Division (EMD) and the Port's Clean Truck Program. He will have overall responsibility for the project, and will be supported by the Harbor Department's Environmental Management and Engineering Divisions. EMD's key project personnel, Tim DeMoss (Technology Demonstration Lead) and Carter Atkins (Grant Administration Lead), bring over a decade of experience testing and demonstrating new and emerging technologies through the TAP. Mr. DeMoss will work with CE-CERT on the development of technical evaluation protocols for the zero emission equipment and vehicles. Mr. Atkins will work with the ARB Project Liaison. He will coordinate with ARB staff to assure that appropriate reporting requirements for the use of State money are being followed by the team. Port Electrical

Engineer, Mr. Haddadian brings over 30 years of experience to the project. He will provide oversight of electrical infrastructure design and construction to ensure that equipment meets Harbor Department and City specifications.

Pasha Stevedoring & Terminal

Mr. Braxton Craghill (Director of Finance) will oversee the operation of all grant-funded equipment, infrastructure, and systems at the Pasha Terminal. Mr. Craghill brings to the project 16 years of experience managing complex logistical operations, including marine terminal operations, customer contracts, union contract negotiations, trucking, finance, information technology, and human resources and administration. He is responsible for overseeing Pasha's $200 million West Coast Maritime Division, which includes the Ports of Los Angeles, Long Beach, San Diego, Longview Washington, Grays Harbor Washington, and Honolulu Hawaii.

Burns & McDonnell

Dr. Matt Wartian will serve as the Project Manager of the Green Terminal Project. He will be responsible for managing the project's overall schedule and budget, and will manage our team's execution of all phases of the project. Dr. Wartian offers 13 years of experience leading multi-disciplinary teams to deliver innovative approaches in the assessment of environmental issues in port, harbor, and coastal systems. He has managed multiyear and multimillion dollar programs, working with engineering teams to identify, plan, and design energy management and electrical system continuity solutions at California ports. Burns & McDonnell's Design-Build Team includes engineers (Eric Putnam, PE and Matt Germann, PE) and construction manager (Phil Stephenson) who have designed and constructed microgrids that incorporate renewable generation, battery storage, bi-directional charging infrastructure, and energy management control systems for mission critical facilities.

Technical Advisors

The Green Omni Terminal Team is supported by technical advisors who include technology, regulatory, academic, and community leaders at LADWP (Marvin Moon), SCAQMD (Dr. Matt Miyasato), UCLA (Dr. J.R. DeShazo) UCR (Dr. Wayne Miller), and CCA (Dr. Joseph Lyou). These leaders will provide input on the integration of multiple zero emission technologies at the terminal, testing and analysis, and community outreach and engagement.

Technology Providers

Key personnel from our technology provider partners include presidents and CEOs from their respective companies, as well as technology development leads. These technology developers will work as a team, under the leadership of the Harbor Department and management of Burns & McDonnell to develop and demonstrate their technologies in an integrated fashion at the Pasha Terminal.

Relationship and Degree of Collaboration with Technology Providers

The Green Omni Terminal Team of technology providers has a history of performing energy and technology demonstration projects in and associated with ports. Each brings unique strength in the development, wide-spread commercialization, and operation of distributed renewable generation solutions and zero and near-zero emission technologies. The Harbor Department will serve as the integrator of this team, building on the experience and relationships that it has developed working with Pasha, Burns & McDonnell, and a number of technology demonstrators on past projects.

As the Applicant, the Harbor Department will be responsible for leading the technology providers as an integrated team, and supporting the commercialization of the zero and near-zero emission technologies being demonstrated. Pasha, as the end-user, will work with the Harbor Department and the technology providers to demonstrate multiple battery-electric cargo handling equipment and vehicles at their terminal. In doing so, the project will help overcome concerns by other terminal operators that electric equipment cannot meet the operational needs of their terminals through lifecycle analyses and use under real world operating conditions.

The Harbor Department assembled this team with commercialization in mind. BYD and TransPower have preexisting agreements in place to collaborate on the development and commercialization of battery EVs. As an OEM that designs, refines, and manufactures battery-electric products, BYD will help the team expedite the commercialization process. Electrifying the transportation and freight sectors is BYD's primary long-term focus in addition to engineering renewable solutions that provide green power. The team's commercialization focus will help make the Green Omni Terminal Project a catalyst for scalable and widespread commercialization.

3. Project Objectives and Work Plan

Objectives

The Green Omni Terminal Project meets all of ARB's goals under the Multi-Source Facility Demonstration Project and the FY 2014-2015 Funding Plan.

- **Provides GHG, criteria pollutant, and toxic air contaminant emission reduction benefits to the Wilmington DAC.** The project will reduce 3,230.7 tpy of CO_2e, 0.623 tpy of PM_{10}, 25.9 tpy of NO_x, and 1.44 tpy of ROG emissions in a DAC that is not meeting National Ambient Air Quality Standards.
- **Demonstrates multiple types of equipment and vehicles employing zero and near zero-emission technologies at one port facility.** Pasha will serve as a test facility for the commercialization of zero and near-zero emission technologies that can move high-tonnage break bulk and containerized cargo.
- **Provides economic, environmental, and public health co-benefits.** The Green Omni Terminal will serve as a catalyst for change at the San Pedro Bay Port Complex, providing a cost-effective and scalable model for sustainable and low-emission terminal operations at thousands of distribution centers and marine terminals throughout the state, nation, and world.
- **Demonstrates the practicality and economic viability of wide-spread adoption of advanced freight technologies for various sources at a single facility.** The Green Omni Terminal goes beyond this goal to demonstrate how a sustainable and resilient terminal can integrate electric zero emission equipment into the first seaport terminal microgrid. This microgrid will use renewable power to operate independent of the electric grid in the event of a natural or man-made disaster that causes the electric grid to lose power.
- **Funds technologies on the cusp of commercialization that further the purpose of AB 32.** This project will help reduce the costs of electric drayage trucks and yard tractors to continue the process of increasing the commercial viability of these zero emission technologies. It will also demonstrate the applicability of a solar-powered microgrid that integrates solar photovoltaic (PV) and battery storage systems to enhance operational sustainability and resiliency.

Work Plan

A detailed work plan that describes how the proposed Green Omni Terminal Project will develop a solar-powered, resilient facility that demonstrates how zero emissions cargo handling equipment can move goods from ships through the terminal to clean transportation to their final destinations is presented at the end of the Project Narrative.

4. Budget, Match Funding, and Financial Capabilities

The proposed project budget is $27 million, consisting of $15 million in grant funds, and $12 million in matching funds. Table 2 presents details on the sources of project funding, including cash, in-kind services, and grant funds. As shown in the table, the Green Omni Terminal Project team will contribute 44% of the total project cost in matching funds, including 20% in cash. Letters of commitment are provided in Attachment 5.

Table 2: Sources and Types of Project Funding

Task	Source of Matching Funds	Cash	In-Kind	Grant	Total
Project Management & Administration				$750,000	$750,000
Solar PV System	PST	$3,047,000		$840,000	$3,887,000
Battery Storage	BYD			$1,720,000	$1,720,000
Energy Control System				$500,000	$500,000
Charging Equipment (10)				$320,000	$320,000
Lighting Control System (1)				$40,000	$40,000
Engineering & Construction				$1,161,200	$1,161,200
Wharf Crane Drive Upgrades (2)	PST	$2,500,000			$2,500,000
ShoreCat (1)				$3,700,000	$3,700,000
Yard Tractors (4)	TransPower		$200,000	$1,445,000	$1,645,000
21-Ton Forklifts (2)	PST, TransPower		$488,000	$1,700,000	$2,188,000
Top Handler (1)	PST, TransPower		$507,000	$1,260,000	$1,767,000
Drayage Trucks (2)	TransPower		$150,000	$955,000	$1,105,000
Passenger Vehicle Solar Charger (1)				$50,000	$50,000
Electric Passenger Bus (1)				$450,000	$450,000
Pasha Operator Labor	PST		$5,200,000		$5,200,000
Data Collection & Analysis				$126,000	$126,000
Data Loggers (20)				$40,000	$40,000
Totals		$5,547,000	$6,545,000	$15,057,200	$27,149,200

5. Potential Emission Reduction Benefits

The Green Omni Terminal Project will result in the following estimated emission reductions:

- 3,230.7 tpy of CO_2e
- 0.623 tpy of PM_{10}
- 25.9 tpy of NO_x
- 1.44 tpy of ROG

Detailed calculations are provided in Attachment 4.

6. Cost-Effectiveness

The project cost-effectiveness measures in terms of emissions reductions per dollar are presented in Table 3. Detailed calculations are provided in Attachment 4.

Table 3: Emissions Reductions Cost-Effectiveness

Emission Reduction Period	Combined Criteria Pollutant & Weighted PM	GHG Emissions
2-Yr Demonstration	$154,886/ton	$1,974/metric ton
Marketplace Deployment	$14,989/ton	$191/metric ton

7. Benefits to Disadvantaged Communities

The POLA Green Omni Terminal Project will be performed at the Pasha Terminal, which is located at 802 South Fries Avenue Wilmington, CA 90744. The proposed project will provide environmental, social, and economic benefits to the Wilmington DAC, as detailed in Attachment 6.

8. Technology and Innovation

The innovative technology proposed in the Green Omni Terminal Project, including the solar-powered microgrid, energy efficiency upgrades, zero emission cargo handling equipment and vehicles, charging infrastructure, and ShoreCat, will directly help California achieve its climate change and air quality goals by reducing GHG, criteria pollutant, and toxic air contaminant emissions in the Wilmington DAC. Furthermore, the project will demonstrate the operational and commercial viability of a wide range of electrified equipment and vehicles, helping to address concerns in the seaport industry that electrified equipment does not have the capacity, range, and flexibility to meet the unique operational needs of this environment.

Solar Powered Microgrid

The Pasha microgrid will be the first microgrid at a seaport terminal. It will incorporate distributed solar power and energy storage to enhance terminal resiliency. The Pasha microgrid is being designed with the capacity to integrate and control multiple local generation and storage assets to provide on-site generation for local loads in both grid-tied and islanded modes of operation. This will allow key elements of Pasha to stay operational with solar and battery storage to provide emergency goods and services to the Wilmington DAC and the broader Southern California region in the event of a natural or man-made disaster.

ShoreCat Marine Exhaust Treatment System

CAEM's Marine Exhaust Treatment System (METS-1) is the only ARB approved alternative control technology for compliance with the At-Berth Regulation. The Green Omni Terminal Project includes the development and testing the next generation of treatment systems—"ShoreCat." The ShoreCat technology has the increased capability of 90% CO_2 reduction. Energy efficiency design and operational improvements will reduce the system's carbon footprint. The ShoreCat will treat NO_x at a rate that is greater than the 90% of METS-1. There will also be an increase in mobility since it will be a shore based technology with transport capability that incorporates an improved exhaust connect and capture method.

Attachment 3: PROJECT NARRATIVE AND WORK PLAN

Bi-directional Charging Infrastructure

BYD uses 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 an on-board converter. The DC power is stored in the batteries and then passes through BYD's on-board inverters to create AC power for powering all of the motors. All BYD vehicles will have bi-directional inverters, which means that the electricity stored in the batteries can be used to power the on-board motors or it can be discharged from the vehicle back to the grid, to another vehicle, to battery storage, or to any other load source.

Electrified Cargo Handling Equipment and Vehicles

Manufacturing reliable electric port vehicles capable of lifting and hauling loads in excess of 100,000 pounds is a formidable challenge, but one that technology demonstrator, TransPower, has addressed effectively in prior demonstration projects. By combining TransPower's port and trucking experience with BYD's manufacturing and commercialization experience, the Green Omni Terminal Project will accelerate commercialization of EVs.

Drayage Trucks: TransPower's Class 8 drayage trucks include the "ElecTruck™" battery-electric drive system, which has been successfully deployed in real-world commercial operational environments. These zero emission trucks have consistently shown hauling capacity and road performance equal to or surpassing that of conventional vehicles, with greater operating range and energy efficiency than any other heavy EV. TransPower's drayage trucks are on the cusp of commercialization, as required in the ARB's solicitation.

Electric Employee Transport Bus: BYD will provide a full battery electric bus for transporting workers between facilities. The K7 model bus is a 30-foot electric bus with an operating range of 155 miles and 28 seats. This bus costs just $0.13/mile to operate and the batteries are warranted for 12 years. The electric bus will serve as a field application of zero emission technologies to move personnel within the Port. Moreover, the bus will replace transport of personnel using smaller passenger vehicles, providing further emission reduction benefits.

Yard Tractors: TransPower will deploy two yard tractors with upgraded drive systems that include larger battery enclosures, a more robust transmission, and an integrated power and accessories assembly — similar improvements to those that have made TransPower's electric drayage trucks efficient and reliable. BYD will deploy two T9A yard tractors. The T9A will have 175 kWh of battery capacity, allowing it to operate for at least one continuous eight hour shift between charges. The traction motor is a 180 kW proprietary BYD traction motor with a maximum torque of 1,106 ft-lbs and a maximum speed of 5,000 RPM. The T9A is designed to match or exceed the performance of diesel trucks across each key performance specification.

21-ton Forklifts and Top Handler: TransPower will Incorporate its proven ElecTruck™ battery-electric drive system to convert two of Pasha's 21-ton Kalmar forklifts and one Kalmar top handler from diesel to electric operation. These vehicles will be designed to move heavy tonnage steal and containers throughout an 8-hour shift. They will demonstrate the sustained lifting capacity of battery electric cargo handling equipment, beyond currently available commercially available battery electric technologies.

Battery EVs and equipment that will be demonstrated in the project incorporate technological advancements that are unique to each manufacturer. By working with two different technology demonstrators, the project will be able to compare the relative benefits of different technologies and innovations. Technological advancements incorporated in BYD and TransPower equipment and vehicles include the following.

BYD

Iron Phosphate Battery (Fe): BYD's Fe battery will retain 70% of its original charge after 10,000 cycles or 27 years if cycled every day. This far exceeds competitive lithium ion batteries that rapidly degrade after 2,000 cycles or 5-6 years or regular use. The Fe battery is also safe – no oxygen is released during discharge, so there is no catalyst for combustion and the heat across the cells is both lower than alternatives and evenly distributed, so there is no propensity to spark. No heavy metals are used in BYD's Fe battery and the electrolyte is non-toxic.

Battery Management System (BMS): The batteries are closely controlled by BYD's proprietary BMS, which monitors the voltage, temperature, and charge/discharge from each individual cell, module, and pack.

Traction Motors: The traction motors used on BYD's vehicles are also proprietary products and are permanent magnet (neodymium) synchronous motors. They consist of a stator and rotor assembly. The stator assembly includes motor housing, stator core and stator three-phase winding; the rotor assembly includes the rotor core, permanent magnets, spindle, and bearings. In addition to these critical components, BYD makes the high voltage distribution boxes, DC-DC converters, accessory inverters for power steering, ABS brakes, ancillary motors, and every other major electrical component. This vertical integration ensures that all components will communicate seamlessly, resulting in reliable and high performing vehicles.

TransPower

Automated manual transmission (AMT): The AMT advances the state of the art of transmitting torque from electric motors, combining rugged off-the-shelf manual transmissions with state-of-the art shifting controls and software. The AMT provides improved performance at both high and low speeds, while enabling use of a more efficient manual transmission, which reduces energy consumption and increases operating range.

Inverter-Charger Unit (ICU): The ICU handles high power loads much more reliably than off-the-shelf inverters, and has the unique feature of combining the functions of the inverter, which controls the drive motors and the battery charger, which recharges the vehicle's batteries on a "plug-in" basis. Each ICU delivers 150 kW of continuous power for the drive motor and supports battery charging at up to 70 kW. One ICU easily meets the motive power requirements of the heaviest duty yard tractors and enables recharging of yard tractor battery packs in two hours.

Advanced Battery Management System (BMS): Another key TransPower innovation is the "Cell-Saver™" BMS. The innovative new BMS installs more easily, measures cell voltage and temperature more accurately, and balances cells more rapidly and efficiently than competing BMS systems.

Power Control and Accessory Subsystem (PCAS): The PCAS is an innovative system integration concept to accommodate components for vehicle control and electrically-driven accessories, including the ICUs discussed above. In the PCAS approach, components are pre-integrated into a specially designed structure and the many wiring and cooling connections between these components are completed before installation into the vehicle.

Safety Measures

Safe working conditions and careful cargo handling are paramount to Pasha's ongoing operations. Pasha is ever-vigilant in maintaining crucial safety standards and working conditions at all times. They provide on-going safety training for management, staff, and union labor to ensure federal and state OSHA requirements are not just met, but are surpassed. Their safety manager will be in the field daily, interacting with labor and management to ensure personnel safety when operating conventional and demonstration vehicles and equipment. Safety training will be provided to all fleet operations and maintenance personnel. Operations and Maintenance Manuals will contain written safety instructions. A First Responder Guide will be provided to alert first responders to safety measures necessary in the event of an accident.

Burns & McDonnell brings an exceptional record of managing projects safely, as demonstrated by their industry leading safety record. In the last five years, they have completed 35,550,299 total manhours on all projects with a total recordable incident rate of 0.19, compared to the industry average of 3.1. This excellent safety record stems from mandatory, proactive safety training for all Burns & McDonnell employees, as well as all subconsultants. Burns & McDonnell will work with the Harbor Department to design and construct project infrastructure so that it meets City and Port design, operational, and safety standards.

TransPower's and BYD's EV designs incorporate many safety features such as ground fault detection and labeling of high-voltage cables. Additionally, safety is one of the primary benefits of BYD's Fe batteries. BYD's Fe battery was designed to prevent both the release of oxygen and the potential for cells to overheat. First, the temperature at which the BYD Fe battery decomposes is higher than competitive lithium ion battery chemistries (i.e., 500-600 °C as compared 150-250 °C). Second, BYD batteries are less likely to reach high temperatures because the Fe chemical reaction is not released during charging or discharging.

BYD's BMS provides an added level of safety. There are signal circuits or contactors on each individual cell, which monitor temperature, voltage, current, strength-of-charge, and circuiting. If any issues are detected the BMS can disconnect the contactors to isolate the problem areas. Furthermore, each battery string is outfitted with an isolation switch, which can disconnect the anode and cathode of the string at the exact same time to isolate modules or packs of cells. Lastly, even if all of the previous systems fail, the connections between each cell have rapid melting fuses. If any accidents or short circuits occur, the current in the main circuit will increase and will rapidly melt the fuses to prevent any major problems. BYD has tested its batteries under the harshest conditions that any manufacturer has attempted, and under no tests did BYD's Fe battery explode.

Technical Advantages

Table 4: Summary of Green Omni Terminal Technical Advantages

Solar Microgrid
➢ 1 MW solar PV meets 100% of the Pasha Terminal's current electricity demand ➢ Over 30 inverters in the PV system will allow controllability of solar generation when islanded ➢ Microgrid control system will allow terminal to operate when islanded from grid, while providing energy management capabilities to enhance energy efficiency ➢ Fe battery storage station provides backup power for critical terminal loads, including operation of one wharf crane

ShoreCat Marine Exhaust Treatment System
➢ Treats >90% of NO_x Emissions ➢ Includes module for CO_2 treatment ➢ On-dock design increases system mobility
Charging Infrastructure
➢ Uniform design standards for electrical service to charging units provides flexibility to terminal operators in using multiple technologies ➢ Bi-directional charging capabilities provide emergency backup power and peak shaving opportunities
Cargo Handling Equipment and Vessels
➢ Improved acceleration and efficiency by using an automated manual transmission ➢ Simplification of external charging infrastructure for TransPower vehicles by locating chargers on the vehicles ➢ Simplified energy storage subsystem design by using large, modular battery packaging ➢ Improved battery reliability and lifetime by using an advanced battery management system ➢ Fe battery retains 70% of its original charge after 10,000 cycles to provide long lasting, safe, and environmentally friendly operation ➢ Fe battery provides added safety and stability by avoiding oxygen release and sparking ➢ Eight (8) hours of continuous operation for T9A yard tractors ➢ Lower maintenance and operational costs per mile of electric than diesel yard tractors can result in over $10,000 in maintenance and fuel savings annually ➢ Improved economies of scale by using similar components in multiple vehicle applications

Completed Emission Testing

Working with UC Riverside CE-CERT, TransPower has performed emissions testing of its vehicles. Testing has been performed on a yard tractor, which has been put into service at IKEA. Emission testing has shown that the yard tractor produces 57% fewer GHG emissions than a conventional diesel tractor when operating in a typical yard tractor duty cycle with a total weight of 26,000 lb., assuming electric power produced by a mix of sources typical in California. At a heavier 72,000 lb., these reductions were calculated to be 39% using a California mix of electrical power.

ARB-certified source test company, Delta Air Quality Services, Inc., performed emissions testing to support the development of control factors for METS-1 for use by regulated fleets subject to ARB's "Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port" Regulation, as documented in the March 9, 2015 Test Report provided to ARB. The data compiled for the Test Report for ARB were collected from testing performed during six different vessel calls over a 3 month period. CAEM demonstrated a combined reduction of 90% for PM and NO_x when combined with capture efficiency, while consistently maintaining an ammonia slip less than 10 ppmv (pursuant to our Test Plan) and mostly at 5 ppmv (pursuant to regulation). Accordingly, ARB approved the results of the emission measurements and issued the Executive Order AB-15-01 which allows the use of METS-1 by specified container vessels for compliance with the At-Berth Regulation.

9. Potential for Market Penetration and Technology Commercialization

Technological innovations being demonstrated through the Green Omni Terminal Project have broad commercialization potential at thousands of seaports as well as at railyards, warehouses, and distribution centers in California, across the country, and around the world. This is true for the solar-powered microgrid, which provides one potential model for sustainable and resilient operations at key industrial facilities, as well as the zero emission cargo handling equipment and vehicles, which will be demonstrated to have the sustained capacity to move higher tonnages than current commercially available technologies. Target markets for the project's technologies are described as follows.

Microgrids

Many large utility customers, including military installations, hospital campuses, universities, airports, and now seaports, are designing and constructing microgrids to better manage energy usage and enhance power quality and system reliability. A microgrid can be designed that integrates and controls multiple local generation and storage assets (e.g., PV arrays, wind turbines, generators, combustion turbines, fuel cells, battery systems, and combined heat power) to provide on-site generation for local loads in both grid-tied and islanded modes of operation. The Green Omni Terminal Project will demonstrate the applicability of microgrid technologies for secure and reliable emergency operation off the grid at seaports, providing commercialization operations at thousands of similar facilities that require such an energy source to sustain operations.

ShoreCat Emission Treatment System

The ShoreCat emissions treatment system can be deployed in a variety of applications where shore power is not available or where ships are not equipped for connection to shore power. The initial market focus for ShoreCat is California vessel and terminal operators servicing Fleet ships other than cruise ships that require the flexibility of a shore mounted mobile solution for emissions capture. Other U.S. ports with environmental initiatives or regulatory requirements that need alternative technologies to shore power will be pursued as they begin to adopt similar at-berth regulations. Using ShoreCat emissions control technology will ensure operators can comply with the At-Berth Regulation thereby reducing emissions and avoiding potentially significant fines and penalties.

Battery Electric Vehicles and Equipment

With more than 2.5 million Class 8 trucks currently in operation in the U.S., and sales of new Class 8 trucks historically in the range of 200,000 to 250,000 per year, a viable commercial drive system business can be sustained by capturing a relatively small share of this market. Within California, targeted markets can be expected to grow due to expected growth in port container traffic, and development of zero and near zero emission solutions. EV conversion is expected to be a technically viable solution for trucks and tractors with daily operating ranges of 100-150 miles. These types of trucks, which include drayage trucks, yard tractors, refuse trucks, delivery trucks, and construction vehicles, represent about 20% of the trucks in the Class 8 market, or 40,000 to 50,000 trucks per year. The Green Omni Terminal Project will help show that battery-electric systems can meet the daily demands of such vehicles, and will provide a business case for adopting such vehicles based on long-term fuel savings.

Specific Market Niche

The target market for the project's battery-electric technology is focused on the heaviest trucks and yard tractors, large buses, and smaller numbers of larger specialized vehicles such as the high tonnage forklifts and top handlers, which can take advantage of unique high-power components and where fuel savings and emissions reductions will be maximized. Using current-design drayage truck battery subsystems with 215 kWh battery energy storage capacities, TransPower drayage trucks have operating ranges of 70-100 miles, and with its standard 153 kWh yard tractor battery subsystem, these tractors are capable of operating for 8-12 hours on a single charge.

Specific Barriers to Entry and Adoption

There are three major barriers to entry for adoption EV technologies. One of these barriers is the need to demonstrate long-term reliability to fleet operators and, eventually, to major vehicle OEMs. The second key obstacle to large-scale commercial adoption of heavy-duty EVs is the high capital cost of such vehicles. For example, TransPower currently can manufacture and assemble complete drive system "kits," consisting of all of the components and subsystems required for the conversion of large Class 8 trucks, in very low volumes at a total cost of about $300,000. Factoring in the cost of the truck itself and installation of the kit, the total cost of the truck is about $450,000. These figures must be reduced to achieve significant market capture. The third barrier to entry is operational range of vehicles, which is limited by current battery technology and availability of adequate charging infrastructure.

Our team's strategy for addressing the reliability issue is to expand testing of prototype and demonstration vehicles. To address the cost issue, our technology demonstrators plan to continue achieving dramatic reductions in the labor effort required to convert or manufacture battery-electric trucks, tractors, and equipment. To address, the range issue, BYD continues to develop new battery technologies that increase range, and TransPower is developing more efficient drive systems.

Commercialization Plan

The Green Omni Terminal Project team's plan for commercialization of the proposed technologies directly addresses the key market barriers just discussed – long-term reliability and capital cost. Both TransPower and BYD have unique commercialization plans, which are briefly described below.

TransPower

Expanding vehicle testing and demonstration to validate long-term reliability is a key commercialization need. Focusing on the State of California, TransPower's near-term goal is to increase its vehicle population from the ~40 vehicles currently funded to at least 100 electric trucks and yard tractors over the next three years. This will enable the accumulation of millions of miles and hundreds of thousands of hours of operation over this period, providing sufficient experience and data to perfect the electric drive system and build the interest of major vehicle OEMs such as Navistar, Cargotec, and Peterbilt – just to name a few of the OEMs presently working with TransPower. Navistar, for example, has a requirement that all its truck components be qualified for 1.2 million miles of use. This level of durability can be demonstrated only by accumulation of millions of miles of use on test vehicles.

Cost reduction is another key element of TransPower's commercialization strategy. TransPower believes that a reduction of about one-third from today's costs is possible by 2017, and that another reduction of approximately one-third is possible by 2020 with further manufacturing improvements and increases in manufacturing scale. TransPower believes that most of these cost reductions can be achieved through intelligent redesign and manufacturing of a few key components.

In addition to driving down component costs, another element of TransPower's commercialization strategy is to transition TransPower's current three-stage production line, which is geared toward turn-key conversion of vehicles, to a modified three-stage production line where many integrated subsystems can be validated and shipped to OEMs for installation on their assembly lines, rather than always installed into vehicles by TransPower. TransPower will continue performing complete vehicle conversions indefinitely, but truly large-scale penetration of the heavy-duty EV market with its ElecTruck™ components will require that OEMs begin installing these components into their vehicles.

BYD

Once performance is proven in part through the Green Omni Terminal Project, BYD intends to use voucher funding through programs like the Hybrid and Electric Vehicle Incentive Program in California, the Drive Clean Chicago program, and the New York Incentive Program to reduce the short-term price premium. These programs successfully close the price gap with diesel equivalents and are a key driver to commercializing electric trucks in the immediate future.

Long-term BYD anticipates price reductions that will foster the commercialization of the T9 and T9A without any incentives. Price reductions will come from the following sources:

1. **Battery Price Reduction** – BYD's Fe battery has improved in energy density by over 7 % year over year during the last 4 years. The amp-hours out of each cell increased from 200 A-hrs in 2012 to 220 A-hrs in 2014 to 270 A-hrs in 2016. BYD is forecasting 10% year over year improvement for the next several years due to mass production and R&D advancements.
2. **Scale Economies** – Once these truck platforms are sold in higher quantities BYD will be able to mass produce parts that are sourced internally, as well as command volume discounts from parts that are sourced externally. In BYD's past experience with buses and taxis, these scale economies have reduced the vehicle price by approximately 15%.
3. **Recoup Engineering Costs** – Part of the premium for BYD's trucks is that amortized engineering costs are included as part of the purchase price. Once these non-recurring engineering costs have been recouped, BYD can lower the price of the truck by approximately 10%. This is the same price reduction that BYD was able to offer on their bus product lines.
4. **Fuel and Maintenance Savings** – BYD anticipates that T9 and T9A truck owners will realize fuel and maintenance savings. This project will help prove these savings through acquisition of field service performance data that can be shared with customers.

The combination of these different cost savings results in a future state whereby BYD could provide a vehicle by 2020 that would be priced comparably or less than diesel equivalents after factoring in a three- year payback for fuel and maintenance savings. Specifically, the T9A would be priced at a 1% premium and the T9 would be priced at a 17% discount. These economics would lead to widespread adoption of the technology, especially from progressive private companies who are interested in both sustainability and long-term cost savings.

ARB Certification/Verification Plans

BYD's and TransPower's proposed battery-EVs and equipment currently do not require ARB certification. The ShoreCat system will undergo ARB verification for certification by the USEPA. ARB approval will be obtained by receiving an approved test plan during the manufacturing of the ShoreCat and subsequent completion of ARB approved test plan.

Legal Operation on California Roadways and at the Port

TransPower is a registered vehicle manufacturer with the U.S. Department of Transportation and a licensed vehicle manufacturer in California. It self-certifies its vehicles in accordance with Federal Motor Vehicle Safety Standards (FMVSS) and, when required, obtains additional approvals such as the

California Highway Patrol approval required for deployment of school buses in California. For the BYD K7 bus, FMVSS testing and registration with USEPA, ARB, and DOT, as well as compliance with the California Code of Regulations has been completed. For off-road vehicles, such as yard tractors and forklifts, no FMVSS testing or DOT registration is required.

Economic Benefits

The primary economic benefit of electrified cargo handling equipment and vehicles is reduced operations and maintenance costs, particularly in the form of fuel savings, as demonstrated by TransPower's previous demonstrations. UC Riverside estimated the energy cost of operating a TransPower electric yard tractor to be $0.31/mile, which is less than one-third of the energy cost UCR calculated for a conventional diesel tractor ($1.12/mile). UCR came to similar conclusions in testing TransPower's electric on-road truck, which UCR estimated would have an energy cost of $0.23 per mile in performing near-dock port drayage operations, versus $1.49/mile for a diesel truck performing the same duty cycle.

Real-world operation of TransPower's vehicles has also demonstrated other types of operational savings. Based on data collected during operation of the first IKEA electric tractor over the past year, TransPower and IKEA personnel have estimated that the TransPower electric tractor would cost about $5,000 to $6,000 less per year to maintain than a typical IKEA diesel tractor. IKEA has also found that it can achieve even greater energy use savings by recharging its tractor using energy generated from the solar PV system installed at its distribution center. About 90% of the electric tractor's energy has been provided by the solar system, resulting in an estimated actual energy cost of 2.5 cents per mile. If the electric tractor continues operating at its current rate, which would result in about 20,000 miles of use per year, the total energy savings per year would be $21,900/year. Adding in $5,500/year of estimated maintenance savings, the total estimated cost savings are $27,400 per year.

Special Training Requirements

BYD, TransPower, and CAEM will provide special training to vehicle fleet operators, maintenance personnel, and longshoremen. For EVs, very little special training will be required during the course of the project because EVs are designed to operate with a similar feel to conventional diesel vehicles. A few minutes of orientation is all that is typically required to train an experienced truck or tractor operator on how to drive these vehicles. Training on basic troubleshooting will be provided to maintenance personnel, but on-site BYD and TransPower field representatives will be the primary resource for maintaining the vehicles for the duration of the project.

10. Application Completeness

All parties participating in the demonstration project have read the Sample Grant Agreement.

11. Timeline for Project Completion

The project is anticipated to begin in February 2016 following the kick off meeting with ARB. The first stage of the project will involve the design of terminal infrastructure, equipment, and vehicles, as well as procurement of zero emission vehicle and equipment components. Solar, battery storage, and charging infrastructure will then be installed at the terminal along with energy management systems. Next, zero and near-zero emission equipment will be incorporated into operations upon delivery and commissioning at Pasha. Once equipment has been determined to be operating according to designs, testing will be conducted for two years. All project components will be accomplished by March 31, 2019 as detailed in the project schedule that is presented at the end of the Work Plan.

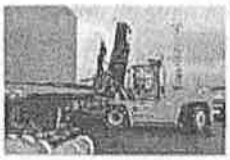
Attachment 3: PROJECT NARRATIVE AND WORK PLAN

Work Plan

The proposed Green Omni Terminal Project will develop a solar-powered, resilient facility that demonstrates how zero emissions cargo handling equipment can move goods from ships through the terminal to clean transportation to their final destinations. ***A 1 MW rooftop solar PV array will provide renewable energy to the Green Omni Terminal to meet Pasha's current electricity demands.*** When combined with a 2.6 MWh battery storage system (BSS) and microgrid/energy management control system, the PV system will allow key elements of the facility to remain operational for a finite period when islanded from the electrical grid in the event of a power outage.

The project will demonstrate the following near-commercial electrified equipment and vehicles:


Four (4) electric yard tractors


Two (2) 21-ton electric forklifts


One (1) electric top handler


Two (2) on-road drayage trucks


One (1) electric bus for moving workers between facilities

The demonstration vehicles and equipment will be integrated into the existing fleet for in-use testing at a terminal that moves both heavy break bulk and containers. The vehicles and equipment will be demonstrated in a variety of port operations including intra- and inter-terminal moves and short haul drayage to and from nearby rail facilities.

Electric equipment will be powered by standardized charging infrastructure that can power electric equipment and vehicles from different manufacturers, while also tapping into BYD vehicles as a power source during a grid outage. A modular, solar-powered passenger vehicle charging system (EV ARC™) will be added in the employee and visitor parking lot to provide solar-powered electric charging.

An on-dock ShoreCat treatment system will be integrated into the project to treat at-berth vessel emissions. ShoreCat expands the emissions treatment of the METS-1 system to include CO_2 in addition to criteria pollutants.

Additional energy efficiency retrofits at the terminal will include:

- Conversion of high mast lights from high-pressure sodium (HPS) to light emitting diode (LED) fixtures to reduce lighting energy demands by over 50% (completed)
- Installation of a lighting control system to further reduce lighting energy demands
- Wharf crane drive and lighting upgrades to enhance energy efficiency at the terminal
- Incorporation of an energy management/microgrid control system to improve overall terminal energy efficiency, as well as resiliency

By incorporating these technologies, the Green Omni Terminal Project will provide a scalable and replicable model for sustainable and resilient goods movement. The proposed project has been sited where supporting electrical infrastructure exists and can support robust and significant field demonstration, as shown in Figure 1.

A detailed breakdown of tasks, showing responsible parties for key tasks and subtasks, is provided as follows. A project schedule, which shows the timing of tasks that lead to the on-time completion of the demonstration project, is presented in Table 5, following the work plan. Detailed work plans from each of the technology demonstrators are provided in Exhibit B.

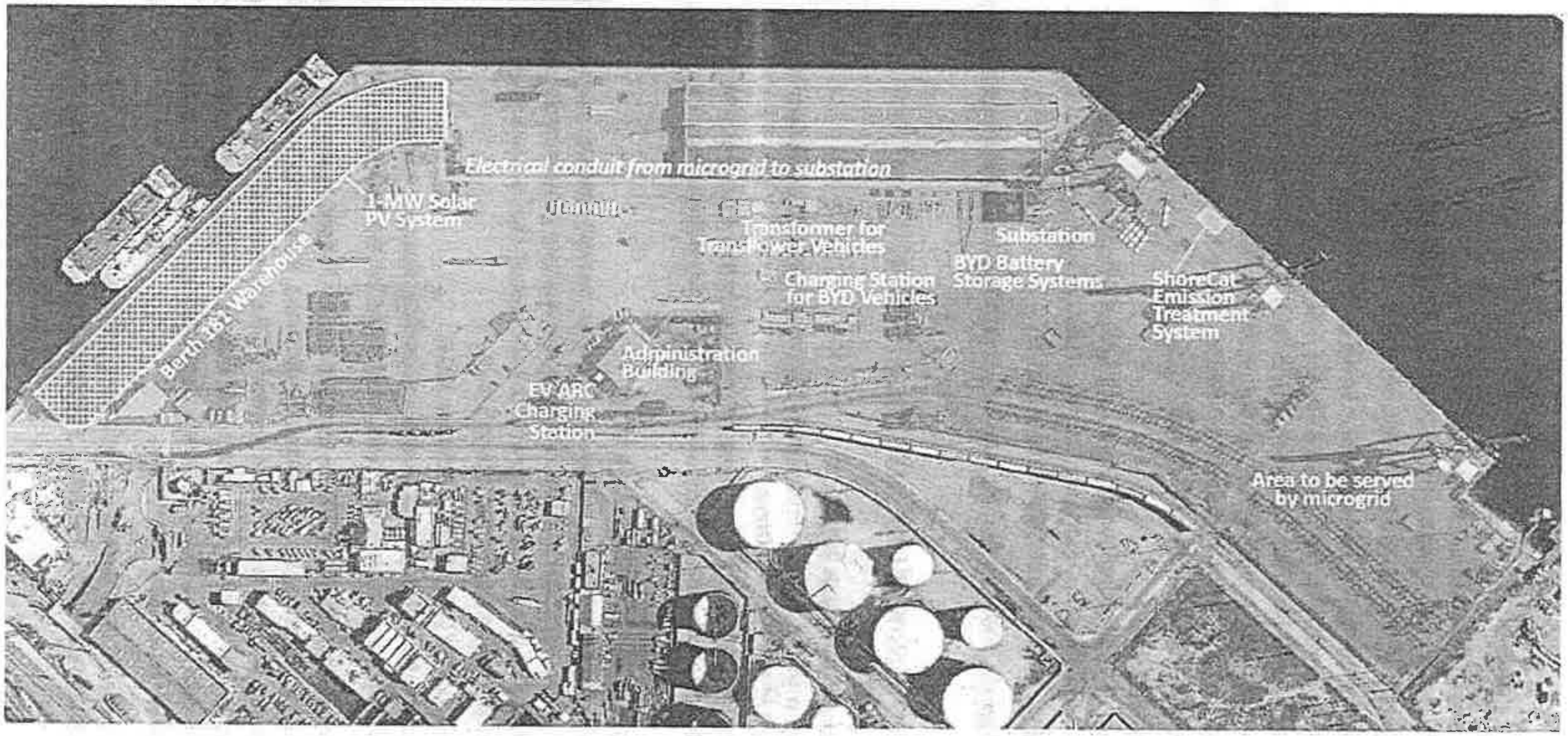


Figure 1: Site Diagram of Key Electrical Infrastructure at the Pasha Omni Terminal in the Port of Los Angeles

Attachment 3: PROJECT NARRATIVE AND WORK PLAN

Task 1.0 Administration and Project Management – LAHD and BMcD
(January 2016 – March 2019)

- **Task 1.1 Kick-off Meeting – Green Omni Terminal Project Team**
  The project team will meet with ARB and third-party data analysis provider to discuss the work plan, details of task performance, schedule, and resolution of issues.
- **Task 1.2 Monthly Project Update Meetings and Reports – LAHD and BMcD**
  The Harbor Department will coordinate monthly project update meetings that will be held via WebEx and teleconference to discuss progress. The meetings will follow a defined agenda that will cover project status update, difficulties encountered, upcoming deliverables, pending disbursement requests, and schedule of the next update meeting. These meetings will discuss the submitted Project Status Reports and disbursement requests.
- **Task 1.3 Final Report – LAHD and BMcD**
  At the completion of the project, the Harbor Department will submit a final report to ARB that describes the projects goals and objectives, methods, results of the demonstration, future application of the technologies, and commercialization prospects.

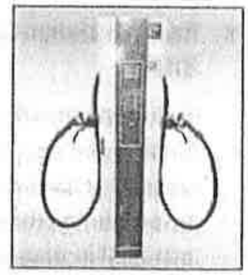
Task 1.0 Deliverables: Monthly Agenda, Monthly Project Status Reports, Disbursement Requests, and Final Report

Task 2.0 Design and Construction of Infrastructure – BMcD
(February 2016 – November 2016)

- **Task 2.1 Permitting (February 2016-March 2016)**
  Burns & McDonnell will work with the Harbor Department to acquire permits necessary for construction of infrastructure at the Pasha terminal, including an Engineers Permit, Parallel Cogeneration Interconnection Agreement, PV Interconnection Agreement, City of Los Angeles Department of Building and Safety Permits, and will work with the Harbor Department to obtain CEQA approval.
- **Task 2.2 Infrastructure Design (February 2016 – April 2016)**
  Burns & McDonnell will develop designs for the integration of solar, battery storage, and charging infrastructure at the terminal. An assessment of the existing infrastructure determined that the substation on the terminal has a dedicated transformer and switchboard that is more than sufficient to handle the demonstration project's proposed load.
- **Task 2.3 Infrastructure Construction (May 2016 – October 2016)**
  Burns & McDonnell will manage the installation of energy generation, storage, and charging infrastructure along with efficiency upgrades and system integration for the following components:
  - *2.3.1 Solar Installation – PermaCity (May 2016 – October 2016)* - Following the retrofit and reroofing of the Berth 181 Warehouse by the Harbor Department, PermaCity will install a 1.03 MW (DC) solar PV system on the rooftop. The PV system will be connected to a 1500kVA pad-mounted transformer at the existing building, which will feed to a 3000A switchboard with two breakers – 1200A for the new PV and 400A for the existing building. A single 5kV feeder will be run from the warehouse to the existing substation.
  - *2.3.2 Battery Storage System – BYD (February 2016 – August 2016)* - BYD will manufacture two battery storage systems (BSS) to Pasha within 7 months of project kickoff. The BSS will

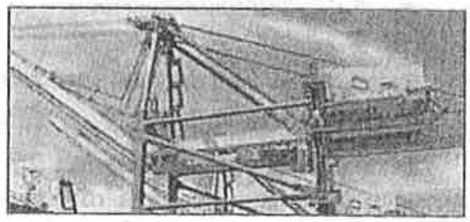
include batteries, power conversion system (PCS), container, and supporting systems. The BSSs are housed in 40-foot containers, which will be positioned adjacent to the existing substation.

- *2.3.3 Charging Equipment – BYD and TransPower (July 2016 – August 2016)* - TransPower will provide eight charging units and BYD will provide three for proposed vehicles and equipment. Both systems will connect to standardized electrical infrastructure. The TransPower system consists of a transformer, EV support equipment, and cable to connect to the on-board inverter charger unit. BYD will install a 200kW that uses 480V 3-phase supply and 240A input current charger charging equipment.



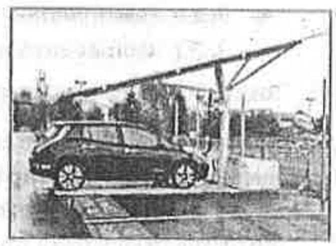
BYD BIDIRECTIONAL CHARGER

- *2.3.4 Energy Management/Microgrid and Lighting Control System – BMcD (July 2016 – August 2016)* - The microgrid control system is currently envisioned to be a single, NEMA 4X, stainless steel enclosure with redundant programmable controllers, internal UPS, and a touch-screen HMI. This enclosure will be located adjacent to the batteries (outside of the substation fence line). It will communicate to each of the EVs (for charge control), the batteries, and the new power meter in the 4160V switchgear.



EFFICIENCY UPGRADES TO SHORE CRANES

- *2.3.5 Wharf Crane Drive Upgrades – TMEIC (May 2016 – June 2016)* - TMEIC will upgrade the electrical drive and crane control systems for two of the hammerhead wharf cranes to increase the energy efficiency of cargo handling operations.
- *2.3.6 EV ARC™ Installation (March 2016)* - Envision Solar will deliver and install the EV ARC™ passenger vehicle solar charger in the Pasha employee and visitor parking lot.



ENVISION SOLAR EV ARC

➢ **Task 2.4 Testing and Commissioning (November 2016)**

Burns & McDonnell will provide the desired sequences of operation for the electrical monitoring and controls system. This will include both grid-tied as well as islanded operation of the system. Once all of the equipment is fully operational, Burns & McDonnell will lead the commissioning effort of the overall system being installed under this project. This will include operation for peak shaving and islanded operation. The commissioning procedures and results will be documented in a final commissioning report to be included in the reports to be submitted to ARB.

Task 2.0 Deliverables: As-Built Drawings and Testing and Commissioning Report

Task 3.0 Vehicles and Cargo Handling Equipment – BYD and TransPower (February 2016 – September 2017)

Cargo handling equipment and vehicles will be developed in two phases. During Phase 1, TransPower will manufacture and deliver the two drayage trucks, two yard tractors, and one 21-ton forklift; and BYD will manufacture and deliver two yard tractors. In Phase 2, TransPower will manufacture the second 21-ton forklift and top handler to build on the lessons learned during the manufacturing and commissioning of the Phase 1 forklift. BYD will deliver its two yard tractors within 6 months of receiving an order. The following tasks provide details on the delivery process of TransPower vehicles and equipment.

➢ **Task 3.1 Design Adaptation to Forklift and Top Handler – TransPower (February 2016 – April 2017)**

Pasha will provide TransPower with two Kalmar 21-ton forklifts and one top handler for conversion from diesel engines to battery electric drives. TransPower will use propulsion systems that are similar to the ElecTruckTM drives installed in drayage trucks and yard tractors to power this equipment. This will include a design effort to lay out how the drive systems will be installed into the Kalmar equipment. The first forklift design will be completed in Phase 1, and the second forklift and top handler design will be completed in Phase 2.

Electrified Top Handler

- *3.1.1 Performance Analysis*
- *3.1.2 Drive System Design*

➢ **Task 3.2 Drayage Truck and Yard Tractor Procurement**

TransPower will procure the base trucks from Navistar and base yard tractors from Cargotec. The base vehicles can take up to 3-4 months to receive from issuance of purchase order, so they will be ordered following project kick off.

TransPower Yard Tractor

- *3.2.1 Determination of Final Vehicle Specifications*
- *3.2.2 Vehicle Purchases*

➢ **Task 3.3: Subsystem Assembly – TransPower**

The first step in this process is to order major externally-sourced drive system components. Most purchased components are already elements of our standard drive system bill of material and can be procured efficiently from known suppliers. Once components are acquired or, when appropriate, manufactured in-house, TransPower will assemble the major subsystems. These are the Motive Drive Subsystem, Power Control and Accessory Subsystem, and Energy Storage Subsystem.

- *3.3.1 Order Externally-Sourced Components – Phase I vehicles*
- *3.3.2 Subsystem Assembly – Phase I vehicles*
- *3.3.3 Order Externally-Sourced Components – Phase II vehicles*
- *3.3.4 Subsystem Assembly – Phase II vehicles*

Subsystem Installation

➢ **Task 3.4: Vehicle Integration and Commissioning – BYD and TransPower**

TransPower will install subsystems into the demonstration vehicles in two phases, as previously described. One key lesson learned from past projects is to complete the installation of a specific subsystem in one vehicle, before attempting to replicate the installation in additional vehicles. This way, if a mistake is made in installation or a design change is determined to be necessary, the problem is not repeated on multiple vehicles and the remedy has to be applied only once. Once learning from the first vehicle is achieved, the pre-assembled subsystems for other vehicles will be installed very quickly. During commissioning, TransPower will test all drive system components on the integrated vehicle and then test the entire system to assure it functions properly. They will then undertake a series of drive tests to validate the basic functionality and safety of the system, and to optimize vehicle controls.

- *3.4.1 Phase I Vehicle Integration – Drayage Truck, Yard Tractor, and First Forklift*
- *3.4.2 Phase I Vehicle Commissioning*
- *3.4.3 Phase II Vehicle Integration – Second Forklift, Top Handler*
- *3.4.4 Phase II Vehicle Commissioning*

➤ **Task 3.5: Vehicle Deployment – BYD, TransPower, and PST**

Upon delivery and deployment of vehicles at Pasha, charging infrastructure will be tested, and training of Pasha operational and maintenance crews will begin. BYD and TransPower will provide on-site and classroom training up to 40 hours for drivers of all the vehicles, as well as a printed and digital set of operator training manuals.

BYD Yard Tractor Assembly Line

- *3.5.1 Vehicle Delivery*
- *3.5.2 Personnel Training*

Task 3.0 Deliverables: Updated Design Package (3.1), Invoices for vehicle purchases (3.2), Photographs of assembled subsystems (3.3), and Commissioning Report (3.4).

Task 4.0 ShoreCat Emissions Treatment System – CAEM
(February 2016 – August 2016)

CAEM will manufacture the new ShoreCat system over a 20-week period followed by a 4-week period for delivery, at-berth assembly, and commissioning. Emission testing will be conducted over a month period to validate system performance.

➤ **Task 4.1 Design and Fabrication (February 2016 – Jun 2016)**

System design will include the packaging of the technology used in METS into a system that can be operated from and moved along a pier. Primary design considerations are the ability of the system to operate as a self-contained unit for a minimum duration that is equivalent to one vessel call. The system will also be enhanced to accommodate a wide variety of auxiliary engine stacks. Additional design improvements will include NO_x removal efficiency, improved energy efficiency, non-methane VOC and SO_2 reduction, and CO_2 capture.

The primary focus of fabrication will be to greatly reduce construction time and level of effort in the field and reduce shipping costs from the factory. This will be accomplished by focusing on a modular type of design that incorporates many elements into a single integrated component. The goal is to shift labor delivered in the field to being delivered at the factory.

➤ **Task 4.2 Delivery & Installation (July 2016)**

The ShoreCat's modular design will facilitate a shipping and delivery approach that is greatly simplified over what was required for the METS-1 system. This approach will eliminate field construction and will convert those activities to a short assembly process. This approach will also allow full functional testing at the factory, greatly reducing troubleshooting in the field during startup.

- **Task 4.3 Startup & Commissioning (July 2016)**

  Successful completion of Tasks 1 and 2 will greatly reduce the level of effort required for field startup and commissioning. The focus of these activities will be operator training and system performance evaluations. Limiting construction in the field will also reduce associated safety issues.

- **Task 4.4 Performance Verification (August 2016)**

  ShoreCat will incorporate onboard monitoring systems to determine the removal efficiency of NO_x and corresponding ammonia slip. The system will also have the ability to determine CO_2 capture on a continuous basis and fuel consumption. The performance demonstration period is expected to last four to six weeks. During that time, the system will collect continuous particulate efficiency data. An independent source test company will be contracted to perform emission testing to validate all of the onboard measurements and to demonstrate SO_2 and non-methane VOC treatment efficiency.

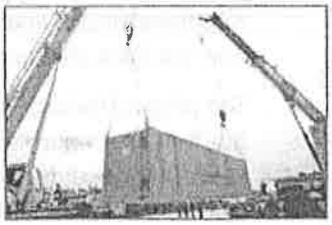
Task 4.0 Deliverables: As-built design package, commissioning report, emission testing report

Task 5.0 Demonstration – BMcD, BYD, CAEM, PST, and TransPower (January 2017 – December 2018)

The demonstration phase will show how multiple zero and near-zero equipment can operate together to sustainably move break bulk and container cargo through the terminal to clean transportation. Following successful commissioning and deployment of equipment and training of staff on operation and maintenance, a two-year demonstration will begin. EVs and cargo handling equipment will be placed in operation alongside baseline diesel equipment. Once at berth, vessels will be connected to the ShoreCat treatment system to reduce emissions. Efficient wharf cranes, powered by solar energy, will offload vessels where electrified forklifts and top handlers will move cargo to staging areas, yard tractors, drayage trucks, or rail for transport. All equipment will be operated by Pasha personnel who will be transported between terminals by an electric bus. It is anticipated that equipment will be capable of operating continuously for an 8-hour shift.

- **Task 5.1 Microgrid, Energy and Lighting Management System, Efficiency Retrofits – BMcD and PST**

  Burns & McDonnell will demonstrate energy efficiency and resiliency gained through the microgrid and energy management control systems. This will include peak shaving and islanded operation.



BYD Battery Storage System

- **Task 5.2 Vehicles and Equipment – BYD, TransPower, and PST**

  EVs and cargo handling equipment will be placed in operation alongside baseline diesel equipment to demonstrate the operational viability and cost-effectiveness of operating multiple zero emission vehicles and equipment at one facility.

- *5.2.1 Phase 1 Vehicles and Equipment* - Class 8 drayage trucks, yard tractors, employee bus, and forklift will be placed in service during Phase 1. Electric drayage trucks and employee transport bus will primarily be use to move cargo and personnel within the Port complex. Additional demonstrations will include longer hauls to distribution and processing facilities.
- *5.2.2 Phase 2 Cargo Handling Equipment* - The second forklift and top handler will be placed in service during Phase 2.

➢ **Task 5.3 ShoreCat – CAEM and PST**

Following emission testing, the ShoreCat system will continue to be used throughout the project demonstration period to test the long-term operation and maintenance of the system at the terminal. Pasha is an ideal terminal for testing this system because the vessels calling on the terminal are not equipped with alternative maritime power infrastructure.

Task 5.0 Deliverables: Status reports on equipment in-servicing and operation

Task 6.0 Data Collection and Analysis – LAHD, CE-CERT, PST, and ARB Third Party Data Contractor

(January 2017 – March 2019)

During demonstration, data will be collected from baseline and electrified vehicles and equipment for hours of use, energy usage, vehicle performance variables, type of operation/application, vehicle/equipment maintenance, as well as general feedback on operator acceptance.

➢ **Task 6.1 Field Data Collection**

EVs and equipment 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. All real-time and historical data will be available in chart form and as a download for analysis by the Harbor Department, PASHA, ARB, and ARB's chosen third party analysis company.

Furthermore, the HAMS has the ability to coordinate the charging profile of all of the vehicles to smooth power demand. An algorithm will determine when to start/stop charging based on commands from the web server. Lastly, the HAMS has GPS capability, so it can identify where trucks are at any given time and also provide telematics information related to when the trucks are operating in disadvantaged communities.

Demonstration and baseline vehicles will be equipped with ARB-specified data loggers to support collection of ARB-required data, per the requirements of the solicitation.

➢ **Task 6.2 Laboratory Data Collection**

CE-CERT will evaluate representative EVs at their Heavy-Duty Chassis Dynamometer facility in Riverside, CA. Laboratory testing will include a BYD electric yard tractor, a TransPower drayage truck, and a 21-ton forklift. Dynamometer testing will evaluate power, energy efficiency, and fuel economy. These measurements will be made using a series of power consumption measurements over the range of cycles seen at Pasha and other Port terminals. The data will be collected for both integrated cycles and on a second-by-second basis.

- **Task 6.3 Data Analysis**

  Data analysis will be accomplished by an independent third party that ARB selects. It is understood that all types of data to be collected will be determined by ARB's sole discretion, in consultation with the project team.

Task 6.0 Deliverables: Electronic data in the format required by ARB, Data Analysis Report

Project Schedule

Table 5: Timeline for Project Completion

Task	Description	Start Date	Completion Date
1.0	**Administration & Project Management**	**February 1, 2016**	**March 31, 2019**
1.1	*Kick Off Meeting*	*February 1, 2016*	*February 1, 2016*
1.2	*Monthly Project Update Meetings & Reports*	*March 1, 2016*	*March 31, 2019*
1.3	*Final Report*	*January 31, 2019*	*March 31, 2019*
2.0	**Infrastructure Design & Construction**	**February 2, 2016**	**November 31, 2016**
2.1	*Permitting*	*February 2, 2016*	*April 30, 2016*
2.2	*Infrastructure Design*	*February 2, 2016*	*April 30, 2016*
2.3	*Infrastructure Construction*	*May 1, 2016*	*October 31, 2016*
2.3.1	Solar PV Installation	May 1, 2016	October 31, 2016
2.3.2	Battery Storage System	February 2, 2016	August 31, 2016
2.3.3	Charging Equipment	July 1, 2016	August 31, 2016
2.3.4	Energy/Microgrid Control System	July 1, 2016	August 31, 2016
2.3.5	Wharf Crane Drive Upgrades	May 1, 2016	June 30, 2016
2.3.6	EV ARC Installation	March 1, 2016	March 30, 2016
2.4	*Testing & Commissioning*	*November 1, 2016*	*November 31, 2016*
3.0	**Vehicles & Cargo Handling Equipment**	**February 2, 2016**	**September 30, 2017**
3.1	*Design Adaptation to Forklift #1*	*February 2, 2016*	*April 30, 2016*
3.1	Design Adaptation to Yard Tractor	November 1, 2016	February 28, 2017
3.2	*Drayage Truck & Yard Tractor Procurement*	*March 1, 2016*	*April 30, 2016*
3.3	*Subsystem Assembly*	*April 1, 2016*	*May 30, 2016*
3.3.1	Order Components – Phase 1	March 1, 2016	April 30, 2016
3.3.2	Subsystem Assembly – Phase 1	April 1, 2016	August 31, 2016
3.3.3	Order Components – Phase 2	November 1, 2016	February 28, 2017
3.3.4	Subsystem Assembly – Phase 2	December 1, 2016	March 31, 2017
3.4-3.5	*Vehicle Delivery & Training – Phase 1*	*October 1, 2016*	*February 28, 2017*
3.4-3.5	*Vehicle Delivery & Training – Phase 2*	*June 1, 2017*	*August 31, 2017*
4.0	**ShoreCat Emissions Treatment System**	**February 2, 2016**	**August 31, 2016**
4.1	*Design & Fabrication*	*February 2, 2016*	*June 30, 2016*
4.2	*Delivery & Installation*	*July 1, 2016*	*July 15, 2016*
4.3	*Startup & Commissioning*	*July 16, 2016*	*July 31, 2016*
4.4	*Performance Verification*	*August 1, 2016*	*August 31, 2016*
5.0	**Equipment Demonstration**	**January 1, 2017**	**December 31, 2018**
5.1	*Energy/Microgrid Control System*	*January 1, 2017*	*December 31, 2018*
5.2.1	Electric Equipment & Vehicles – Phase 1	January 1, 2017	December 31, 2018
5.2.2	Electric Equipment – Phase 2	August 1, 2017	December 31, 2018
5.3	*ShoreCat Demonstration*	*January 1, 2017*	*December 31, 2018*
6.0	Data Collection & Analysis	January 1, 2017	December 31, 2018

ID	Task Name	Start	Finish
1	**Task 1.0: Administration & Project Management**	2/1/2016	4/3/2019
2	1.1: Kick Off Meeting	2/1/2016	2/1/2016
3	1.2: Monthly Project Update Meetings & Reports	3/1/2016	3/29/2019
4	1.3: Final Report	2/1/2019	4/3/2019
5	**Task 2.0: Infrastructure Design & Construction**	2/2/2016	11/30/2016
6	2.1: Permitting	2/2/2016	4/29/2016
7	2.2: Infrastructure Design	2/2/2016	4/29/2016
8	2.3: Infrastructure Construction	2/2/2016	10/31/2016
9	*2.3.1: Solar PV Installation*	5/2/2016	10/31/2016
10	*2.3.2: Battery Storage System*	2/2/2016	8/31/2016
11	*2.3.3: Charging Equipment*	7/1/2016	8/31/2016
12	*2.3.4: Energy/Microgrid Control System*	7/1/2016	8/31/2016
13	*2.3.5: Wharf Crane Drive Upgrades*	5/2/2016	6/30/2016
14	*2.3.6: EV ARC Installation*	3/1/2016	3/30/2016
15	2.4: Testing & Commissioning	11/1/2016	11/30/2016
16	**Task 3.0: Vehicles & Cargo Handling Equipment**	2/2/2016	8/31/2017
17	3.1: Design Adaptation to Forklift #1	2/2/2016	4/29/2016
18	Design Adaptation to Yard Tractor	11/1/2016	2/28/2017
19	3.2: Drayage Truck & Yard Tractor Procurement	3/1/2016	4/29/2016
20	3.3: Subsystem Assembly	3/1/2016	3/31/2017
21	*3.3.1: Order Components – Phase 1*	3/1/2016	4/29/2016
22	*3.3.2: Subsystem Assembly – Phase 1*	4/1/2016	8/31/2016
23	*3.3.3: Order Components – Phase 2*	11/1/2016	2/28/2017
24	*3.3.4: Subsystem Assembly – Phase 2*	12/1/2016	3/31/2017
25	3.4-3.5: Vehicle Delivery & Training – Phase 1	10/3/2016	2/28/2017
26	3.4-3.5: Vehicle Delivery & Training – Phase 2	6/1/2017	8/31/2017
27	**Task 4.0: ShoreCat Emissions Treatment System**	2/2/2016	8/31/2016
28	4.1: Design & Fabrication	2/2/2016	6/30/2016
29	4.2: Delivery & Installation	7/1/2016	7/15/2016
30	4.3: Startup & Commissioning	7/18/2016	7/29/2016
31	4.4: Performance Verification	8/1/2016	8/31/2016
32	**Task 5.0: Equipment Demonstration**	1/2/2017	12/31/2018
33	5.1: Energy/Microgrid Control System	1/2/2017	12/31/2018
34	*5.2.1: Electric Equipment & Vehicles – Phase 1*	1/2/2017	12/31/2018
35	*5.2.2: Electric Equipment – Phase 2*	8/1/2017	12/31/2018
36	5.3: ShoreCat Demonstration	1/2/2017	12/31/2018
37	**Task 6.0: Data Collection & Analysis**	1/2/2017	12/31/2018

Figure 2: Schedule of Key Project Milestone Tasks

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

Calculation for 21-Ton Fork Lifts

- 2 forklifts

Baseline Vehicle:

- Off-Road diesel engine: Tier-4 initial certification, 180-hp
- 21-ton lift capacity
- Diesel Usage: 2,995 gal per year
- Forklift cost at demonstration: $169,000
- Forklift cost two years after demonstration: $169,000

Advanced Technology:

- Battery-electric forklift charged via solar
- Forklift cost at demonstration: $519,000
- Forklift cost two years after demonstration: $460,000

Variables Used in Calculation:

Carbon Intensity

From MSF App Table D2: Fuel Carbon Intensity Values

CI = Carbon Intensity

$$CI_{diesel} = \frac{102.76 gCO2e}{MJ}$$

Energy Density

From MSF App Table D1: Fuel Energy Density

ED = Energy Density

$$ED_{diesel} = \frac{134.47 MJ}{gal\ diesel}$$

Step 1: Determine the GHG emissions that are attributed to the base case diesel-fueled 21-ton forklift using Formula 1 and the variables identified above.

Formula 1:

$$Forklift\ GHG\ EF_{base} = CI * \frac{ED}{efficiency} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams}$$

$$= \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{2995\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams} * 2$$

$$= 82.77\ \frac{metric\ tons\ CO_2e}{year}$$

Step 2: Determine the GHG emissions that are attributed to the advanced technology forklift. There are no GHG emissions attributed to the use of solar electricity to power the forklift.

$$GHG\ EF_{adv\ tech} = 0$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

Step 3: Determine the GHG emissions reductions that are associated with the proposed project using Formula 4, populated by results from Step 1 and Step 2 above.

Formula 4:

$$Project\ GHG\ ER_{annual} = GHG\ EF_{base} - GHG\ EF_{adv\ tech} = \frac{82.77\ metric\ tons\ CO_2e}{year} - 0$$
$$= \frac{82.77\ metric\ tons\ CO_2e}{year}$$

Step 4: Determine the annual criteria pollutant emission reductions that are associated with the proposed project. The base case diesel fueled forklift is using a 180-hp diesel engine that is certified to the Tier-4 initial emissions standard. Therefore, emission values from Table D-12 are used along with fuel consumption rate factors from Table D-24 and the result of Step 1 above to populate Formula C-8. The forklift will be used 100% of the time in California. There are no criteria pollutant emissions associated with the use of the battery-electric forklift.

For a Tier-4 initial off-road engine at 180 hp, Table D-12 gives criteria emissions in grams per bhp-hr. The conversion factor from Table D-24 allows for the conversion from gram per bhp-hr to gram per gallon of fuel consumed. Therefore:

$NO_x = 1.29 \frac{g\ NO_x}{bhp-hr}$; ROG = $0.08 \frac{g\ ROG}{bhp-hr}$; $PM_{10} = 0.008 \frac{g\ PM_{10}}{bhp-hr}$

Formula C-8:

$$Annual\ ER = EF\ or\ (CES * FCRF) * Activity * \%\ Operation\ in\ CA * \frac{ton}{907{,}200\ g}$$

Where,

ER = Emission Reductions

EF = Emission Factor

CES = Converted Emission Standard in g/bhp-hr

FCRP = Fuel Consumption Rate Factor in bhp-hr/gal

$$Forklift\ Annual\ ER_{NO_x} = \frac{1.29\ g\ NO_x}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{2{,}995\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 2$$
$$= \frac{0.158\ ton\ NO_x}{year}$$

$$Forklift\ Annual\ ER_{ROG} = \frac{0.08\ g\ ROG}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{2{,}995\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 2$$
$$= \frac{0.010\ ton\ ROG}{year}$$

$$Forklift\ Annual\ ER_{PM_{10}} = \frac{0.008\ g\ PM_{10}}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{2{,}995\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 2$$
$$= \frac{0.001\ ton\ PM_{10}}{year}$$

Step 5: Determine the weighted annual surplus emission reductions that are associated with the proposed project using the results from Step 4 above and Formula C-5.

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

Formula C-5:

WER = Weighted Emissions Reductions

$$Forklift\ WER = Annual\ ER_{NO_x} + Annual\ ER_{ROG} + 20 * (Annual\ ER_{PM_{10}})$$
$$= \frac{0.158\ ton\ NO_x}{year} + \frac{0.010\ ton\ ROG}{year} + 20 * \frac{0.001 ton\ PM_{10}}{year} = \frac{0.187\ ton}{year}$$

Step 6: Determine the incremental cost of the proposed technology using Formula C-3 and the equipment costs for the base case diesel-fueled forklift and battery-electric forklift. Cost effectiveness is calculated for two scenarios: for two years during the demonstration and for 10 years, two years after the completion of the demonstration project.

Formula C-3:

IC = Incremental Cost

$$IC = Cost\ of\ New\ Tech - Cost\ of\ Baseline\ Tech$$

$$Forklift\ IC_{2\ years} = \$519{,}000 * 2 - \$169{,}000 * 2 = \$700{,}000$$

$$Forklift\ IC_{10\ years} = \$460{,}000 * 2 - \$169{,}000 * 2 = \$582{,}000$$

Step 7: Determine the GHG emission reduction cost effectiveness for the proposed project using Formula 5.

Formula 5:

CE = Cost Effectiveness; CRF = Capitol Recovery Factor

$$GHG\ CE = \frac{CRF * IC}{GHG\ ER_{annual}}$$

$CRF_2 = 0.515$ and $CRF_{10} = 0.111$ per Moyer Table G-3b (2-year and 10-year lives, respectively)

$$Forklift\ GHG\ CE_2 = \frac{\frac{0.515 * \$700{,}000}{year}}{\frac{82.77\ metric\ tons\ CO_2e}{year}} = \frac{\$4{,}355}{metric\ ton\ CO_2e}$$

$$Forklift\ GHG\ CE_{10} = \frac{\frac{0.111 * \$582{,}000}{year}}{\frac{82.77\ metric\ tons\ CO_2e}{year}} = \frac{\$781}{metric\ ton\ CO_2e}$$

Step 8: Determine the criteria pollutant cost effectiveness for the proposed technology using Formula C-1.

Formula C-1:

$$Criteria\ CE = \frac{CRF * IC}{WER}$$

$$Forklift\ Criteria\ CE_2 = \frac{\frac{0.515 * \$700{,}000}{year}}{\frac{0.187\ ton}{year}} = \frac{\$1{,}928{,}938}{ton\ pollutant}$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

$$Forklift\ Criteria\ CE_{10} = \frac{\frac{0.111 * \$582{,}000}{year}}{\frac{0.187\ ton}{year}} = \frac{\$345{,}668}{ton\ pollutant}$$

The above steps are repeated for each additional piece of equipment listed below modified for the specific emission factors and usage pertaining to each equipment type.

Calculations for Remaining Facility Equipment:

Yard Tractor

- Four new electric tractors
- Baseline 2010 on-road 200-hp engine with Certification Standard of 0.20 g NO_x/bhp-hr
- Diesel Usage: 4,550 gallons per year
- Baseline cost at demonstration and two years after: $115,800
- Advanced Tech cost at demonstration: Two at $410,000 and two at $300,000 for average of $355,000
- Advanced Tech cost two years after: Two at $280,000 and two at $238,000 for average of $259,000

Top Handler

- One new electric top handler
- Baseline 2010 Tier-4 375-hp off-road engine
- Diesel Usage: 1,270 gallons per year
- Baseline cost at demonstration and two years after: $357,000
- Advanced Tech cost at demonstration: $732,000
- Advanced Tech cost two years after: $660,000

Drayage Trucks

- 2 new electric drayage trucks
- Baseline 2010 on-road engine with Certification Standard of 0.20 g NO_x/bhp-hr
- Diesel Usage: 958 gallons per year
- Baseline cost at demonstration and two years after: $123,000
- Advanced Tech cost at demonstration: $465,500
- Advanced Tech cost two years after: $350,000

Passenger Bus

- 1 new electric passenger bus
- Baseline 2010 14,001 – 33,000 lbs GVWR vehicle
- 10 miles traveled per day
- Baseline cost at demonstration and two years after: $320,000
- Advanced Tech cost at demonstration: $450,000
- Advanced Tech cost two years after: $410,000

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

ShoreCat Marine Exhaust Treatment System (METS)

- 1 ShoreCat METS
- Baseline is no treatment system installed
- Baseline emissions:
  - Auxiliary vessel engine; 700-hp 2010 uncontrolled harbor craft aux engine; 104,200 gallons of diesel per year
  - Auxiliary vessel boiler; 135-hp 2010 uncontrolled off-road diesel engine; 7,525 gallons of diesel per year
- Baseline cost at demonstration and two years after: $0
- Advanced Tech cost at demonstration: $3,700,000
- Advanced Tech cost two years after: $3,145,000

Facility Electricity

- New Solar electricity generation for facility – 1 MW
- Baseline 1 MW standard CA electricity
- 2,125,000 kWh/yr energy usage
- Baseline cost: $0
- Baseline annual cost at demonstration and two years after: $437,750
- Advanced Tech cost at demonstration: $3,000,000
- Advanced Tech cost two years after: $2,700,000

Step 1: Determine the GHG emissions that are attributed to the base case equipment using Formula 1.

Yard Tractor

$$Tractor\ GHG\ EF_{base} = \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{4{,}550\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams} * 4 = 252\ \frac{metric\ tons\ CO_2e}{year}$$

Top Handler

$$Handler\ GHG\ EF_{base} = \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{1{,}270\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams} * 1 = 17.55\ \frac{metric\ tons\ CO_2e}{year}$$

Drayage Trucks

$$Truck\ GHG\ EF_{base} = \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{958\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams} * 2 = 26.48\ \frac{metric\ tons\ CO_2e}{year}$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

Passenger Bus

$$Bus\ GHG\ EF_{base} = \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{410\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams}$$
$$= 5.67\ \frac{metric\ tons\ CO_2e}{year}$$

METS Auxiliary Engine

$$METS\ Engine\ GHG\ EF_{base} = \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{104{,}200\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams}$$
$$= 1{,}440\ \frac{metric\ tons\ CO_2e}{year}$$

METS Auxiliary Boiler

$$METS\ Boiler\ GHG\ EF_{base} = \frac{102.76\ g\ CO_2e}{MJ} * \frac{134.47\ MJ}{gal\ diesel} * \frac{7{,}525\ gal}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams}$$
$$= 104\ \frac{metric\ tons\ CO_2e}{year}$$

Facility Electricity

$$Electricity\ GHG\ EF_{base} = \frac{105.16\ g\ CO_2e}{MJ} * \frac{3.60\ MJ}{KWh} * \frac{2{,}125{,}000\ KWh}{year} * \frac{1\ metric\ ton\ CO_2e}{1{,}000{,}000\ grams}$$
$$= 804\ \frac{metric\ tons\ CO_2e}{year}$$

Total Facility GHG Baseline Emissions

$$Facility\ GHG\ EF_{base}$$
$$= Forklift\ GHG\ EF_{base} + Tractor\ GHG\ EF_{base} + Handler\ GHG\ EF_{base} + Truck\ GHG\ EF_{base} + Bus\ GHG\ EF_{base} + METS\ Engine\ GHG\ EF_{base} + METS\ Boiler\ GHG\ EF_{base} + Electricity\ GHG\ EF_{base}$$
$$= (252 + 22.66 + 17.55 + 26.48 + 5.67 + 1{,}440 + 104 + 804)\frac{metric\ tons\ CO_2e}{year}$$
$$= 2{,}732\frac{metric\ tons\ CO_2e}{year}$$

Step 2: Determine the GHG emissions that are attributed to the advanced technology. There are no GHG emissions attributed to the use of solar electricity. The only GHG emissions are attributed to vessels calling into the port. The emissions from these vessels will be reduces by the METS system which reduces the emissions determined by the control efficiency. This technology removes 70% of CO_2e, 99% of PM_{10}, 98% of NO_x, and 80% of ROG according to the vendor. As such, the emissions from the vessels for the advanced technology will be attributed to the METS.

METS Auxiliary Engine

$$METS\ Engine\ GHG\ EF_{adv\ tech} = 1{,}440\ \frac{metric\ tons\ CO_2e}{year} * 0.3 = 432\frac{metric\ tons\ CO_2e}{year}$$

METS Auxiliary Boiler

$$METS\ Boiler\ GHG\ EF_{adv\ tech} = 104\ \frac{metric\ tons\ CO_2e}{year} * 0.3 = 31.19\frac{metric\ tons\ CO_2e}{year}$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

Total Facility GHG Advanced Technology Emissions

$$Facility\ GHG\ EF_{adv\ tech} = METS\ Engine\ GHG\ EF_{adv\ tech} + METS\ Boiler\ GHG\ EF_{adv\ tech}$$
$$= 432\frac{metric\ tons\ CO_2e}{year} + 31.19\frac{metric\ tons\ CO_2e}{year} = 463.15\frac{metric\ tons\ CO_2e}{year}$$

Step 3: Determine the Total GHG emissions reductions that are associated with the proposed project using Formula 4, populated by results from Step 1 and Step 2 above.

Formula 4: Total Facility ER

$$Project\ GHG\ ER_{annual} = Facility\ GHG\ EF_{base} - Facility\ GHG\ EF_{adv\ tech}$$
$$= 2{,}732\frac{metric\ tons\ CO_2e}{year} - 463.15\frac{metric\ tons\ CO_2e}{year} = \frac{2{,}269\ metric\ tons\ CO_2e}{year}$$

Step 4: Determine the annual criteria pollutant emission reductions that are associated with the proposed project. There are no criteria emissions associated with the tank to wheel electricity analysis. For all but the METS system, the Emission Reductions will be equal to the baseline emissions as there are no criteria emissions associated with the battery electric advanced technology vehicles or the solar electricity generation.

Yard Tractor

From Table D-1 for 2010 200-hp on-road engine with Certification Standard of 0.20 g NO_x/bph-hr.

$NO_x = 3.44\frac{g\ NO_x}{gal}$; ROG = $0.18\frac{g\ ROG}{gal}$; $PM_{10} = 0.148\frac{g\ PM_{10}}{gal}$

$$Tractor\ Annual\ ER_{NO_x} = 3.44\frac{g\ NO_x}{gal} * \frac{4{,}550\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907{,}200\ g} * 4 = \frac{0.069\ ton\ NO_x}{year}$$

$$Tractor\ Annual\ ER_{ROG} = 0.18\frac{g\ ROG}{gal} * \frac{4{,}550\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907{,}200\ g} * 4 = \frac{0.004\ ton\ ROG}{year}$$

$$Tractor\ Annual\ ER_{PM_{10}} = 0.148\frac{g\ PM_{10}}{gal} * \frac{4{,}550\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907{,}200\ g} * 4 = \frac{0.003\ ton\ PM_{10}}{year}$$

Top Handler

From Table D-12 for 2010 375-hp Tier-4 off-road engine.

$NO_x = 0.26\frac{g\ NO_x}{bhp-hr}$; ROG = $0.06\frac{g\ ROG}{bhp-hr}$; $PM_{10} = 0.008\frac{g\ PM_{10}}{bhp-hr}$

$$Handler\ Annual\ ER_{NO_x} = 0.26\frac{g\ NO_x}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{1{,}270\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907{,}200\ g} * 1$$
$$= \frac{0.007\ ton\ NO_x}{year}$$

$$Handler\ Annual\ ER_{ROG} = 0.06\frac{g\ ROG}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{1{,}270\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907{,}200\ g} * 1$$
$$= \frac{0.002\ ton\ ROG}{year}$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

$$Handler\ Annual\ ER_{PM_{10}} = \frac{0.008\ g\ PM_{10}}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{1270\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907{,}200\ g} * 1 = \frac{2.07E-4\ ton\ PM_{10}}{year}$$

Drayage Truck

From Table D-1 for 2010 200-hp on-road engine with Certification Standard of 0.20 g NO_x/bph-hr.

$NO_x = 3.44 \frac{g\ NO_x}{gal}$; ROG = $0.18 \frac{g\ ROG}{gal}$; $PM_{10} = 0.148 \frac{g\ PM_{10}}{gal}$

$$Truck\ Annual\ ER_{NO_x} = 3.44 \frac{g\ NO_x}{gal} * \frac{958\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 2 = \frac{0.007\ ton\ NO_x}{year}$$

$$Truck\ Annual\ ER_{ROG} = 0.18 \frac{g\ ROG}{gal} * \frac{958\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 2 = \frac{3.8E-4\ ton\ ROG}{year}$$

$$Truck\ Annual\ ER_{PM_{10}} = 0.148 \frac{g\ PM_{10}}{gal} * \frac{958\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 2 = \frac{3.13E-4\ ton\ PM_{10}}{year}$$

Passenger Bus

From Table D-3 for 2010 14,001-30,000-lbs GVWR vehicle. The bus will be in operation 262 days per year.

$NO_x = 0.74 \frac{g\ NO_x}{mile}$; ROG = $0.09 \frac{g\ ROG}{mile}$; PM10 = $0.02 \frac{g\ PM_{10}}{mile}$

$$Bus\ Annual\ ER_{NO_x} = 0.74 \frac{g\ NO_x}{mile} * \frac{10\ miles}{day} * \frac{262\ days}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 = \frac{0.002\ ton\ NO_x}{year}$$

$$Bus\ Annual\ ER_{ROG} = 0.18 \frac{g\ ROG}{gal} * \frac{10\ miles}{day} * \frac{262\ days}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 = \frac{2.6E-4\ ton\ ROG}{year}$$

$$Bus\ Annual\ ER_{PM_{10}} = 0.148 \frac{g\ PM_{10}}{gal} * \frac{10\ miles}{day} * \frac{262\ days}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 = \frac{5.77E-5\ ton\ PM_{10}}{year}$$

METS Engine

From Table D-20a for 2010 700-hp uncontrolled harbor craft auxiliary engine. Reduction is based on 90% control efficiency.

$NO_x = 7.6 \frac{g\ NO_x}{bhp-hr}$; ROG = $0.58 \frac{g\ ROG}{bhp-hr}$; PM10 = $0.23 \frac{g\ PM_{10}}{bhp-hr}$

$$METS\ Engine\ Annual\ ER_{NOx} = 7.6 \frac{g\ NO_x}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{104{,}200\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 * 0.98 = \frac{15.83\ ton\ NO_x}{year}$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

METS Engine Annual ER_{ROG}

$$= 0.58 \frac{g\ ROG}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{104{,}200\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 * 0.8 = \frac{0.986\ ton\ ROG}{year}$$

METS Engine Annual $ER_{PM_{10}}$

$$= 0.23 \frac{g\ PM_{10}}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{104{,}200\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 * 0.99 = \frac{0.484\ ton\ PM_{10}}{year}$$

METS Boiler

From Table D-11 for 2010 275 hp uncontrolled off-road diesel engine. Reduction is based on 90% control efficiency.

$NO_x = 7.6 \frac{g\ NO_x}{bhp-hr}$; $ROG = 0.82 \frac{g\ ROG}{bhp-hr}$; $PM_{10} = 0.274 \frac{g\ PM_{10}}{bhp-hr}$

METS Boiler Annual ER_{NOx}

$$= 7.6 \frac{g\ NO_x}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{7{,}525\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 * 0.98 = \frac{1.14\ ton\ NO_x}{year}$$

METS Boiler Annual ER_{ROG}

$$= 0.82 \frac{g\ ROG}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{7{,}525\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 * 0.8 = \frac{0.101\ ton\ ROG}{year}$$

METS Boiler Annual $ER_{PM_{10}}$

$$= 0.274 \frac{g\ PM_{10}}{bhp-hr} * \frac{18.5\ bhp-hr}{gal\ diesel} * \frac{7{,}525\ gal\ diesel}{year} * 1 * \frac{1\ ton}{907200\ g} * 1 * 0.99 = \frac{0.042\ ton\ PM_{10}}{year}$$

Facility Total Emission Reductions

$$Facility\ Annual\ ER_{NO_x} = sum\ of\ Annual\ ER_{NO_x}s$$

$$= (0.158 + 0.069 + 0.007 + 0.007 + 0.002 + 1.14 + 15.83) \frac{ton\ NO_x}{year} = 17.21 \frac{ton\ NO_x}{year}$$

$$Facility\ Annual\ ER_{ROG} = sum\ of\ Annual\ ER_{ROG}s$$

$$= (0.010 + 0.004 + 0.002 + 3.8E-4 + 2.6E-4 + 0.101 + 0.986) \frac{ton\ ROG}{year} = 1.10 \frac{ton\ ROG}{year}$$

$$Facility\ Annual\ ER_{PM_{10}} = sum\ of\ Annual\ ER_{PM_{10}}s$$
$$= (0.001 + 0.003 + 2.07E-4 + 3.13E-4 + 5.78E-5 + 0.042 + 0.484)\frac{ton\ PM_{10}}{year}$$
$$= 0.530\frac{ton\ PM_{10}}{year}$$

Step 5: Determine the weighted annual surplus emission reductions that are associated with the proposed project using the results from Step 4 above and Formula C-5.

Formula C-5:

$$Facility\ WER = Facility\ Annual\ ER_{NO_x} + Facility\ Annual\ ER_{ROG} + 20 * (Facilty\ Annual\ ER_{PM_{10}})$$
$$= \frac{17.21\ ton\ NO_x}{year} + \frac{1.10\ ton\ ROG}{year} + 20 * \frac{0.530\ ton\ PM_{10}}{year} = \frac{28.91\ ton}{year}$$

Step 6: Determine the incremental cost of the proposed technology using Formula C-3 and the equipment costs for the base case and advanced technology. Cost effectiveness is calculated for two scenarios: for two years during the demonstration and for 10 years, two years after the completion of the demonstration project.

Yard Tractor:

$$IC = Cost\ of\ New\ Tech - Cost\ of\ Baseline\ Tech$$

$$Tractor\ IC_{2\ years} = \$355{,}000 * 4 - \$115{,}800 * 4 = \$956{,}800$$

$$Tractor\ IC_{10\ years} = \$259{,}000 * 4 - \$115{,}800 * 4 = \$572{,}800$$

Top Handler:

$$Handler\ IC_{2\ years} = \$732{,}000 * 1 - \$357{,}000 * 1 = \$375{,}000$$

$$Handler\ IC_{10\ years} = \$660{,}000 * 1 - \$357{,}000 * 1 = \$303{,}000$$

Drayage Truck:

$$Truck\ IC_{2\ years} = \$465{,}000 * 2 - \$123{,}000 * 2 = \$684{,}000$$

$$Truck\ IC_{10\ years} = \$350{,}000 * 2 - \$123{,}000 * 2 = \$454{,}000$$

Passenger Bus:

$$Bus\ IC_{2\ years} = \$450{,}000 * 1 - \$320{,}000 * 1 = \$130{,}000$$

$$Bus\ IC_{10\ years} = \$410{,}000 * 1 - \$320{,}000 * 1 = \$90{,}000$$

METS System: No Baseline Cost

$$METS\ IC_{2\ years} = \$3{,}700{,}000$$

$$METS\ IC_{10\ years} = \$3{,}145{,}000$$

Facility Electricity:

$$Electricity\ IC_{2\ years} = \$3{,}000{,}000$$

$$Electricity\ IC_{10\ years} = \$2{,}700{,}000$$

Attachment 4: EMISSION REDUCTIONS AND COST-EFFECTIVENESS CALCULATIONS

Total Facility Incremental Cost:

$$Facility\ IC_{2\,years} = Sum\ of\ IC_{2\,years}s$$
$$= \$700{,}000 + \$956{,}800 + \$375{,}000 + \$684{,}000 + \$130{,}000 + \$3{,}700{,}000 + \$3{,}000{,}000 = \$9{,}545{,}800$$

$$Facility\ IC_{10\,years} = Sum\ of\ IC_{10\,years}s$$
$$= \$582{,}000 + \$572{,}800 + \$303{,}000 + \$454{,}000 + \$90{,}000 + \$3{,}145{,}000 + \$2{,}700{,}000 = \$7{,}846{,}800$$

Step 7: Determine the GHG emission reduction cost effectiveness for the proposed project using Formula 5 modified to account for annual baseline electricity costs.

Formula 5: Total Facility GHG Emission Reduction Cost Effectiveness

$$GHG\ CE = \frac{CRF * IC}{GHG\ ER_{annual}}$$

$$Facility\ GHG\ CE_2 = \frac{\frac{0.515 * \$9{,}545{,}800}{year} - \frac{\$437{,}750}{year}}{\frac{2{,}269\ metric\ tons\ CO_2e}{year}} = \frac{\$1{,}974}{metric\ ton\ CO_2e}$$

$$Facility\ GHG\ CE_{10} = \frac{\frac{0.111 * \$7{,}846{,}800}{year} - \frac{\$437{,}750}{year}}{\frac{2{,}269\ metric\ tons\ CO_2e}{year}} = \frac{\$191}{metric\ ton\ CO_2e}$$

Step 8: Determine the criteria pollutant cost effectiveness for the proposed technology using Formula C-1.

Formula C-1: Total Facility Criteria Emission Reduction Cost Effectiveness

$$Criteria\ CE = \frac{CRF * IC}{WER}$$

$$Facility\ Criteria\ CE_2 = \frac{\frac{0.515 * \$9{,}545{,}800}{year} - \frac{\$437{,}750}{year}}{\frac{28.91\ ton}{year}} = \frac{\$154{,}886}{ton\ pollutant}$$

$$Facility\ Criteria\ CE_{10} = \frac{\frac{0.111 * \$7{,}846{,}800}{year} - \frac{\$437{,}750}{year}}{\frac{28.91\ ton}{year}} = \frac{\$14{,}984}{ton\ pollutant}$$

ATTACHMENT 5

Attachment 5: PROPOSED BUDGET AND PROJECT MILESTONES AND DISBURSEMENT SCHEDULE

The proposed budget includes all estimated labor and material costs associated with managing the Green Omni Terminal Project. The proposed project budget is $27.3 million, consisting of $15.2 million in grant funds, and $12.1 million in matching funds. Table 6 presents details on the sources of project funding, including cash, in-kind services, and grant funds. As shown in the table, the Green Omni Terminal Project team will contribute 44% of the total project cost in matching funds, including 20% in cash. A draft disbursement schedule is presented in Table 7.

Table 6: Green Omni Terminal Proposed Budget

Expense	Cash	In-Kind	Grant	Total
Los Angeles Harbor Department				
Harbor Department staff time is being contributed as needed to successfully implement this project, but not as an official match.				
Data Loggers (20)			$40,000	$40,000
Pasha Stevedoring & Terminal				
PermaCity 1 MW Solar PV System	$3,047,000			$3,047,000
Wharf Crane Upgrades	$2,500,000			$2,500,000
Vehicle Operator Labor		$5,200,000		$5,200,000
21-Ton Forklift Base Vehicles (2)		$338,000		$338,000
Top Handler Base Vehicle		$357,000		$357,000
Burns & McDonnell				
Project Management			$750,000	$750,000
Engineering			$50,000	$50,000
Construction			$1,051,200	$1,051,200
Commissioning			$60,000	$60,000
Microgrid Control System			$500,000	$500,000
Lighting Control System			$40,000	$40,000
Solar Transformer, Panels, Reconductor to Substation			$840,000	$840,000
Battery Storage System Installation			$420,000	$420,000
EV Charging Infrastructure			$115,000	$115,000
BYD				
Electric Yard Tractors (2)			$600,000	$600,000
Electric Passenger Bus (1)			$450,000	$450,000
Battery Storage System(2)			$1,300,000	$1,300,000
TransPower				
Electric Yard Tractor #1		$100,000	$435,000	$535,000
Electric Yard Tractor #2		$100,000	$410,000	$510,000
Electric Drayage Truck #1		$75,000	$490,000	$565,000
Electric Drayage Truck #2		$75,000	$465,000	$540,000
21-ton Forklift #1		$75,000	$1,210,000	$1,285,000
21-ton Forklift #2		$75,000	$490,000	$565,000

Attachment 5: PROPOSED BUDGET AND PROJECT MILESTONES AND DISBURSEMENT SCHEDULE

Expense	Cash	In-Kind	Grant	Total
Top Handler		$150,000	$1,260,000	$1,410,000
EV Chargers			$205,000	$205,000
Clean Air Engineering-Maritime				
ShoreCat Treatment System			$3,700,000	$3,700,000
Envision Solar				
Passenger EV Solar Charger (1)			$50,000	$50,000
UCR CE-CERT				
Data Collection & Analysis			$119,200	$119,200
Totals	$5,547,000	$6,545,000	$15,050,400	$27,142,400

Table 7: Project Milestones and Disbursement Schedule

Milestone	Task Description	Project Funding	
		Project Funds	Administrative Funds
1.0	**Administration & Project Management**		
1.1	*Kick Off Meeting*	*$0*	*$0*
1.2	*Monthly Project Update Meetings & Reports (invoiced at $18,055 per month for 36 months)*	*$0*	*$650,000*
1.3	*Final Report*	*$165,000*	*$100,000*
2.0	**Infrastructure Design & Construction**		
2.1-2.2	*Permitting & Infrastructure Designs Completed*	*$110,000*	*$0*
2.3.1	Solar PV Installed	*$1,190,400*	*$0*
2.3.2	Battery Storage System Installed	*$2,070,400*	*$0*
2.3.3-2.3.4	Microgrid Control System & Charging Equipment Installed	*$1,195,400*	*$0*
2.3.6	EV ARC Installed	*$50,000*	*$0*
2.4	*Testing & Commissioning*	*$50,000*	*$0*
3.0	**Vehicles & Cargo Handling Equipment**		
3.1	Phase 1 TransPower Operations Report Submitted	*$100,000*	*$0*
3.1	Updated Design Layouts for TransPower Phase 1 Vehicles Completed	*$500,000*	*$0*
3.1	*Phase 1 TransPower Yard Tractors and Drayage Trucks; Invoices Submitted*	*$500,000*	*$0*
3.2	*TransPower Phase 1 Vehicle Components Procured*	*$300,000*	*$0*
3.3	*TransPower Phase 1 Motive Drive Subsystems Assembled*	*$200,000*	*$0*
3.3.1	*TransPower Phase 1 Power Control and Accessory Subsystems Assembled*	*$300,000*	*$0*
3.3.2	*TransPower Phase 1 Energy Storage Subsystems*	*$300,000*	*$0*

Attachment 5: PROPOSED BUDGET AND PROJECT MILESTONES AND DISBURSEMENT SCHEDULE

Milestone	Task Description	Project Funding	
		Project Funds	Administrative Funds
	Assembled		
3.4-3.5	*TransPower Yard Tractor #1 Delivered*	*$200,000*	*$0*
3.4-3.5	*TransPower Yard Tractor #2 Delivered*	*$200,000*	*$0*
	TransPower Drayage Truck #1 Delivered	*$200,000*	*$0*
	TransPower Drayage Truck #2 Delivered	*$200,000*	*$0*
	TransPower Forklift #1 Delivered	*$200,000*	*$0*
	BYD Yard Tractor # 1 Delivered	*$300,000*	*$0*
	BYD Yard Tractor # 2 Delivered	*$300,000*	*$0*
	BYD Passenger Bus Delivered	*$450,000*	*$0*
3.3.3	*TransPower Phase 2 Vehicle Components Purchased*	*$500,000*	*$0*
3.3.4	*TransPower Phase 2 Motive Drive Systems Assembled*	*$100,000*	*$0*
3.3.4	*TransPower Phase 2 Power Control and Accessory Subsystems Assembled*	*$200,000*	*$0*
3.3.4	*TransPower Phase 2 Energy Storage Subsystems Assembled*	*$200,000*	*$0*
3.3.4	*TransPower Forklift #2 Delivered*	*$200,000*	*$0*
3.3.4	*Top Handler Delivered*	*$200,000*	*$0*
4.0	**ShoreCat Emissions Treatment System**		
4.1	*Engineering Designs Completed*	*$70,000*	*$0*
4.1	*Emission Control System Procured*	*$985,327*	*$0*
4.1	*Infrastructure Equipment Procured*	*$553,305*	*$0*
4.1	*Crane/Extraction System Procured*	*$1,329,621*	*$0*
4.2-4.3	*Equipment Installed and Commissioned*	*$563,808*	*$0*
4.4	*Performance/Emission Testing Completed*	*$197,939*	*$0*
5.0	**Equipment Demonstration**	*$0*	*$0*
6.0	Data Collection & Analysis		
6.2	Data Analysis Report Submitted	*$119,200*	*$0*
Subtotal of Project Funds and Administrative Funds		***$14,300,400***	***$750,000***
Grant Total Funding Amount		***$15,050,400***	

ATTACHMENT 6

Attachment 6: DISADVANTAGED COMMUNITIES ELIGIBILITY DETERMINATION

The Port of Los Angeles Green Omni Terminal Project will be performed at the Pasha Terminal, located at 802 South Fries Avenue in Wilmington, California. As discussed in previous sections of this application, the proposed project will provide environmental and economic benefits to the Wilmington DAC. These benefits are summarized below:

BENEFIT: **Reduction of Air and Noise Pollution.** *The conversion of cargo handling equipment from diesel motors to battery-electric drives, use of the ShoreCat at-berth vessel emissions treatment system, and use of EVs will reduce air pollution and noise within the DAC. Cargo handling equipment will be operated exclusively within the DAC for the life of the project, as well as throughout the useful life of the equipment, which is assumed to be a minimum of 10 years.*

BENEFIT: **Emergency Response Services Availability.** *The ability to operate key equipment independent of the electrical grid through the use of the solar-powered microgrid will allow Pasha to continue to provide emergency personnel, goods, and services to the DAC and the surrounding region in the event of a natural or man-made disaster.*

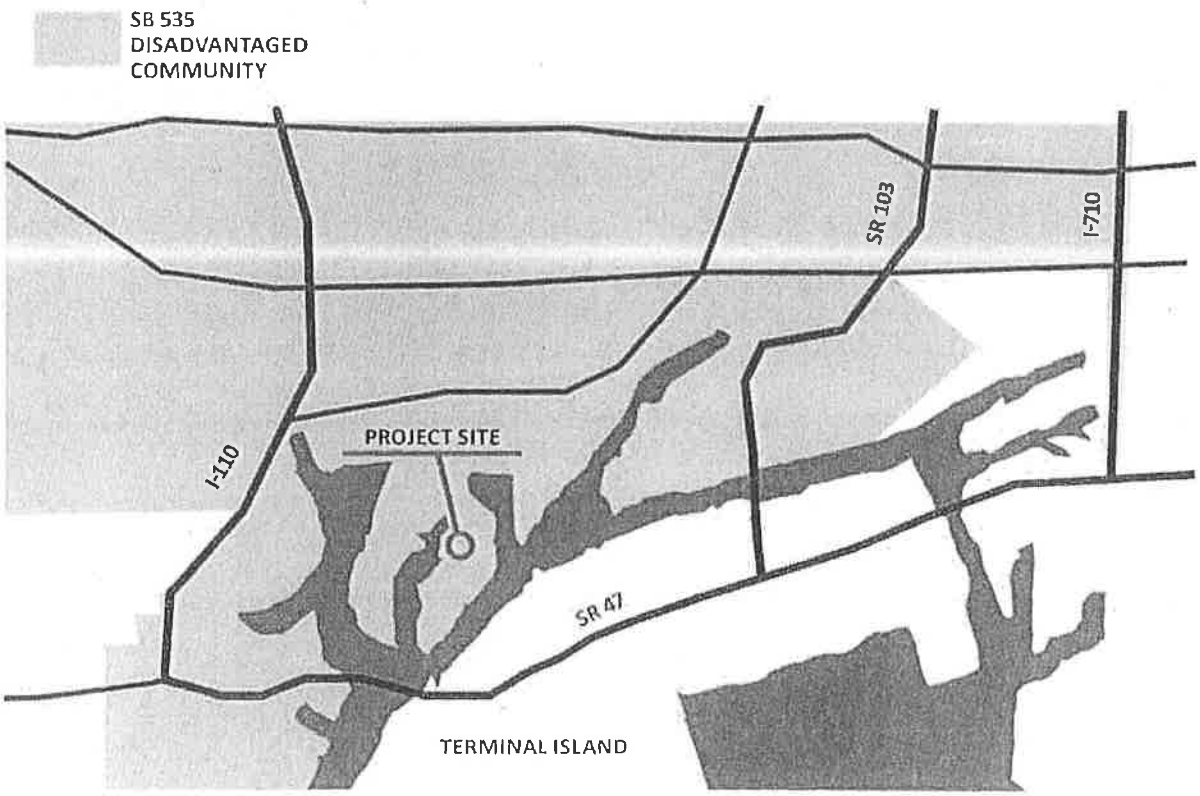
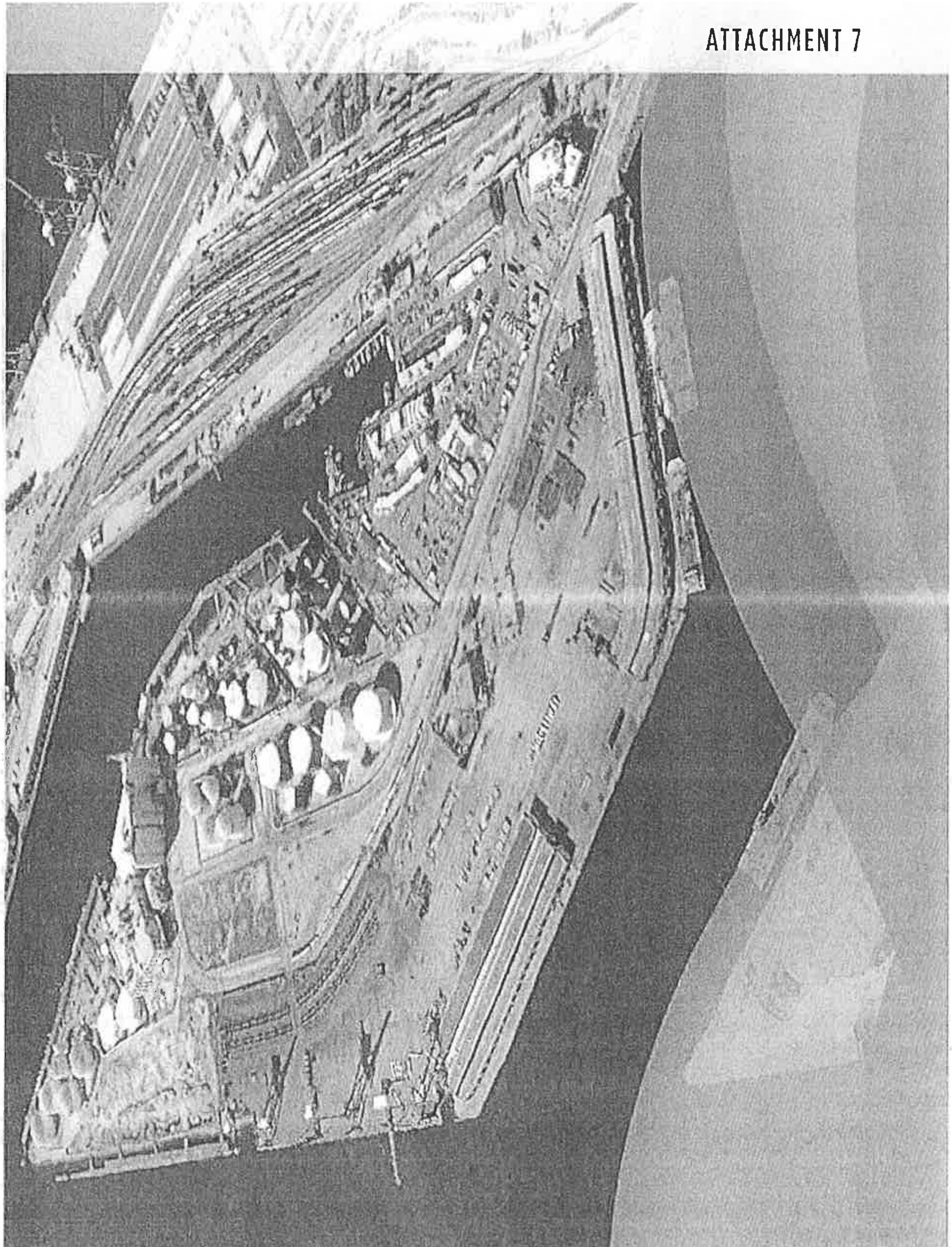


Figure 3: The Port of Los Angeles Green Omni Terminal Project will be located in Wilmington, California, an SB 535 DAC.

ATTACHMENT 7



Attachment 7: PROCEDURES FOR HANDLING CONFIDENTIAL INFORMATION

The Green Omni Terminal Project proposal does not include any confidential information.

Attachment 8: LETTERS OF COMMITMENT

The Harbor Department has included letters of commitment from our partners, subcontractors and technology demonstrators, as listed below to complete the application.

- Pasha Stevedoring & Terminals
- Burns & McDonnell Engineering Co
- Los Angeles Department of Water & Power
- South Coast Air Quality Management District
- UCLA Luskin Center for Innovation
- UC Riverside Center for Environmental Research and Technology
- BYD
- Clean Air Engineering – Maritime
- Envision Solar
- PermaCity
- TransPower

PASHA STEVEDORING & TERMINALS L.P.

September 18, 2015

Chris Cannon
Chief Sustainability Officer
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms Pasha Stevedoring & Terminals, L.P.'s commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. Pasha Stevedoring & Terminals' Port of Los Angeles Terminal located in the disadvantaged community of Wilmington will serve as the end user facility. Pasha Stevedoring & Terminals will participate in and support the Multi-Source Facility Demonstration Project by contributing $8,842,000 in matching funds. Matching funds include $5,547,000 in cash to install a 1 MW solar photovoltaic system to offset 100% of Pasha's electrical use ($3,047,000) and a Crane Drive Efficiency Upgrade Project ($2,500,000). The remainder of the matching funds includes $695,000 in base equipment for the conversion of two 21-ton forklifts and one top handler to battery electric technology and $2,600,000 in wages for ILWU labor for operating electric vehicles.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create a test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact us at 310-835-9869 or Mr. Braxton Craghill, Director of Finance at 310-233-2011.

Sincerely,

Braxton H. Craghill
Director of Finance

802 S. FRIES AVENUE, WILMINGTON, CALIFORNIA 90744
EXECUTIVE OFFICE: TEL: (310) 835-9869 FAX: (310) 835-9361 GENERAL OFFICE: TEL: (310) 835-5042 FAX: (310) 835-1082

BURNS & McDONNELL

September 21, 2015

Chris Cannon
Chief Sustainability Officer
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms Burns & McDonnell Engineering Company Inc.'s commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. Burns & McDonnell will participate in and support the Multi-Source Facility Demonstration Project by providing project management for the Green Omni Terminal Project; engineering, procurement, and construction services for the terminal microgrid and associated electrical infrastructure; and commissioning services the Pasha Terminal's microgrid and associated electrical infrastructure.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact Matt Wartian at 858-320-2945 or mwartian@burnsmcd.com.

Sincerely,

Matthew J. Wartian, Ph.D.
Regional Global Practice Manager
Environmental Studies & Permitting
Burns & McDonnell

COALITION FOR CLEAN AIR

September 21, 2015

Chris Cannon
Chief Sustainability Officer
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms **Coalition for Clean Air's** commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. CCA will participate in and support the Multi-Source Facility Demonstration Project by **participating as a Community Advisor to the project.**

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact us at **213-223-6866.**

Sincerely,

Joseph K. Lyou, Ph.D.

President and CEO, Coalition for Clean Air

800 Wilshire Blvd. | Suite 1010 | Los Angeles, CA 90017
(213) 223-6866 | ccair.org | @joe_lyou | @CleanairCA

Los Angeles Department of Water & Power

ERIC GARCETTI
Mayor

Commission
MEL LEVINE, *President*
WILLIAM W. FUNDERBURK JR., *Vice President*
JILL BANKS BARAD
MICHAEL F. FLEMING
CHRISTINA E. NOONAN
BARBARA E. MOSCHOS, *Secretary*

MARCIE L. EDWARDS
General Manager

September 18, 2015

Mr. Chris Cannon
Chief Sustainability Officer
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

Dear Mr. Cannon:

Subject: Letter of Support to the Los Angeles Harbor Department for the Port of Los Angeles Multi-Source Demonstration Project

The Los Angeles Department of Water and Power (LADWP) is pleased to offer this letter of support for your proposed project. The objective of the project is to demonstrate integration of solar, energy storage, electric transportation, and bi-directional power flow.

LADWP is involved in the United States Department of Energy's Smart Grid Regional Demonstration Project which, among other objectives, aims to evaluate the potential of data-driven voluntary demand response, energy storage and plug-in electrical vehicles and their impact in the Los Angeles area electric power grid. There may be an opportunity for our smart grid experts to collaborate on the proposed research project by providing valuable advice on best practices for energy optimization scenarios. It is not clear if there are any opportunities for LADWP to contribute financially or in-kind at this time, but that is worth additional discussion as the project develops.

We are grateful for the opportunity to provide this letter of support for a very important project.

Yours sincerely,

Marvin D. Moon
Director of Power Engineering

MDM:mw
c: Carter T. Atkins
Michael S. Webster
Mukhlesur Bhuiyan
Sungly Chiu

111 N. Hope Street, Los Angeles, California 90012-2607 *Mailing address:* Box 51111, Los Angeles, CA 90051-5700
Telephone: (213) 367-4211 www.LADWP.com

South Coast
Air Quality Management District
21865 Copley Drive, Diamond Bar, CA 91765-4178
(909) 396-2000 • www.aqmd.gov

Matt Miyasato, Ph.D.
Science and Technology Advancement
909.396.3249 mmiyasato@aqmd.gov

September 22, 2015

Lisa Williams
California Air Resources Board
Mobile Source Control Division
P.O. Box 2815
Sacramento, CA 95812-2815

Dear Ms. Williams:

The South Coast Air Quality Management District (SCAQMD) staff is pleased to support the application submitted by the Port of Los Angeles (POLA) in response to the Multi-Source Facility Demonstration Project Solicitation under CARB's Low Carbon Transportation Investments and Air Quality Improvement Program.

POLA proposes to develop and demonstrate a "Green Omni Terminal" at the Pasha Stevedoring Terminal by integrating various zero emission goods movement technologies into a microgrid that includes solar generation, battery storage and energy management system, making the terminal operation independent of the grid under certain circumstances. This project will demonstrate the feasibility and real-world benefits of a fully integrated, zero-emission cargo-handling operation at a container terminal, serving as a scalable model that can be replicated locally, nationally and globally.

The South Coast Air Basin is classified as an "extreme" nonattainment area for ozone under the federal Clean Air Act. A wide-scale deployment of zero emission vehicles and equipment, including cargo-handling equipment, will be a critical step toward achieving healthful air quality for our region. The benefits will be even greater for disadvantaged communities near the ports and railyards that are disproportionately exposed to harmful diesel emissions.

In light of the criteria pollutants and GHG emissions benefits, SCAQMD staff strongly urges your favorable consideration for POLA's proposal.

If you have any questions about our support, please do not hesitate to contact me.

Sincerely,

Matt Miyasato, Ph.D.
Deputy Executive Officer

MMM:NB

LUSKIN CENTER FOR INNOVATION
SCHOOL OF PUBLIC AFFAIRS
337 Charles E. Young Drive
Los Angeles, CA 90095-1656
Mail Code: 165606

September 17, 2015

Chris Cannon
Chief Sustainability Officer
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms the UCLA Luskin Center for Innovation's commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. The Luskin Center will participate in and support the Multi-Source Facility Demonstration Project by i) evaluating financial costs and ii) GHG and environmental benefits relative to the status quo technologies. We will also assess the role that current and future policy incentives and technology cost trend will play in encouraging other terminal operators to adopt similar technologies. Finally, we will quantify the GHG, air pollution and economic development benefits of scaling these technologies to other terminals at POLA and POLB as well as other ports potentially.

The Luskin Center unites the intellectual capital of UCLA with forward-looking civic leaders to address the most pressing issues confronting our community, nation, and world. We partner with leaders from the public, private, and civil society sectors to advance environmental sustainability in Los Angeles through a mixture of scholarship, research, and community engagement.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact me at 310.267.5435.

Sincerely,

J.R. DeShazo
Director

UNIVERSITY OF CALIFORNIA, RIVERSIDE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

COLLEGE OF ENGINEERING
CENTER FOR ENVIRONMENTAL RESEARCH AND TECHNOLOGY
1084 Columbia Ave. Riverside, CA 92507

(951) 781-5791 FAX (951) 781-5790
http://www.cert.ucr.edu

September 23, 2015

Chris Cannon
Chief Sustainability Officer
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms the University of California at Riverside (UCR), Bourns College of Engineering – Center for Environmental Research and Technology's (CE-CERT's) commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. UCR will participate in and support the Multi-Source Facility Demonstration Project by assisting in the installation and helping to maintain the operation of data loggers, by conducting a performance test of an electric yard tractor on its heavy-duty chassis dynamometer, and by performing two field tests to evaluate the performance of two all electrical pieces of equipment.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact me at Tom Durbin, 951-781-5794, durbin@cert.ucr.edu.

Sincerely,

Tom Durbin

Thomas Durbin, Ph.D.
Research Engineer

BYD Motors Inc.
1800 South Figueroa Street, Los Angeles, CA 90015

22 September 2015

Chris Cannon
Chief Sustainability Officer
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms BYD Motors commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. BYD will participate in and support the Multi-Source Facility Demonstration Project as a technology demonstrator by providing yard tractors, drayage trucks, buses, and battery storage. As a global manufacturing company, BYD has the financial and engineering resources to support the rapid development and production of each of the products in this proposal. This project has received approval and support from the highest ranks of BYD's executive team. All vehicles in this demonstration project will be manufactured at BYD's manufacturing facilities in Lancaster, CA, and will therefore provide economic benefits for the State of California.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact us at 213-458-6918 or andy.swanton@byd.com.

Sincerely,

Stella Li
President
BYD Motors

September 9, 2015

Chris Cannon
Chief Sustainability Officer
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms Clean Air Engineering – Maritime, Inc. commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. Clean Air Engineering – Maritime, Inc. will participate in and support the Multi-Source Facility Demonstration Project by matching funds as required.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact us at (310)241-1208 or ntonsich@caemaritime.com.

Sincerely,

Nick Tonsich

Nick Tonsich, Principal

ENVISION
SOLAR

September 18, 2015

Chris Cannon
Chief Sustainability Officer
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms Envision Solar International commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. Envision Solar International will participate in and support the Multi-Source Facility Demonstration Project by manufacturing and delivering the world's first transportable solar EV charging station, the EV ARC™.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact us at Envision Solar International, David Greenfader at 310.961.4669.

Sincerely,

David Greenfader
VP Business Development
Envision Solar International, Inc.

PermaCity
the solar revolution

September 23, 2015

Chris Cannon
Chief Sustainability Officer
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, CA 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms PermaCity Construction Corp's commitment to support the Los Angeles Harbor Department's proposed Green Omni Terminal Project. PermaCity Construction will participate in and support the Multi-Source Facility Demonstration Project by installing a commercial-grade solar electric photovoltaic system. The system will be built using the most sophisticated solar racking system available on the market today, PermaCity's patent-pending SolarStrap system.

We look forward to working with the Los Angeles Harbor Department and the rest of the project participants to create a test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact PermaCity's Operations Department at (323) 692-9264 ext. 205.

Sincerely,

John Mason

Commercial Sales Director

TransPower

September 10, 2015

Chris Cannon
Chief Sustainability Officer
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, California 90731

RE: Letter of Commitment to the Los Angeles Harbor Department for Participation in the Port of Los Angeles Multi-Source Demonstration Project

Dear Mr. Cannon:

This letter confirms TransPower's commitment to support the Los Angeles Harbor Department's proposed *Green Omni Terminal Project*. TransPower will participate in and support this Multi-Source Facility Demonstration Project as a key technology provider, delivering and supporting electric drayage trucks, yard tractors, and other cargo handling equipment. As part of our commitment to the success of this project, TransPower will provide cash and in-kind cost sharing of $650,000.

TransPower, an emerging leader in development and manufacturing of zero-emission port vehicles, looks forward to working with the Los Angeles Harbor Department and the rest of the project participants to create test facility that can demonstrate zero and near-zero emission technologies and serve as a model for other ports and industrial facilities throughout California, the nation, and the world. If you need any additional information, please feel free to contact me at (85) 248-4255 or mike@transpowerusa.com.

Sincerely,

Michael C. Simon
President & CEO

13000 Danielson Street, Suite B Poway, California 92064

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

1. **What are the physical aspects of the project? (Check all that apply and provide brief description of work, including any size or dimensions of the project).**

Project Aspect	Yes	No	Description of Project Aspect
Construction *(including grading, paving, etc.)*	☐	☒	*The installation of approximately 1 MW of solar at Berth 181 will include upgrades to electrical infrastructure that is servicing the Berth 181 Warehouse. Upgrades to electrical panels, transformers, conductors, and overhead electric transmission structures are anticipated with implementation of the project. The existing conduit is not sufficiently sized to pull a new conductor to connect the substation to the warehouse. The project will require trenching (approximately 18 inch x 42 inch) for approximately 0.20 to 0.35 miles from the rooftop solar installation to the substation. The trench will accommodate a larger conduit, duct bank, and conductor to support the substation. Other construction involves installation of electric vehicle (EV) charging infrastructure, rooftop solar PV array, and 40-foot containerized battery storage units.*
Trenching	☒	☐	*Please see the above response.*
New or replaced pipelines	☐	☒	*The project does not require new or replacement of existing pipelines.*
Construction of underground facilities *(including tanks)*	☒	☐	*The project will install transmission conductor in underground conduit/duct banks (approximately 18" x 42" for 0.20-0.35 miles) between the solar installation at the Berth 181 Warehouse to the substation.*
Modification or conversion of a facility	☒	☐	*The project is a modification and conversion to a solar-powered, resilient facility with testing of zero and near-zero emissions cargo handling equipment and vehicles.*
New or modified operation of a facility or equipment	☒	☐	*The Pasha Terminal will be equipped with charging infrastructure to charge battery EVs and equipment. It will also incorporate a solar PV system to meet the terminal's current electrical demands.*

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

On-road demonstration	☒	☐	*This project will test two (2) near-commercial electric drayage trucks and one (1) electric bus for moving workers between facilities.*
Paper study *(including analyses on economics, feedstock availability, workforce availability, etc.)*	☐	☒	*No paper study was performed for the project.*
Laboratory research	☐	☒	*Implementation of the project does not involve construction or installation of laboratory research facilities. However electric equipment and vehicles may be tested in an offsite laboratory as a component of the project.*
Temporary or mobile structures *(skid-mounted)*	☒	☐	*The project includes a temporary (skid-mounted) modular solar-powered electric passenger vehicle charging unit, which will be installed in the employee and visitor parking lot.*
Design/Planning	☒	☐	*The project involves substantial design and planning elements for new charging infrastructure, battery storage, and on-site solar. Initial conceptual plans have been developed for the project. Detailed plans and designs will be developed following grant award.*
Other *(describe and add pages as necessary)*	☐	☒	*N/A*

2. Where is the project located or where will it be located? (Attach additional sheets as necessary.)

Address	County	Type of Work to Be Completed at Site
Pasha Stevedoring & Terminals is located at 802 South Fries Avenue Wilmington, CA 90744	Los Angeles	Facility upgrades and minor modifications. Installation of a 1 MW solar PV system on an existing warehouse rooftop, battery storage units, cargo handling equipment charging units, and a passenger vehicle charging station within existing visitor and employee parking lot and use of EVs and equipment.

3. **Will the project potentially have environmental impacts that trigger CEQA review? (Check a box and explain the answer for each question. Additionally, please provide a complete description of any direct physical changes and reasonably foreseeable indirect changes to the environment that may result from the project. Please provide as much detail as possible. You may provide additional information on supplemental pages as necessary.)**

The proposed project would introduce minor alterations to the terminal. No expansion of capacity or uses are projected with implementation of the project. The project would install appurtenances to demonstrate zero and near-zero emissions technologies and would demonstrate how renewable generation and battery storage can contribute to a sustainable and resilient terminal that is capable of operating when connected or independent of the electric grid. Solar PV panels would be installed on an existing rooftop and would occupy no more than 100,000 square feet of area, battery storage equipment would be installed within the existing footprint of the terminal and would occupy approximately 2,000 square feet. Ten (10) electric cargo handling equipment and vehicle charging stations would be installed on the terminal and would occupy approximately 2,000 square feet. Vehicle charging stations would be installed in an existing parking lot and would occupy approximately 100 square feet. Other changes involve converting diesel vehicles and equipment to EVs and equipment. The proposed project construction and operation activities are all minor changes and would not be located on an environmentally sensitive site, because all project activities would take place within an existing developed terminal facility. Furthermore, there would be net beneficial cumulative impacts associated with reduced air quality emissions and noise.

The proposed project involves installation of new equipment involving negligible or no expansion of use as required for health and environmental control as well as basic data collection and field testing activities by the Harbor Department which do not result in a serious or major disturbance to an environmental resource. As such, the Harbor Department determined that the proposed project is Categorically Exempt from the requirements of CEQA in accordance with <u>City of Los Angeles Environmental Quality Act Guidelines Article III Class 3(4) and 6(2).</u>

Question	Yes	No	Don't Know	Explanation
Is the project site environmentally sensitive?	☐	☒	☐	The project is located at an existing Port of Los Angeles Terminal (Pasha Stevedoring & Terminals is located at 802 South Fries Avenue in Wilmington). Because the project construction and operation will be entirely within existing disturbed and previously developed areas there will be no impact to potentially sensitive areas.
Is the project site on agricultural land?	☐	☒	☐	The project is located at an existing Port of Los Angeles Terminal. The project construction and operation will be entirely within existing disturbed and previously developed areas.

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

Question	Yes	No	Don't Know	Explanation
Is the land on which the project would be built previously disturbed?	☒	☐	☐	The project is at an existing Port of Los Angeles Terminal. The project construction and operation will be entirely within existing disturbed and previously developed areas.
Is this project part of a larger project?	☐	☒	☐	This project is not part of a larger project or program.
Is there public controversy about the proposed project or larger project?	☐	☒	☐	This project will benefit the community at large by reducing emissions and pollutants utilizing clean energy and will serve as a model for future sustainability projects and facilities world-wide.
Will historic resources or historic buildings be impacted by the project?	☐	☒	☐	There are no historic resources or historic buildings within the terminal.
Is the project located on a site the Department of Toxic Substances Control and the Secretary of the Environmental Protection have identified as being affected by hazardous wastes or cleanup problems?	☐	☒	☐	The Pasha Omni Terminal is not located on a site listed as a hazardous waste site on the Envirostor database[1] (Department of Toxic Substances Control). Berth 174 at the former GATX Marine Terminals is adjacent to the Pasha Omni Terminal on Mormon Island and is listed on the Envirostor database as being affected by hazardous wastes (Envirostor ID 19440005). However, this project does not involve activities at that site. Furthermore, there is no known contamination at the Pasha Terminal. Although there is known contamination adjacent to the Pasha Terminal, the project activities would not represent a threat for release of hazardous waste. If contamination is encountered during trenching activities, all contaminated materials, including those contaminated with petroleum waste products, shall be properly removed from the project site, treated, and disposed of at an appropriate facility in accordance with applicable

[1] Available here: http://www.envirostor.dtsc.ca.gov/public/

Question	Yes	No	Don't Know	Explanation
				regulations.
Will the project generate noise or odors in excess of permitted levels?	☐	☒	☐	Introduction of EVs and equipment will be an overall beneficial improvement with reduced noise and odors (quieter engines and no diesel odor or fumes). During the construction phase, vehicles will be used to transport equipment to the site for installation and in-servicing. Transport of equipment by truck is consistent with goods movement activities of the terminal. Additionally, noise generated by other construction related activities, such as installation of solar panels and trenching, will be consistent with the existing general operations at the terminal; therefore, any associated incremental increases in noise or odor is considered to be negligible.
Will the project increase traffic at the site and by what amount?	☐	☒	☐	Traffic patterns within the existing terminal facility and street traffic outside the terminal facility will not be affected by the project.
Is the project expected to result in environmental impacts to any other resource area (e.g., air quality, aesthetics, water quality)? (Add pages as necessary.)	☐	☒	☐	The project will result in a net benefit to air quality. The project will reduce greenhouse gas, diesel particulate matter, and nitrogen oxide emissions in an area that doesn't currently meet National Ambient Air Quality Standards and would improve air quality in an area adjacent to disadvantaged communities.

4. Will the project require discretionary permits or determinations, as listed below?

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

Type of Permit	No	Modified	New	Approving Agency	Reason for Permit, Summary of Process, and Anticipated Date of Issuance
Air Quality Permit	☒	☐	☐		
Water Quality Permit	☒	☐	☐		
Conditional Use Permit or Variance	☒	☐	☐		
Building Expansion Permit	☒	☐	☐		
Hazardous Waste Permit	☒	☐	☐		
Rezoning	☒	☐	☐		
Authority to Construct	☒	☐	☐		
Other Permits (List types)	☐	☐	☒		• Engineers Permit - The project will need to obtain a Harbor Engineer Permit from City of Los Angeles Harbor Department. • Parallel Cogeneration Interconnection Agreement - Pasha will need to enter with DWP into a Parallel Cogeneration Interconnection Agreement. This agreement has life of 3 years and must be renewed every 3 years. • Photovoltaic Interconnection Agreement - Similar to above, Pasha will have to enter with DWP into a Photovoltaic Interconnection Agreement. • City of Los Angeles Department of Building and Safety permits - Pasha will need to obtain City of Los Angeles Department of Building and Safety permits (electrical, structural, building permit for re-roofing), Fire Department approval for solar installations. Anticipated dates of issuance are

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

					unknown at this time. Additional City permits may be required.

5. **Of the agencies listed in #4, have you identified and contacted the public agency who will be the lead CEQA agency on the project?**

☒ **Yes.** Provide the name and contact information for the lead agency.
City of Los Angeles, Harbor Department

☐ **No.** Explain why no contact has been made and/or a proposed process for making contact with the lead agency.

6. **If you identified an agency with discretionary approval authority over the project (see Item 4 above), has as the public agency prepared environmental documents (e.g., Notice of Exemption, Initial Study/Negative Declaration/Mitigated Negative Declaration, Environmental Impact Report,**

☒ **Yes.** Please complete the following and attach the CEQA document to this worksheet. (For "Not a project," the title of the document may be an e-mail, resolution, or letter.)

Type of Environmental Review	Title of Environmental Document (Attach the document to this form)	State Clearinghouse Number	Completion Date	Planned Completion Date (must be before approval of grant)

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

Type of Environmental Review	Title of Environmental Document (Attach the document to this form)	State Clearinghouse Number	Completion Date	Planned Completion Date (must be before approval of grant)
"Not a project" ☐ Email ☐ Letter ☐ Resolution ☐ Other:		N/A		N/A
Exempt (Resolution of public agency or Agenda Item approving Exemption)	Resolution via Board of Harbor Commissioners approval.	N/A	TBD	N/A
Exempt (Notice of Exemption)	N/A	N/A		
Initial Study				
Negative Declaration				
Mitigated Negative Declaration				
Notice of Preparation				
Environmental Impact Report				
Master Environmental Impact Report				
Notice of Determination				

Attachment 9: CALIFORNIA ENVIRONMENTAL QUALITY ACT WORKSHEET

Type of Environmental Review	Title of Environmental Document (Attach the document to this form)	State Clearinghouse Number	Completion Date	Planned Completion Date (must be before approval of grant)
NEPA Document (Environmental Assessment, Finding of No Significant Impact, and/or Environmental Impact Statement)				

☐ **No.** Explain why no document has been prepared. Propose a process for obtaining lead agency approval and estimated date for that approval (must occur before ARB will approve the grant).

Certification: I certify to the best of my knowledge that the information contained in this worksheet is true and complete. I further certify that I am authorized to complete and sign this form on behalf of the proposing organization.

Name: Christopher Cannon

Title: Chief Sustainability Officer

Signature:

Phone Number: (310) 732-3763

Email: ccannon@portla.org

Date: September 22, 2015

ATTACHMENT 10

Attachment 10: CONFLICT OF INTEREST DECLARATION

The Los Angeles Harbor Department finds no conflict of interest with its ability to fulfill the necessary duties as the Multi-Source Facility Demonstration Program Grantee. In addition, neither the Harbor Department nor its subcontractors, identified in Attachment 1 of this application, has any current, ongoing, or pending direct or indirect interest, which poses an actual, apparent, or potential conflict of interest with its ability to fulfill the duties as the Grantee.

ATTACHMENT 11

Attachment 11: STD. 204 PAYEE DATA RECORD

State of California—Department of Health Care Services

PAYEE DATA RECORD

(Required when receiving payment from the State of California in lieu of IRS W-9)

STD 204 (Rev. 5/06) DHCS

1	INSTRUCTIONS: Complete all information on this form. Sign, date, and return to the State agency (department/office) address shown at the bottom of this page. Prompt return of this fully completed form will prevent delays when processing payments. Information provided in this form will be used by State agencies to prepare Information Returns (1099). See reverse side for more information and Privacy Statement. **NOTE: Governmental entities, federal, state, and local (including school districts), are not required to submit this form.**
2	PAYEE'S LEGAL BUSINESS NAME (Type or Print): City of Los Angeles Harbor Department SOLE PROPRIETOR—ENTER NAME AS SHOWN ON SSN (Last, First, M.I.): E-MAIL ADDRESS: MAILING ADDRESS: 425 South Palos Verdes Street CITY, STATE, ZIP CODE: San Pedro, CA 90731 BUSINESS ADDRESS: 425 South Palos Verdes Street CITY, STATE, ZIP CODE: San Pedro, CA 90731
3 PAYEE ENTITY TYPE CHECK ONE BOX ONLY	**ENTER FEDERAL EMPLOYER IDENTIFICATION NUMBER (FEIN):** 95-6000735 ☐ PARTNERSHIP ☐ ESTATE OR TRUST **CORPORATION:** ☐ MEDICAL (e.g., dentistry, psychotherapy, chiropractic, etc.) ☐ LEGAL (e.g., attorney services) ☐ EXEMPT (nonprofit) ☒ ALL OTHERS ☐ INDIVIDUAL OR SOLE PROPRIETOR ENTER SOCIAL SECURITY NUMBER: ___-__-____ (SSN required by authority of California Revenue and Tax Code Section 18646) **NOTE: Payment will not be processed without an accompanying taxpayer I.D. number.**
4 PAYEE RESIDENCY TYPE	☒ California resident—qualified to do business in California or maintains a permanent place of business in California. ☐ California nonresident (see reverse side)—Payments to nonresidents for services may be subject to State income tax withholding. ☐ No services performed in California. ☐ Copy of Franchise Tax Board waiver of State withholding attached.
5	**I hereby certify under penalty of perjury that the information provided on this document is true and correct. Should my residency status change, I will promptly notify the State agency below.** AUTHORIZED PAYEE REPRESENTATIVE'S NAME (Type or Print): Eugene D. Seroka TITLE: Executive Director SIGNATURE: [signature] FOR EUGENE SEROKA DATE: 9/23/15 TELEPHONE: (310) 732-3456
6	Please return completed form to: Department/Office: Department of Health Care Services- TPLRD Unit/Section: Mailing Address: City/State/ZIP: Telephone: ( ) FAX: ( ) E-Mail Address:

Attachment 11: STD. 204 PAYEE DATA RECORD

State of California—Department of Health Care Services

PAYEE DATA RECORD

STD. 204 (Rev. 5/08)_DHCS (Page 2)

1	**Requirement to Complete Payee Data Record, STD. 204** A completed Payee Data Record, STD. 204, is required for payments to all non-governmental entities and will be kept on file at each State agency. Since each State agency with which you do business must have a separate STD. 204 on file, it is possible for a payee to receive this form from various State agencies. Payees who do not wish to complete the STD. 204 may elect to not do business with the State. If the payee does not complete the STD. 204 and the required payee data is not otherwise provided, payment may be reduced for federal backup withholding and nonresident State income tax withholding. Amounts reported on Information Returns (1099) are in accordance with the Internal Revenue Code and the California Revenue and Taxation Code.
2	Enter the payee's legal business name. Sole proprietorships must also include the owner's full name. An individual must list his/her full name. The mailing address should be the address at which the payee chooses to receive correspondence. Do not enter payment address or lock box information here.
3	Check the box that corresponds to the payee business type. Check only one box. Corporations must check the box that identifies the type of corporation. The State of California requires that all parties entering into business transactions that may lead to payment(s) from the State provide their Taxpayer Identification Number (TIN). The TIN is required by the California Revenue and Taxation Code Section 18646 to facilitate tax compliance enforcement activities and the preparation of Form 1099 and other information returns as required by the Internal Revenue Code Section 6109(a). The TIN for individuals and sole proprietorships is the Social Security Number (SSN). Only partnerships, estates, trusts, and corporations will enter their Federal Employer Identification Number (FEIN).
4	<u>Are you a California resident or nonresident</u>? A corporation will be defined as a "resident" if it has a permanent place of business in California or is qualified through the Secretary of State to do business in California. A partnership is considered a resident partnership if it has a permanent place of business in California. An estate is a resident if the decedent was a California resident at time of death. A trust is a resident if at least one trustee is a California resident. For individuals and sole proprietors, the term "resident" includes every individual who is in California for other than a temporary or transitory purpose and any individual domiciled in California who is absent for a temporary or transitory purpose. Generally, an individual who comes to California for a purpose that will extend over a long or indefinite period will be considered a resident. However, an individual who comes to perform a particular contract of short duration will be considered a nonresident. Payments to all nonresidents may be subject to withholding. Nonresident payees performing services in California or receiving rent, lease, or royalty payments from property (real or personal) located in California will have 7% of their total payments withheld for State income taxes. However, no withholding is required if total payments to the payee are $1,500 or less for the calendar year. For information on Nonresident Withholding, contact the Franchise Tax Board at the numbers listed below: Withholding Services and Compliance Section: 1-888-792-4900 E-mail address: wscs.gen@ftb.ca.gov For hearing impaired with TDD, call: 1-800-822-6268 Website: www.ftb.ca.gov
5	Provide the name, title, signature, and telephone number of the individual completing this form. Provide the date the form was completed.
6	This section must be completed by the State agency requesting the STD. 204.

Privacy Statement

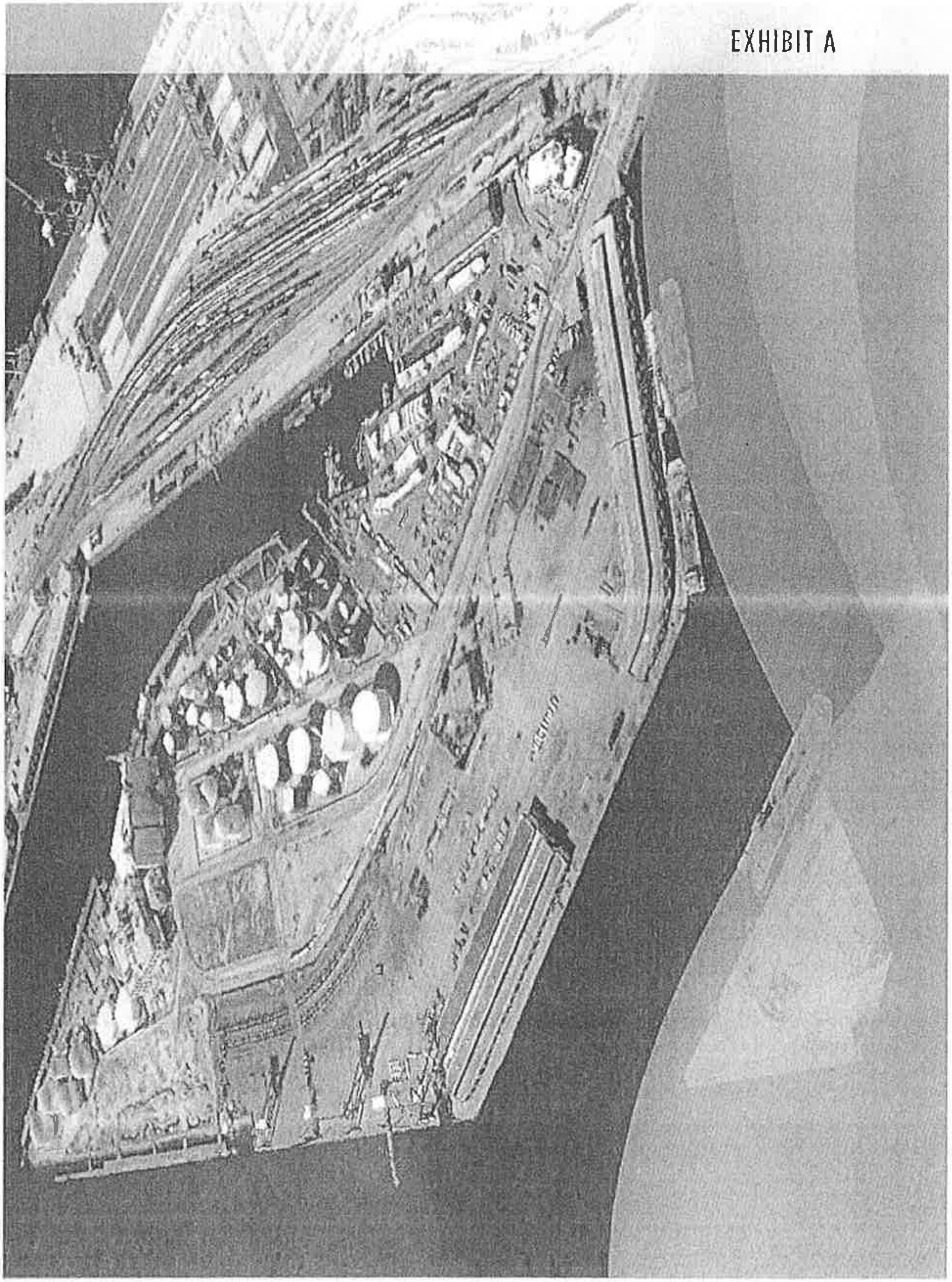
Section 7(b) of the Privacy Act of 1974 (Public Law 93-579) requires that any federal, State, or local governmental agency, which requests an individual to disclose their social security account number, shall inform that individual whether that disclosure is mandatory or voluntary, by which statutory or other authority such number is solicited, and what uses will be made of it.

It is mandatory to furnish the information requested. Federal law requires that payment for which the requested information is not provided is subject to federal backup withholding and State law imposes noncompliance penalties of up to $20,000.

You have the right to access records containing your personal information, such as your SSN. To exercise that right, please contact the business services unit or the accounts payable unit of the State agency(ies) with which you transact that business.

All questions should be referred to the requesting State agency listed on the bottom front of this form.

EXHIBIT A



CHRISTOPHER CANNON
- Director of Environmental Management
- Chief Sustainability Officer

Christopher Cannon is the Director of Environmental Management for the Port of Los Angeles, a position he has held since October 2010. In 2015, he was named Chief Sustainability Officer of the Port.

In this role, Mr. Cannon is responsible for balancing commerce and growth with ecological sustainability and social responsibility at the nation's busiest container port. The Environmental Management Division provides full environmental services related to water, soils and sediments, air and biological resources, and is responsible for preparation of environmental impact assessments mandated by state and federal law; special studies involving dredging, noise abatement, water quality and air quality; site restoration, remediation and contamination characterizations; wildlife management; and establishment of policies regarding environmental quality issues.

Mr. Cannon first worked at the Port of Los Angeles as a consultant, starting in 2004, where he worked with the Port Environmental Management Division's Air Quality and CEQA groups, supporting the development of key air projects such as the Clean Air Action Plan as well as the Harbor Department's efforts to complete critical environmental impact reports for Port-related projects. In 2008, he helped to develop and served as the Project Manager of the Port's highly successful Clean Truck Program.

Mr. Cannon has 21 years of experience in the environmental services industry, working on a range of projects while employed by ENVIRON International Corporation and TRC Environmental Solutions.

Mr. Cannon also spent two years as a legislative assistant for environmental policy on the Washington, D.C. staff of U.S. Representative Martin Sabo of Minnesota.

Cannon received a bachelor's degree in international relations from Dartmouth College and a law degree from University of California at Berkeley's Boalt Hall School of Law. He currently lives in Los Angeles.

425 S. Palos Verdes Street, San Pedro, CA 90731
(310) 732-7649
catkins@portla.org

Carter T. Atkins

Work History

City of Los Angeles – Harbor Department, Environmental Management Division

Environmental Specialist III — November 2007 – Current

Technical project manager for Port of Los Angeles Environmental Ship Index, Low Sulfur Fuel Incentive Program, Vessel Speed Reduction Incentive Program, Clean Air Action Plan control measures OGV5 and OGV6. Project manager for all Ocean Going Vessel related projects, coordinated with shipping lines; terminal operators; regulatory agencies and consultants to develop incentive programs. Serve as liaison to terminal operators and shipping lines regarding upcoming regulations. Staff liaison to Port Community Advisory Committee (PCAC) Air Quality Subcommittee. International Port of Los Angeles representative for International Association of Ports and Harbors, World Ports Climate Initiative, Environmental Ship Index meetings. Assist Business Development and Engineering with AMP projects. Prepared a $23.5 million dollar grant package to defray costs for ten shore side AMP installations. Directed/Supervised consultants as needed basis to assist to perform work.

City of Los Angeles - Los Angeles World Airports, Construction and Maintenance

Environmental Specialist II/III — April 2005 – October 2007

Project Manager to implement an air quality compliance plan to bring LAWA into compliance with all SCAQMD permitted and non-permitted emission sources. Database architect to document compliance with SCAQMD recordkeeping requirements.

City of Los Angeles – Bureau of Engineering, Environmental Management Group

Environmental Specialist II — July 2001 – April 2005

Technical Project Manager for CEQA (California Environmental Quality Act) environmental clearance for City of Los Angeles (City) projects. Wrote phase I environmental site assessments, CEQA initial studies, CEQA negative declarations, CEQA mitigated negative declarations. Manage and supervised consultants to write Environmental Impact Reports. Served as liaison with consultants to complete technical wildlife, archaeological and historical surveys. Other tasks included attending city council meetings, board of public works meetings, and community meetings.

AQC Environmental Engineers

Air Quality Consultant — April 1999 – July 2001

Technical Project Lead for manufacturing companies to achieve environmental compliance with federal, state, & local regulations. Major work emphasis was to obtain SCAQMD equipment permits and report emissions for manufacturing facilities in the Orange and Los Angeles Counties. Permitting included SCAQMD Title V and equipment specific permits. Emissions reporting included preparing annual emissions reports, NOx reporting, and source testing. Other work included Form R reporting, storm water reporting, industrial wastewater sampling, and hazardous waste reporting. Other responsibilities included software sales, acquiring new clients through marketing. Managed summer internship program.

Atkins Environmental H.E.L.P., Inc.

Environmental Consultant — April 1998 – April 1999

Consulted with manufacturing companies to achieve environmental and health & safety compliance in the Los Angeles and Ventura Counties. Work emphasis included SCAQMD air permitting; wastewater permitting; environmental audits, environmental site assessments; hazardous materials business plans, cleanup, and minimization projects.

Transportable Treatment Services, Inc.

Supervisor — September 1997 – April 1998

Managed sludge dewatering and sewer manhole rehabilitation projects. Supervised projects that included day to day operations, personnel, and project delivery.

Education

- **Certificate in Geographic Information Science and Technology**, University of Southern California, 2012
- **Masters of Business Administration**, Pepperdine University, 2005.
- **Bachelor of Science in Forestry & Natural Resource Management**, California Polytechnic State University, 1997.

Vahik Haddadian, P.E.

Bus. (310) 732-3647 ; Mobile: (626) 233-8407
E-mail: vhaddadian@aol.com

Current Position

Harbor Engineer – Chief of Design at the Port of Los Angeles (POLA).

Summary of Qualifications

- Over 30 years of progressively responsible engineering and design management experience in the City of Los Angeles Harbor Department. During last 13 years I have served as the Senior Electrical Engineer responsible for directing POLA's electrical engineering design section. I provide engineering, project management, and supervision to produce engineering design plans, specifications, and construction document packages required for the construction of complex medium voltage and low voltage electrical power distribution, lighting, and communication systems for heavy industrial/commercial/marine facilities, containerized cargo handling facilities, Alternative Maritime Power (AMP) shore-to-ship power system, cruise passenger and baggage handling facilities, roadways, bridges, solar system power generation design, terminal automation and electrification, port-wide energy management, and waterfront capital improvement projects.

- Experienced in providing leadership to plan, control, organize, direct, evaluate and coordinate to prepare cost and time schedules, design and construction documentations required for the construction of Port facilities, directing the coordination of work with multidiscipline engineering staff, consultants, governmental entities, utility companies, Port tenants and other Port divisions such as environmental, real estate, wharfingers, homeland security, construction, maintenance, port police, and local as well as national and international regulatory entities.

- Experienced in setting goals, measure performance, update administrative directives and apply Port's policy and procedures to manage electrical engineering design staff.

- Serve as the program manager of a $200 Million **Alternative Marine Power (AMP)** shore-to-ship power design and installation program. The program included 12 various construction contracts for the construction and commissioning of the shore to ship power distribution system for 26 berths within the POLA facilities. Coordinated required work and received $23M state funding incentive for the installation of AMP system.

- Experienced in the **Automated Terminal Design** including the certification and application of automated cargo handling equipment. Engineer in charge of review, approval and permitting process for electric cranes and electrified cargo handling equipment.

- Supervised the planning, development of the specification and design drawings, construction and commissioning of a One (1) Mega-Watt of **solar photovoltaic generation rooftop plant** for POLA Cruise Passenger Terminal Building. Oversaw various consultants for the commissioning and inspection process. The project included installation of approximately 5600 solar photovoltaic panels, collectors, inverters, switchgear and protection equipment and the electrical connection to the utility network.

- In charge of the technical development of POLA's **Energy Management Action Plan (EMAP),** and the implementation of energy efficiency as well as power conservation measures such as installation of the first ever LED based high mast lighting system for the container terminals.

- Experienced in review, selection and management of various consultants and contractors. Experienced in managing the development and management of design services contracts, authorization and approval of directives and payments, validation of services rendered or work performed, managing change orders while controlling impact of project cost and delivery schedule.

- Since 2003 I continue to serve as **U.S. Expert in IEC/ISO/IEEE international standards development committee,** serving as chair of the Container Vessel shore-to-ship connection annex. I actively participated and led the POLA Electrical Engineering team to invent and develop the High Voltage Shore Connection (HVSC) power systems for container vessels. This invention is used as the international standard, which was internationally approved in 2012, and is currently in effect for all ports around the globe for the design, construction, operation, commissioning and maintenance of shore power connection facilities.

- Current duties as the Chief of Design include the development, administration, management and control of various engineering sections such as Electrical, Permits, and others as assigned.

- Experienced in applying effective supervision, resolve conflicts, provide clear work instructions, and establish and maintain effective working relationships amongst various levels of employees and the public. Manage day-to-day employee relational issues, monitor performance and keep records, and train new employees.

- Talented with independent thinking and strong, self motivated leadership qualities in negotiation, development and implementation of large and complex projects from concept to completion.

- Strongly fluent in oral, written, and interpersonal communication skills and capabilities. Highly skilled in public speaking and experienced in presenting technical subject matter to large and diverse audiences. Experienced in representing the Department in variety of public, private national and international settings.

- Able to take on unprecedented assignments and deliver pioneering new solutions with creative and resourceful ***"Thinking-Out-of-the-Box"*** mentality.

- Fluent in three languages and able to represent the organization to a multi-cultural and diverse communities.

Education

Bachelor of Science, Electrical Engineering (BSEE)
University of Southern California, (USC) Los Angeles, CA, 1984

Professional Profile

July 2015 – Present	Harbor Engineer I – Chief of Design
March 2007 – July 2015	Bldg. Electrical Engineer II – Chief Electrical Engineer – Elec. Engr. Design Section Head City of Los Angeles Harbor Department, San Pedro, CA
Jan 2002 – March 2007	Bldg. Electrical Engineer – Electrical Engineering Section Head City of Los Angeles Harbor Department, San Pedro, CA.
Apr 1989 – Jan 2002	Electrical Engineering Associate III - City of Los Angeles Harbor Department, San Pedro, CA.
Feb 1986 – Apr 1989	Electrical Engineering Assistant II - City of Los Angeles Harbor Department, San Pedro, CA.
Feb 1985 – Feb 1986	Electrical Engineering Assistant I - City of Los Angeles Harbor Department, San Pedro, CA.
June 1984 – Dec 1984	Electrical Engineering Assistant - Boyle Engineering Corporation, New Port Beach, CA.

Certifications

- Registered Professional Electrical Engineer (PE) - California State Board of Registration for Professional Engineers
- Member of the City of Los Angeles Technical Advisory Committee.
- Member of Institute of Electrical and Electronics Engineers (IEEE)
- Member of Illuminating Engineering Society (IES)
- Member of International Standards Organization (ISO) working subcommittee TC 8 SC 3 N and International Electrotechnical Commission (IEC) TC18/MT26 IIVSC standardization committee,
- U.S. Technical Expert in ship-to-shore electrical connection systems.
- Represent City of Los Angeles Harbor Department and the United States of America in IEC/ISO/IEEE multi-organizational and multinational global standardization setting international committee.

References

References are available upon request

TIM De MOSS

28518 Vista Madera, Rancho Palos Verdes, California 90275
Phone: (310) 221-4782 E-mail: tdemoss@portla.org

WORK EXPERIENCE

MARINE ENVIRONMENTAL SUPERVISOR

Port of Los Angeles, Environmental Management Division June 2014 - Present

- Supervises the Air Quality Section with the major focus of reducing air pollutant emissions from the 5 major sources (Ocean Going Vessels, Heavy Duty Vehicles, Cargo Handling Equipment, Locomotives and Harbor Craft) that move freight in and out of the Port of Los Angeles.
- Zero Emissions Project Manager since June of 2013. Duties involve studying, recommending, implementing, and demonstrating near zero and zero emission equipment in and around the Port complex.
- Project Manager for the preparation of the Port of Los Angeles Zero Emission White Paper
- Assists in the development of Port policy for major air quality programs with the regulatory agencies including the California Air Resources Board's (ARB) Sustainable Freight Strategy Program, ARB's reduction of greenhouse gases Cap and Trade Program, and the South Coast Air Quality Management District (SCAQMD) Air Quality Management Plan

ENVIRONMENTAL SPECIALIST III

Port of Los Angeles (POLA), Environmental Management Division May 2007 – June 2014

- Clean Truck Program Manager since October of 2010. Duties involved managing the implementation, monitoring and enforcement of the program.
- Managed POLA's private consultants in order to complete various air quality projects.
- Maintained a professional link of communication with members of the ARB, SCAQMD, private consultants, business contractors, environmental advocacy groups, and Port of Long Beach staff.
- Prepared various Division Memos, Board Reports, and Letters.

ENVIRONMENTAL SPECIALIST II

Los Angeles World Airports (LAWA), Environmental Management Division January 2005 – May 2007

- Project Manager for Air Quality projects. Duties involved researching air quality and environmental compliance regulations, coordinating regulatory compliance projects for all 4 LAWA Airports, and representing LAWA on annual and periodic SCAQMD audits of LAWA facilities.

SANITARY ENGINEERING ASSOCIATE II

City of Los Angeles, Bureau of Sanitation, Various Divisions June 1991 - January 2005

- Worked in the Wastewater Capital Improvement group managing funding for Capital Improvement projects.
- Worked in the Regulatory Affairs Division's Permits group managing various Water Quality projects.
- Worked in the Human Resources Development Division's Safety group managing various Hazardous Waste/Materials projects.
- Worked in the Recycling and Waste Reduction Division managing various Recycling projects.

EDUCATION

LOYOLA MARYMOUNT UNIVERSITY, LOS ANGELES, CA August 2000

- Master of Science in Civil Engineering with emphasis on Environmental Science

  Course work: Air Pollution Analysis, Environmental Engineering and Science Laboratory, Aquatic Chemistry, Principals of Water Quality Management

LOYOLA MARYMOUNT UNIVERSITY, LOS ANGELES, CA May 1991

- Bachelor of Science in Civil Engineering

  Course work: Analytical Methods in Civil Engineering, Introduction to Environmental Engineering, Water Resources Planning and Design, Water and Wastewater Treatment

Braxton H Craghill
Resume for Cap and Trade Program 2015

SKILLS & ABILITIES

Complete command of complex logistical operations including; marine terminal operations, customer contracts, Union contract negotiations, Trucking, Finance, Information technology, and Human Resources and Administration, Awarded over 6MM in Port Security Grants covering security hardening of marine facilities, video camera systems, and support hardware, software and equipment. Responsible for Financial and Operational needs for Pasha Stevedoring & Terminals, L.P in the Ports of Los Angeles/Long Beach, San Diego, Longview Washington, Gray's Harbor Washington, and Honolulu, Hawaii.

EXPERIENCE

DIRECTOR OF FINANCE, PASHA STEVEDORING & TERMINALS, L.P.

October 2012 - Present

Oversight of West Coast Maritime Division with gross revenues exceeding 200 Million annually. Successfully created and implemented a complete terminal operating system with financial systems integration creating managerial expense accountability, process streamlining and systematic security checks and balance. Increased terminals ability to handle volume increases of 100% with no headcount increase. Applied for and received six million dollars in FEMA/PSGP grants related to the Transportation Worker Identification Credential created after 9/11 to offset capital expenses relating to security. Help develop staff of five to centralize A/R, A/P, general ledger, collections, and contracts in one location. Accountable for managing and financial reporting for five geographic regions - Washington State, Los Angeles/Long Beach, San Diego, and Honolulu and neighbor Islands in developing budgets, managing capital purchases, leasing, and personnel management. Involved in every aspect of the marine terminal operation including; CTPAT certification, USCG Security Plans, ISO9000, and disaster recovery initiatives. Partnered with non-profit agencies such as the Red Cross to create emergency plans and stores for over 100 personnel working at multiple geographic locations.

CONTROLLER, PASHA STEVEDORING & TERMINALS, L.P.

December 2007 – September 2012

Transitioned from Information Systems to Controller with acumen in creating cost effective database and reporting tools for accurate management of 70 Million in direct labor expenses. Strength in cross department communication enabling operations to take responsibility for cost control. Navigated recession by downsizing and kept potential losses at bay through process improvement and efficiency.

MANAGER, INFORMATION SYSTEMS – PASHA STEVEDORING & TERMINALS, L.P.

October 2003 – November 2007

Coordinate and implement the transition from legacy financial system to MAS500. Create job costing program and developed an automated billing system for container operations. Created application to track stevedoring expenses that represent 70% of the company's' direct expenses.

EDUCATION

CALIFORNIA STATE UNIVERSITY LONG BEACH – GLOBAL LOGISTICS SPECIALIST – LONG BEACH

SONOMA STATE UNIVERSITY CALIFORNIA – DEGREE IN ENGLISH – ROHNERT PARK

COMMUNICATION

Seized the opportunity to be one of the largest recipients of federal grants to a private company in the Port of Los Angeles by effectively communicating the need for and ability of Pasha Stevedoring & Terminals to implement TWIC systems and security related initiatives.

LEADERSHIP

As part of a team of Executives I help direct the activity of 21 management staff and the full time equivalent of 500 International Longshore workers with payroll of over 70 million per year.

REFERENCES

BOB MARSOCCI

Senior Corporate Communications Strategist

DAVID BALES

Principal at Lee & Associates Los Angeles - Long Beach

MATTHEW J. WARTIAN PHD

Project Manager

Dr. Wartian specializes in leading multidisciplinary teams to deliver innovative approaches to assess and solve natural resource, energy management, and sustainability issues. He oversees teams performing environmental compliance support for multi-billion-dollar electrical transmission projects, and engages with clients to develop environmental strategies and confirm that our team's services are meeting/exceeding client expectations. Dr. Wartian has provided consulting services to California marine ports for more than eight years, managing multiyear and multimillion dollar programs. This experience includes leading energy management programs for two of the busiest West Coast seaports, working with teams of planners and engineers to develop programs to increase energy sustainability, efficiency, reliability, and resiliency for their operations. Dr. Wartian is experienced in facilitating stakeholder meetings with the public, environmental groups, and regulators, and has assisted clients in successfully negotiating agreements that meet regulatory requirements, address concerns of environmental groups, and limit environmental liabilities.

EDUCATION

- PhD, Biology, University of California, Los Angeles
- BS, Marine Biology, California State University Long Beach

REGISTRATION

- Open Water SCUBA Certification, NAUI
- SCUBA Certification, American Academy of Underwater Sciences

3 YEARS WITH BURNS & MCDONNELL

14 YEARS OF EXPERIENCE

Port of Los Angles, Energy Management Action Plan (EMAP)

Los Angeles, California

Project Manager. Dr. Wartian managed the development of the EMAP, which serves as a guide for future energy improvement and usage options for the Port. The EMAP focuses on: Resiliency, Availability, Quality, Efficiency and Sustainability, and outlines near, medium, and long-term actions to provide a direction to improve energy management, while protecting the natural environment. Our team engaged multiple stakeholders, including Port, City, and Utility staff, as well as tenants to assess existing conditions, determine future energy needs, identify areas of improvement, and develop new initiatives to meet the projected needs for the Port and its tenants. Our team also helped the Port perform utility rate comparisons, develop electric load projections, assess the economic viability of energy conservation measures, evaluate the potential for integrating renewable generation into microgrids, and pursue grant funds for these initiatives.

Port of Oakland, Energy Innovation Study

Oakland, California

Project Manager. Dr. Wartian managed a team of planners, engineers, and scientists in the development of a study that evaluated electrical infrastructure and energy use for all Port Divisions – Aviation, Maritime and Commercial Real Estate. The study considered security, resiliency, reliability, quality, and sustainability of the Ports energy supply. The Study provided a roadmap for addressing energy, environmental, climate and sustainability objectives. A key element of the program was engaging multiple stakeholders, including Port and City of Oakland staff, tenant terminal operators, industrial manufacturers, and the community to gain an understanding of the current practices being used to manage energy sustainably, as well as their concerns and goals/plans for the future.

Los Angeles Department of Water and Power, Sylmar Electrode Array Marine Resource Assessment

Santa Monica, CA

Project Manager. Dr. Wartian developed and implemented a study to assess baseline conditions of marine biological resources and potential impacts from construction, operation (electromagnetic fields and chemical releases), and maintenance of a proposed undersea electrode. The surveys Dr. Wartian implemented consisted of sediment and water sampling to assess the biological community and benthic habitat. Using Phase 1 Sediment Quality Objectives (SQOs), sediment quality was assessed.

San Diego Unified Port District, Regional Harbor Monitoring Program

San Diego & Orange Counties, CA

Program Manager. Dr. Wartian managed a multi-million dollar San Diego region-wide monitoring program to assess sediment, water quality, and biological community conditions within San Diego Bay, Mission Bay, Oceanside Harbor, and Dana Point Harbor. Dr. Wartian implemented a core monitoring program and special focused studies to answer San Diego Regional Water Quality Control Board (RWQCB) questions regarding the health of San Diego harbors in response to the RWQCB California Water Code §13225 letter. Sediment assessments were performed at 75 stations following the Phase 1 SQOs.

Port of Los Angeles, Biological Mitigation Credit Negotiation

Port of Los Angeles, CA

Project Manager. Dr. Wartian managed a team of restoration and mitigation banking experts to develop mitigation options to compensate for approximately 200 acres of anticipated biological impacts associated with future capital improvement projects. Dr. Wartian identified and prioritized coastal mitigation sites from Santa Barbara to San Diego, and worked with the client to develop mitigation strategies.

Port of Los Angeles, Anchorage Road Wetland Mitigation

San Pedro, CA

Project Manager. Dr. Wartian worked with the Port of Los Angeles to develop and implement a Habitat Mitigation and Monitoring Plan to restore/enhance native wetland vegetation in a marine tidal wetland in support of the Channel Deepening Project. He implemented the re-grading of the site to improve tidal inundation, including the construction of a tidal channel, and replanted pickleweed along the expanded salt marsh habitat to meet mitigation requirements. The restoration also included removal of upland non-native species and replanting of slopes with native vegetation via hydroseeding and plantings.

San Diego Unified Port District, Shelter Island Yacht Basin Copper Total Maximum Daily Load (TMDL) Implementation

San Diego, CA

Project Manager. Dr. Wartian designed and implemented a plan to reduce copper loading into Shelter Island Yacht Basin to meet compliance with the TMDL. He facilitated meetings among multiple stakeholders to conduct a basin-wide program that focuses on implementation of management practices that facilitate the transition from copper-based hull coatings to non-copper-based coatings. Additionally, Dr. Wartian designed and conducted a monitoring program of water quality conditions and vessel tracking to provide a cost-effective and scientifically-defensible solution to assess TMDL compliance. He successfully supported the Port in winning $750,000 319(h) grant to implement vessel hull paint conversions.

Port of Los Angeles, Del Ray Lagoon Biological Baseline Study

Marina del Rey, CA

Project Manager. Dr. Wartian managed and participated in field surveys of portions of the Marina del Rey Harbor, Del Rey Lagoon, and Ballona Channel to assess the baseline biological conditions of fish and invertebrate communities. Results were used to assess the applicability and potential success of restoration efforts.

MATTHEW GERMANN PE, LEED® AP BD+C, ENV SP

Design-Build Engineer Lead

Mr. Germann serves Burns & McDonnell as an electrical engineer specializing in the design of aviation facilities. Mr. Germann currently is a Commander serving in the Navy Reserves. Recently returned from mobilization with SEABEE's in Iraq, Afghanistan and Kuwait and is a member of the SEVENTH Fleet Reserve Staff drilling at Navy Operational Support Center (NOSC) Fort Worth. On active duty he has served as Officer-in-Charge of Embarked Security Teams operating in the Middle East AOR, Commanding Officer NOSC Des Moines, IA, Ship's Electrical Officer on the Aircraft Carrier USS George Washington, and Combat Information Center/Communications Officer on the Cruiser USS California.

EDUCATION

- BS, Electrical Engineering
- MS, Engineering Management

REGISTRATIONS

- Professional Engineer (KS)
- ISI Envision Sustainability Professional
- LEED® Accredited Professional, Building Design & Construction

11 YEARS WITH BURNS & MCDONNELL

21 YEARS OF EXPERIENCE

Replace Fuel Pier, US Navy (NAVFAC)

Navy FLC Point Loma, San Diego, California

Electrical Engineer. Mr. Germann served as the electrical engineer for this project in which Burns & McDonnell provided design for the replacement of the fuel storage facilities and pier at FISC Point Loma in San Diego, California. The project involves the design and construction of eight new 125,000 bbl. aboveground fuel storage tanks, a new fuel pier, a consolidated pumping system, and ancillary fuel receipt and distribution systems and support buildings. This project also includes complex phasing of demolition of the existing above ground and underground storage tanks and pumping and piping system and construction of the new facilities in the same footprint as the existing facility while maintaining full operation of the facility throughout the construction period.

Biofuel Blending and Evaluation Facility, US Navy (NAVFAC)

NAS Patuxent River, Maryland

Project Manager. Mr. Germann served as project manager during this project. His role included client interface, permitting, budget and cost control, construction estimating, team management, communications, developing specifications, providing oversight and quality assurance from project scope development through final construction documents and post construction award services. Work included design and post construction award services for petroleum, oil and lubricant (POL) facilities, infrastructure, and specialized facility-related designs. POL facilities include above ground storage tanks, bulk storage systems, transfer pump houses and controls, and a petroleum operations building, including canopy. Related POL infrastructure design includes site utilities, site planning, facilities, fill stands, and roads. Additional facility related design includes, paint and coatings systems, and tank demolition building demolition.

Enhanced Follow-On Integrity Management Plans–POL Piping Investigation, US Navy (NAVFAC)

DFSP Hakozaki Terminal, FLC Yokosuka, Japan

Project Manager. Mr. Germann served as project manager with his efforts including development of a project execution and EM385-1 compliant accident prevention plans, development of sub-contracting agreements, base access, overseas logistics, client interface, permitting for excavation, dive plan approval with Japanese Coast Guard and NAVFAC Team members, team communications, construction estimating and quality assurance. The project work included an enhanced integrity investigation, assessment and design to supplement the Integrity Management Plans (IMP) for Petroleum, Oils, and Lubricants (POL) fuels piping at DFSP Hakozaki Terminal, FLC Yokosuka, Japan. The general scope included the design of POL facilities, infrastructure and specialized facility related designs, including seismic analysis, thermal relief analysis and underwater piping evaluation using divers. POL facility design includes above ground and underground storage tanks, bulk storage systems, transfer pump houses and controls and pump houses. POL infrastructure design includes site utilities, site planning, fuel pits, off-load facilities; fill stands, and roads and bridges. Specialized facility-related designs include cathodic protection, fire protection, NATO cut-and-cover tanks, above ground and underground fuel storage tanks, pipeline inspections, paint and coating systems and demolition.

Distributed Common Ground Station Beddown (DCGS)

Terre Haute, Indiana

Lead Electrical Engineer. Mr. Germann served as the lead electrical engineer for the power, lighting and communications design renovations of 33,156 sq. feet in two buildings to support the operational and administrative missions in a new Sensitive Compartmented Information Facilities (SCIF) for the Indiana Air National Guard. The project will include extensive raised floor systems, UPS and generator back up power systems and dense Information Technology requirements.

Three-Bay Apache Longbow Helicopter Hangar

Marana, Arizona

Lead Electrical Engineer. Mr. Germann served as the lead electrical engineer for the power, lighting and communications design to support the operational and maintenance missions of the combined Royal Singapore Air Force and Arizona Army National Guard (Peace Vanguard) at Pinal Air Field Silver Bell ARANG Heliport near Marana, Arizona. The project will include a 36,500 square-foot Army Aviation Support Facility comprised of 3 hangar bays and supporting operations/administrative areas.

Weather Training Complex

Camp Blanding, Florida

Lead Electrical Engineer. Mr. Germann served as the lead electrical engineer for the design to support the operational and training missions of the Weather Readiness Training Center (WRTC) and the 159th Weather Flight (159th WF) at Camp Blanding Training Site, Florida. The project included a 15,300 SF dormitory, an 11,000 square-foot WRTC and a 3,500 SF Weather Flight facility.

Composite Aircraft Maintenance Complex, Utah Air National Guard

Salt Lake City, Utah

Electrical Engineer. He served as an electrical engineer for the consolidation of composite aircraft maintenance functions for the Utah Air National Guard at Salt Lake City, Utah. The project consisted of a new 38,500 SF facility to house the command and administrative functions of the 151st Aircraft Generation Squadron, the 151st Logistics Support Flight and the 151st Maintenance Squadron. The project also included reviewing (2) C130 hangars and designing updates to bring them into current electrical code compliance.

Run Station Electrical Service Upgrade, Lockheed Martin

Fort Worth, Texas

Electrical Engineer. He served as an electrical engineer for the replacement of two 5 kV services. This project included upgrading the existing electrical service from the main substation yard west of Building 5 to throughout the south run stations to support the electrical demand requirements of the new JSF program. The scope of work included the replacement of four existing undersized unit substations and the installation of new 5 kV feeders from the main substation yard to a new 5 kV lineup of arc flash resistant air switches with capacity to support future loads that may be needed in the area. Distributing power from the main substation yard to the run stations on the other end of the plant required several infrastructure upgrades. Approximately 2,200 feet of new structural framing was constructed on the roof of Buildings 4 and 5 to support new and future cable trays. Also, a 2,100 feet underground duct bank system with double manholes was installed from Building 4 to the switchgear lineup then to Building 168.

ERIC PUTNAM PE, CEM

Engineering Lead

Mr. Eric Putnam specializes in the management and design of electrical systems for complex military, federal, industrial and commercial facilities. His experience includes new construction, alteration, repair and installation of low and medium voltage electrical systems for central utility plants, data centers and microgrids, with services focused on energy efficiency, enhanced power quality and system reliability. Mr. Putnam has also provided start-up and commissioning services for microgrids and high technology facilities such as combined heat and power plants, data centers and biosafety laboratories. He has designed and programmed control systems for both electrical systems and building management systems and has extensive experience starting up and maintaining these systems.

EDUCATION

- BS, Electrical Engineering

REGISTRATIONS

- Professional Engineer (MO, AZ, CA, FL, GA, KY, LA, MT, NV, ND, OR, TX, UT, WA)
- Certified Energy Manager

9 YEARS WITH BURNS & MCDONNELL

19 YEARS OF EXPERIENCE

Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS)-Phase I, US Army Corps of Engineers

Joint Base Pearl Harbor-Hickam, Hawaii

Electrical Project Manager. Mr. Putnam managed the electrical design of a $5.4M design-build energy surety micro-grid that includes low and medium voltage electrical infrastructure upgrades, a dedicated telecommunications network and a micro-grid monitoring and control system. The micro-grid includes two diesel generators, a battery storage system, solar array and future wind power to serve two critical loads. It can seamlessly transition to and from islanded/grid-tied modes of operation. His responsibilities included development of the electrical systems necessary to support the system's desired operation and also led the system start-up and commissioning. The micro-grid includes two, diesel generators, a battery storage system, solar array and future wind power to serve two critical loads. It can seamlessly transition to and from islanded/grid-tied modes of operation.

SPIDERS-Phase II, US Army Corps of Engineers

Fort Carson, Colorado

Electrical Project Manager. Mr. Putnam managed the electrical design of three new stand-alone micro-grids that include centralized prime generation assets coupled with existing backup power generators and distributed PV systems. The micro-grid includes three diesel generators, bi-directional electric vehicle charging stations, and a solar array to serve multiple loads of various levels of criticality. The three micro-grids connect to each other and to the utility to supply backup power to all of Camp Smith. The system is also designed to participate in any potential utility ancillary services markets utilizing the EPA Tier 4i generators and battery storage units. Services were delivered under a single Task Order. Mr. Putnam was responsible for conceptual design of the micro-grids and their interface to each other. He also developed the sequences of operation for the micro-grids and how they would interconnect to each other and the utility grid.

Philadelphia Naval Shipyard Micro-grid Evaluation, US Navy

Philadelphia, Pennsylvania

Lead Electrical Engineer. Mr. Putnam participated in a feasibility study of various options to create a micro-grid within the US Navy facilities at the Philadelphia Naval Shipyard. The Shipyard's electrical system was privatized in the 1990s, so the existing distribution system is now shared between US Navy and civilian facilities. The Navy is evaluating possible approaches to use existing and new on-site generation assets with minimal distribution system changes. He was responsible for developing the strategy for creating a micro-grid within the existing Navy facilities and how it would interface with the privatized utility's infrastructure. Additionally, Mr. Putnam carried out the initial site assessment and worked with Navy personnel to identify potential assets including existing turbine engines from ships which could be repurposed for electrical generation.

White Oak ESPCIII, FDA

White Oak, Maryland

Lead Electrical Engineer. Mr. Putnam served as the lead electrical engineer for commissioning of the power and load management system for the micro-grid at the FDA's new campus in White Oak, Maryland. This system includes 17 generators in three separate plants with over 50 MW of total capacity. The system is capable of operating either paralleled or islanded to the utility as well being able to restore the site from a complete loss of power. Mr. Putnam developed the functional performance test plan and checklists integrated system testing.

Master Plan Implementation, Thermal Energy Corporation (TECO)

Houston, Texas

Project Manager. Mr. Putnam served as the project manager for the renovation of an active 138 kV five position ring bus substation to include two new positions; modifications to existing 5 kV switchgear due to increased fault current; and installation of two 138 kV underground feeders within a working plant site. In addition, Mr. Putnam was the lead electrical engineer for a new, 80 MW central chilled water facility which included 13.8 kV, 4160V, and 480V distribution systems operating with paralleled transformers in a closed loop configuration for increased redundancy. Finally, Mr. Putnam was also responsible for the coordination of all electrical work between all of the active task orders within the overall Master Plan Implementation project.

Burns & McDonnell was the lead contractor for this design-build effort to construct a new, 80,000 ton chilled water plant, 45 MW combined heat and power combustion turbine, four-story office building, and 8.8 million gallon thermal energy storage tank at an existing operating chilled water and steam plant serving the Texas Medical Center member institutions. As the electrical coordinator for all of the work, Mr. Putnam was actively involved in all aspects of the project. He developed the conceptual designs for the chilled water building's electrical system, connection of the turbine generator for use in a micro-grid, and was the lead electrical engineer for the construction of the chilled water building. Finally, he prepared and presented operational training to the staff on the operation of the electrical systems within the chilled water building.

Hospital Central Utilities Plant, TECO

Houston, Texas

Electrical Engineering Manager. This was an Engineer, Procure, and Construct project to provide a new 50 MW combined heat and power (CHP) gas turbine generator and heat recovery steam generator (HRSG); 8.8 million gallon chilled water storage tank; and 80,000 ton chilled water generation plant at an existing central utility plant. Due to the many subprojects within this overall effort, Mr. Putnam was utilized as the manager for all of the electrical work involved. He was responsible for ensuring that coordination occurred between the lead engineers for each of the projects and for ensuring that the Owner's requirements were being met on each of the subprojects. He also served as project manager for one of the subprojects which involved additions to the on-site 138 kV substation, 138 kV underground distributions to the new chilled water building, and upgrades to the existing Central Plant's electrical system due to fault current withstand issues. Finally, Mr. Putnam was responsible for the design of the medium voltage switchgear in the new chilled water building which included both 13.8 kV and 4,160V distribution rings to provide a highly robust and dependable distribution system and was the lead electrical engineer during the construction phase of the chilled water building.

Central Utility Plant, Shands Healthcare Cancer Hospital Campus

Gainesville, Florida

Lead Electrical Engineer. Burns & McDonnell was the lead contractor for this design-build effort to construct a new 38,500 SF central utility plant (CUP) that provides the campus with commercial and life safety electricity, steam, chilled water, backup well water, and medical gasses. Due to the hospital's location in a hurricane-prone area, multiple levels of redundancy were provided to ensure that the campus would survive the most brutal of natural events. In addition to the typical design review processes, this facility was also subject to review by the hospital authorities (Joint Commission and Florida AHCA). Mr. Putnam served as lead electrical engineer for the design and construction of this design-build project. He was responsible for the design of the 15 kV generation and distribution systems to serve the various buildings on campus with both commercial and emergency power. He was also part of the commissioning team and focused on the 15 kV and 480V generation and distribution systems.

PHILLIP STEPHENSON LEED AP

Construction Lead

Mr. Stephenson is a Senior Project Manager in the Construction Design-Build and Transmission & Distribution divisions at Burns & McDonnell. He has over 17 years of experience in project management, project controls, construction management and design in the construction industry. His expertise includes coordination with clients, contractors, material suppliers, supervision and coordination of contract drawings and specification preparation, bid evaluation, contract administration, quality control, public involvement, permitting and construction management. Mr. Stephenson is a Lean Six Sigma Green Belt and regularly attends Lean Construction Institute of Los Angeles - Community of Practice meetings. He is currently consulting with another renewable project Owner on the delivery of a gen-tie system under Target Value Delivery, as opposed to Design-Bid-Build or EPC.

Chino Hills Underground Transmission Line Project, Southern California Edison

Chino Hills, California

Contract Manager. Mr. Stephenson serves as the contract manager on the Chino Hills Underground project, a three and a half mile segment of the Tehachapi Renewable Transmission Project for SCE that will be constructed underground. The $2.1 billion Tehachapi project is intended to bring wind-produced electricity from Kern County to the Los Angeles Basin, over a 225-mile stretch and is part of a state mandate to generate more sustainable energy by 2015. As contract manager, Mr. Stephenson is responsible for enforcing the contract between the Owner and the contractor, as well as providing strategies / advice to the Owner.

LADWP Substation

Los Angeles, California

Project Engineer. Mr. Stephenson served as the project engineer coordinating all elements of construction on the LADWP substation dedicated to the Children's Hospital Los Angeles campus. The substation transformed 34.5kV power down to 4,160V, which fed every building on campus. The work included routing conduits across Sunset Boulevard and required project 'cut-over' / outage schedules scheduled in minutes, not days.

EDUCATION

- BS, Construction Engineering, Iowa State, University of Technology

REGISTRATION

- LEED Accredited Professional
- Lean Six Sigma Greenbelt

EXPERTISE

- Project Management and Project Controls
- Large, Complex Design, and Construction

4 YEARS WITH BURNS & MCDONNELL

18 YEARS OF EXPERIENCE

B610 HVAC, Lockheed Martin Aerospace

Palmdale, California

Construction Manager. Mr. Stephenson serves as construction manager on the design of a replacement mechanical system which will include new at-grade Air Handing Units (AHUs) and a pre-package central plant for the Paint Hangar. His responsibilities include managing the design process from concept to final documents, as well as providing estimates of probable construction cost. The design will meet the stringent temperature and humidity requirements ninety-five percent (95%) of the calendar year. The design will include a new 12kV electrical service and a step-down transformer to support the new mechanical equipment. To minimize the impact / down time of this manufacturing facility, he is advocating the client engage subcontractors early in the design process, use large sections of prefabricated materials to reduce the construction duration.

Townsite Solar, KOWEPO America LLC

Boulder City, Nevada

Consulting Project Manager. Mr. Stephenson served as the consulting project manager on the development of a 150 MW photovoltaic solar field and 230 kV generation tie line to a substation in Eldorado Valley. His duties included providing design, budgeting and scheduling oversight.

Northrop Grumman, B401 E-Line Office Building

Palmdale, California

Project Manager. Design and construction administration services for a new 80,000 SF Sensitive Compartmented Information Facility (SCIF) office structure within existing hangar B-401 at the Northrop Grumman Corporation (NGC) Palmdale, California site. The new structure will consist of two office floors located adjacent to an existing office area within the hangar. Each floor consists of a number of enclosed office spaces, conference rooms, open office areas for modular workstations, break areas, huddle rooms, and restrooms. Interior spaces are defined by strategic use of various colors, materials, and textures such as wood slat paneling, butt-glazed storefront, and a combination of exposed and suspended acoustical tile ceilings to place emphasis on work groups or special areas.

Kaiser Permanente, Redwood City Medical Center

Redwood City, California

Project Executive. 286,000 square foot, seven-story hospital tower with 149 patient beds and a 16,000 square foot, two level Central Utility Plant. Mr. Stephenson served as Project Executive on the mechanically intensive central utility plant and was also heavily involved with the Building Information Modeling (BIM) of the Mechanical, Electrical, Plumbing and architectural/structural elements in three dimensional software for both the hospital and central plant. Mr. Stephenson's involvement commenced during design and continued through preconstruction. It included procurement of the Mechanical, Electrical and Plumbing subcontractors under a Cost-Plus-A-Fee Guaranteed Maximum Price (GMP) delivery method.

Children's Hospital Los Angeles: New Patient Tower, Parking Structure Phase II and Central Plant Expansion

Los Angeles, California

Senior Project Manager. 603,000 square foot, seven-story tower with 317 patient beds. Includes a three-level below grade parking structure with 210 spaces and a central plant expansion. Mr. Stephenson served as Senior Project Manager and Project Executive. As part of a highly technical, complex project, Mr. Stephenson championed the procurement of the Mechanical ($51M), Electrical ($44M), Plumbing ($32M), Curtain Wall ($18M) and Framing ($42M) subcontractors under a Cost-Plus-A-Fee Guaranteed Maximum Price (GMP) delivery method. Mr. Stephenson's involvement commenced prior to selection of a design team and ended with completion of the project.

Children's Hospital Los Angeles: The Saban Research Institute

Los Angeles, California

Project Manager. 100,000 square foot, five-story above grade laboratory building including an auditorium and a one-story below grade vivarium. Mr. Stephenson served as Project Manager, overseeing all aspects of preconstruction, procurement and construction of the research facility. The facility had redundant mechanical systems to ensure continuity of supply air to critical lab equipment and specimens at all times.

Children's Hospital Los Angeles: Surgery Center and Central Plant

Los Angeles, California

Senior Project Manager. 100,000 square foot, three-story building containing a central plant, patient admitting and 15 operating rooms. Mr. Stephenson served as Senior Project Engineer, focusing on the spatial coordination and construction of the mechanical, electrical and plumbing systems. The central plant included three (3) dual fuel boilers, two (2) steam absorption chillers, three (3) centrifugal chillers, five (5) cooling towers and four (4) 1,250kW generators.

AMGEN Inc., Building 15, Vivarium and Research Lab Expansion Project

Thousand Oaks, CA

Project Engineer. 51,000 square foot expansion to an existing vivarium and research facility, with two levels below grade and one above grade. Mr. Stephenson served as Project Engineer, focusing on the spatial coordination and construction of the mechanical, electrical and plumbing systems.

The Krausz Companies, Inc.: Puente Hills Mall AMC Theater Complex Project

City of Industry, CA

Project Engineer. Asbestos abatement and demolition of an existing 3-story concrete structure and construction of a 20-screen, 4,056 seat movie theater. Mr. Stephenson served as Project Engineer for all of the building systems.

Joseph Lyou, PhD - President & CEO
Coalition for Clean Air

Dr. Joseph Lyou is a highly regarded leader in California's environmental movement. Joe came to CCA with 20 years of experience in state environmental policy and advocacy, as well as knowledge of science and air quality policy. He previously founded the California Environmental Rights Alliance and has held management positions with the California League of Conservation Voters Education Fund and Committee to Bridge the Gap. Dr. Lyou is an active participant on many regional and statewide advisory committees on air pollution, air toxics, environmental justice and environmental health. He received his Ph.D. from UC Santa Cruz in 1990.

MARVIN D. MOON

Director of

POWER ENGINEERING DIVISION, LADWP

Marvin D. Moon is the Director of the Power Engineering Division. Mr. Moon is responsible for the design and management of all projects related to the Power System infrastructure of the Los Angeles Department of Water and Power (LADWP). This includes projects for generation, substations, transmission, renewable projects, and the distribution system. He is also the LADWP's Electric Vehicle Program Manager.

Mr. Moon as been recognized as an Innovator by the Electric Power Research Institute, and has twice received the Los Angeles City Productivity Award.

*** *** ***

9/21/15

MATT M. MIYASATO

South Coast Air Quality Management District
Diamond Bar, CA 91765
mmiyasato@aqmd.gov
(909) 396-3249

EDUCATION:

Degree	Year Conferred	University
Management & Leadership Classes	2002-2005	University of La Verne
Ph.D. in Engineering	1998	University of California, Irvine
M.S. in Mech. Eng.	1993	University of California, Irvine
B.S. in Mech. Eng. (cum laude)	1988	University of California, Irvine

SUMMARY:

- Technical leader with excellent communication skills and successful experience in engaging local, regional, state and federal stakeholders to implement aggressive strategies to synergistically improve air quality, reduce greenhouse gas emissions and enhance national energy security.
- Team-player with proven success in collaborating while maintaining mutually respectful relationships with internal staff as well as external stakeholders.
- Well-regarded and sought-after SCAQMD representative for technical input and agency perspective.

EXPERIENCE:

Apr 13 – present: Deputy Executive Officer. South Coast AQMD

Responsible for the Technology Advancement Office, Mobile Source Division, and Monitoring and Laboratory Analysis Division. Principal charges are to identify, evaluate and stimulate development and commercialization of clean air technologies, develop and coordinate mobile source regulations, and to conduct ambient monitoring, source testing and laboratory analysis.

Feb 08 – Apr 13: Assistant Deputy Executive Officer. South Coast AQMD

Served as the principal technology and operational lead under the Chief Scientist for the Technology Advancement Office, comprised of the Incentives, Demonstrations, Best Available Control Technologies and Outreach Groups. The funding throughput for these groups totaled over $100M annually. Major responsibilities included overseeing daily operations and approvals, representing the AQMD on all major technology initiatives, including zero emission goods movement and plug-in hybrid vehicles, and interfacing with Board members, media and other regional, state and federal stakeholders. Notable accomplishments: lead technical staff for securing reauthorization of the AQMD Clean Fuels (research and demonstrations) Program, Principal Investigator on $45M DOE American Reinvestment and Recovery Act project for plug-in electric work trucks, Principal Investigator on $4.2M DOE Zero Emissions Cargo Movement project, and lead staff on Regional Zero Emissions Freight Movement Collaborative with LAMTA, Ports, SCAG, CalTrans and GCCOG.

Mar 03 – Feb 08: Technology Demonstrations Manager. South Coast AQMD

Administered the Clean Fuels Program for the advancement of clean, alternative mobile and stationary technologies. Managed approximately $12M in awards annually, with 5 technical and 4 administrative staff. Responsible for the Clean Fuels Annual Report and Plan Update to State legislature. Co-managed Blueprint Rollout Team for California Hydrogen Highway Network Blueprint effort. Staff representative to California Fuel Cell Partnership, California Stationary Fuel Cell Collaborative, Plug-in Hybrid activities, CARB Research Evaluation Screening Committee, and Ports Technology Advancement Advisory Committee.

Jun 02 – Mar 03: Program Supervisor, Clean Fuels Program. South Coast AQMD.

Executed advanced technology projects under the Clean Fuels Program from concept to completion. Responsible for the stationary fuel cell projects and heavy duty natural gas engine projects with DOE/NREL, which resulted in commercialized clean products.

Feb 01 – Jun 02: Senior Research Engineer. GE–Energy and Environmental Research Corp.

Conducted and managed commercial, low NO_x technology implementation projects for utility boilers. Oversaw the scheduling, construction, and testing of the physical flow laboratory as well as enhancing laboratory capabilities. Certified in GE's Six Sigma quality program, led new product development for low-NOx burner and identified as a GE top performer in 2001.

Jul 98 – Jan 01: Senior Research Engineer. Advanced Power and Energy Program, UC Irvine.

Conducted and directed the research for the Industrial Burners Program, encompassing active control implementation, stability sensor development, low NO_x mechanism research, and catalytic piloting as applied to industrial burners on sub- and commercial scales. Other duties included proposal writing, maintaining the five Laboratory Web sites, and serving as representative to the American Flame Research Committee

Jul 90 – Jul 98: Graduate Researcher. UCI Combustion Laboratory

Conducted research on pollutant formation mechanisms in industrial burners, specifically by applying laser diagnostics and CFD modeling to a practical burner system. Experience with laser systems, emissions analyzers, and practical burner hardware. Familiarity with machining and welding.

Jul 88 – Jul 90: Engineer. Nuclear Rate Regulation, Southern California Edison

Provided support to San Onofre Nuclear Generating Stations by interpreting data and writing testimony for rate cases before the Public Utilities Commission such that capital expenditures could be collected in rates.

PROFESSIONAL ACTIVITIES:

Society of Automotive Engineers
American Society of Mechanical Engineers
Air and Waste Management Association
Combustion Institute/Western States Section (Secretary 2003-04)
Adjunct Lecturer at UC Irvine (2001-2003)
Engineer in Training (1987)

AWARDS:

Mechanical Engineering Department Fellowship, 1996
Department of Education Fellowship, 1995
Air and Waste Management Association Fellowship, 1992
Engineering Corporate Affiliates Fellowship, 1990
Golden Key National Honor Society, 1988
Tau Beta Pi, Engineering Honor Society, 1987

RECENT PRESESENTATIONS:

"Goods Movement in the South Coast Region: Challenges and Opportunities," American Trucking Association Technical Advisory Group, Pasadena, CA, March 12, 2015.

"Air Quality in the South Coast Basin," American Lung Association Lung Force Expo, Ontario, CA, May 2, 2015.

"Zero & Near-Zero Emissions Goods Movement: Progress, Lessons Learned, and Outlook," Transportation Research Board Clean Trucks Corridor Workshop, Washington D.C., January 11, 2015.

"The Need for Zero and Near-Zero Emission Goods Movement Technologies," SCAG General Assembly, April 25, 2014.

"Transforming Transportation: the Air Quality Need for Zero & Near-Zero Emission Technologies," National Academies of Science study on fuel consumption, July 31, 2013.

"Transforming Transportation: Southern California Challenges, Lessons-learned and National Implications," Transportation Research Board Executive Committee, Washington, D.C., June 20, 2013.

"Implementing the Vision of Clean Transportation and Energy Technologies," Transportation Research Board Annual Meeting, January 14, 2013. Joint presentation with P. Greenwald.

PUBLICATIONS:

D. Dunn-Rankin, M. Miyasato, and T. K. Pham, Introductory Chapter for *Lean Combustion: Fundamentals, Applications, and Prospects*, Elsevier. March 2007.

M. M. Miyasato, V. G. McDonell, G. S. Samuelsen, "Active Optimization of the Performance of a Gas-Turbine Combustor." *Combustion Science and Technology*, 2005.

R. M. Flores, M. M. Miyasato, V. G. McDonell, and G. S. Samuelsen, "Response of a Model Gas Turbine Combustor to Variation in Gaseous Fuel Composition." *Journal of Engineering for Gas Turbines and Power*, 2000.

T. N. Demayo, M. M. Miyasato and G. S. Samuelsen, "Hazardous Air Pollutant and Ozone Precursor Emissions from a Low-NO_x Natural Gas-Fired Industrial Burner." *Twenty-Seventh Symposium (International) on Combustion*, the Combustion Institute, 1998.

R. K. Cheng, D. T. Yegian, M. M. Miyasato, G. S. Samuelsen, C. E. Benson, R. Pellizzari, and P. Loftus,"Scaling and Development of Low-Swirl Burners for Low Emission Furnaces and Boilers." *Twenty-Seventh Symposium (International) on Combustion*, the Combustion Institute, 2000.

ACADEMIC CONFERENCE PAPERS:

M. M. Miyasato, R. M. Flores, V. G. McDonell, and G. S. Samuelsen, "Active Optimization of a Model Gas Turbine Combustor." *Western States Section/Combustion Institute 2000 Winter Meeting*, Golden, CO March 13-14, 2000.

M. M. Miyasato, V. G. McDonell, and G. S. Samuelsen, "Adaptive Fuel Injection Strategies For Industrial Combustion Sources." *Western States Section/Combustion Institute 1999 Fall Meeting*, Irvine, CA October 25-26, 1999.

M. M. Miyasato and G. S. Samuelsen, "Reaction Chemiluminescence and Its Relationship To Emissions and Stability in a Model Industrial Burner." *American Flame Research Committee International Symposium*, San Francisco, October 3-6, 1999.

M. M. Miyasato and G. S. Samuelsen, "Multivariate Optimization for NO_x and CO Emissions in a Model Industrial, Natural Gas Fired Burner." *American Flame Research Committee International Symposium*, Maui, Hawaii. October 1998.

M. M. Miyasato and G. S. Samuelsen, "Modeling and Velocity Measurements at the Burner Throat: The Relationship to Performance in a Model Industrial, Natural Gas Fired Burner." *American Flame Research Committee International Symposium*, Baltimore, Maryland. October 1996.

J.R. DeShazo

Professor of Public Policy and Urban Planning
UCLA Luskin School of Public Affairs
http://innovation.luskin.ucla.edu/jr-deshazo
Phone: 310-593-1198 • Email: deshazo@ucla.edu

UPDATED: 09/10/2015

EDUCATION

Ph.D., Harvard University (1997) Urban Planning, Economics concentration;
Dissertation: "Essays on the Theory and Measurement of Public Goods"
Co-chairs: Amartya Sen and Robert Stavins

M.Sc., Oxford University, St. Antony's College (1991) Development Economics, Rhodes Scholar

B.A., College of William and Mary (1989) Economics and History (Interdisciplinary) with honors

PROFESSIONAL EXPERIENCE

2012 – Present Professor, Department of Public Policy, UCLA
2006 – 2012 Associate Professor, Department of Public Policy, UCLA
1997 – 2006 Assistant Professor, Department of Public Policy, UCLA
2000 – 2004 Faculty Associate, Harvard Institute for International Development
1993 – 2000 Urban/Environmental Economist, Harvard Institute for International Development
1990 – 1991 Hydrogeologist, OHM Services Corporation, Richmond, Virginia

Administrative Experience

2009 – Present Director, Luskin Center for Innovation, UCLA
2007 – Present Vice-Chair, Department of Public Policy, UCLA
2006 – 2011 Director, Ralph and Goldy Lewis Center, UCLA

IN PRINT OR FORTHCOMING

1. "Cost–Benefit Analysis of Onsite Residential Graywater Recycling: A Case Study on the City of Los Angeles." Z. Yu, J.R. Deshazo, M. Stenstrom, and Y. Cohen. *Journal American Water Works Association.* 107(9): E436-E444 (September 2015)
2. "Creation of Malaysia's Royal Belum State Park: A Case Study of Conservation in a Developing Country." K. Schwabe, R. Carson, J.R. DeShazo, M. Potts, A. Reese, and J. Vincent. *Journal of Environment & Development.* 24(1): 54-81. (March 2015)
3. "Designing and Implementing Surveys to Value Tropical Forests." J.R. DeShazo, R. Carson, K. Schwabe, J. Vincent, I. Ahmad, C. Kook, and C. Tan. *Journal of Tropical Forest Science.* 27(1): 91-114. (January 2015)
4. "Willingness to Pay for Public Health Policies to Treat Illnesses." R. Bosworth, T.A. Cameron, and J.R. DeShazo. *Journal of Health Economics.* 39: 74-88. (January 2015)
5. "Tropical countries may be willing to pay more to protect their forests." J. Vincent, R. Carson, J. R. DeShazo, K. Schwabe, I. Ahmad, S. Chong, Y. Chang, and M. Potts. *Proceedings of the National Academy of Science.* (15 July 2014)
6. "Pricing Workplace Charging: Financial Viability and Fueling Costs." B. Williams and J.R. DeShazo. *Transportation Research Board 93rd Annual Meeting,* no. 14-1137. (January 2014)

7. "Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States." Zita Yu, Anditya Rahardianto, J.R. DeShazo, Michael Stenstrom, and Yoram Cohen. *Water Environment Research,* Volume 85, Number 7, pp. 650-662(13) (July 2013)
8. "Demand for Health Risk Reductions." T.A. Cameron and J.R. DeShazo. *Journal of Environmental Economics and Management.* (January 2013)
9. "Scenario Adjustment in Stated Preference Research." T.A. Cameron, J.R. DeShazo, and E.H. Johnson. *Journal of Choice Modelling.* (March 2011)
10. "Differential Attention to Attributes in Utility-theoretic Choice Models." T.A. Cameron and J.R. DeShazo. *Journal of Choice Modelling.* 3(3) 73-115 (November 2010)
11. "Demand for Health Risk Reductions: A Cross-national Comparison between the U.S. and Canada." T.A. Cameron, J.R. DeShazo, and P. Stiffler. *Journal of Risk and Uncertainty.* 41(3) 245-273 (December 2010)
12. "Is An Ounce of Prevention Worth a Pound of Cure? Comparing Demand for Public Prevention and Treatment Policies." R. Bosworth, T.A. Cameron, and J.R. DeShazo. *Medical Decision Making.* 30(4): E40-E56 (2010)
13. "The Effect of Children on Adult Demands for Health-risk Reductions." T.A. Cameron, J.R. DeShazo, and E.H. Johnson. *Journal of Health Economics.* 29(3): 364-376 (May 2010)
14. "Demand for Environmental Policies to Improve Health: Evaluating Community-level Policy Scenarios." R. Bosworth, T.A. Cameron, and J.R. DeShazo. *Journal of Environmental Economics and Management.* 57(3): 293-308 (2009)
15. "The Effect of Consumers' Real-world Choice Sets on Inferences from a Stated Preference Field Experiment." J.R. DeShazo, T.A. Cameron, and M. Saenz. *Environmental and Resource Economics.* 42(3):319-343 (2009)
16. "The Environmental Consequences of Decentralizing the Decision to Decentralize." W.B. Cutter and J.R. DeShazo. *Journal of Environmental Economics and Management.* 53 (1): 32-53 (2007)
17. "Activities in Models of Recreational Demand." W.B. Cutter, L. Pendleton, and J.R. DeShazo. *Land Economics.* 83(3): 370-381 (2007)
18. "Timing and Form of Federal Regulation: The Case of Climate Change." J.R. DeShazo and J. Freeman. *University of Pennsylvania Law Review.* 155:1499-1558 (2007)
19. "Evaluation Reforms in the Implementation of Hazardous Waste Policies in California." W.B. Cutter and J.R. DeShazo. *California Policy Options.* (2006)
20. "Frontiers in Stated Preferences Methods: An Introduction." V. Adamowicz and J.R. DeShazo. *Environmental and Resource Economics.* 34(1): 1-6 (2006)
21. "Congressional Politics." J.R. DeShazo and J. Freeman. Chapter 6 in "*The Endangered Species Act at Thirty: Renewing the Conservation Promise*" edited by Dale Goble, J. Michael Scott, Frank W. Davis. Island Press. (2006)
22. "Public Agencies as Lobbyists." J.R. DeShazo and J. Freeman. *Columbia Law Review.* 105(8): 2217-2305 (2005)
23. "The Effect of Health Status on Willingness to Pay for Morbidity and Mortality Risk Reductions." J.R. DeShazo and T.A. Cameron. *California Center for Population Research.* (2005)
24. "Upgrading Municipal Environmental Services to European Union Levels: A Case Study of Household Willingness to Pay in Lithuania." R. Bluffstone and J.R. DeShazo. *Environment and Development Economics.* 8(4): 637-654 (2003)
25. "The Congressional Competition to Control Delegated Power." J.R. DeShazo and J. Freeman. *Texas Law Review.* 81(6): 1443-1519 (2003)

26. "Designing Transactions without Framing Effects in Iterative Question Formats." J.R. DeShazo, *Journal of Environmental Economics and Management.* 44(1): 123-143 (2002)
27. "Dissecting the Random Component of Utility." J. Louvier, R. Carson, A. Anislie, T.A. Cameron, J.R. DeShazo, D. Hensher, R. Kohn, T. Marley, and D. Street. *Marketing Letters.* 13(3): 177-193 (2002)
28. "Designing Choice Sets for Stated Preference Methods: The Effects of Complexity on Choice Consistency." J.R. DeShazo and G. Fermo. *Journal of Environmental Economics and Management.* 43(3): 360-385 (2002) (Paper identified as one of the three of the most influential articles of the year at the 2002 World Congress of Environmental and Resource Economics by Ian Bateman, Editor of *Environmental and Resource Economics.*)
29. "The Effect of Supply and Demand Shocks on the Non-market Valuation of Public Goods." J.R. DeShazo. *Journal of Environment and Development Economics.* 4: 471-492 (1999)
30. "Demand for Solid Waste Management: A Case Study of Gujranwala, Pakistan." A. Altaf and J.R. DeShazo. *World Development.* 24(5): 857-868 (1996)

Unpublished Articles

31. "A Comprehensive Assessment of Selection in a Major Internet Panel for the Case of Attitudes toward Government Regulation." T.A. Cameron and J.R. DeShazo.
32. "Subjective Choice Difficulty in Stated Preference Surveys." Eric Duquette, T.A. Cameron, and J.R. DeShazo.
33. "Willingness to Pay for Health Risk Reductions: Differences by Type of Illness." T.A. Cameron and J.R. DeShazo.
34. "Two Types of Age Effects in the Demand for Reductions in Mortality Risks with Differing Latencies." J.R. DeShazo and T.A. Cameron.
35. "The Effect of Health Status on Willingness to Pay for Morbidity and Mortality Risk Reductions." J.R. DeShazo and T.A. Cameron.

Non-peer Reviewed Articles and Book Chapters

36. "Los Angeles County Community Water Systems: Atlas and Policy Guide Volume I, Supply vulnerabilities, at-risk populations, opportunities for conservation." J.R. DeShazo, H. McCann. UCLA Luskin Center for Innovation Report. (2015)
37. "Los Angeles Solar and Efficiency Report (LASER) Version 2.0." J.R. DeShazo, C. Callahan H. McCann and N, Wong. UCLA Luskin Center for Innovation Report for the Environmental Defense Fund. (2014)
38. "Pricing Plug-in Electric Vehicle Recharging in Multi-Unit Dwellings: Financial Viability and Fueling Costs," B. Williams and J.R. DeShazo. UCLA Luskin Center for Innovation Report. (2013)
39. "Los Angeles Solar and Efficiency Report (LASER)." J.R. DeShazo, C. Callahan and N, Wong. UCLA Luskin Center for Innovation Report for the Environmental Defense Fund. (2013)
40. "South Bay Cities Plug-in Electric Vehicle Readiness Plan." J.R. DeShazo, A. Ben-Yehuda, N. Wong and A. Turek. UCLA Luskin Center for Innovation Report for Southern California Association of Governments. (2013)
41. "Western Riverside Plug-in Electric Vehicle Deployment Plan." J.R. DeShazo, A. Ben-Yehuda, N. Wong and V. Hsu. UCLA Luskin Center for Innovation Report for Southern California Association of Governments. (2013)
42. "Moving Towards Resiliency: An Assessment of the Costs and Benefits of Energy Investments for the San Pedro Bay Ports." R. Matulka, J.R. DeShazo and C. Callahan. UCLA Luskin Center for Innovation Report. (2013)

43. "Achieving Proposition 39's Clean Energy Promise: Investing in Jobs, Energy Efficiency and Renewal Resources." J.R. DeShazo, C. Callahan, and E. Beryt. UCLA Luskin Center for Innovation Report for the Los Angeles Business Council. (2013)
44. "Southern California Plug-in Electric Vehicle Readiness Plan." J.R. DeShazo and A. Ben-Yehuda. UCLA Luskin Center for Innovation Report for Southern California Association of Governments. (2012)
45. "Southern California Plug-in Electric Vehicle Atlas." J.R. DeShazo, A. Ben-Yehuda and N. Wong. UCLA Luskin Center for Innovation Report for Southern California Association of Governments. (2012)
46. "Climate Action Planning in Southern California." J.R. DeShazo and J. Matute. UCLA Luskin Center for Innovation Report (2012)
47. "Empowering LA's Solar Workforce: New Policies that Deliver Investments and Jobs." J.R DeShazo, M. Pastor, and M. Auer. Produced by the LABC Institute, City of Los Angeles, JP Morgan Chase & Co., Global Green USA, UCLA Luskin Center, and USC Program for Environmental and Regional Equity. (2011)
48. "Towards Measuring Green House Gases from Local Jurisdictions." J.R. DeShazo and J. Matute. Oxford Handbook of Urban Planning. Oxford: Oxford University Press. (2012)
49. "Making a Market: Multifamily Rooftop Solar and Social Equity in Los Angeles." J.R. DeShazo, M. Pastor, M. Auer, V. Carter, and N. Vartanian. UCLA Luskin Center for Innovation Report. (April 2011)
50. "Los Angeles Solar Atlas." J.R. DeShazo, R. Matulka, and N. Wong. Produced by the UCLA Luskin Center for Innovation with financial and data support from Los Angeles County, the Los Angeles Business Council, and the UCLA Lewis Center. (2011)
51. "Best Practices for Implementing a Feed-in Tariff Program." J.R. DeShazo and R. Matulka, UCLA Luskin Center for Innovation Report. (2010)
52. "Bringing Solar Energy to Los Angeles: An Assessment of the Feasibility and Impacts of an In-basin Solar Feed-in Tariff Program." J.R. DeShazo and R. Matulka, UCLA Luskin Center for Innovation Report. (2010)
53. "Designing an Effective Feed-in Tariff for Greater Los Angeles." J.R. DeShazo and R. Matulka. UCLA Luskin Center for Innovation Report. (2010)
54. "Early Steps toward Climate Action Planning in Southern California." J. Matute and J.R. DeShazo. UCLA Luskin Center for Innovation Report. (2010)
55. "Economic Analysis of California's Green Chemistry Regulations for Safer Consumer Products." M. Kahn and J.R. DeShazo. UCLA Institute of the Environment and Sustainability Report. (2010)
56. "Persistent Market Failures in the Chemical Sector: Consequences for Health and Product Innovation." J.R. DeShazo and M. Cohen. Report prepared for the California Department of Toxic Substances Control. (2007)
57. "Congressional Oversight of the Endangered Species Act: How Politics Influences Policy." J.R. DeShazo and J. Freeman. In *30 Years After the Endangered Species Act.* (2005)
58. "Hazardous Waste." *Southern California Environmental Report Card.* W.B. Cutter and J.R. DeShazo. UCLA Institute of the Environment. (2005)
59. "REACHING THE TIPPING POINT IN LOS ANGELES: An Evaluation of the Safer Cities Initiative in MacArthur Park." J.R. DeShazo and M. Klieman. Report prepared for Hanover Associates on behalf of the Los Angeles Police Department. (2004)
60. "The Congressional Competition to Control Delegated Power." J.R. DeShazo and J. Freeman. *Land Use and Environmental Law Review* 35. (2004)

61. "Linking Growth in Tourism with the Conservation of Protected Areas: Toward a National Paradigm in Central America." J.R. DeShazo. In T. Panayotou, ed. *Environment for Growth: Environmental Management for Sustainability and Competitiveness in Central America.* Cambridge, MA: Harvard University Press. (2001)
62. "Travel Patterns of Domestic and International Tourists in Central America." J.R. DeShazo. In T. Panayotou, ed. *Environment for Growth: Environmental Management for Sustainability and Competitiveness in Central America.* Cambridge, MA: Harvard University Press. (2001)
63. "The Demand for Types of Recreational Sites in Central America: Comparison of Guatemala and Costa Rica." J.R. DeShazo. In T. Panayotou, ed. *Environment for Growth: Environmental Management for Sustainability and Competitiveness in Central America.* Cambridge, MA: Harvard University Press. (2001)
64. "An Economic Model of Smallholder Deforestation: A Consideration of the Shadow Value of Land on the Frontier." R. DeShazo and J.R. DeShazo. In *International Symposium on Tropical Forest Management in Asia Proceedings*, Oslo, Norway. (1994)

RESEARCH GRANTS AND CONTRACTS

Principal Investigator. 2014. Trust for Public Land (contract total $15,000), "Green Alley Case Study."

Principal Investigator. 2014. California Environmental Protection Agency and the Office of Environmental Health Hazard Assessment (contract total $9,683), "Evaluating Benefits in Disadvantaged Communities for Implementation of the Greenhouse Gas Reduction Fund."

Principal Investigator. 2014. Los Angeles Department of Water and Power (contract total $96,150), "Job Creation Benefits from Energy Efficiency Programs at the Los Angeles Department of Water and Power."

Principal Investigator. 2014. The California Endowment via the Coalition for Clean Air (gift total $20,000), "Investment Justice through the Greenhouse Gas Reduction Fund."

Co-Principal Investigator. 2013-2014. Edison International Foundation (grant total $50,000), "Transportation Electrification Curriculum Development."

Principal Investigator. 2013-2014. Environmental Defense Fund (grant total $43,178), "Los Angeles Solar and Efficiency Report (LASER): An Atlas of Investment Potential."

Co-Principal Investigator. 2013-2014. Shell Oil Company (contract total $394,403), "Carousel Tract Environmental Remediation."

Co-Principal Investigator. 2013-2015. California Air Resources Board. (grant total $302,993). "Examining Factors that Influence ZEV Sales in California."

Principal Investigator. 2013-2014. South Coast Air Quality Management District (grant total $32,000). "South Coast Plug-in Electric Vehicle Readiness Plan."

Principal Investigator. 2012-2014. California Air Resources Board (grant total $83,859). "Analyzing the Economic Benefits and Costs of Smart Growth Strategies."

Principal Investigator. 2013. Environmental Defense Foundation (grant total $35,000). "Assessing Local Clean Energy Investment Potential and Need in Los Angeles County."

Co-Principal Investigator. 2012-2013. California Air Resources Board (grant total $360,000, $120,000 allocated to UCLA Luskin Center). "Designing Transit Oriented Development to Reduce Pedestrian and Residential Air Pollution Exposure."

Co-Principal Investigator. 2012-2013. U.S. Forest Service ($19,500). "Water, Climate Change, and Environmental Justice: A Vulnerability Assessment Framework."

Co-Principal Investigator. 2012-2013. University of California Transportation Center (grant total $130,600, $28,900 allocated to UCLA Luskin Center). "Air Quality in Transit Oriented Developments."

Principal Investigator. 2012-2013. Southern California Association of Governments ($193,000). "Plug-In Electric Vehicle Readiness Plan."

Principal Investigator. 2012. Los Angeles Business Council ($11,000). "Implementing Public-Private Partnership for Prop 39: The California Clean Energy Jobs Act."

Principal Investigator. 2012. UCLA Center for Civil Society ($17,000). "UCLA partnership with CicLAvia and the Los Angeles Sustainability Collaborative to conduct an economic impact analysis of a community-based CicLAvia open street event."

Principal Investigator. 2012. Aquamarine Institute ($25,000). "Energy Efficiency and Energy Generation for the San Pedro Bay Ports."

Principal Investigator. 2010-2012. University of California Transportation Center ($26,300). Multi-campus Research Programs and Initiatives (MRPI).

Co-Principal Investigator. 2011-2012. UC Institute of Transportation Studies ($26,000). "Planning for Electric Vehicle Growth."

Principal Investigator. 2011. U.S. Environmental Protection Agency ($15,000). "Closing the Environmental Justice Gap: Advancing Evaluation Methods."

Principal Investigator. 2011. Southern California Association of Governments ($50,700). "Maintaining Lots Online GIS."

Principal Investigator. 2010. California Environmental Protection Agency Toxic Substances Control ($75,710). "Economic Analysis of California's Green Chemistry Regulations for Safer Consumer Products."

Principal Investigator. 2010. Los Angeles Business Council ($92,000). "Analyzing Alternative Designs for In-Basin Solar Programs."

Principal Investigator. 2010. Kern COG Regional Transportation ($10,101). "Kern COG Database and Website Improvement."

Principal Investigator. 2010. University of California Transportation Center ($33,000). Multi-campus Research Programs and Initiatives (MRPI).

Principal Investigator. 2009. Latino Business Chamber ($42,000). "Strengthening Latino Businesses in Greater Los Angeles."

Principal Investigator. 2007-2008. California Environmental Protection Agency Toxic Substances Control ($31,262). "Persistent Market Failures in the Chemical Sector: Consequences for Health and Product Innovation."

Co-Principal Investigator. 2006-2009. National Science Foundation ($40,529). "Improving the Valuations of Risk Reductions."

Co-Principal Investigator. 2005-2010. United Nations Development Programme, Global Environment Facility (grant total of $5.6 million, $769,600 allocated for economic valuation tools component). "Conservation of Biological Diversity through Improved Forest Planning Tools." PI: Jeffrey Vincent; Economic Valuation team: Richard Carson, J.R. DeShazo, Kurt Schwabe, Jeffrey Vincent.

Principal Investigator. 2003. Haynes Foundation ($59,000). "Evaluating Privatization as a Governance Strategy for Bus Transit in Southern California."

Principal Investigator. 2003. California Policy Research Center ($40,000). "Evaluating the Governance and Privatization of Public Bus Transit in California."

Co-Principal Investigator. 2003. U.S. Environmental Protection Agency ($69,000). "Not All Deaths are Created Equal: Understanding Individual Preferences for Reductions in Morbidity-Mortality Events." Co-PI: Trudy Cameron.

Co-Principal Investigator. 2001. National Science Foundation/US Environmental Protection Agency ($360,000). "Not All Deaths are Created Equal: Understanding Individual Preferences for Reductions in Morbidity-Mortality Events." Co-PI: Trudy Cameron.

Co-Principal Investigator. 2001. Health Canada ($195,000). "Not All Deaths are Created Equal: Understanding Individual Preferences for Reductions in Morbidity-Mortality Events." Co-PI: Trudy Cameron.

Co-Principal Investigator. 1999. National Science Foundation/US Environmental Protection Agency ($107,000). "Understanding the Effects of Choice Set Complexity in Stated Preference Methods." Co-PI: Trudy Cameron.

Contractor. 1998. United Nations Industrial Development Organization: Costa Rica ($10,000). "Measuring the Benefits of National Park Visitation in Costa Rica."

Contractor. 1998. Guatemalan Institute of Tourism (INGUAT) ($10,000). "Understanding the Demand for Recreational and Tourism Destinations in Guatemala."

Principal Investigator. 1997. Harvard University and INCAE ($163,000). "Understanding Nature and Cultural Tourism in Central America." Project Director: Theodore Panayotou.

Subcontractor. 1997. National Science Foundation ($16,000). "Endangered Species Act: Understanding Public Policy Outcomes." Co-PIs: Andrew Metrick and Martin Weitzman.

Academic Awards

Professor of the Year, Master of Public Policy (MPP) Program, UCLA (2001, 2004, 2007)
Faculty Career Development Award, UCLA (2000)
Center for American Politics and Public Policy Fellowship, UCLA (1999)
Commencement Marshal, Harvard University (1997)
Harvard University Fellowship (1992-95)
Rhodes Scholar (1989-90)
Marshall Scholar Nominee (1989)
Phi Beta Kappa, College of William and Mary (1988-89)
Edward-Carr Cup Winner, College of William and Mary (1989)
Zelda B. Winwright Scholar, College of William and Mary (1988)

Professional Service

Committee Member: U.S. Environmental Protection Agency Science Advisory Board's Environmental Economics Advisory Committee. Serves as a special government employee and provides independent advice on technical issues underlying the EPA's policies and decision making. (2013-2016)

Associated Policy Editor for Energy and Environment, *Behavioral Science & Policy (BSP) Journal.* The journal publishes accessible short-form articles applying the findings of behavioral science research to policy questions and is published by the Behavioral Science & Policy Association and the Brookings Institution Press. (2014)

Committee Member: Southern California Plug-In Electric Vehicle Coordinating Council. The Council is responsible for creating the Southern California Plug-in Electric Vehicle Readiness Plan, published in 2012. (2012-2013)

Panel Member: National Water Research Institute Los Angeles Department of Water and Power "Groundwater Recharge Project." (2013)

Committee Member: Statewide workshop on Plug-In Electric Vehicles (PEV) Infrastructure Planning held by the California Energy Commission in coordination with the Governor's Office and the Air Resources Board. (2013)

Expert Panelist: Carousel Site Review in Carson, CA. Review possible exposure to homeowners on Shell Oil site (2012-2013).

Committee Member: Los Angeles Metro Energy Blue Ribbon Committee. Committee provides recommendations and facilitates partnerships to develop innovative and cost effective strategies to enhance Metro's Energy Conservation and Management (2012-2013).

Review Panelist: The Tillman Water Reclamation Plant Review Committee for the Department of Water and Power. The committee established policies for all aspects of long-range planning for garden activities and projects (2010-2011).

Plan Special Editor, *Environmental and Resource Economics*. Issue entitled "Frontiers in the Non-Market Valuation Methods" with Vic Adamowicz (2005).

Research Staff: Metropolitan Water District Blue Ribbon Committee. The Blue Ribbon Committee provided Metropolitan with a report analyzing water challenges for the next 50 years. The committee reviewed developing new water options for Southern California; energy for the future; economic development and new technologies; financial stability; workforce; and external and internal communications functions (2004-2006).

Editorial Council, *Journal of Environmental Economics and Management* (2003-2007).

Program Committee, Association of Environmental and Resource Economists (2002-2006). (This three-person committee selects papers for two AERE sessions at the ASSA and AAEA annual meetings.)

Proposal Reviewer, U.S. Environmental Protection Agency, Corporate Environmental Behavior: Examining the Effectiveness of Government Interventions and Voluntary Initiatives (2000), and Valuation of Environmental Impacts on Human Health (2001).

Proposal Reviewer, National Science Foundation, Environmental Decision Making and Valuation (1999).

Alternate, U.S. Environmental Protection Agency's Children's Health Protection Advisory Committee (1999-2000).

Lecturer, Executive Education Program, Environmental Economics and Policy Work (for professionals in developing countries), John F. Kennedy School of Government, Harvard University (1994-1998).

Lecturer, Executive Education Program, Environmental Economics Workshop (for professionals).

Lecturer, PPIA Program (for minority students bound for graduate school), University of California at Berkeley (2003).

DOCTORAL DISSERTATION COMMITTEES

1. German Fermo*	Economics Department	Ph.D. Completed 1999
2. Andres Lerner*	Economics Department	Ph.D. Completed 1999
3. Lea-Rachel Kosnik*	Economics Department	Ph.D. Completed 2002
4. Manrique Saenz*	Economics Department	Ph.D. Completed 2001
5. Bowman Cutter*	Economics Department	Ph.D. Completed 2001
6. Jae-seung Lee	Economics Department	Ph.D. Completed 2003
7. Matthew Neidell	Economics Department	Ph.D. Completed 2003
8. Jurens Meinecke	Economics Department	Ph.D. Candidate
9. Ryan Vaughn	Economics Department	Ph.D. Candidate
10. Mitzy Taggart	Environ. Sci & Engin. Department	Ph.D. Completed 2002
11. Monique Meyers	Environ. Sci.& Engin. Department	Ph.D. Completed 2003
12. Felicia Federico	Environ. Sci & Engin. Department	Ph.D. Completed 2006
13. Kathleen Shaver	Public Health Sci. Department	Ph.D. Candidate

14. Christian B. Jensen	Political Science Department	Ph.D. Completed 2004
15. Jeeyang Rhee Baum	Political Science Department	Ph.D. Completed 2002
16. Eric Sussman	Political Science Department	Ph.D. Completed 2005
17. Perla Atiyah	School of Public Health	Ph.D. Completed 2007
18. Cari Coe	Political Science Department	Ph.D. Completed 2007
19. Dan Chatman	Urban Planning Department	Ph.D. Completed 2005
20. Hiro Iseki*	Urban Planning Department	Ph.D. Completed 2004
21. Jan Mazurek*	Urban Planning Department	Ph.D. Completed 2008
22. Michael Manville	Urban Planning Department	Ph.D. Completed 2009
23. Nadim Ouladi	School of Public Health	Ph.D. Completed 2012
24. Nicholas Narin-Birch	School of Public Health	Ph.D. Completed 2012
25. Victor Rigor Vasquez	Environ. Sci & Engin. Department	Ph.D. Completed 2013
26. Tamanna Rahman	School of Public Health	Ph.D. Candidate
27. Rongzhang Wang	Economics Department	Ph.D. Candidate
28. Zita Lai Ting Yu	Chemical Engineering	Ph.D. Candidate

*Co-chair of Doctoral Committee

Selected Academic Presentations

Conjoint Analysis in Health Economics Meetings (2010)
UC San Diego, Economics (2008)
Stanford University, Law School (2004)
University of Southern California, Law School (2004)
Choice Symposium (2001, 2004)
NBER, Environment and Public Economics (2003)
University of California at San Diego, Political Science Department (2003)
Georgetown University, Law School (2003)
Colorado University, Economics Department (1999, 2003)
North Carolina State University, School of Agriculture and Natural Resources (2003)
University of Maryland, Department of Agriculture and Natural Resources (2003)
University of San Diego, Law School (2003)
University of North Carolina at Chapel Hill, Department of Public Policy (2002)
Stanford University, Graduate School of Business (2002)
Harvard University, Environmental Economic Seminar (1996, 2002)
Environmental Protection Agency Workshop (November 2001, 2002, 2003)
UCLA, Marschak Lecture Series (2001)
Association of Public Choice Meetings (2001)
Allied Social Sciences Association (Annual Economics Conferences) (1998. 1999, 2001, 2002, 2004)
University of California at Irvine, Political Economy Series (2000)
University of California at Berkeley, Symposium on Choice (2000)
Association of Public Policy and Management Biannual Conference (1998)
University of California at Santa Barbara, Workshop on Environmental Economics (1998, 2001, 2003)
UCLA Department of Economics (1998)
UCLA School of Public Policy and Social Research, All-School Seminar (1997)
Association of Environmental and Resource Economists Workshop (1996, 2000)

Policy-related Work

Selected Reports, Working Papers, and Published Abstracts

Evaluating Improvements in the Portfolio and Quality of Recreational Sites in Guatemala and Costa Rica. *Development Discussion Paper Series*, Harvard Institute for International Development, Harvard University (in Spanish) (with L. Monestel). (1999)

On the Consumption of Managed and Natural Quality at National Parks in Central America. *Development Discussion Paper Series*, Harvard Institute for International Development, Harvard University (in Spanish) (with L. Monestel). (1999)

Measuring and Managing the Demand for Urban Environmental Infrastructure in Transitional Economies: A Case Study of Iasi, Romania. *Environmental Discussion Paper Series*, Harvard Institute for International Development, Harvard University. (1997)

La importancia de las areas protegidas en el desarrollo del turismo en Costa Rica: Evidencia sobre el comportamiento del gasto de los turistas nacionales y extranjeros. Harvard Institute for International Development, Harvard University (with L. Monestel). (1998)

Evaluación de la calidad de lugares recreativos y preferencias por lugares y actividades recreacionales: La perspectiva de los turistas nacionales y extranjeros sobre las areas protegidas públicas de Costa Rica. Harvard Institute for International Development, Harvard University (with L. Monestel). (1998)

On the level of and demand for environmental quality in Asia. Background Paper for the Asian Development Bank, Harvard Institute for International Development. (1996)

Full resource cost pricing: A study of water and wastewater management in Phuket, Thailand. Thailand Development Research Institute (with others). (1995)

Green finance: A case study of Khao Yai National Park. Thailand Development Research Institute and Harvard Institute for International Development (with others). (1994)

Water supply and demand in Palestine in the years 1990, 2010 and 2020. Applied Research Institute of Jerusalem with technical assistance by the Harvard Institute for International Development (with others). (1994)

Towards a new paradigm of policy formulation for non-point source pollution: The role of submarine groundwater discharge. In *American Water Resources Association Symposium Proceedings*, Raleigh, NC (with R. A. Purdy). (1992)

The correlation between nitrate concentrations in groundwater and adjacent surface water. In *Collected Abstracts of the Virginia Water Resources Forum* (with R. A. Purdy and G. H. Johnson). (1991)

The effect of tidal oscillations in the James River on adjacent groundwater configuration and quality. In *Collected Abstracts of the Virginia Water Resources Forum* (with R. A. Purdy and G. H. Johnson). (1989)

The influx and movement of nitrogen in groundwater in an agricultural setting. In *Collected Abstracts of the Virginia Water Resources Forum* (with R. A. Purdy and G. H. Johnson). (1989)

Selected Policy Presentations

National Congress of Tourism, San José, Costa Rica (September 1998), Counting the Economic Benefits Generated by Protected Areas in the Costa Rican Economy.

Association of Environmental Non-governmental Organizations of Guatemala, Guatemala City, Guest Lecturer (June 1998), Capturing the Benefits of Tourism for Local Communities: An Agenda for the Future.

Institute for Anthropology and History, Minister of the Interior, Copán, Honduras, Guest Lecturer (December 1997), On the Role of National Parks in Local Economic Development.

Ministerial Conference on National Park Management, Alajuela, Costa Rica (September 1997), Strategies for Improving Private-Public Partnerships in National Parks (Attended by all Ministers of Environment in Central America and U.S. Secretary of Interior, Bruce Babbitt).

Environment and Economics Program for Southeast Asia, Singapore, Invited Speaker (1997), Single-site Travel Cost Models: An Application to Khao Yai National Park.

PROFESSIONAL POLICY EXPERIENCE

Urban/Environmental Economist, Harvard Institute for International Development

- Central American Project. Designed and managed a study to estimate the supply of, and demand for, environmentally based recreational experiences in Central America. (May 1997 – June 2000)
- Asian Development Bank. Prepared a background paper on the demand for improved environmental quality (air, water, and recreational services) in Asia. (May 1996 – October 1996)
- Iasi, Romania. Designed and managed a study which sought to value and improve municipal water, wastewater, and solid waste services. (February 1995 – June 1996)
- Phuket, Thailand. Estimated the cost of water supply and wastewater treatment, performed a market analysis of household and hotel demand, and conducted a risk assessment and cost/benefit analysis of capacity expansion projects. (November 1994 – May 1995)
- Khao Yai National Park, Thailand. Employed the contingent valuation and travel cost methods to determine ways to increase producer and consumer surplus through improved park management. (December 1993 – June 1994)
- West Bank and Gaza, Occupied Territories. Estimated the quantity and average unit cost of annually renewable water and projected water demand for domestic, industrial and agricultural users in the West Bank and Gaza through the year 2020 for negotiations between the Palestinians and Israelis. (November 1993 – March 1994)

Economic Valuation Advisor, National Wildlife Federation/Northeast Resource Center
Advised the Federation on the use of environmental valuation techniques to value water-based recreation in New England and in FERC relicensing litigation. (October 1994 – September 1996)

Economist, The World Bank
Evaluated the infrastructure investment policies of the Philippines and the World Bank in terms of revenue sustainability, efficient use of water resources, and economic efficiency. (May 1994 – September 1994)

Hydrogeologist, OHM Services Corporation, Richmond, Virginia
Carried out Superfund and RCRA remedial investigations and feasibility studies, permitting procedures for effluent release, risk assessments, and corrective action plans. (September 1990 – July 1991)

Hydrogeologist, United States Geological Survey/Water Resources Division, Richmond, Virginia
Designed and implemented a project to determine the extent of groundwater contamination to evaluate the need for centralized sewer and water systems in coastal Virginia. (May 1989 – August 1989)

POLICY ADVISING AND CONSULTING

U.S. Government Agencies: Environmental Protection Agency, Department of Interior, National Oceanic and Atmospheric Administration, National Science Foundation, United States Agency for International Development, United States Geological Survey, Department of Energy, U.S. Forest Service.

California and Los Angeles Government Agencies: California Governor's Office, Los Angeles Mayor's Office, Southern California Association of Governments, Los Angeles Department of Water and Power, California Energy Commission, California Environmental Protection Agency, South Coast Air Quality Management District, California Air Resources Board.

International Development and Lending Organizations: United Nations, UNEP, World Bank, European Union, Central American Bank for Development and Integration, Inter-American Development Bank, Asian Development Bank, Shell Oil Company.

Foreign Governments: Canada, Thailand, Romania, Kenya, Guatemala, Costa Rica, El Salvador, Honduras, Nicaragua, Philippines, Israel and the Palestinian Authority.

Foundations and Non-profits: Tinker Foundation, McArthur Foundation, Ford Foundation, National Wildlife Federation, The Nature Conservancy, RARE, Catholic Relief Service, Los Angeles Business Council, Edison International Foundation, Environmental Defense Fund, Gilbert Foundation.

SCHOLARLY AND PROFESSIONAL ACTIVITY

Speaker, UCLA Anderson, Shanghai Municipal Executive Education Program (2012, 2013)
Speaker, 2012 Economic Summit "The American Dream in the 21st Century: Jobs, the Economy & Moving Forward." (2012)
Speaker, Southern California Conference in Applied Microeconomics (2012)
Speaker, UCLA Institute of the Environment: Luskin Lunch Research Seminar (2010, 2011, 2012, 2013)
Panel Moderator, UCLA Environmental Justice Workshop (2011)
Speaker, Air Quality Management District Technology Symposium (2011)
Speaker, Institute of Medicine/Integration of Environment Public Health & Economics (2011)
Speaker, UCLA Arrowhead Symposium (2010, 2011)
Panel Member, National Water Research Institute Reliability Project Review Committee (2011)
Speaker, Young Professionals in Energy (2010)
Speaker, Los Angeles Business Council Solar Leadership Roundtable (2010)
Speaker, Los Angeles Business Council Solar Forum (2010)
Speaker, Los Angeles Business Council Sustainability Summit (2010, 2011)
Panel Member, Los Angeles Business Council: The Future of Green Building and Development (2010)
Speaker, Climate Change Developments, 24th Annual Los Angeles County Bar Association Environmental Law Super Symposium (2010)
Speaker, Webinar – InterSolar North America (2010)
Speaker, UCLA, Measuring Progress Towards Transportation GHG Goals (2010)

Panel Member, USC's Keston Institute's "Pricing and Social Equity: An Unplugged Conversation with the Experts" (2010)
Panel Member, The Resnick Institute: Sustainable Energy & Institute Forum (2010)
Speaker, UCLA Luskin School of Public Affairs: Environmental Speaker Series (2009)
Speaker, Leon Hoffman Urban Technology Conference (2009)
Panel Member, UCLA International Institute: Greening Conference (2009)

OTHER PROFESSIONAL ACTIVITY

Expert Speaker, "How to Redesign PEV Rebates for California?" Joint Workshop & Webinar of the Southern California Clean Cities Coalition and Plug-in Electric Vehicle Coordinating Council sponsored by the Southern California Association of Governments. (2014)
Expert Speaker, "What Spain's Experience with the Feed-in Tariffs Means for California." 2014 Aspen Accord Study & Discussion Tour in Barcelona, Spain. Sponsored by the Energy Coalition. (2014)
Panel Moderator, "Social Interaction & Citizen Participation" UCLA Luskin School of Public Affairs' Conference: *Who Owns the Digital City?* (2014)
Speaker, South Bay Cities Council of Governments' Annual General Assembly (2014)
Panel Moderator, "Global Water Management by 2050: Regional and National Solutions" US-Australia Water Conference (2014)
Panel Member, "Water Resources Economics and the Value of Water Reliability" NWRI Clarke Prize Conference (2013)
Panel Moderator, City of Santa Monica AltCar Exposition & Conference (2012, 2013)
Panel Member, Los Angeles Business Council's Annual Sustainability Summit (2013, 2014)
Expert Panel Member, UCLA Anderson TED Talks Week, Elon Musk Talk (2013)
Panel Member, 11th Annual Southern California Transportation Summit/Mobility 21 Panel (2012)
Panel Member, The Mediterranean City Conference's "The Built Environment." (2012)
Speaker, EVS26 Symposium (2012)
Panel Moderator, World Electric Vehicle Cities and Ecosystems conference (2012)
Speaker, Complete Streets for Los Angeles (2011, 2012)
Panel Moderator, The Future of Water in Southern California conference (2012)
Panel Member, E-Mobility: The Future of the Automobile (2011)
Speaker, Mayoral Housing, Transportation & Job Summit (2010, 2011)
Panel Member, Governor's Energy Conference (2011)
Speaker, The Contributions of Latino-Owned Businesses to the Economy of Greater Los Angeles (2009)
Panel Member, Focus the Nation (Climate Change Initiative) (2008)
Panel Member, Pardee Rand Graduate School Symposium: Beyond Health Insurance (2007)

J. Wayne Miller

Adj Prof & Assoc Director CERT wayne.miller@ucr.edu

Education

B.S. Chem. Eng., WPI
Ph.D. Chem. Eng., Caltech

Continuing Education

Numerous mgmt. classes, including some at Harvard Business School and Penn's Wharton School

Career Highlights

- *Over 39 years commercial experience in management of technical people & projects. Prior position was VP, Technology & Development for $10B company.*
- *Lead peer reviewer for ARB diesel fuel rule (July 2003))*
- *WPI Goddard Award (2012); UCR non-faculty Research & Teaching Award (2008), EPA Climate Change Award (2007), Judge for DoD Environmental Awards (2003-2013)*
- *Member: Air Quality Board (Philadelphia), Clean Fuels Advisory Gp. (AQMD) & FAA PM Tech Comm.*
- *Over 100 publications and presentations on fuel manufacture and port emissions. Nine patents.*

Dr. Miller joined UCR's CE-CERT lab in December 2000 after a distinguished career with Sunoco and UNOCAL. He has over 39 years of experience in technology planning, new product commercialization, business development and working within multi-national relationships. He was a member of several nationally acclaimed studies related to refinery products and the environment.

His research at UCR is focused on the measurement of gaseous and particulate emissions from a multitude of fuels and sources under real world operating conditions. Selected funding examples: US EPA, California Air Resources Board, California Energy Commission, Port of Los Angeles, U.S. Maritime Administration (MARAD), Health Effects Institute, Dept. of Defense, Coordinating Research Council (auto/oil companies) and many private companies.

Experience

- *Sunoco (1995-2001) VP Technology and Development* for 150 people with annual budget of $20M that carried out R/D for new fuel, lubricant and chemical processes and products.
- *Sunoco* Managed largest race/specialty fuel business in US; revenue ~$25M.
- *DOE,* NPC Member and contributing author of **Assuring the Adequacy and Affordability of Cleaner Fuels** (2000)
- *UCR:* since 2001, taught classes on Heat & Mass Transfer; Separation Sciences, Air Pollution Controls and Water Quality.
- *UCR.* Since 2003 worked over 50 projects to characterize real world emissions from various fuels, sources and control technologies; including: port trucks, locomotives, cargo handling equipment, harbor craft and ocean going vessels.
- *UCR:* Published over 35 papers in peer review journals and additional numerous client reports related to real world emissions from port activities.

ANDREW A. SWANTON
5810 Wooster Ave
Los Angeles, CA 90056
aswanton@mba2012.hbs.edu
213.458.6918

experience

2015-present **BYD MOTORS**

Director of Business Development US and Canada, Electric Trucks **LOS ANGELES, CA**

First hire for new zero emission electric truck team for world leader in electric buses and cars.

- Identify target markets and customers for medium and heavy duty trucks and coordinate product development.
- Building team to support product and business development for North American market.

2012-2015 **DANAHER**

ORMCO, Medical Devices – Senior Manager **LOS ANGELES, CA**

Managed operations team of 50 associates to design and manufacture custom appliance for orthodontic treatment.

- Instituted productivity performance metrics for all designers and grading procedure to track and improve quality. Changed manufacturing processes to reduce waste and increase accountability among each team member.
- Improved the following performance metrics while supporting 60% year over year growth: margins from 60% to 85%; lead time from 13 to 10 days; on time delivery from 95% to 99%; and quality from 14,000 to 5,000 ppm.
- Led Customer Service Team: improved 24-hr resolution rate of email inquiries from 52% in 2013 to 89% in 2015

ORMCO, Medical Devices – Manager Digital Customer Training and Support **LOS ANGELES, CA**

Oversaw launch of brand new imaging equipment in orthodontic market by building field training and support staff, creating marketing materials, and training the sales team.

- Lythos Training: built training program for product launch, including online/on-demand, in-office, and remote instruction for each new customer. Hired four fulltime staff and twelve 1099 contractors to execute.
- Lythos Technical Support: built three person team to provide remote troubleshooting.

CHEMTREAT, Chemicals – Product Manager **RICHMOND, VA**

Second hire in brand new Marketing Department. Operating Company grew by double digits each quarter.

- Product Management: prioritized R&D projects by cost/opportunity; rationalized SKUs eliminating 15% of products; managed cost savings projects totaling $1.1M in 2012; led creation of pricing tools for sales team.
- Digital Marketing: introduced digital marketing to ChemTreat - search engine optimization (+30% web visitors), pay per click, virtual trade shows, and lead nurturing programs.

2008-2010 **CAMP, DRESSER & McKEE**

Project Engineer: ***Los Angeles Recycled Water Master Plan*** **LOS ANGELES, CA**

- Authored winning project proposal for design of Water Reclamation Facility to recycle wastewater into drinking water. Led $12M project by managing team of 4 to complete design deliverables. Delivered presentations to senior Los Angeles city officials.

Design Engineer: ***Haworth Water Treatment Plant Upgrade*** **CAMBRIDGE, MA**

- Promoted to hydraulic design specialist by chief engineer for $100 million water treatment facility that serves 3 million people in Bergen County, NJ. Selected and designed all flow control devices – pumps, gates, valves, weirs, etc. Spearheaded introduction of water to new facility by organizing team of 15 engineers. Team received National Design-Build Excellence Award.

education

2010-2012 **HARVARD BUSINESS SCHOOL** **BOSTON, MA**

MBA

Cameron International – summer internship at $7.0B Oil & Gas manufacturer in Houston. Determined optimal production plan for $25M facility with capital requirements and IRRs. Recommendations were implemented.

2007-2008 **MIT (Massachusetts Institute of Technology)** **CAMBRIDGE, MA**

Master of Engineering. GPA: 5.0/5.0. Thesis analyzing effectiveness and adoption of low-cost water purification technologies in rural Ghana. Engineered new solution being used by 35,000 people and counting.

2003-2007 **TUFTS UNIVERSITY** **MEDFORD, MA**

Bachelor of Science, *Magna Cum Laude*, Civil Engineering. GPA: 3.7/4.0. Tau Beta Pi Honors Society.

personal Enjoy basketball, dogs, water sports, live music and comedy.

David Greenfader, Business Development and Sales Envision Solar

David Greenfader is in charge of Business Development and Sales for Envision Solar. Mr. Greenfader is a multi-lingual executive with over 20 years experience in international sales, business development, and human capital in the U.S., Asia, and Latin America. He is a graduate of University of Southern California in International Relations and is a proud father of one 18 month old boy.

As President & CEO of The Human Capital Group, Inc. for 15 years, Mr. Greenfader has built a successful executive search firm for top level management for early stage startup ventures to Fortune 500 companies across a varied industries; biotech, computer software, building automation, healthcare and transportation.

For the last 10 years, Mr. Greenfader has worked in the renewable energy sector, providing business development consulting for companies that feature photovoltaic, solar thermal, and alternative energy technologies.

Presently as Vice President of Business Development for Envision Solar, Mr. Greenfader spearheads strategic sales and business development initiatives across a multitude of channels. Mr. Greenfader is recently negotiated and finalized a statewide contract with the State of California's Department of General Services which will allow all state and local agencies an opportunity to drive on nothing but sunshine using the EV ARC™ - the world's first full transportable solar tracking electric vehicle charging station.

Mr. Michael Simon, TransPower Program Control Manager

Role on Project: Mr. Simon will manage administrative and budgeting activities relating to TransPower tasks. He will also actively participate in development and execution of commercialization plans.

Mr. Simon, who has 38 years of professional experience, is TranPower's founder, President & CEO. Under his leadership, TransPower has grown from a company that generated less than $1 million in 2011 to one that is projected to generate nearly $6 million in revenue in 2015 and more than $12 million in 2016. Mr. Simon's unique blend of technical and economic expertise, along with his lifelong focus on transportation and energy technologies, has enabled him to achieve numerous successes in commercialization of new technologies.

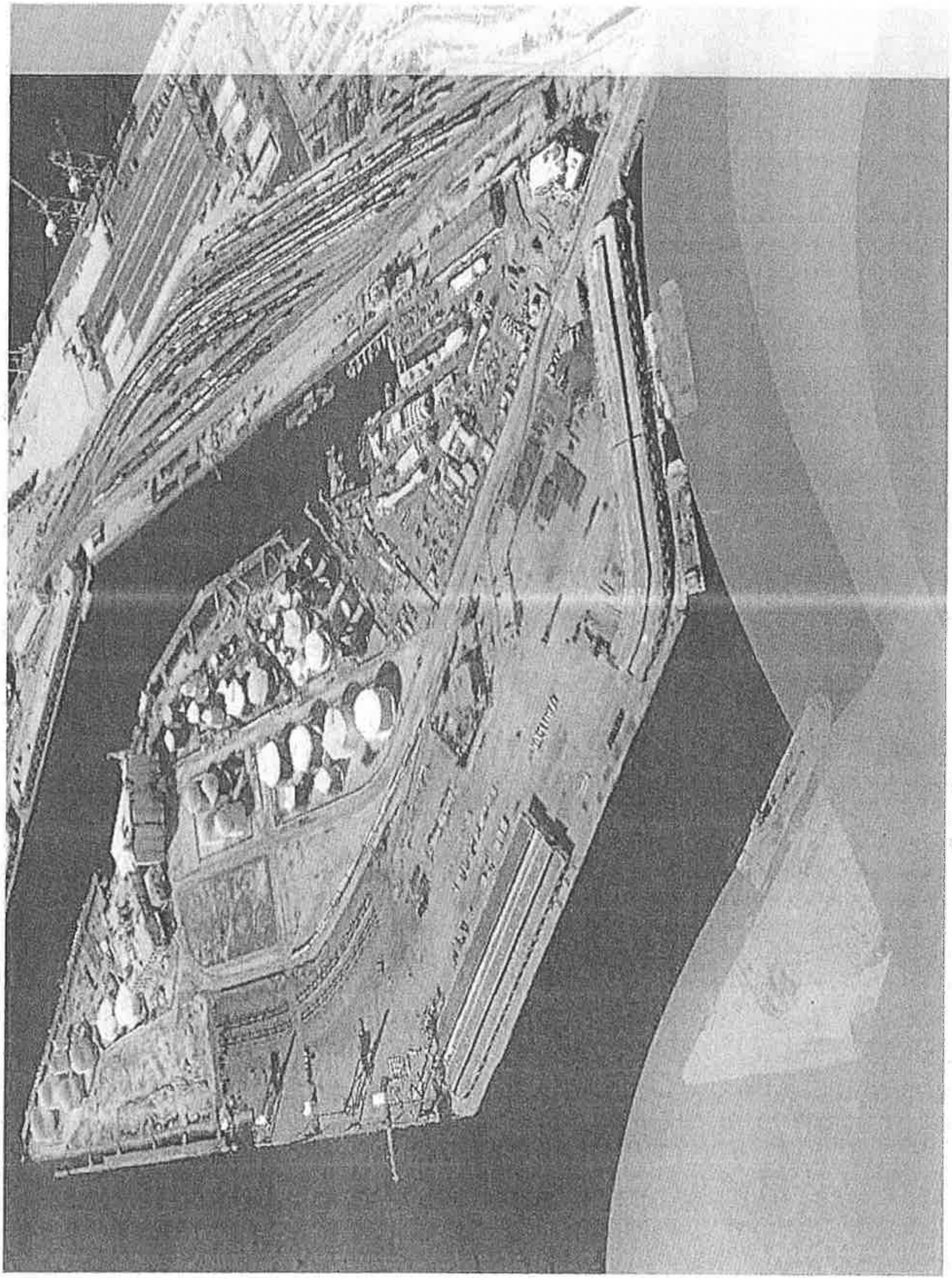
Prior to founding TransPower, Mr. Simon was Director of Commercial Business Development for the Electromagnetic Systems Division of General Atomics (GA), where he led the company's marketing of transportation and renewable energy technologies from 2006 until early 2010. In this capacity, Simon led the marketing of GA's maglev and linear motor systems, and helped originate concepts such as "LIM-Rail," "MagneRail," and "MagneTruck." Simon also led GA's marketing of high-power inverters for wind turbines, utility-scale solar systems, and other renewable energy applications. Simon's primary focus at GA was to develop a maglev business for moving containers at the Ports of Los Angeles and Long Beach, based on a GA maglev technology called the Electromagnetic Cargo Conveyor (ECCO). However, the high cost of maglev prompted Simon to investigate lower cost means of applying electric technology to the problem of goods movement, such as via electric drayage trucks.

Before joining GA, Mr. Simon was Chairman and Co-CEO of ISE Corporation, a company he co-founded in 1995 with colleague David Mazaika. From 1995 until 2005, Mike directed all company financial, business development, and administrative matters. ISE achieved ten consecutive years of revenue growth over this period, and grew from a start-up operation to a fast-growing high-tech firm with 60 employees and more than $20 million in revenues by the time Mike departed in 2005. While at ISE, Mike also played a leading role in conceiving and designing ISE's industry-leading products, co-inventing ISE's gasoline hybrid and fuel cell hybrid drive systems.

From 1992 through 1998, Mr. Simon also served as President & CEO of International Space Enterprises, whose long term goal was to promote space colonization and manufacturing by reducing the cost of access to space. ISE negotiated the rights to use low cost Russian launch vehicles, and even arranged for the launch of a facsimile of a Pepsi can into space for a 1996 advertising campaign.

From 1982 until 1993, Mr. Simon held engineering and management positions of increasing responsibility at General Dynamics Space Systems Division, specializing in advanced space programs. During this period, he won GD's Extraordinary Achievement Award for helping to establish the company's Commercial Atlas launch vehicle program (which still exists to this day as a multibillion dollar Lockheed-Martin program), and managed a key NASA study of future space transportation options. From mid-1981 until mid-1982, Mr. Simon worked for NASA Headquarters in Washington, DC as a Stanford research fellow, where he helped develop policies for use of the Space Shuttle and participated in the early planning for NASA's Space Station. From mid-1980 until mid-1981, Mr. Simon performed research on solar power systems as a Stanford graduate student.

Mr. Simon's first technical job was as a research assistant helping to design large scale space habitats, also referred to as "space colonies," during a NASA summer study in 1977. A year later, Mike began teaching a course on Space Colonization, which became one of the most popular Stanford courses ever taught by a student. Mr. Simon is author of the 1987 book, *Keeping the Dream Alive – Putting NASA and America Back in Space,* and has written numerous technical papers on aerospace and automotive technologies. Mr. Simon received his Master's Degree in Engineering-Economic Systems from Stanford in 1981, after pursuing a multidisciplinary undergraduate program combining engineering, economics, and political science and receiving two Bachelor's Degrees, also from Stanford, in 1980.



Burns & McDonnell

BURNS McDONNELL

September 22, 2015

Carter Atkins
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, California 90731

Re: Proposal for Project Management and Engineering, Procurement, and Construction Services for the Green Omni Terminal Project

Dear Carter:

Burns & McDonnell Engineering Company, Inc. is providing this scope and cost estimate to provide project management and engineering, procurement, construction (EPC) services in support the Los Angeles Harbor Department (Harbor Department) in implementing the Green Omni Terminal should it receive funding to implement the Multi-Source Facility Demonstration Project (MSFDP) under the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments. This proposed project supports the Port's Energy Management Action Plan (EMAP) and supports the Port of Los Angeles' sustainability initiatives, and Burns & McDonnell will provide every effort to help the Harbor Department make this program successful.

BACKGROUND

The Harbor Department and Pasha Stevedoring & Terminals (Pasha) are partnering together to develop a Green Omni Terminal at Pasha's POLA Terminal in the Wilmington disadvantaged community (DAC). The vision for the terminal is to incorporate zero and near-zero emissions cargo handling equipment to move goods from ships through the terminal to clean transportation to their final destinations, while making portions of terminal operations more resilient through solar power generation and battery storage.

A 1 MW rooftop solar PV array will be added to the terminal to supplement current power usage and help meet resiliency objectives. The system will be capable of meeting 100% of Pasha's current electricity demands for terminal operations. When combined with a 2.6 MWh battery storage system (BSS) and microgrid/energy management control system, key elements of the facility will be able to remain operational for finite periods of time when islanded from the electrical grid in the event of power outages caused by unforeseen man-made and natural events. This infrastructure will integrate with electric vehicle (EV) charging infrastructure, which will be used to charge battery-electric cargo handling equipment and vehicles.

BURNS & McDONNELL

SCOPE OF SERVICES

At the request of the Harbor Department, Burns & McDonnell has developed the following scope of services and cost estimate for the following tasks:

1. Project Management
2. Engineering Design and Permitting Support
3. Procurement and Construction
4. Commissioning

Task 1: Project Management
(January 2016 – March 2019)

Upon successful award of the MSFDP grant to the Harbor Department, Burns & McDonnell will provide project management support for the proposed Green Omni Terminal Project from January 2016 through March 2019. Project management services will include supporting the Harbor Department in managing the technology providers involved in the project and administering the grant per the requirements of the grant agreement. Grant administration support will include:

- **Task 1.1 Kick-off Meeting**

  The project team will meet with the Air Resource Board (ARB) and third-party data analysis provider to discuss the work plan, details of task performance, schedule, and resolution of issues. Burns & McDonnell will prepare the agenda for the meeting

- **Task 1.2 Monthly Project Update Meetings and Reports**

  Burns & McDonnell will work with the Harbor Department to coordinate monthly project update meetings that will be held via WebEx and teleconference to discuss progress. The meetings will follow a defined agenda that will cover project status update, difficulties encountered, upcoming deliverables, pending disbursement requests, and schedule of the next update meeting. These meetings will discuss the submitted Project Status Reports and disbursement requests.

- **Task 1.3 Final Report**

  At the completion of the project, Burns & McDonnell, in coordination with the Harbor Department, will develop and submit a final report to ARB that describes the projects goals and objectives, methods, results of the demonstration, future application of the technologies, and commercialization prospects.

Burns & McDonnell will provide up to $750,000 in support to the Harbor Department for the project management task. This budget is expected to cover approximately 20 hours per week of support from our proposed project manager, Dr. Matt Wartian.

Task 1 Deliverables: Monthly Agenda, Monthly Project Status Reports, Disbursement Requests, and Final Report

Task 2: Electrical Infrastructure Engineering Design and Permitting Support (February 2016-November 2016)
Burns & McDonnell will provide EPC services in support of the design, construction, and commissioning of the electrical infrastructure that will be added to support the Pasha Green Omni Terminal.

- **Task 2.1 Permitting Support (February 2016-March 2016)**
  Burns & McDonnell will work with the Harbor Department to acquire permits necessary for construction of infrastructure at the Pasha terminal, including an Engineers Permit, Parallel Cogeneration Interconnection Agreement, PV Interconnection Agreement, City of Los Angeles Department of Building and Safety Permits, and will work with the Harbor Department to obtain California Environmental Quality Act (CEQA) approval.

- **Task 2.2 Infrastructure Design (February 2016 – April 2016)**
  Burns & McDonnell will develop designs for the integration of solar, battery storage, and charging infrastructure at the terminal. An assessment of the existing infrastructure determined that the substation on the terminal has a dedicated transformer and switchboard that is more than sufficient to handle the demonstration project's proposed load. The installation of 1 MW of solar at Berth 181 Warehouse will require electrical upgrades to handle the additional loads to the substation.

  - ***Task 2.2.1 Design Support of Installation of Solar Array on Berth 181***
    Burns & McDonnell will design a new underground feeder from Berth 181 to existing switchboard in substation yard. The current feeder is rated for 400A which would limit the potential solar to only 270kW. The new feeder will need to be rated for at least 1200A at 480V. Additionally, Burns & McDonnell will also act as the Owner's Engineer and review the submitted plans and specifications from the PV system installing contractor (PermaCity) for suitability.

- ***Task 2.2.2 Design Support of Charging Infrastructure***

Burns & McDonnell will design an electrical distribution system to permit the electric cargo handling equipment and vehicles to connect their charging systems. For equipment supplied by BYD, the assumption is that each of their three vehicles will be provided with a 200kW, 480V charging station. Each of these will be fed from a new, 350A breaker in the existing reefer switchboard. For equipment supplied by TransPower, a total of four charging stations will be provided; each shall consist of a 150kVA, 480-208Y/120V transformer with two, 225A output breakers all integrated into a single, NEMA 4X stainless steel enclosure. TransPower shall supply the necessary charging cable to the Electrical Contractor for connection to the output breakers. It is currently anticipated that the TransPower stations will also include an approximately 72" tall post with cord reel near the vehicle's charging point to keep the receptacle end off of the ground when not in use (BYD stations already have a provision for this). Each of the TransPower charging stations shall be fed from an existing 250A breaker in the refer switchboard.

There will be a total of thirteen conduits from the substation area to the equipment supplied in this task (four battery power feeders; one battery control; three BYD charging stations; four TransPower charging stations; one convenience power). It is currently anticipated that these rigid metal conduits will be mounted on a 10' high pipe rack constructed as part of this project. Burns & McDonnell will provide the design for the structure of this rack. On six of the support posts, a GFCI receptacle with weatherproof, cast device box and cover shall be provided.

Burns & McDonnell will also assist Pasha and the vendors in determining the best charging strategy for the overall system. We will perform an initial calculation of the charging limits and schedule for all equipment. Once the equipment is installed and fully operational, we will then help Pasha evaluate the effectiveness of this strategy and make recommendations for improvements. This follow-up evaluation will be performed twice: once two months after all equipment is operational, and once nine months after all equipment is operational.

- ***Task 2.2.3 Design Support of Battery Storage System Electrical Infrastructure***

Included in this task is the addition of two energy storage batteries. Each unit will be rated for 500kW/1.3MWh and will be fed from the refer switchboard using new, 800A breakers. To prevent sheet-flow runoff from entering the containers, all four shipping containers for these units will be mounted on a pad designed by Burns & McDonnell. Each BSS will also need to be connected to a new power meter in the 4160V switchgear in order to perform peak shaving functions. Finally, a #4/0 ground ring shall be supplied around the pad and bonded to opposite corners of each shipping container.

- ***Task 2.2.4 Microgrid Controls and Commissioning***

The microgrid control system is currently envisioned to be a single, NEMA 4X, stainless steel enclosure with redundant programmable controllers, internal UPS, and a touch-screen HMI. This enclosure will be located adjacent to the batteries (outside of the substation fence line). It will communicate to each of the TransPower vehicles (for charge control), the batteries, and the new power meter in the 4160V switchgear.

Burns & McDonnell will provide the desired sequences of operation for the electrical monitoring and controls system. This will include both grid-tied as well as islanded operation of the system. Please note that due to the limited scope of this current project, the transitions between islanded and grid-tied operation will be executed manually and will include a brief outage.

Task 2 Deliverables: Electrical Infrastructure Designs and Permitting Packages

The estimated cost to develop engineering designs for the electrical infrastructure is $50,000.

Task 3 Infrastructure Procurement & Construction (May 2016 – October 2016)
Burns & McDonnell will manage the installation of energy generation, storage, and charging infrastructure along with efficiency upgrades and system integration for the following components:

- **Task 3.1 Solar Installation – (May 2016 – October 2016) -** Following the retrofit and reroofing of the Berth 181 Warehouse by the Harbor Department, PermaCity will install a 1.03 MW (DC) solar PV system on the rooftop. The PV system will be connect to a 1500kVA pad-mounted transformer at the existing building, which will feed to a 3000A switchboard with two breakers – 1200A for the new PV and 400A for the existing building. A single 5kV feeder will be run from the warehouse to the existing substation. Burns & McDonnell will procure and construct the required infrastructure to connect the 1 MW PV array to the terminal's substation.

- **Task 3.2 Battery Storage System – (February 2016 – August 2016) -** BYD will manufacture and deliver two battery storage systems (BSS) to Pasha within 7 months of project kickoff. The BSS will include batteries, power conversion system (PCS), container, and supporting systems. The BSS are housed in 40-foot containers, which will be positioned adjacent to the existing substation. Burns & McDonnell will procure and construct the required infrastructure to connect the BSS to the terminal's substation and incorporate the BSS into the terminal's microgrid.

- **Task 3.3 Charging Equipment – (July 2016 – August 2016)** - TransPower will provide eight charging units and BYD will provide three for proposed vehicles and equipment. Both systems will connect to standardized electrical infrastructure. The TransPower system consists of a transformer, electric vehicle support equipment, and cable to connect to the on-board inverter charger unit. BYD will install a 200kW that uses 480V 3-phase supply and 240A input current charger charging equipment. Burns & McDonnell will procure and construct the required infrastructure to connect the electric chargers to the terminal's substation and incorporate the chargers into the terminal's microgrid.
- **3.4 Energy Management/Microgrid and Lighting Control System – (July 2016 – August 2016)** – Burns & McDonnell will procure and construct the energy management/microgrid and lighting control systems. The microgrid control system is currently envisioned to be a single, NEMA 4X, stainless steel enclosure with redundant programmable controllers, internal UPS, and a touch-screen HMI. This enclosure will be located adjacent to the batteries (outside of the substation fence line). It will communicate to each of the EVs (for charge control), the batteries, and the new power meter in the 4160V switchgear.

Task 3 Deliverables: As-built drawings, documentation, and reports

The estimated cost for Burns & McDonnell to provide procurement and construction services in support of the design and construction of the Green Omni Terminal's microgrid and electrical infrastructure is $2,966,200. A detailed breakdown of this cost is provided in the Cost Summary Section.

Task 4 Testing and Commissioning (November 2016)

Burns & McDonnell will provide the desired sequences of operation for the electrical monitoring and controls system. This will include both grid-tied as well as islanded operation of the system. Once all of the equipment is fully operational, Burns & McDonnell will lead the commissioning effort of the overall system being installed under this project. This will include operation for peak shaving and islanded operation. The commissioning procedures and results will be documented in a final commissioning report to be included in the reports to be submitted to ARB.

Task 4 Deliverables: Testing and Commissioning Report

The estimated cost for Burns & McDonnell to provide commissioning services in support of the design and construction of the Green Omni Terminal's microgrid and electrical infrastructure is $60,000.

ASSUMPTIONS

This scope of work assumes the following:

- The MSFGP grant will be awarded no later than January 2016 and the project will begin February 1, 2016.
- Technology demonstrators will provide their respective infrastructure as specified in their scopes of work and cost proposals.
- The Pasha Terminal does not have soil contamination that would require special handling and disposal during ground disturbing activities.

COST ESTIMATE

Burns & McDonnell will perform the scope of services cost reimbursable basis according to the terms and conditions of the MSFDP agreement. This proposal does not include escalation, design contingency, or construction contingency.

The estimated cost to perform the scope of services is $3,826,200, as detailed in Table 1

Table 1: Estimated Costs by Task

Task	Service/Equipment	Cost
1	Project Management	$750,000
2	Engineering	$50,000
3	Construction	$1,051,200
3.1	Solar Transformer, Panels, Reconductor to Substation	$840,000
3.2	Battery Storage System Installation	$420,000
3.3	EV Charging Infrastructure	$115,000
3.4	Microgrid Control System	$540,000
4	Commissioning	$60,000
Total	Engineering, Procurement, & Construction	$3,826,200

BURNS & McDONNELL

SCHEDULE

Burns & McDonnell will complete the proposed scope of work according to the schedule presented in Table 2:

Table 2: Proposed Project Schedule

Task	Description	Start Date	Completion Date
1.0	**Administration & Project Management**	**February 1, 2016**	**March 31, 2019**
1.1	*Kick Off Meeting*	*February 1, 2016*	*February 1, 2016*
1.2	*Monthly Project Update Meetings & Reports*	*March 1, 2016*	*March 31, 2019*
1.3	*Final Report*	*January 31, 2019*	*March 31, 2019*
2.0	**Infrastructure Design & Permitting**	**February 2, 2016**	**April 30, 2016**
2.1	*Permitting*	*February 2, 2016*	*April 30, 2016*
2.2	*Infrastructure Design*	*February 2, 2016*	*April 30, 2016*
3.0	**Infrastructure Construction**	**May 1, 2016**	**October 31, 2016**
3.1	*Solar PV Installation*	*May 1, 2016*	*October 31, 2016*
3.2	*Battery Storage System*	*February 2, 2016*	*August 31, 2016*
3.3	*Charging Equipment*	*July 1, 2016*	*August 31, 2016*
3.4	*Energy/Microgrid Control System*	*July 1, 2016*	*August 31, 2016*
4.0	**Testing & Commissioning**	**November 1, 2016**	**November 31, 2016**

Thank you for the opportunity to support the Harbor Department on this important project. If you have any questions regarding this scope of work and cost estimate, please feel free to contact me directly at (760) 795-6983 or via email at mwartian@burnsmcd.com.

Sincerely,

Matthew J. Wartian, Ph.D.
Burns & McDonnell

UC Riverside, Center for Environmental Research & Technology

UNIVERSITY OF CALIFORNIA, RIVERSIDE

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COLLEGE OF ENGINEERING
CENTER FOR ENVIRONMENTAL RESEARCH AND TECHNOLOGY
1084 Columbia Ave. Riverside, CA 92507

(951) 781-5791 FAX (951) 781-5790
http://www.cert.ucr.edu

September 22, 2015

Dr. Matt Wartian
Regional Global Practice Manager
Environmental Studies & Permitting
Burns & McDonnell

RE: Cost estimates for Harbor Department and Pasha Proposal for a Multi-Source Facility Demonstration Project

Dear Dr. Wartian:

The following is a summary of the cost estimates for a scope of work to be provided by the University of California at Riverside's (UCR), Bourns College of Engineering – Center for Environmental Research and Technology (CE-CERT) for proposal by the Los Angeles Harbor Department (Harbor Department) and Pasha Stevedoring & Terminals (Pasha) under the California Air Resources Board solicitation for a Multi-Source Facility Demonstration Project.

An important goal of this project is to provide greenhouse gas, criteria pollutant, and toxic air contaminant emission reduction benefits to disadvantaged communities. Toward that end the benefits must be measureable and UCR is partnering with the Harbor Department and Pasha to demonstrate how a terminal can use zero emission vehicles and equipment in their business. Further the facility uses rooftop solar panels to generate the electricity needed for operations. UCR's primary role is to assist the grantee's obligation to ensure the activities monitoring equipment is reliable and to provide a deeper analysis of the data.

The scope of work includes three main tasks.

1. Dr. Kent Johnson will assist in the process of installing dataloggers onto the new technology vehicles, facilitate communication with the contractor that will be doing the data monitoring for the CARB, and assist with troubleshooting datalogger problems that occur over the course of the demonstration program.
2. UCR will perform a chassis dynamometer test on its heavy-duty chassis dynamometer to evaluate the overall performance of an electric yard tractor. This will include an evaluation of the energy consumption and state of charge change over different drive cycles appropriate to a yard tractor, measurements of peak power, and determination of an equivalent fuel economy.
3. UCR will perform two field tests of the performance of two all electrical pieces of equipment. Each piece of equipment will be tested over a two day period. UCR will conduct an analysis of the activity data to determine the most appropriate duty cycle for which to operate the vehicle during this field test. The parameters to be monitored in the field testing include information similar to that being collected in the chassis

dynamometer testing, including energy consumption, state of charge, peak power, fuel efficiency, and other variables of significance.

A summary report will be provided for both tasks 2 and 3. Additionally, a report describing the results of all elements of this study will be provided. The total costs for the completion of the full scope of work will be $100,000, including personnel costs, equipment costs, travel, supplies, and associated overhead charges. Please feel free to contact me at (951) 781-5794 with any questions regarding the cost estimate or the scope of work. We look forward to teaming with the Harbor Department and Pasha on this effort.

Sincerely,

Tom Durbin

Thomas Durbin, Ph.D.
Research Engineer

Project Descriptions and Related Expertise

Introduction

UC Riverside is a leading research institute in the area of over the road/real-world vehicle testing and field testing.

UCR Riverside has done a number of field studies to characterize the emissions and activity of vehicles in the field. This includes a number of ongoing studies where we are monitoring the activity of a number of fleets throughout the LA Basin. UC Riverside played a central role in the validation of portable emissions measurement systems (PEMS) systems for use in EPA's in-use testing program of heavy-duty vehicles thought the Measurement Allowance Program. As part of this program, UC Riverside conducted in the in-use testing validation portion of this program utilizing UC Riverside's Mobile Emissions Laboratory (MEL).

UC Riverside has also been a leading research institute in the characterization of in-use emissions using PEMS and the MEL. This has included measurements of light-duty vehicles, heavy-duty vehicles, construction equipment, ships, port support equipment, trains, and even jet aircraft. As part of these studies, UC Riverside has construction some of the most comprehensive PEMs systems. This includes a PEMS system based around the AVL microsoot sensor (MSS) with either an AVL or Sensor Inc. gas-phase PEMS. We have recently been utilizing this system installed on construction equipment as part of program for CARB and Caltrans. UC Riverside has a separate PEMS system based on a Horiba PG250 portable multi-gas analyzer for steady state measurements in compliance with ISO 8178. This PEMS system has been utilized for testing on ships, of generators, and port support equipment. UC Riverside has developed protocols for technology verifications of emission control technologies for such applications as generators, marine vessels, and rubber tire gantry cranes.

Field Studies

CARB "Aerodynamic GHG Emissions Reduction Assessment of Non 53-foot Trailers Pulled by Heavy-Duty Tractors", 7/14 – 6/16, $500,000. The purpose of this research is to gather data from a broader spectrum of trailer types (referred to here as exempted trailers) than those subject to the Tractor-Trailer GHG regulation, to assist ARB in determining whether other trailer configurations and applications would benefit from using similar aerodynamic technologies. There is limited activity data for exempted trailers. Specifically, additional work is needed to characterize the activity of HD tractors pulling exempted trailers to determine whether they operate at high enough speeds and accrue enough annual VMT to benefit from improved aerodynamics. In order to characterize the benefit potential of aerodynamic drag improvements for exempt trailers it is necessary to know the number of trailer types, unique trailer models, vehicle miles traveled (VMT), loads, trailer-to-tractor ratios, VMT distributions by speed, and fleet routes. These details are not well understood and need to be characterized as a first step in understanding the potential value of expanding the implementation of aerodynamic improvements. Given the diversity of possible trailer types, VMT, and fleet operations, the first steps in GHG emission reductions should involve a comprehensive assessment of the fleet and their real world activity. To do this requires an assessment of the fleet through surveys, existing database queries and in-use trailer data logging.

CARB "Collection of Activity Data from On-Road Heavy-Duty Diesel Vehicles", 10/13 – 10/15, $371,321. In this research project, UCR is performing a screening analysis to identify truck categories and vocation types that potentially contribute the most to the California NO_x emission inventory. We are recruiting and instrumenting 80 of these trucks with GPS-only data loggers and another 20 with ECU plus GPS data loggers. The collected GPS and ECU data will be analyzed to reveal their activity profiles (e.g., duty cycles, starts, and soak time) with the specific goal of identifying what fraction of the vehicle operation may be such that SCR functionality is challenged. The research will also put these results in comparison with the emission certification test cycle and provide an analysis of the representativeness of the certification cycle in reflecting real world emissions of NO_x for the different types and vocational uses of heavy-duty diesel vehicles.

SCAQMD "In-Use Emissions Testing and Demonstration of Retrofit Technology for Control of On-Road Heavy-Duty Engines", 11/2/2011 – 12/01/2013, $708,534. This project was about measuring the real in-use emissions of

HDD trucks operating in the AQMD District. The approach was to work with AQMD and an Advisory Committee to select trucks that represented the mix of vehicles operating in the AQMD District. UCR tested 16 heavy-duty vehicles, mainly diesel fueled engines, used for goods movement, refuse hauling and transient applications. The testing protocol involved measuring emissions while the vehicles followed driving cycles that were better at representing the in-use emissions than those used for certification. For example, the trucks used in goods movement were tested on three port driving cycles; refuse haulers tested on the AQMD refuse hauler cycle and buses were tested on the central business district cycle. All testing was carried out on a chassis dynamometer with measurements being made with a laboratory meeting 40 CFR Part 1065 specifications.

Program for the Study of Extremely-Low-Emission Vehicles, cofunded by Honda R & D Americas Inc., ChevronTexaco Products, U.S. Environmental Protection Agency, California Air Resources Board, Manufacturers of Emission Controls Association, 2000-2006. >$1,000,000. UC Riverside was the prime contractor for this program. This program was designed to provide information on the "real world" emissions of a new generation of extremely-low-emission vehicles powered by gasoline and alternative fuels, with conventional and advanced powertrains. The scope included the development and validation of emissions measurement technologies that can be used in the laboratory and/or on the road under actual operating conditions. CE-CERT used these data to develop Comprehensive Modal Emissions Model (CMEM) modules to characterize the emissions performance of these vehicles under a wide range of driving conditions. The emissions models were used in conjunction with air quality models to calculate the actual benefit that a new generation of vehicles will produce for overall air quality. As part of this study, the U.S. EPA funded additional research on the emissions of ammonia from late-model vehicles.

US EPA, "On-Board Measurement of Emission Reductions from Fuel Switching at the Port of Houston and a Mexican Port", 7/09-12/10, $85,000. This is one of a number of programs that UC Riverside has been conducted for testing ships and port related equipment, with total funding in excess of $2,000,000 from CARB, various port authorities, and EPA. UC Riverside is a subcontractor to ICF International for this program. This project is designed as a part of study on efficacy of selected management strategies – especially fuel switching- to reduce air emissions and potentially fuel consumption from ocean going vessels that call at the Port of Houston and a selected foreign port on either the Gulf of Mexico or the Caribbean Sea. The heart of the work is measurement of the gaseous emissions, carbon oxides (CO, CO_2,), oxides of nitrogen (NO_x) and particulate matter (PM), while the main and auxiliary engines operate at the steady and transient conditions with heavy fuel oil (HFO) and distillate fuel. Measurement will use IMO compliant instruments for the gases, a method following ISO 8178-1 for PM mass and a proven empirical method to monitor the transient PM emissions.

CARB, "Measurement of Diesel Solid Nanoparticle Emissions using a Catalytic Stripper for Comparison with Europe's PMP Protocol,"7/09-12/11, $170,000. UC Riverside was the prime contractor for this program, with particle expert Dr. David Kittelson as a consultant. This program involves on-road testing with our Mobile Emissions Laboratory of different measurement systems for measuring solid particles according to the European Particle Measurement Program (PMP) protocols. This testing was conducted over various routes between Riverside and Palm Springs, CA. The setup for this program involved a full, on-road dilution tunnel setup for the on-road evaluations. This program also involved a retrofitted class 8 truck that was the test vehicle. This program was the second phase of our efforts with CARB in evaluating the European PMP. The first phase of this program was funded by CARB ($250k) and it produced several presentations and a journal article.

CARB, "Off-Highway Motorcycle/All Terrain Vehicle Activity-Data Collection; Personal Watercraft Activity-Data Collection; and Test Cycle Development," 6/99-12/00, $220,000. UC Riverside was the prime contractor for this program. For this program, UC Riverside collected activity measurements from in-use operation of off-road motorcycles and personal watercraft. The activity measurements for the personal watercraft were used to develop a test cycle that was utilized for emissions tests of two engines on an engine dynamometer. These data were in the development and enhancement of CARB's off-road model.

URS Inc in cooperation with Burlington Northern Santa Fe (BNSF), San Bernardino Intermodal Rail Yard "Truck Activity and Emissions for the BNSF Facility in San Bernardino", 6/08 – 6/09, $50,000.

Measurement Allowance Program

California Air Resources Board (CARB), "PM PEMS Validation Testing with a 1065 Compliant PM Laboratory for the PM-PEMS Measurement Allowance Determination for the HDIUT Program," 5/09-6/10, $573,113. UC Riverside was the prime contractor for this program. It should be noted that while this program was contracted through CARB, it was part of the cooperative Measurement Allowance program the included the US EPA and the Engine Manufactures Association (EMA). For this program, UC Riverside provided the on-road validation testing of PEMS using our Mobile Emissions Laboratory (MEL), with an emphasis on the PM measurement capability. This is a fully-1065 compliant laboratory that is house in the back of a 53' trailer that can be hooked to a standard class 8 truck. The testing involved simultaneous measurements of vehicle exhaust under on-road conditions using the Portable Emissions Measurement Systems (PEMS) and the MEL. The on-road test routes include routes from Riverside to San Diego, from Riverside to Palm Springs, and from Riverside towards Las Vegas. Two pilot studies and one follow-up study were conducted in conjunction with this effort that were funded by CARB ($284K), EMA ($193k), and Sensors Inc. ($67k), respectively. The measurements and performance evaluations by UC Riverside played a critical role in the determination of the Measurement Allowance values for PM PEMS being used as part of EPA's in-use testing requirements.

CARB, "Measurement Allowance Project," 7/04-1/08, $400,000. UC Riverside was the prime contractor for this program. This program was also co-funded through the Measurement Allowance program. UC Riverside on-road validation tests of PEMS using our Mobile Emissions Laboratory (MEL), with an emphasis on their gas-phase emissions measurement capability. The testing involved simultaneous measurements of vehicle exhaust under on-road conditions using the PEMS and the MEL. The testing included routes from Riverside to San Diego, from Riverside to Palm Springs, and from Riverside to Northern California. The measurements and performance evaluations by UC Riverside played a critical role in the determination of the Measurement Allowance values for gas-phase PEMS being used as part of EPA's in-use testing requirements.

- Sensors, Inc. "Supplemental Testing of PPMD to Resolve Issues with PPMD Observed During the HDIUT PM MA Program," 7/10-2/11, $67,338.
- CARB, "Comparison of PM PEMS for the HDIUT Program with a 1065 Compliant PM Mobile Laboratory,"12/07-6/09, $284,667.
- Engine Manufacturers Association "PM Measurement Allowance Phase 1: On-Road Testing Using the CE-CERT Mobile Emissions Laboratory." 11/07-6/09, $192,770.

Construction Equipment

California Air Resources Board (CARB), AB 118 Hybrid Incentive Demonstration and Evaluation Program AQIP, 7/1/2011 – 2013, $2,000,000. As part of this project, CE-CERT facilitated the deployment of ten hybrid Caterpillar D7E bulldozers and six hybrid Komatsu HB215LC-1 excavators with eight California-based fleets. Hundreds of hours of in-use D7E dozer and HB215LC-1 excavator activity were observed and logged at six locations to develop typical in-use hybrid dozer and excavator duty cycles. Since exact non-hybrid versions of the hybrid D7E dozer and HB215LC-1 excavator do not exist, emission comparisons were made relative to the most similar non-hybrid dozer and excavator models. The emissions and fuel consumption for the hybrid equipment were measured in-use during real world operation with AVL's federally compliant M.O.V.E portable emission measurement systems (PEMS).

CARB, "Study of In-Use Engine Deterioration in Diesel Off-Road Equipment,"11/09-5/11, $300,000. UC Riverside is the prime contractor for this program. For this program UC Riverside measured PM and gas-phase emissions from approximately 15 pieces of construction equipment using a PEMS system. The PEMS system will consist of a Sensors or AVL gas-phase PEMS coupled with an AVL microsoot sensor (MSS). The microsoot sensor is one of the few instruments available that can accurately measure PM to the standards used in EPA's in-use measurement regulations. Testing has been conducted on 5 pieces of equipment to date, and UC Riverside is working with CARB to identify further pieces of equipment for testing based on a representative sample of the in-use fleet. This program is being coordinated with the Caltrans program listed immediately below.

Caltrans, "Measuring and Modeling PM Emissions from Heavy-Duty Construction Equipment." 7/08-6/11, $150,000. UC Riverside is the prime contractor for this program. For this program UC Riverside will measure PM and gas-phase emissions from approximately 7 pieces of construction equipment using the PEMS equipment described above. The data from these emissions measurements will then be used to develop a real-time emissions model for gaseous and PM emissions. The gas-phase emissions model will be an extension of a model developed as part of a previous Caltrans study. The PM model will be based on real-time PM measurements made with the AVL MSS. This program is being coordinated with the CARB program listed immediately above.

Caltrans, "Evaluation of In-Field Emissions Impacts of Biodiesel Fuels." 7/08-12/09, $100,000. UC Riverside was the prime contractor for this program. UC Riverside measured the gas-phase emissions using a PEMS from various pieces of construction equipment operated on regular diesel fuel, biodiesel blends, and with an aftertreatment system.

Caltrans, "Evaluating the Emissions from Heavy-Duty Construction Equipment", 4/05-6/08, $299,641. UC Riverside was the prime contractor for this program. UC Riverside measured the gas-phase emissions using a PEMS from 12 in-use pieces of construction equipment in the Southern California area. These emissions data were subsequently used in the development of a model that allows the determination of emissions from different pieces of construction equipment or for construction projects as a whole. The model developed is a fuel-based, user-friendly, spreadsheet program that can be readily deployed by program staff at Caltrans, outside contractors or other government agencies.

U.S. EPA, "Evaluation of Emissions from Off-Road, 8/01-3/03, $247,799. UC Riverside was the prime contractor for this program. For this study, UC Riverside evaluated activity patterns for a subset of in-use construction equipment. In this study, a total of 18 pieces of nonroad equipment were instrumented, with collected data including intake manifold air pressure (MAP), exhaust temperature and, on a subset of vehicles, engine rpm and throttle position. The equipment included backhoes, compactors, dozers, motor graders, loaders and scrappers used in applications such as landfilling, street maintenance and general roadwork. From this data information such as daily actual operating time, number of starts per day, and per idle time was obtained.

BYD

Los Angeles Harbor Department and Pasha Stevedoring & Terminals Multi-Source Project Proposal

FINAL

22 September 2015

This proposal does not contain confidential information

BYD is a global company with operations in every developed country in the world. With over $9B in revenue and 180,000 employees worldwide BYD has the financial resources, the technology and the organizational depth to continuously design, refine, and manufacture world class products for the global markets that we serve.

BYD is a battery company first and foremost, manufacturing approximately 25% of the world's rechargeable batteries. BYD's iron phosphate (Fe) battery was purpose built for vehicle electrification. Already at price parity with traditional lithium ion batteries that have reached their technological maturity, BYD's Fe technology is improving in energy density (i.e. size and hence price) at a rate of 10% year over year. The Fe battery is also safe – no oxygen is released during discharge, so there is no catalyst for combustion and the heat across the cells is both lower than alternatives and evenly distributed, so there is no propensity to spark. No heavy metals are used in BYD's Fe battery and the electrolyte is so environmentally friendly that our CEO has been known to drink it. Lastly, testing indicates that the Fe battery will still have 70% of the original charging capacity after 10,000 cycles, or 28 years if fully charged and discharged every day. Our Fe technology is the core of both our electric vehicles and our battery storage stations.

Electrifying the transportation and freight sectors is BYD's primary long-term focus, however, negative environmental impacts remain as long as fossil fuels and energy sources like coal are generating the power. For this reason BYD is committed to engineering renewable solutions and our current solar technology is expected to reach 18.20% efficiency by this time next year, best in class for the industry.

BYD's expertise in each of the three components of microgrids makes it an ideal partner for the PASHA Stevedoring & Terminals (PASHA) microgrid project. We've achieved wide-scale commercialization of 100% battery electric transit buses and taxis, with over 50 million operating miles in both categories, battery storage stations, with solutions up to 40 megawatt hours, and solar, with farms in service up to 75 megawatts. Electric trucks are the next focus area for our company and we have 1,000 R&D engineers dedicated to these product lines. We also manufacture every major component ourselves, starting with the batteries and battery management system, and including the inverters and traction motors. This vertical integration means that all the major components will communicate seamlessly. It is our expectation to provide high performing and reliable electric trucks that allow you to continue operating your facility in the exact same fashion as with diesel trucks without changing the way you do business.

At BYD you will be working with one supplier and one contact person. Our administrative office is less than 30 minutes away in Downtown Los Angeles, so you will have immediate access to our sales, engineering, and technical support teams. All products will be assembled in our Lancaster, CA facilities, so you can visit and will have direct access for any maintenance needs or spare parts.

Our approach would be to make PASHA the gold standard for truck electrification. The project will have exposure to the highest levels of our organization and we will have no shortage of financial and engineering resources to ensure that the project is a success. Successful execution on this project will allow BYD to invest in building dedicated manufacturing resources for our truck product lines right here in California. It is our intention to exceed your expectations so that we can scale these technologies to all port terminals in North America and then extend the applications to intermodal rail facilities, warehouses, and other industrial applications.

Table of Contents

Summary

A summary of BYD's technologies to support the PASHA-Port of Los Angeles Multi-Source proposal is included below.

Component	Price Per Unit	No. @ PASHA	Grant Request	Battery Warranty (yrs)	Lead Time (months)
Yard Tractors - T9A	$300,000	2	$600,000	8	6
Electric Bus - K7	$450,000	1	$450,000	12	3
Data Loggers	$2,000	3	$6,000	N/A	N/A
Battery Storage – 2 1,3000 kWh systems	$656,500	2	$1,313,000	20	7
Battery Storage – Installation	$200,000	2	$400,000	N/A	N/A
Total			$2,769,000		

BYD is also able to provide service vehicles or supervisor vehicles. Information on these vehicles is attached to this proposal.

Yard Tractors – T9A

Specifications

Our battery electric T9A yard tractor will fit in seamlessly into your operation. Our approach to engineering the T9A yard tractor was to make a vehicle that at a minimum matches the performance of diesel alternatives across every performance specification, including duty cycle, payload, and uptime.

Items	Spec.
Length×Width×Height	20.13 ft.×98.43 in.×148.15 in. (6137×2500×3763 mm)
Curb Weight	22,046 lbs (10000 kg)
GCWR	77,162 lbs (35000kg)
Wheelbase	141.73 in.(3600 mm)
Wheel Track (Front/Rear)	81.10/73.35 in.(2060/1863 mm)
Overhang(Front/Rear)	56.57/43.31 in.(1437/1100 mm)
Approach/Departure Angle	24°/41°
Top Speed	56 mph (90 km/h)
Gradeability	≥24%
Operating Range	137 miles (220 km)
Ground Clearance	11.81 In.(300 mm)
Min. Turning Radius	18.04 ft. (5500mm)
Radius of Gyration Front	≥5.58 ft. (≥1700 mm)
Radius of Gyration Rear	≥4.66 ft.(≥1420 mm)
Front Saddle Distance	19.69 in.(500 mm)
Max. Permissible 5th wheel	44,100 lbs (20000 kg)
Tires	11R20

Front Suspension	Leaf Spring
Rear Suspension	Leaf Spring
Brake System	F/R Pneumatic Drum Brake
Steering System	EHPS
Drive Mode	4×2
Max.Power	245 hp (180 kW)
Max.Torque	1,106 lbf·ft (1,500 N·m)
Battery Type	BYD Iron-Phosphate Battery
Battery Capacity	175 kWh
Charging Power	AC 200 kw
Charging Time	< 1 hr

At a minimum BYD's yard tractor will be able to operate for 8 consecutive hours between charges. One gallon of diesel fuel has 12.5 x 10^7 joules of energy and the diesel efficiency rate is approximately 30%, resulting in 3.7 x 10^7 joules of useful energy. One kilowatt of electricity has 3.6 x 10^6 joules of energy and the electric efficiency rate is 90%, resulting in 3.6 x 10^6 joules of energy. BYD's current yard tractor has 175 KWh of battery capacity and can discharge up to 90% of the battery capacity. According to CALSTART's *LNG Yard Hostler Demonstration and Commercialization Project Final Report* for the Port of Long Beach in 2008 diesel yard hostlers consume approximately 1.7 gallons of diesel fuel/hr. Therefore, BYD's tractors will be able to operate for 8 consecutive hours between charges. These estimates are conservative as diesel engines burn fuel while idling, whereas BYD's electric truck will not consume any energy. Therefore, BYD is hopeful that the yard tractors in this project will be able to operate for two consecutive shifts and charge overnight.

The weight and power specifications are comparable to diesel alternatives. See below for a comparison with the Capacity Sabre 5 and Kalmar Ottawa 4x2 yard tractors.

Performance Metric	Capacity Sabre 5	Kalmar Ottawa 4x2	BYD
GCWR (lbs)	81,000	96,000	102,000
Curb Weight (lbs)	15,000	14,500	20,000
Front Axle (lbs)	12,000	12,000	15,432
Rear Axle (lbs)	30,000	23,000	24,251
Motor (kW)	122-168	115	180
Torque (lb-ft)	541-760	440	1,106
5th Wheel Capacity (lbs)	70,000	70,000	100,000

The T9A curb weight is 5,000-5,500 lbs more than diesel alternatives due to the weight of the batteries. The additional weight of BYD's truck is compensated for with higher axle ratings. The GCWR rating is dependent on the axle ratings of the trailers that are attached to the T9A. Assuming an axle rating comparable to the rear axle of BYD's T9A at 35,000 lbs, the GCWR would be 91,000 lbs. If two or more trailers are affixed in series, the GCWR would increase accordingly. The limiting factor for towing capacity is the torque on the motor. BYD's 180 kW motor has a higher power rating and a much higher max torque value than each competitive product, meaning it will be able to exceed the performance of the diesel alternatives.

Cost Savings

BYD anticipates significant operational benefits compared to diesel engines. Maintenance costs will be lower as there will be no need for changing oil and transmission and other fluids, there are fewer moving parts, there is no transmission, and the component life is longer. Internal data and testing suggests that the average maintenance cost per mile for the T9A will be $0.23/mile compared to $0.39/mile for diesel yard tractors. Furthermore, because the battery electric trucks will require less service there will be less vehicle downtime at the terminals. Assuming 58 miles/day and 6 operating days/week, annual maintenance savings will be approximately $2,900.

There will also be fuel savings. The US Energy Information Administration indicates that the current diesel rate is $2.87/gallon and the current electricity rate for the industrial sector is $.0679/kWh. Conversations with prospective customers indicate approximate mileage of 58 miles/day and 6 days/week for typical yard tractor operations, yielding $11,700 in annual fuel savings and a total of $14,600 in savings per year.

Timeline

BYD is developing the T9A model specifically for the North American market. We are currently scheduled to have a demonstration vehicle available in California by December, 2015, irrespective of customer orders. However, if we receive a purchase order for a T9A tractor we will be able to accelerate the development of the vehicle and can deliver 6 months from the date of the purchase order.

Warranty

Our proprietary battery technology has gradual capacity degradation compared to other lithium ion batteries. Field testing suggests 8% degradation in the first year, 3% degradation in years 2 and 3, and 1% degradation each year thereafter. We are confident that our batteries will perform for the vehicle's full useful life and therefore we are offering an 8 year warranty or 250,000 miles for our batteries, whichever is sooner. Other components including the motor, inverters, etc. will be warranted for 4 years or 125,000 miles.

Electric Bus – K7

BYD can also provide a full battery electric bus for transporting workers between facilities. Our K7 bus is a 30 foot electric bus with an operating range of 155 miles and 28 seats. Our K7 costs just $0.13/mile to operate and the batteries are warranted for 12 years. The price for our K7 is $450,000. Relevant specifications are included below.

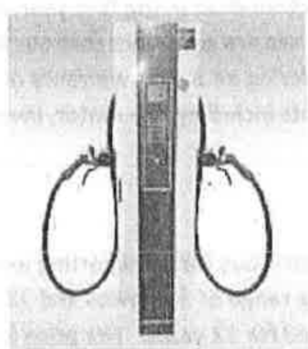
Items	Specification
Length×Width×Height	30.71ft x 94.49in x 125.98in
Wheelbase	196.06 in
Curb Weight	19,842 lbs

Gross Weight	27,117 lbs
Seats	Up to 28
Wheelchair Area	2
Top Speed	56 mph
Max Gradeability	17.9%
Min Ground Clearance	9.84 in
Range	155 miles
Turning Radius	26.25 ft
Approach/Departure Angle	9°/9°
Front Axle	ZF low floor axle
Rear Axle	BYD in-wheel drive axle
Suspension	Air suspension (ECAS)
Brakes	Disc – front and rear; ABS; Regenerative Braking
Tires	285/70R 19.5
Motor Type	AC Synchronous Motor – BYDTYC90A
Max Power	180 kW (90 kWx2)
Rated Power	150 kW (75 kWx2)
Max Torque	700 N*m (350N*mx2)
Battery Type	Lithium Iron Phosphate
Battery Capacity	182.5 kWh

Charging Infrastructure

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 an on-board converter. The DC power is stored in the batteries and then passes through BYD's on-board inverters to create AC power for powering all the motors.

BYD recommends our 200 kW charger, which uses 480V 3-phase supply and 240A input current. Complete specifications are included below. The price of this charger is included in the price of each vehicle and additional chargers are available for purchase at a price of $20,000 per charger.



Model		EVA200KS/01
ELECTRICS	Rated Input Voltage	AC480V(three phase)
	Operating Voltage Range	AC432V-528V
	Input Current	≤280A

	Input Power	≤200KW
	Operating Frequency	60Hz
	Output Voltage	AC432V-528V(three phase)
	Output Current	≤120A/ Charging connector
	Output Power	≤100KW/ Charging connector
	Output Interface Standard	IEC62196(BYD charging connector)
PHYSICAL	Product Size(mm)	500*400*2000 (Length* Width* Height (mm))
	Net Weight	180kg
	Number of Charging Connectors	2
	Length of Charging Cable	3m
SAFETY	Protection Function	short circuit protection /over-temperature protection /surge protection
	Certification	DEKRA
	IP Degree for Enclosure	IP54
OTHERS	Noise	≤60dB
	Cooling Method	Natural cooling
	Operation Temperature	-25°C～+40°C
	Storage Temperature	-30°C～+60°C
	Environment Humidity	5～95% non-condensing
	Display Method	Touch screen, LED lights
	Documents and Manuals	User manual
	Transportation Requirements	Avoid water, bumping, upside-down and handle with care

All BYD vehicles will have bi-directional inverters, which means that the electricity stored in the batteries can be used to power the on-board motors or it can be discharged from the vehicle back to the grid, to another vehicle, to battery storage, or to any load source.

Data Loggers

All BYD vehicles will be equipped with a health activity monitoring system (HAMS) as part of the chassis module control. The HAMS will allow PASHA the ability to monitor all performance parameters in real-time from a cloud-based server, including Strength of Charge (SOC), mileage, runtime, battery temperature, speed, and charging current/voltage. This information is sent to and from the vehicle via low cost SMS messaging.

The HAMS system will also coordinate the charging profile of all of the vehicles to smooth the power demand at the PASHA terminal. An algorithm will determine when to start/stop charging based on commands from the web server.

Battery Storage

BYD offers two different configurations for our battery storage stations (BSS), both of which are in 40 foot containers. Our Energy Scenario can charge/discharge up to 500 kW and has a capacity of 1.3 MWhr and our Power Scenario can charge/discharge up to 2 MW and has a capacity of 0.9 MWhr. BYD would recommend the Energy Scenario for PASHA. If BYD electrifies all vehicles at the terminal and each vehicle is fully discharged every day the approximate energy required for the vehicles would be 10 MWhr. Providing battery storage for this full amount would be cost prohibitive within the current scope of the project, so we recommend purchasing 2 BSSs at 1.3 MWhr. Once more funds become available for this project, the concept could be scaled to include additional battery storage and solar panels.

Our Q1 2017 pricing for battery storage is $505/kWh, which includes batteries, power conversion system (PCS), container, and supporting systems. Therefore, BYD's price for each 1.3 MWhr BSS is $656,500. The lead time on our battery storage stations is 7 months. Installation is approximately $200,000 for non-union labor for each BSS.

Clean Air Engineering - Maritime

Work Plan and Timeline:

Weeks 1-20: Manufacture ShoreCat
Week 21: Ship ShoreCat to Port of Los Angeles;
Weeks 22-23: Assemble ShoreCat;
Week 24: Commissioning;
Weeks 25-28: Testing

Safety: The system will comply with all U.S Coast Guard and OSHA requirements. No potential first responder issues.

Technical Advantages: The "ShoreCat" technology has the increased capability of CO_2 reduction. The system will also have a reduction in the carbon footprint and be more energy efficient. The ShoreCat will also be treating NOx at a greater rate than the 90% of the METS-1. There will be an increase in mobility since it will be a shore based technology with transport capability. The ShoreCat will also have an improved exhaust connect and capture method.

Completed Emissions Testing: Currently, there has not been testing on the proposed technology.

Potential for Market: Large potential for market as there is only one approved alternative control technology (METS-1). ARB approval will be obtained by receiving an approved test plan during the manufacturing of the ShoreCat and subsequent completion of ARB approved test plan. The system will be legal to operate in the Port of Los Angeles (as with the METS-1).

Ceramic Catalyst Filter (CCF) Air Pollution Control System
Specification Summary
Clean Air Engineering Maritime (CAEM)
P-15.658 Rev 2
September 17, 2015

I. Source Parameters

Generator Exhaust				
Engine Output	bph	1,788	1,341	894
Capacity	kW	1,530	1,148	765
Inlet Static Pressure	"H2O	0.0	0.0	0.0
Inlet Temperature	F	536	518	500
Inlet Flow Rate	acfm	10,289	8,038	4,959
Standard Flow	scfm, wet	5,455	4,340	2,727
Standard Flow	scfm, dry	5,160	4,118	2,580
H_2O	%	5.4	5.1	5.4
O_2	%	13.7	14.1	13.7
CO_2	%	5.4	5.1	5.4

Particulate Data				
Particulates	lb/hr	1.1	0.0	0.6
	mg/Nm3	41	0	42
	g/hp-hr	0.28	0.37	0.28

Gas Data				
NOx	lb/hr	38	28	19
	ppmv	970	893	970
	g/hp-hr	9.61	9.39	9.61
SO2	lb/hr	0.0	0.0	0.0
	ppmv	0	0	0
	g/hp-hr	0.00	0.00	0.00

II. System Configuration

Barge		
ID		
Capture System		
Nozzle ID		
Pressure Target	"H2O	-0.5

Treatment System		
Temperature Setpoint	F	500
Active Housings		2
Sorbent Type		Hydrated Lime

Filter	
Filter Type	TK-3000
Filter Count	240
Housing Number	1
Housing Weight	36,480

III. Estimated Utility Usage

Power				
Fan	kW	18.6	11.9	5.9
Compressor	kW	5.3	5.1	5.0
SCR Fluid Delivery System	kW	1.0	1.0	1.0
Sorbent Injection System	kW	2.0	2.0	2.0
Liquid Cooling System	kW	0.0	0.0	0.0
Heat Exchanger System	kW	0.0	0.0	0.0
Waste Handling System	kW	0.0	0.0	0.0
CEMS	kW	0.0	0.0	0.0
Controls	kW	0.5	0.5	0.5
Unspecified	kW	1.0	1.0	1.0
Total	kW	28.5	21.5	15.4

Solid Waste				
PM (Method 5)	lb/hr	0.96	1.00	0.54
Metals	lb/hr	0.02	0.02	0.01
CaSO3	lb/hr	0.0	0.0	0.0
CaCl2	lb/hr	0.0	0.0	0.0
CaSO4	lb/hr	0.0	0.0	0.0
CaCO3	lb/hr	0.0	0.0	0.0
Ca(OH)2	lb/hr	0.0	0.0	0.0
Total Solid Waste	lb/hr	0.98	1.01	0.55

Chemical Usage and Utility Usage				
Anhydrous Ammonia	SLPM	146	107	73
Hydrated Lime	lb/hr	0.0	0.0	0.0
Compressed Air	scfm	31.3	30.3	29.4
Propane	gph	1636.1	1598.3	1005.2
Tracer Gas	mg/min	11.2	7.5	3.7

Envision Solar

Multi-Source Facility Demonstration Project Grant Application
Envision Solar International

I. Qualifications Narrative:

Envision Solar is a small publicly traded manufacturer based in San Diego, CA. We have little if no experience in grant projects of this nature, specifically with ARB grants. We see our role is a Technology Demonstrator that will manufacturer and deliver a fully operational transportable solar EV charging station(s) to the Multi-source Facility Demo Project. Our participation on this project will be as a technology demonstrator. David Greenfader is the head of Business Development for Envision and will be the primary contact for the Envision Solar team.

Envision invents, designs, and manufactures solar products and proprietary technology solutions targeting three verticals: electric vehicle charging infrastructure; out of home advertising infrastructure; and renewable energy production and disaster preparedness. The Company focuses on creating renewably energized platforms for EV charging, and media and branding which management believes are attractive, rapidly deployed, and of the highest quality. Management believes that the Company's chief differentiator is its ability to invent, design, engineer and manufacture solar products which are a complex integration of simple, commonly available engineered components. The resulting products are built to have the longest life expectancy in the industry while also delivering valuable amenities and potential revenue opportunities for our customers. Management believes that Envision's products deliver multiple layers of value such as: renewably energized EV charging; media, branding, and advertising platforms; renewable and reliable energy production; architectural enhancement; reduced carbon footprint; reduction of heat islanding and improved parking experiences through shading; high visibility "green halo" branding; reduction of net operating costs through reduced utility bills; and revenue creation opportunities through the sales of digital out of home (DOOH) media. The Company sells its products to customers with requirements in one or more of the three verticals the Company addresses. Envision's products can qualify for various Federal, State and local incentives which could reduce by over 50% final out-of-pocket costs, from the Company's selling price, for eligible customers.

Products and Technologies

The Company produces two categories of product: the EV ARC™ product (Electric Vehicle Autonomous Renewable Charger) and the Solar Tree® product. Both product lines incorporate the same underlying technology and value, but one is in a transportable format and one is in a fixed format.

Leveraging the structural and technological attributes of its existing products, the Company developed a product called EV ARC™. We have observed that the EV ARC™ can solve many problems associated with electric vehicle charging infrastructure deployments and, we believe, is a product with a potentially large addressable market. Until now, the deployment of EV chargers could be hindered by complications in the site acquisition process caused by the complicated and invasive processes required to fulfill the installation. Entitlements, easements, leases, and other site acquisition requirements may slow, or prevent entirely, the deployment of large numbers of chargers. Hosts often do not perceive enough value creation in the deployment of an EV charger, and as such, may not be inclined to grant permission to the service providers who approach them, or to install EV Chargers for their own employees and guests, because the costs and disruption associated with grid tied chargers can be prohibitive.

We believe EV ARC™ changes this paradigm completely because it is entirely self-contained and is delivered to the site ready to operate. It requires no foundation, trenching, concrete, electrical or civil works and can be deployed in minutes. Its high traction ballasted base pad creates a structurally sound platform that supports the rest of the structure. The solar array is connected via our EnvisionTrak™ tracking solution to a column which is mounted to the ballasted pad. An electrical cabinet integrated into the unit houses various components enabling the conversion of sunlight to electricity which is stored in on-board batteries, and delivers that electricity to the EV charging station. Incorporating battery storage means that an EV ARC™ can operate day and night. An EV ARC™ delivers a clean source of power to any model of EV charger that is integrated into the structure. Further, the EV ARC™ can be remotely monitored through a cellular data connection for energy production and the state of health of its vital components.

The Company integrated a digital advertising screen onto the EV ARC™ creating the EV ARC™ Digital. The introduction of the advertising screen creates new potential revenue streams for the owner of the EV ARC™ and we have observed that this makes EV ARC™ a more attractive product for certain prospective customers. We believe this advancement could lead to multiple other similar uses of our products.

EV ARC™ also provides a highly reliable source of energy that is not susceptible to grid interruptions. Because EV ARC™ has on-board energy storage; it can be used as a disaster preparedness tool. We believe it is a reliable back up source of energy in times of emergency or grid failure caused by hurricanes, terrorism, cascading blackouts or other grid vulnerabilities. The EV ARC™ does not require the level of ongoing maintenance that a diesel or gasoline generator requires and we believe there is much less chance that it will not be operational in times of emergency. We believe, and we have been told by our customers and prospects, that the triple use of EV charging, digital advertising and emergency energy production make the EV ARC™ an extremely compelling value proposition.

The Company's Solar Tree® structure has been in deployment and continued improvement for over several years. We believe the resulting product has become the standard of quality in solar shaded parking, and while there are an increasing number of competitors in the space, we believe there is no competing product which includes all of the important attributes of the Solar Tree® structure. The Solar Tree® structure's canopy measures 35'X35' and covers between six and eight parking spaces. We understand it to be the only single column, bio mimicked, tracking, and architectural solar support structure designed specifically for parking lots.

The Company has invented and incorporated EnvisionTrak™, its patented and proprietary tracking solution, to the Solar Tree® structure, furthering the unique nature of the product, and we believe, increasing the Company's technological leadership within the industry. We believe EnvisionTrak™ to be a complex integration of the highest quality gearing, electrical motors, and controls which are combined in a robust, highly engineered, and supremely reliable manner. While there are many tracking solutions available to the solar industry, we believe EnvsionTrak™ is the only tracking solution which causes the solar array to orient itself in alignment with the sun without swinging, rotating, or leaving its lineal alignment with the parking spaces below. We believe this is a vital attribute in solar shaded parking as any swinging or rotating of the arrays could result in impeding the flow of traffic, particularly first responders such as fire trucks, in the drive aisles. EnvisionTrak™ has been demonstrated, through data obtained from our past customers, to significantly increase electrical production, but perhaps a greater value is the high visual appeal created by Solar Tree® structures which are tracking the sun in perfect synchronicity.

The Company has also began deploying its latest generation of Solar Tree® products; the Solar Tree® HVLC (High Value, Low Cost) array. This Solar Tree® product incorporates our latest engineering and fabrication improvements. This has allowed us to reduce costs and time to deploy Solar Tree® structures and we have seen improvements in the fabrication and installation processes. We anticipate further improvements in future deployments of the product.

We strive to produce products integrating only the highest quality components available. The Company's production philosophy is to invest in quality design, components and integration so as to ensure the lowest costs of warranty and service in the industry, while maintaining and growing a brand which we believe is already recognized as one of the leading producers of the highest quality solar products available.

The Company produces a series of product variations based on the two core products which management believes offer multiple layers of value to its customers leveraging the same underlying technology and fabrication techniques and infrastructure. This enables the Company to reach a broad customer base with varied product offerings without maintaining the overhead normally associated with a diverse set of products.

The Company's current list of products includes:

1. EV ARC™ Electric Vehicle Charger,
2. EV ARC™ Digital Electric Vehicle Charger with Digital advertising screen,
3. EV ARC™ Motorcycle Charger,
4. EV ARC™ Bicycle Charger,
5. ARC Mobility™ Trailer,
6. The Solar Tree® Standard structure, a thirty five foot square solar array mounted on a single column,
7. The Branded Solar Tree® (HVBA) structure which includes customized branding, finishes and signage,
8. The Solar Tree® SMP (Sustainable Media Platform) structure, which includes static and digital advertising displays,
9. The Solar Tree® HVLC (High Value Low Cost) structure, a lower cost version of the standard Solar Tree® structure, and
10. The Solar Tree® Socket structure, a single space version of the Solar Tree® structure.

Bios:

Desmond Wheatley, President and CEO

Wheatley has two decades of senior international management experience in technology systems integration, energy management, communications and renewable energy. He is a founding partner in the international consulting practice Crichton Hill LLC. Prior to founding Crichton Hill, Wheatley was CEO of iAxis FZ LLC, a Dubai based alternative energy and technology systems integration company. From 2000 to2007, he held a variety of senior management positions at San Diego based Kratos Defense and Security Solutions, fka Wireless Facilities with the last five years as President of ENS, the largest independent security and energymanagement systems integrator in the USA. Prior to forming ENS in 2002, Wheatley held senior management positions in the cellular and broadband wireless industries, deploying infrastructure and lobbying in Washington DC on behalf of major wireless service providers. Wheatley's teams led turnkey deployments of thousands of cellular sites and designed and deployed broadband wireless networks in many MTAs across the USA.

Wheatley has founded, funded and operated four profitable start-up companies and was previously engaged in M&A activities. Wheatley evaluated acquisition opportunities, conducted due diligence and raised commitments of $500M in debt and equity.

Wheatley sits on the boards of Admonsters, San Francisco CA and the Human Capital Group, Los Angeles, CA and was formerly a board member at DNI in Dallas, Texas.

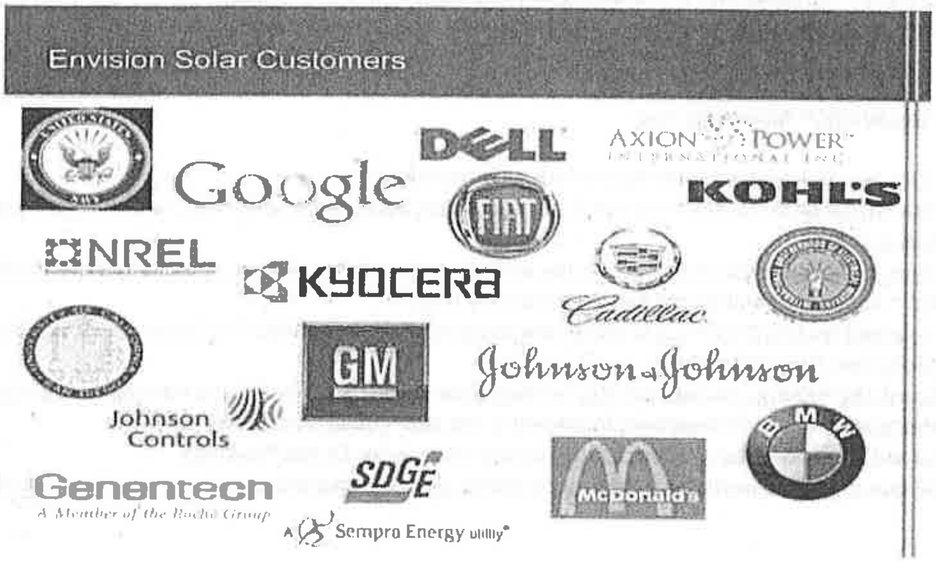
Chris Caulson, *Chief Financial Officer*
Caulson brings close to 20 years of financial management experience, including security infrastructure and technology integration, wireless communications and telecommunications industries. From 2004 through 2009, he held various positions including Vice President of Operations and Finance of ENS, the largest independent Technology Systems Integrator in the United States and a wholly-owned division of Kratos Defense & Security Solutions, Inc. In this role, Caulson was responsible for the operational and financial execution of multiple subsidiaries and well over $100 million of integration projects including networks for security, voice and data, video, life safety and other integrated applications. Prior to 2004, he was CFO of Titan Wireless, Inc., a $200 million International telecommunications division of Titan Corp. (subsequently purchased by L-3.). Caulson, who has a BAcc from the University of San Diego, began his career with the public accounting firm Arthur Andersen.
Board of Directors

Robert Noble AIA, *LEED™ AP Founder and Chairman*
Robert Noble is an accomplished architect, environmental designer, industrial designer and environmental technology entrepreneur. Noble and his work have won numerousawards, including awards from Popular Science Magazine (Best of What's New, 2003), Entrepreneur Magazine (Innovator of the Year, Environmental Category, 1993), National Public Radio (E-chievement Environmental Award), the Urban Land Institute (San Diego Smart Growth Award, Innovation Category) and The American Institute of Architects – San Diego Chapter (Energy Efficiency Award). Prior to founding Envision Solar, Noble was the CEO of Tucker Sadler Architects of San Diego. He received his undergraduate degree in architecture from the University of California – Berkeley, and his Master of Architecture from HarvardUniversity Graduate School of Design. Noble also completed graduate work atCambridge University and Harvard Business School.

John Evey, *Board Member*
As Vice President for Development at the J. Craig Venter Institute, John Evey is responsible for raising non-governmental resources for this major institute that is advancing genomic research to benefit human health and the environment. Evey previously served the Scripps Institution of Oceanography as Assistant Director of Scripps and Executive Director of Development for the Marine Sciences at UC San Diego. Over a thirty-year professional career—including twenty-five years directing development programs—Evey has personally generated more than $100 million in gifts and matching funds.

Jay Potter, *Board Member*
Jay S. Potter has served as our director since 2007. Potter has been active in the financial and energy industries for over 20 years and has successfully participated, directed or placed over two hundred million dollars of capital for start-up and early stage companies. Potter is a seasoned entrepreneur who understands the many varying needs of early stage and start-up companies. He takes an active role in thedevelopment of the funded companies and to that end has participated as advisor, director and officer to defend and enhance shareholder positions. In 2006, Potter served as the interim chief executive officer of EAU Technologies Inc. (Symbol: EAUI:OB), a publicly traded company specializing in non-toxicsanitation and disinfectant technologies. He founded an early stage venturefund in GreenCore Capital, Inc. and serves as the company's chairman and chief executive officer. He has served as chairman, president and chief executiveofficer of Nexcore Capital, Inc. and its financial service affiliates sinceco-founding that company in 1996. Potter serves as the Chairman of SterlingEnergy Resources, Inc. an oil and gas company involved in the acquisition, exploration and development of oil and natural gas from its numerous leases. Potter also serves as a director of Noble Environmental Technologies, Fulcrum Enterprises and an advisor to International WoodFuels and Ambient Control Systems among others.

Customer Snapshot:



II. Narrative and Work Plan Information

1. Once grant has been awarded; and deposit received JIT manufacturing processes go into motion;

   Parts and materials ordered and manufacturing begins

   Timeline: Lead time will be predicated at the time PO and deposit are received. For State of CA contracts, 90 day manufacturing lead time is stipulated.

   Prior to delivery, we will want the attached document "EV ARC LOCATION EVALUATION" completed and returned 30 days prior to delivery.

   Signoff required Wireless connection with authorized administrator signoff required 2 weeks prior to delivery.

2. Technology and Innovation:

Envision Solar's patented EV ARC™ (Electric Vehicle Autonomous Renewable Charger) is the world's only transportable, solar powered EV charging station.

Delivered to your location complete and ready to charge vehicles, it requires no permits, no civil engineering or planning, no foundations, trenching or electrical connections and is operational within minutes. It can easily be moved to a different location at any time.

EV ARC™ Highlights:

- Solar Powered 100% clean, renewable energy – no utility bills!
- Transportable and can be moved after installation

- Charges all Electric Vehicles (EV) and can reach up to 8 parking spaces
- ARC™ Energy Storage allows you to charge day and night or when it's cloudy
- Platform for Digital or Static Media – offer EV charging and generate revenue

Why the EV ARC™ Matters to You:

- The US is one of the fastest growing EV markets in the world
- EVs that charge on an EV ARC™ are 100% emissions free, because our electricity comes from the sky - it's as clean as it gets
- Don't get stuck with fixed EV chargers in the wrong locations (after months of costly work to install them) EV ARC™ deploys in minutes and can be moved any time
- Our patented EnvisionTrak™ sun tracking technology enables the EV ARC™ to generate up to 25% more electricity than fixed solar arrays
- On-board ARC™ Energy Storage can also be used to keep your business up and running during a blackout or other grid failure and is especially important in the event of an emergency
- Digital and static advertising options can generate revenue for EV ARC™ owners
- Digital out-of-home advertising is the second fastest growing advertising medium after internet video

EV ARC™ Features:

- Fully Transportable
- 18x8 Base Footprint (Fits Inside Standard Parking Space) but does not reduce parking space availability because vehicles park in the same space
- Ballasted, High Traction Pad (No Foundation or Trenching)
- EnvisionTrak™ sun tracking for maximum power
- Level I or Level II charging options
- Works with any quality EV charger or service provider (Chargepoint, Blink, Other)
- Rapid zero impact deployment
- Up to 150 solar powered miles delivered every day

3. Safety

We use compact and light weight batteries which combine the highest quality cells with a thermal management system that delivers industry-leading energy density. Using high energy-density cells and packing them closely together is impractical for other battery manufacturers because of the increased heat generation within a small space, but the technology we use, PCM (phase change material) technology effectively and efficiently manages the heat.

Whether generated by cell discharge or absorbed from the environment, heat is the enemy of battery life. By ensuring temperature uniformity across cells and limiting maximum cell temperature, this PCM extends the battery cycle by life by over 50%. Estimated at a 5000 cycle lifespan, (depending on usage) conservatively, should last 10-12 years. With the maturation of the sector, in 10 years batteries will be a fraction of what they cost today.

PCM technology stops the propagation of thermal runaway within the battery pack by rapidly absorbing and distributing heat. The passive thermal management operates even when the system is turned on, making it more effective than the liquid cooling systems prevalent in today's electric cars.
PCC material has a UL94 Flammability rating which essentially means it self-extinguishes.

For crash testing, the battery modules inside your larger enclosure have passed the UN38.3 litany of tests. This was necessary to obtain certification for legal shipping. Among those tests are shock and vibration tests. As well as all of the electrical components we integrate are UL/ETL certified.

EV ARCs are structurally built using bridge construction engineering methodology, made to last a least 30 years. The 3/4" thick steel ballast pad adds considerably to the overall 11,000 pound weight which is intentional in order to allow for wind loads up to 110 mph , without a car parked on top.

4. Technical Advantages;

Stated above.

5. Completed Emissions Testing:

Not applicable

6. Potential for Market Penetration and Commercialization of Technology:

Targeting three verticals: electric vehicle charging infrastructure; out of home advertising infrastructure; and renewable energy production and disaster preparedness

7. Use of State Incentive Program Funded Equipment:

CEC & CARB Funds may be available for EV ARC™ technology.

8. Legal Operation on California Roadways and at the Port:

Temporary structure usually requiring no permits.

TBD.

TransPower

1. TRANSPOWER BACKGROUND AND EXPERIENCE

Transportation Power, Inc., a California-based company, was founded in 2010 for the express purpose of manufacturing components for zero-emission heavy-duty vehicles. Over the past five years, TransPower has established itself as an industry leader in adapting zero emission technologies to port vehicles such as drayage trucks, yard tractors, and reach stackers – all of which are key elements of the Green Omni Terminal project. We are therefore proposing to be the principal technology provider for a *Green Omni Terminal Electric Vehicles ("GOT-EVs")* project to be partially funded by the California Air Resources Board (ARB) Multi-Source Facility program. TransPower has been actively preparing for this solicitation for the past two years by deploying industry-leading prototype vehicles that have validated the feasibility of using EVs for many port applications.

Manufacturing reliable electric port vehicles capable of lifting and hauling loads in excess of 100,000 pounds is a formidable challenge, but one that TransPower has addressed effectively in our early demonstration projects. Our initial business was focused on developing an "ElecTruck™" battery-electric drive system for drayage trucks (Figure 1), but soon after receiving our first contract award for this work in 2010, we branched into development of battery-electric yard tractors (Figure 2). In 2013, we seized an opportunity to develop an electric version of a port reach stacker vehicle (Figure 3).

Figure 1. Electric drayage truck.

Figure 2. Electric yard tractor.

Figure 3. Electric reach stacker.

In addition to these vehicles which commonly operate in port environments, we have adapted our drive system to electrification of school buses as well, enabling us to provide zero-emission transportation solutions. Our work has been supported by a variety of government agencies and has resulted in completion of five working drayage trucks, five working yard tractors, and one working school bus to date. Another eight drayage trucks and six school buses are under contract and will be completed within the next year, including variants using natural gas and fuel cell range extenders. Our electric reach stacker was funded privately by Terminalift with TransPower cost sharing, and has been operating at the Port of San Diego since mid-2014.

The prototype trucks and tractors deployed by TransPower have accumulated approximately 35,000 miles of operation to date. Over the last year, an increasing share of this has been in commercial revenue service under real world operating conditions. The unprecedented successes of these and other vehicles deployed with TransPower's ElecTruck™ system provides a solid foundation for the work proposed under the GOT-EVs project, which will focus on demonstrating a variety of zero-emission electric vehicles operating at the Port of Los

Angeles (POLA) at Pasha's POLA terminal. TransPower is uniquely qualified to execute the proposed demonstration, based on our unparalleled track record in electrification of the largest (Class 8) heavy-duty vehicles. *We believe TransPower is truly unique in having successfully deployed electric vehicles (EVs) of this class in real-world commercial operational environments.* The vehicles built with our ElecTruck™ products have consistently shown hauling capacity and road performance equal to or surpassing that of conventional vehicles, with greater operating range and energy efficiency than any other heavy EVs built by competing firms. Specific expertise and skill sets that have enabled us to achieve this are summarized in Table 1.

Table 1. Expertise and skill sets reflecting TransPower's integrated approach.

Area of Expertise	Specific Skill Sets
Requirements Analysis – Employment of a disciplined process of analyzing vehicle design and operating requirements before manufacturing any components or attempting their integration into vehicles.	• Data capture analysis to understand true vehicle operating requirements. • Automotive mechanical and electrical design expertise to understand existing vehicle design features, component interfaces, wiring, software requirements, etc.
Component Design – Expertise to design complex electrical, electronic, mechanical, and fluid systems need for component operation in harsh environments.	• Familiarity with modern simulation and controls tools such as Matlab, Simulilnk, and Motohawk. • Mastery of computer-aided design (CAD) tools for generation of high-fidelity component designs. • Competent engineering management including oversight of design reviews, change processes, etc.
Component Manufacturing – A broad range of capabilities to manufacture custom components of the type required to generate, store, and manage power on large vehicles.	• Metal-working skills including sheet metal forming and precision welding. • Fabrication of custom wiring harnesses. • Electronics assembly and testing, with a focus on power electronics for high-power devices. • Manufacturing planning and Bill of Material (BOM) management.
Subsystem Assembly – Unique expertise related to the integration of EV components into subsystems that can be validated and installed into vehicles efficiently and effectively, and that are more marketable to OEMs than piecemeal components.	• Safe assembly of high voltage battery packs. • Design and control of transmissions and various gear reduction systems. • Precision mounting of motors and transmissions. • Packaging of electronics for survivability in harsh operating environments.
Vehicle Integration, Commissioning, and Testing – Industry-leading expertise in the turn-key integration of EV components and systems into heavy-duty vehicles, followed by verification of all component and vehicle functionality and testing and optimization of vehicles.	• Diesel engine and fuel system removal. • Vehicle rewiring. • Physical installation of components, mounting hardware, and wiring harnesses. • Installation and validation of control software. • Measurement of component and vehicle performance and optimization through testing.

Thus, TransPower's EV technologies are clearly "on the cusp of commercialization," as required in the ARB's Multi-Source solicitation, and ideally suited to meet the ARB's goals for this program. In fact, the ARB and POLA have helped fund development of these technologies, providing TransPower with nearly $2.5 million in grant funding over the past three years to support TransPower's electric truck, tractor, and school bus technologies. The Scope of Work for the GOT-EVs project involves work very similar to that performed by TransPower successfully on earlier demonstration projects. The components to be used in the GOT-EVs vehicles will be nearly identical to those utilized in current prototypes. However, based on lessons learned from our existing prototypes throughout 2015, we have the opportunity to identify design refinements that might further improve reliability, reduce manufacturing costs, and improve serviceability. Thus the first technical task of the proposed GOT-EVs project will be to identify appropriate design refinements. Subsequent tasks, including component assembly, vehicle integration, vehicle commissioning, and operations support, will parallel similar tasks we have completed successfully on numerous other projects. Table 2 summarizes the experience of the key individuals who will lead the GOT-EVs project. Please see the following main section of this proposal for resumes of these individuals.

Table 2. Resumes of key project personnel.

Name	Organization	Relevant Current and Past Experience	Role on Project
Frank Falcone	TransPower	Manager, IKEA and POLA Yard Tractor projects; Director, Powertrain Engineering. Vehicle Systems Engineer and specialist in advanced electric and hybrid-electric powertrain development, U.S. DOE/Argonne National Laboratory (2008-11).	Project Manager
Dr. James Burns	TransPower	Vice President and Chief Scientist. Manager, Electric Drayage Demonstration (EDD) project. CEO, Motor sports International, electric drive controls company (2009-11). Tenured Associate Professor, San Diego State University (1994-2009).	Technology Advancement Lead
Michael Simon	TransPower	CEO and principal founder. Director of Transportation Business Development, General Atomics (2006-10). Co-founder and Co-CEO of ISE Corp., (1995-2005). Engineer/program manager at General Dynamics (1982-93) and NASA (1980-82).	Administrative and Commercialization Lead
Dr. Paul Scott	TransPower	Vice President, Advanced Technologies. Manager of Battery Testing and Evaluation and Stationary Energy Storage Systems. 54 years of professional experience as a university professor, scientist, and engineer.	Advanced Battery Evaluation and Integration Lead
Ameya Jathar	TransPower	Director of Systems Engineering and Engineering Dept. lead. Powertrain Controls Manager, Tata Consultancy Services (2010-2013). Engineer and project manager, Hamilton Sundstrand (2005-10). Controls Team Leader, San Diego State University (2002-08).	Chief Engineer
Harold Meyer	TransPower	Vice President, Manufacturing. Production lead on drayage truck and yard tractor projects. Vice President, Operations, Bluways, USA (2020-12). Director, Service and Manager, Prototype Vehicle Manufacturing, ISE (2000-10). U.S. Navy (1980-2000).	Manufacturing Lead
Joshua Goldman	TransPower	Vice President, Business Development. Project Manager, Electric School Bus with V2G/V2B Functionality. VP, Business Development, DesignLine International (2013). Director, Business Development, Proterrra (2008-13). Engineer, ISE (2000-08).	Service and Support Lead

2. VEHICLE CONFIGURATIONS OFFERED

Drayage Trucks – TransPower's first fully functional electric Class 8 truck was the "Pilot Truck" shown in Figure 1, whose early successes hauling heavy loads in late 2013 and early 2014 enabled us to undertake one of the most ambitious heavy-duty demonstration projects in the EV industry – the *Electric Drayage Demonstration (EDD)* project – which will result in deployment of seven additional electric drayage trucks by the end of this year. Four of the EDD trucks have been built and *their operation to date has demonstrated capabilities no other electric trucks of this class have ever achieved.* The latest of these trucks to enter service is pictured in Figure 4 on the dynamometer at UC Riverside. Notably, this truck was driven from San Diego County to Riverside and back, then driven up to Long Beach for permanent deployment – not ferried on a flatbed truck like so many other demonstration vehicles. Such intercity trips have become routine for TransPower trucks. In April 2015, UC Riverside published a report documenting the results of its testing of this truck, which proclaimed that "TransPower's electric HDV [heavy-duty vehicle] performed all tests with a high degree of reliability, suggesting that recent advances in electric vehicle technology make applications to on-road Class 8 trucks practical for drayage and intercity operation."

Figure 4. Latest EDD truck to enter service, during dynamometer testing in October 2014.

TransPower's latest four demonstration trucks have accumulated more than 10,000 miles of testing and drayage operation, adding to nearly 4,500 miles accumulated by the Pilot Truck before it was removed from service to be outfitted with a power pickup system that will enable it to operate on the "eHighway" system, an overhead catenary power line being developed by Siemens. Demonstrations of this repurposed truck on an eHighway test segment are scheduled to begin later this year, as are tests of TransPower's first electric truck with a CNG hybrid range extender. Along with the last three battery-electric trucks being built under the EDD project, this will bring TransPower's total fleet of operational Class 8 drayage trucks to nine vehicles by year-end. Two more electric trucks, two more CNGH hybrid trucks, and three new electric trucks with hydrogen fuel cell range extenders will be built and deployed by TransPower in 2016 under contracts recently awarded, increasing the total drayage truck fleet to 16 trucks by mid-2016. No other company has shown that it is even near this level of readiness to deliver fully functional, reliable electric or hybrid-electric drayage trucks, making TransPower the logical choice for provision of electric drayage trucks for the Green Omni Terminal. Figure 5 is a photo of the first four EDD trucks, all of which were driven from the San Diego area to the Long Beach area for demonstration to the U.S. Department of Energy and South Coast Air Quality Management District in March 2015.

Figure 5. First four operational electric EDD trucks.

Yard Tractors – TransPower recently completed two parallel Electric Yard Tractor Demonstration (EYTD) projects, installing the yard tractor variant of our battery-electric drive system into three Kalmar Ottawa tractors. The tractors were manufactured in 2014, drawing on lessons learned from TransPower manufacturing and testing of two earlier prototype electric tractors in 2011-13. The two earlier tractors were subsequently upgraded to use the improved tractor drive system at the end of 2014, resulting in a fleet of five tractors using this system. Key features of the improved yard tractor drive system include larger battery enclosures, a more robust transmission, and an integrated power and accessories assembly – similar improvements to those that have made TransPower's electric drayage trucks efficient and reliable. Figure 6 is a photo showing the installation of the new larger battery enclosures on "POLA-1," the first of two tractors built for long-term operation at the Port of Los Angeles.

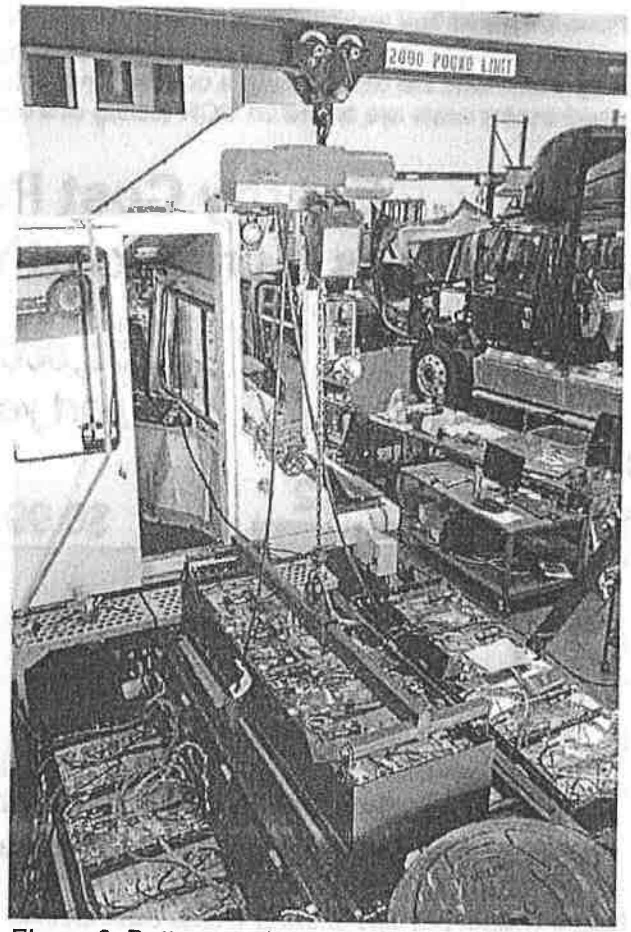


Figure 6. Battery enclosures installed on POLA-1.

POLA-1 and its sister tractor POLA-2 will be placed into operation at APM Terminals and Seaside Terminals, respectively, by the end of this month. This follows completion of an earlier demonstration phase during which POLA-1 was operated by two drayage companies near the Port of Los Angeles for a total of about ten months and POLA-2 was operated by Dole Foods at the Port of San Diego for eight months. A third tractor using the same TransPower drive system was deployed at IKEA's main California distribution center in Lebec in September 2014, and has accumulated more than 10,000 miles of steady use since its deployment. One of the two upgraded yard tractors has been operated at Pasha's San Diego port terminal for the past several months, and the other upgraded tractor was recently deployed at an Osterkamp warehouse facility in Riverside. The performance of these five tractors has validated the ability of the TransPower-built electric tractors to operate reliably for long periods in real-world operating conditions. These are the first battery-electric yard tractors of the 100,000-lb. weight class known to have operated reliably in real-world environments on a sustained basis. Electrically-driven tractors deployed on previous demonstration projects have typically failed to provide the power, towing capacity, operating range, or reliability demanded by fleet operators. In total, these five tractors have accumulated more than 15,000 miles of total in-service use.

The tractor deployed at IKEA was also tested by UC Riverside (UCR) on its chassis dynamometer, in September 2014. During this testing, UCR measured the energy efficiency of the electric tractor and compared it with the efficiency of similar Kalmar Ottawa tractors tested with diesel and diesel-hybrid drive systems. UCR then estimated the potential energy cost savings of electric tractors using TransPower's drive system, taking into account prevailing prices for diesel fuel and electricity. Figure 7 summarizes the results of this testing and analysis, showing the estimated cost per mile of using a TransPower electric tractor in comparison with the cost of using a conventional diesel tractor or a hybrid-electric tractor. The hybrid tractor costs are based on UCR testing of a competing hybrid tractor a few years ago.

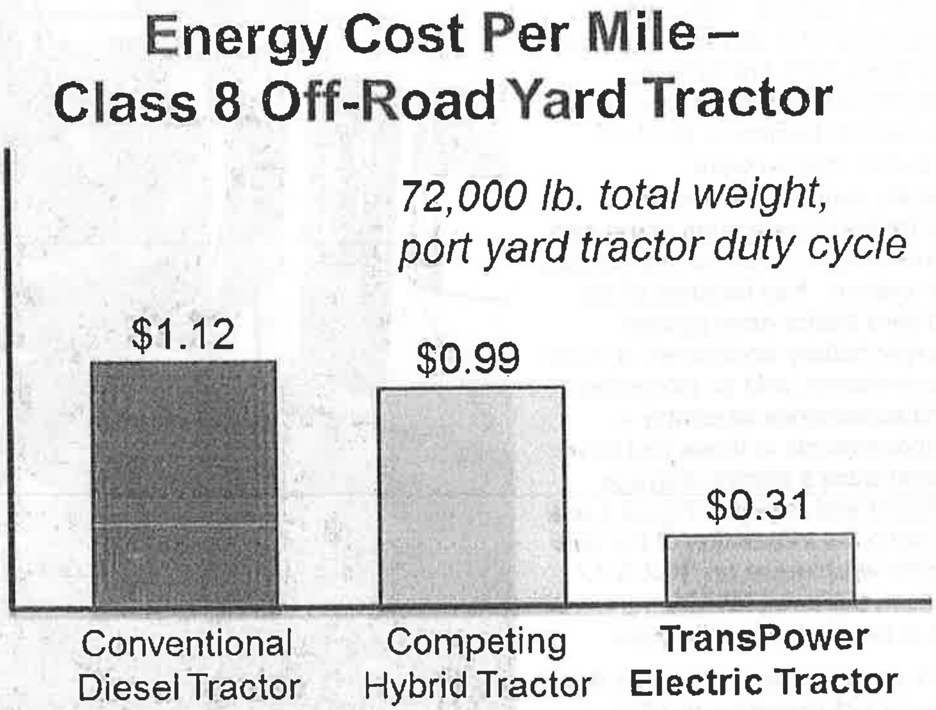


Figure 7. Cost per mile of using TransPower electric tractor versus conventional diesel and competing hybrid-electric designs. (Source: UC Riverside/CE-CERT dynamometer lab).

As indicated, TransPower's electric tractor has an estimated energy cost of 31 cents per mile, compared with $1.12 per mile for an equivalent diesel yard tractor and 99 cents per mile for the latest hybrid yard tractor tested by UCR. This shows that the TransPower electric tractor has less than one-third the energy cost of either of these two options. The high reliability of the TransPower tractors also suggests that additional maintenance savings may accrue to future users. After eight consecutive months of operation of the third tractor at IKEA's distribution center, TransPower and IKEA personnel estimated that the TransPower electric tractor would cost about $5,000 to $6,000 less per year to maintain than a typical IKEA diesel tractor. No significant maintenance or repairs have been required for any of TransPower's five demonstration tractors since their completion in 2014. Figure 8 is a photo of one of the two upgraded tractors while in use at Pasha's San Diego terminal. This tractor has an unusual tandem rear axle feature that was requested by HEB, a Texas retailer that operated the tractor after it was equipped with its original electric drive system in 2013. However, for operations at Pasha's Omni Green Terminal, we would deliver tractors using the more conventional single rear axle as was depicted in Figure 2 at the beginning of this proposal – a photo which incidentally shows the IKEA tractor during its first day of operations in Lebec in September 2014.

Deployment of electric tractors at the Omni Green Terminal fits in well with TransPower's plan for commercialization of the technologies demonstrated on our first five electric tractors. We have since received funding to build and deploy seven additional tractors with six different fleet operators around the State. Our goal for 2016 is to operate these 12 tractors while simultaneously expanding the demonstration fleet to include additional tractors at the Port of Los Angeles, along with expanded tractor operations at warehouses, distribution centers, and other locations where yard tractors are commonly used. Focusing on the State of California, our goal is to place at least 100 electric yard tractors into demonstration fleets over the next five years. This will enable the accumulation of millions of miles and hundreds of thousands of hours of operation over this period, providing sufficient experience and data to perfect the electric drive system and build the interest of tractor OEMs such as Cargotec, along with tractor operators worldwide.

Figure 8. TransPower electric tractor at Pasha San Diego terminal.

Figure 9. Electric reach stacker in operation.

Reach Stackers – TransPower collaborated with Terminalift, a Port of San Diego tenant, to convert an existing diesel Fantuzzi reach stacker to electric operation in 2013-14. This conversion was performed on a limited budget at Terminalift and TransPower expense, so components were used from TransPower's existing inventory to reduce expenses, and the vehicle was equipped with lead-acid batteries, which limits its operations to about two hours between battery charges. Earlier this year, TransPower and Terminalift received grant funding to replace the lead-acid batteries with lithium-ion batteries, which will increase the vehicle's operating range to 8-10 hours. The next logical step in TransPower's development of the reach stacker technology will be to adapt the newer components used in our current drayage trucks and yard tractors to our reach stacker propulsion and power system. We believe this would be an excellent objective for the GOT-EVs project. Figure 9 is a photo of the Terminalift reach stacker in operation shortly after its conversion to electric drive in February 2014.

Shuttle Buses – TransPower installed an advanced battery-electric propulsion system into a 40-foot Thomas Built Type D school bus in 2012-13. Drive testing of the prototype bus was initiated in late August 2013 and, under the auspices of the California Highway Patrol (CHP), a series of road tests and sequential safety improvements were made to the bus over the subsequent six months. On February 12, 2014, the vehicle received CHP approval and a CHP 292 certificate, allowing for transportation of students with the bus. On March 17, 2014, the prototype bus (Figure 10) initiated student service with Escondido Union High School District, continuing to operate at this location for the planned period of one month. On April 28 the bus initiated student transportation services with the Cajon Valley Unified School District in El Cajon, CA. During these trials, the bus logged more than 1,600 miles during eight weeks of passenger service, regularly operating for 30-40 miles each day. The bus utilized approximately 60-80% of its rated battery capacity each day with an operating efficiency of about 2 kWh per mile, which equates to approximately 17 miles per gallon. The equivalent fuel cost for the prototype bus is estimated at $0.22 per mile (based on $0.11 per kWh), vs $0.66 per mile for the comparable diesel bus (at $4 / gallon diesel and 6 MPG).

Figure 10. TransPower electric school bus showing battery compartments to Del Lago Academy of Applied Science.

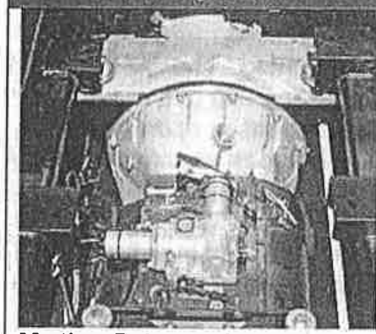
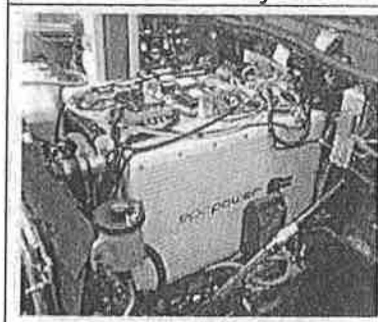
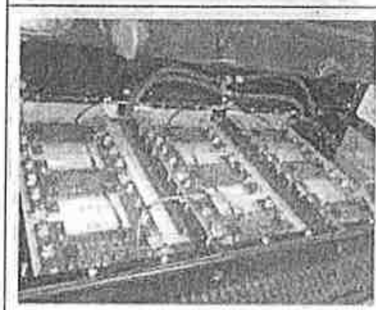
In mid-2014, TransPower initiated a new project to convert six smaller "Type C" school buses to electric operation. The first two of these buses are expected to be completed and deployed with Torrance Unified School District, near the Port of Los Angeles, by the end of this year. The remaining four buses are scheduled for completion and deployment in early 2016. Either Type C or Type D school buses can be used for passenger transportation at port terminals such as the Omni Green Terminal. Alternatively, TransPower's electric drive system could be cost-effectively adapted to a different bus model, including any number of transit buses or touring buses currently in operation worldwide.

These case studies show that TransPower has the proven track record to deliver electric vehicles of the type that are required for successful implementation of the Green Omni Terminal and our proposed GOT-EVs project. The following section provides details on the components and technologies that have helped make these vehicles so successful.

3. KEY VEHICLE COMPONENTS AND TECHNOLOGIES

The successes of the TransPower EVs demonstrated to date are partly attributable to our selection of high quality components and integration of these components into subsystems that have unparalleled capabilities. Our "ElecTruck™" drive system consists of three main subsystems, and can be configured in a variety of ways to meet the requirements of vehicle types such as those described in Section 2. Table 3 identifies the three main subsystems comprising the ElecTruck™ system and summarizes some of their attractive features.

Table 3. Major EV subsystems and components manufactured by TransPower.

Subsystem	Constituent Components	Key Features/Benefits
 **Motive Drive Subsystem**	• Single or dual Fisker/JJE drive motors • Precision-aligned dual motor structure and shaft • Automated manual transmission (6-speed or 10-speed) with Eaton X-Y shifter • Proprietary software that matches gearing ideally to driving and motor conditions	• Compact and lightweight • Higher power and torque, across a broader speed range, than single gear solutions • Higher efficiency than automatic transmission systems • Lower cost than competing motor products in this power range • Single motor/6-speed transmission and dual motor/10-speed transmission provide flexible alternatives
 **Power Control and Accessory Subsystem**	• Single or dual inverter-charger units (ICUs) • Electrically-driven power steering fluid pump • Electrically-driven pneumatic braking system featuring scroll compressor • Central control module (CCM) • housing vehicle controllers • High-voltage distribution module (HVDM) • Accessory inverters • DC-to-DC converters	• Integration of onboard chargers with inverters eliminates need for separate chargers • Modern models-based vehicle controls are easily customized to support different driving cycles or component substitutions • Electrically-driven accessories active on demand, saving energy • Pre-integration of PCAS assembly facilitates manufacturing and verification
 **Energy Storage Subsystem**	• Large format lithium iron phosphate cells • Rugged steel enclosures with removable lids • Bus bars with low internal resistance • Advanced battery management system (BMS) featuring active cell balancing • Provisions for active cooling if required	• Low total cost per kilowatt-hour • Continuous cell balancing maximizes operating range and accelerates battery charging • More accurate cell voltage and temperature measurement help improve safety and reliability • Special structural features enhance crash protection • Bolt-on BMS and other features enhance manufacturability

When it comes to technological innovation, the ElecTruck™ system is unsurpassed. The EVs built to date by TranPower are the only EVs in the world using several innovative new technologies, the most significant of which are summarized below.

Automated manual transmission (AMT) – The AMT advances the state of the art of transmitting torque from electric motors, combining rugged off-the-shelf manual transmissions with state-of-the art shifting controls and software. Our first-generation AMT, which we developed in 2012, used a shifting mechanism designed for racing cars and demonstrated the essential feasibility of this approach during testing of our first two electric yard tractors in 2013. To overcome limitations observed with the racing car shift mechanism in these two tractors, we teamed with Eaton and upgraded our AMT to use Eaton's more robust shifting servo-mechanism. The top photo in Table 3 shows this device atop the Eaton transmission in one of our first trucks. All other electric vehicles use either direct drive between the electric motor and axle – which limits performance – or automatic transmissions, which rely on inefficient torque converters that sap valuable electric energy from the battery pack whenever the vehicle is running. The AMT provides improved performance at both high and low speeds, while enabling use of a more efficient manual transmission, which reduces energy consumption and increases operating range. The yard tractor variant of our AMT uses Eaton's medium-duty 6-speed transmission, which we've also adapted successfully to school buses. For higher power on-road Class 8 trucks, we've developed an AMT variant using Eaton's 10-speed transmission. We continue fine-tuning our AMT shifting software as we acquire data from trucks and tractors in actual service – valuable work that will be expanded during the ABEPV project, helping to advance the AMT's commercial acceptance for both trucks and yard tractors.

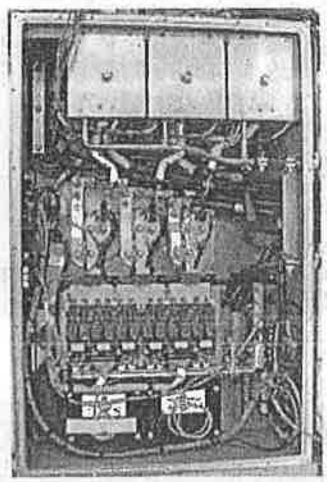


Figure 11. Interior of ICU.

Inverter-Charger Unit (ICU) – The ICU handles high power loads much more reliably than off-the-shelf inverters, and has the unique feature of combining the functions of the inverter, which controls the drive motors, and the battery charger, which recharges the vehicle's batteries on a "plug-in" basis. Figure 11 shows the interior of an ICU. Inductors, visible near the top of the photo, support grid charging of batteries. The power section seen below serves the dual function of converting grid AC power to DC power for the batteries and converting battery DC power to AC power for use by the traction motors. Each ICU delivers 150 kW of continuous power for the drive motor and supports battery charging at up to 70 kW. One ICU easily meets the motive power requirements of the heaviest duty yard tractors and enables us to recharge yard tractor battery packs in two hours. Use of two ICUs on each of our Class 8 on-road trucks provides twice the power. Combining the unique capabilities of our AMT with the ICU, we supply adequate power to operate fully-loaded on-road trucks at freeway speeds while also providing excellent acceleration at low speeds, easily eclipsing the power capabilities of most competing vehicle powertrain components. Using the onboard ICUs for battery charging eliminates the need for external battery chargers, which are large and expensive. We believe the ICU may turn out to be one of the most significant products ever developed with Energy Commission funds.

Battery Module Design – The Energy Storage Subsystem (ESS) in the ElecTruck™ drive system is based on lithium iron phosphate ($LiFEPO_4$) battery cells, which TransPower was one of the first U.S. companies to adopt for transportation applications in 2010 and which have gained widespread market acceptance since, due to their safety, durability, and longevity. Our initial integration strategy was to install batteries into relatively small modules, each weighing 300-400 lb. This approach was employed in our first two electric drayage trucks and our first two yard tractors. Our first drayage truck, the "Pilot Truck" shown in Figure 1, required 20 such modules, six of which were installed in the truck engine compartment in two tiers of three. The upper tier of modules in the Pilot Truck engine compartment is shown in Figure 12. However, integration and testing of the Pilot Truck taught us that it is complex and expensive to integrate this many modules into a vehicle, requiring lots of external wiring and making it difficult to service modules in certain areas (such as the bottom tier of modules in the Pilot Truck engine compartment, hidden beneath the modules shown in Figure 12). To address these issues, we designed and developed larger, more rugged battery enclosures, which are visible in our second EDD truck, "EDD-2," in Figures 4 and 13. New larger battery enclosures were also designed and developed in 2013-14 for use in our electric yard tractors; as shown in Figures 2, 6, and 8.

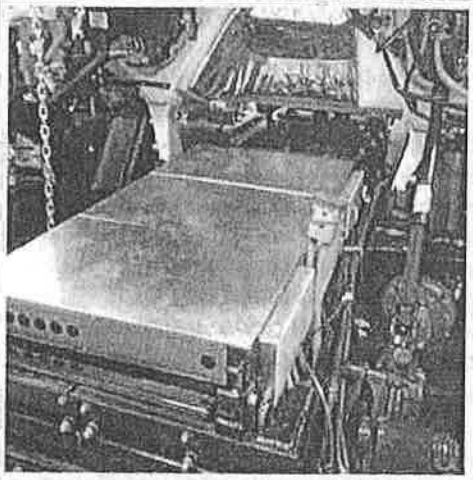


Figure 12. Early generation battery modules – as many as 20 per truck.

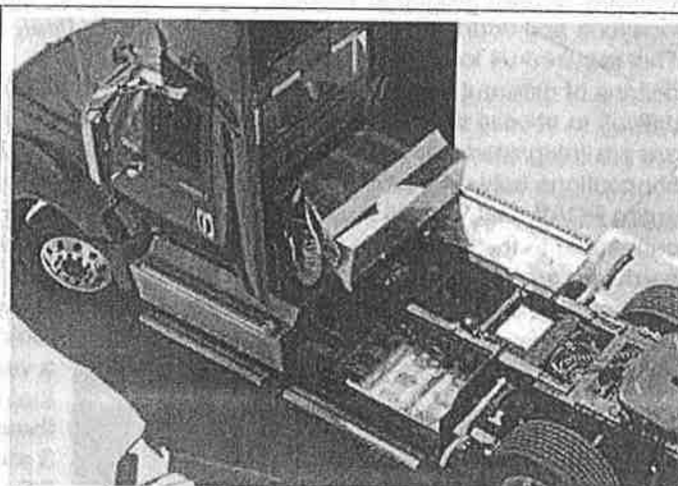


Figure 13. New design battery enclosures – only 3-5 required on each Class 8 drayage truck or yard tractor.

Battery Management System – Another key innovation is the "Cell-Saver™" battery management system (BMS) we have been developing with partner company EPC since mid-2013, which installs more easily, measures cell voltage and temperature more accurately, and balances cells more rapidly and efficiently than competing BMS systems. The custom printed circuit boards used in this new "Cell-Saver™" BMS can be seen mounted to batteries in EDD-2 in Figure 7 above. Early problems experienced with the new Cell-Saver™ BMS boards on EDD-2 have been resolved, so our long term goal is to expand our use of these highly accurate and capable Cell-Saver™ sensor/balancing boards. To make this transition commercially as well as technically viable, we recently acquired funding from the POLA and other sources to refine the design of the Cell-Saver™ sensor/balancing boards to reduce their costs. The GOT-EVs project will benefit from these improvements.

Battery Selection – While we have been satisfied with the prismatic lithium iron phosphate ($LiFEPO_4$) cells we have used on prototype vehicles to date, we are always searching for improved battery cell technologies that can increase operating range, reduce weight, or reduce costs. For this reason we are particularly excited about our recent discovery of a new $LiFEPO_4$ cell product, a cylindrical "60290" cell that stores 60% more energy than the cells we currently use (Figure 14). A higher energy density battery such as the 60290 cell could help reduce weight and/or increase operating range for all three major vehicle types we build that are of interest to ports – yard tractors, drayage trucks, and reach stackers.

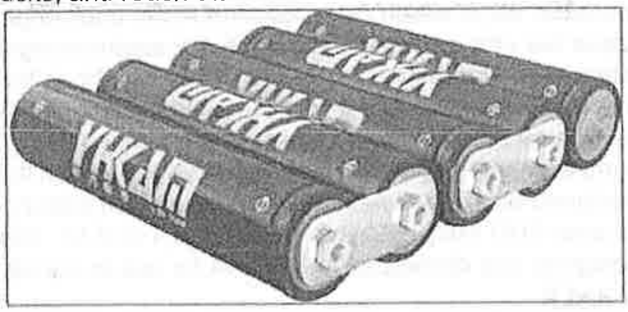


Figure 14. New cylindrical battery to be utilized in ABEPV fleet, subject to favorable 2015 test results.

Power Control and Accessory Subsystem (PCAS) – The PCAS is a new system integration concept to accommodate components for vehicle control and electrically-driven accessories, including the Inverter-Charger Units (ICUs) discussed above. In our first few prototype vehicles, we mounted the ICUs, power controllers, and accessory components directly to vehicles, spread around in various locations and connected with cables. This required us to develop and maintain dozens of different electrical, mechanical, and fluid interfaces with the base vehicle and made it difficult to access and service components once installed. In the PCAS approach, components are pre-integrated into a specially designed structure and the many wiring and cooling connections between these components are completed before installation into the vehicle. The entire PCAS assembly is then hoisted into the engine compartment as a single unit and connected to the vehicle and remainder of the drive system with minimal additional integration hardware and wiring. Two versions of the PCAS have been developed using the same basic components as building blocks – a version for drayage trucks that supports the two ICUs required for this high power application, and a version for yard tractors and school buses that supports the single ICU required for these vehicles. The middle photo in Table 3 shows how the completed dual ICU PCAS assembly appears after installation into an on-road Class 8 truck, and Figure 15 shows a single ICU PCAS assembly installed into a yard tractor. Pre-integrating all of the PCAS components into a single structure not only reduces TransPower's assembly time, but is eventually expected to accelerate market acceptance of the ElecTruck™ system by making it easier for established original equipment manufacturers to install these components.

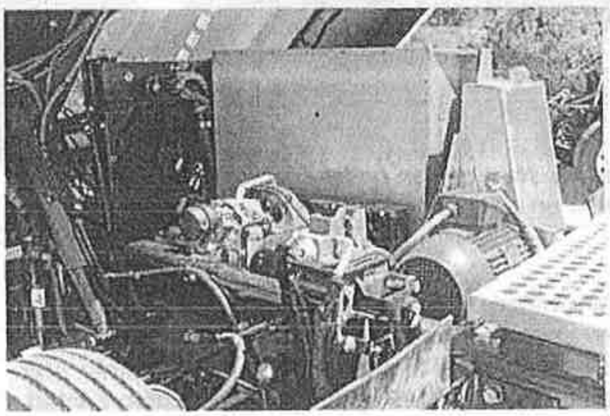


Figure 15. Single ICU PCAS assembly installed in second generation prototype electric yard tractor.

4. VEHICLE COST REDUCTION

One of the key obstacles to large-scale commercial adoption of EVs, including electric port vehicles, is the high capital cost of such vehicles. Our strategy for addressing this issue is to continue achieving dramatic reductions in the labor effort required to convert trucks and tractors using the ElecTruck™ system, while initiating steps to drive down the costs of major ElecTruck™ system components. We currently can manufacture and assemble complete drive system "kits," consisting of all of the components and subsystems required for the conversion of large Class 8 trucks, in very low volumes at a total cost of about $300,000. Factoring in the cost of the truck itself and installation of the kit, the total cost of the truck is about $450,000. These figures must be reduced to achieve significant market capture.

Table 4 provides approximate cost figures to summarize the potential cost reductions we believe are possible. As indicated, we believe that a reduction of about one-third from today's costs is possible by 2017, and that another reduction of approximately one-third is possible by 2020 with further manufacturing improvements and increases in manufacturing scale. We believe that most of these cost reductions can be achieved through intelligent redesign and manufacturing of a few key components. For example, each ICU presently costs $30,000 to manufacture, so for large trucks requiring two ICUs, the cost of this component is $60,000. However, we plan to implement a design improvement on the proposed ABEPV project that will consolidate the power electronics for both drive motors into a single ICU. Even with additional motor control components, we believe the cost of this ICU in large production quantities can be driven down to $15,000, resulting in a $45,000 net cost reduction by 2020.

Table 4. Current EV component manufacturing costs and projected future cost reductions.

Cost Element	Current Cost	2017 Target Cost	2020 Target Cost
Energy storage subsystem structures	$10,000	$5,000	$2,000
Battery management system (BMS)	15,000	7,500	1,500
Inverter-charger unit (ICU)	60,000	30,000	15,000
Motive drive subsystem	30,000	22,000	15,000
PCAS – other components/assembly	75,000	52,500	40,000
Batteries	75,000	60,000	45,000
Other component/subsystem costs	35,000	23,000	15,000
TOTAL COST OF A COMPLETE KIT	**$300,000**	**$200,000**	**$133,500**

We have reduced the cost of the ElecTruck™ battery management system from $15,000 to less than $10,000, and we believe we can reduce this to $7,500 per truck by 2017. By 2020, we believe higher volume manufacturing can reduce this cost to $1,500. Combined with reductions in the costs of battery structures and the batteries themselves, we believe the total cost of the battery subsystem can be reduced from $100,000 today to $48,500 by 2020.

Table 5 provides cost figures to summarize the electric yard tractor cost reductions we believe are possible. As indicated, we believe that a reduction of about 25% from today's total kit cost is possible by 2017, and that another reduction of approximately one-third is possible by 2020.

Table 5. Current yard tractor component manufacturing costs and projected cost reductions.

Cost Element	Current Cost	2017 Target Cost	2020 Target Cost
Energy storage subsystem structures	$10,000	$5,000	$2,000
Battery management system (BMS)	15,000	7,500	1,500
Inverter-charger unit (ICU)	30,000	20,000	15,000
Motive drive subsystem	20,000	17,000	12,000
PCAS – other components/assembly	75,000	55,000	40,000
Batteries	55,000	50,000	35,000
Other component/subsystem costs	35,000	25,000	14,500
TOTAL COST OF A COMPLETE KIT	**$240,000**	**$180,000**	**$120,000**

In addition to driving down our component costs, another key cost-competitiveness goal is to transition our current three-stage production line, which is geared toward turn-key conversion of vehicles, to a modified three-stage production line where many integrated subsystems can be validated and shipped to OEMs for installation on their assembly lines, rather than always installed into vehicles by us. We will continue performing complete vehicle conversions indefinitely, but truly large-scale penetration of the heavy-duty EV market with our ElecTruck™ components will require that OEMs begin installing these components into their vehicles. Packaging our EV components into kits to facilitate this process will drive down manufacturing costs to the lowest possible levels and enable OEMs to provide warranties and support for heavy-duty EVs via their existing distribution networks. At the $133,500 cost shown for drayage truck kits in Table 6, we could sell kits profitably to OEMs at a price that could enable OEMs to sell high-end electric Class 8 tractors for less than $300,000. This would reduce the incremental cost of an electric drayage truck to about $150,000 and increase the likelihood of widespread market acceptance of our technology.

5. VEHICLE DEPLOYMENT

Upon definition of our role on the GOT-EVs project, TransPower will develop a detailed Implementation Plan that reflects three important success factors: (i) our industry-leading understanding of the requirements for manufacturing reliable heavy-duty EV components; (ii) our demonstrated success in meeting the milestones of similar demonstration projects; and (iii) our clear vision of the specific tasks that need to be accomplished to implement small-scale vehicle demonstration projects that can lead to larger scale deployments and successful commercialization. The task sequence of our proposed Scope of Work will reflect a basic progression of nine different activities we use to varying degrees in nearly all our demonstration programs. A generalized summary of the types of tasks we envision performing is provided below.

Task 1: Administration. This task involves project management and reporting.

Task 2: Design Improvements. We begin with a basic design effort to lay out how the drive systems will be installed into the vehicles. On the GOT-EVs project, we would minimize technical risks by sticking with the existing TransPower drayage truck and yard tractor integration concepts, which have already been installed successfully into five Navistar trucks and five Kalmar Ottawa tractors. As an example, our current drayage truck design is illustrated in Figure 16. If a decision is approved to evolve to a new component, such as the higher energy 60290 battery product, physical changes will be limited. For example, to accommodate a new battery, changes would be limited to resizing the battery enclosures shown along the sides and behind the cab of the drayage trucks, as depicted in Figure 16, and to the side-mounted enclosures on our yard tractors. The design improvement process also offers us the option of customizing vehicles to any unique operating requirements we might encounter at a given location. However, our basic philosophy of starting with a proven design will enable us

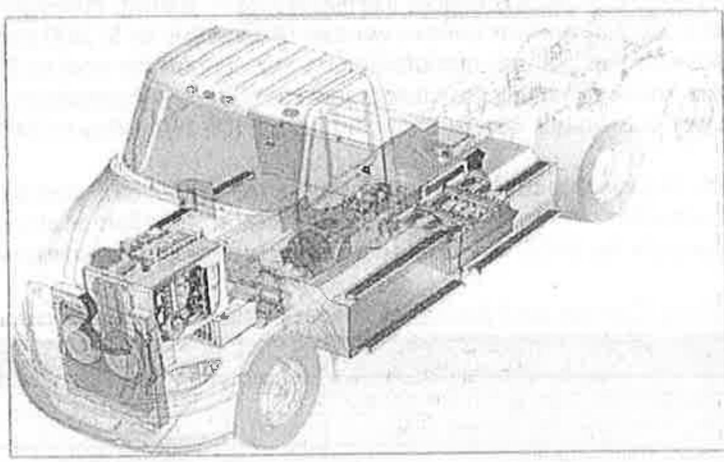


Figure 16. Integration layout showing a typical ElecTruck™ drayage truck installation.

to devote engineering resources to solving a manageable number of specific problems, rather than struggling to make everything work together for the first time.

Task 3: Truck and Tractor Procurement. This task involves procurement of the base trucks from Navistar, base tractors from Cargotec, and reach stackers or other selected vehicles from their original equipment manufacturers (OEMs). The base vehicles can take up to 3-4 months to receive from issuance of Purchase Order, so they are typically ordered early in the project.

Task 4: Subsystem Assembly. Following vehicle procurement, the next major task in most of our vehicle demonstration projects is to build the vehicle subsystems. The first step in this process is to order major externally-sourced drive system components. Most purchased components are already elements of our standard drive system bill of material and can be procured efficiently from known suppliers. Our methods of purchasing and inventory control are constantly evolving to help us become more efficient in these activities. Once enough components are acquired (or, when appropriate, manufactured in house), we assemble the major subsystems. These are the *Motive Drive Subsystem, Power Control and Accessory Subsystem,* and *Energy Storage Subsystem* as described in detail previously, usually built in that order. As discussed previously, our vertically integrated manufacturing approach offers many benefits, such as enabling these subsystems to be built in parallel while avoiding the complexity of dealing with interfaces to the vehicle itself until the final stage of vehicle integration. Another benefit of this approach is that we can shift resources from building one subsystem to another to work around delays in receiving parts, helping us to keep projects on schedule and assure timely completion of projects such as GOT-EVs.

Task 5: Vehicle Integration. As the subsystems assembled in Task 4 come together, we install them into the demonstration vehicles. One key lesson learned from past projects is to complete one or two vehicles first, or at least perfect the installation of a specific subsystem in one vehicle, before attempting to replicate the installation in additional vehicles. This way, if a mistake is made in installation or a design change is determined to be necessary, the problem is not repeated on multiple vehicles and the remedy has to be applied only once. Once learning from the first vehicle is achieved, the pre-assembled subsystems for other vehicles can generally be installed very quickly. This approach is consistent with the ARB Multi-Source Facility solicitation, which suggests breaking projects up into two phases – a first phase during which a small number of vehicles is deployed, followed by a second phase involving a larger number of vehicles.

Task 6: Vehicle Commissioning. An often overlooked part of the process of demonstrating any new vehicle is the commissioning process. During this task, we test all drive system components on the integrated vehicle and then test the entire system to assure it functions properly. We then undertake a series of drive tests to validate the basic functionality and safety of the system, and to enable us to optimize vehicle controls. On GOT-EVs, we want to draw particular attention to the commissioning task because the effectiveness of the commissioning activity can often have a profound impact on how reliably and cost-effectively the vehicles operate during the demonstration phase of the project.

Task 7: Vehicle Deployment. This task involves preparations for vehicle deployment at the fleet operator sites. A vital subtask is design and installation of the vehicle charging infrastructure at the host demonstration sites. While the ICUs greatly reduce the cost of this infrastructure by locating the chargers themselves on board the vehicles, there is still a need for electrical service to be upgraded at the host sites to accommodate the high power operation of the ICUs, along with ancillary switchgear and safety equipment such as isolated transformers and TransPower's customized ElecTruck™ electric vehicle support equipment (EVSE) console.

Task 8: Data Collection and Analysis. To accomplish this task, we place vehicles in operations, observe their performance, collect and analyze data; and provide the product support required to keep vehicles operating reliably. TransPower provides a telematics solution for remote and wireless collection and transfer of data to a cloud-based server. The cloud server permissions can be configured for pull-only file sharing. Each data client is then responsible for modifying and building their own database from these files as well as for providing their own data management interface. This approach supports data integrity by assuring that the original data files remain in their as-created state for use by all clients. Figure 17 illustrates a generic telemetric fleet data management system. TransPower uses a UniCAN2 logger from CSM as the telematic component, and an Amazon cloud service for collecting, storing, and transferring data to program clients.

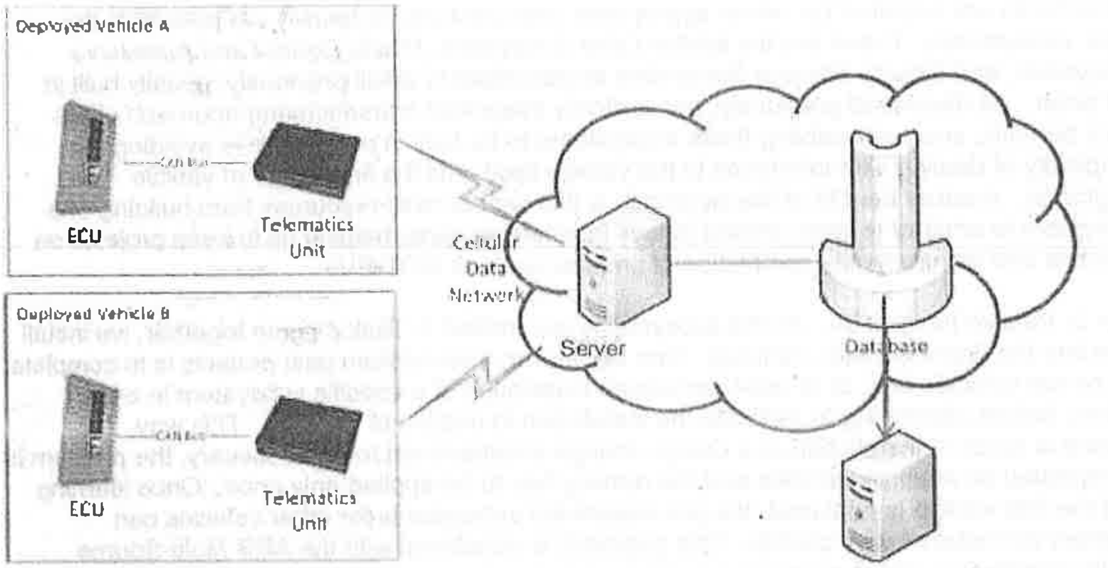


Figure 17. Generic telemetric fleet management system.

The UniCAN2 Pro hardware was chosen based on its complete feature set and TransPower's prior experience with it. This hardware supports both cellular transmission of data and in-unit CF-card backup and manual retrieval if needed. These units support four CAN channels, leaving a spare channel for any future needs. If warranted, TransPower will pursue a strategy that rebroadcasts the set of messages pertinent to our shared data logging requirements on a dedicated CAN channel at a lower rate of at least 1Hz. This may require that a CAN bridge device be added to each of the trucks. Data reporting and storage will have a redundant design. Data in .csv file format will we cached on a primary cloud server, and pushed or pulled to each client's server once each day. In addition, and should the need arise, data stored on the trucks CF card may be extracted and sent by email.

The data collection and analysis methods and protocols just described have been developed in consultation with the U.S. Department of Energy (DOE) on similar zero emission transportation projects and will exceed the data collection requirements of this solicitation. Extensive data will be collected and disseminated on key performance criteria such as energy consumption, miles and hours of operation, efficiency, availability, mean time between failures, and component failure rates.

6. ENVIRONMENTAL BENEFITS

Each gallon of diesel fuel used in transportation produces about 10,000 grams of CO_2. As discussed in Section b.2, we estimate that each drayage truck and yard tractor replaced with an electric vehicle would otherwise use up to 10,000 gallons of diesel fuel per year, so each vehicle would otherwise produce up to 10,000 grams/gallon x 10,000 gallons = 100 million grams of CO_2 per year. Assuming a reach stacker produces similar emissions, and that the GOT-EVs project results in demonstration seven such regularly-used vehicles, the project will save 700 million grams of CO_2 per year.

7. STATIONARY ENERGY STORAGE SYSTEMS

In addition to the capabilities described in the preceding sections related to electric vehicles, TransPower has industry-leading expertise in the development and manufacturing of stationary battery energy storage systems. Under a recent "Grid-Saver™" contract to the California Energy Commission, TransPower developed and tested stationary battery systems rated at 500 kilowatt-hours (kWh) and 1 megawatt-hour (MWh), the latter of which was tested for nearly one year at Sandia National Laboratory in New Mexico. TransPower is also under contract to build an 800 kWh battery system for use with the New York City subway system by New York City Transit (to be delivered in early 2016) and is negotiating with the Navy for delivery of a 750 kWh system that would reuse batteries originally tested as part of its Grid-Saver™ project. A 1 MWh battery system very similar to these previously-built systems can be installed as part of the GOT-EVs project, either in a portable trailer or in indoor cabinets installed in a terminal building. Figure 18 is a photo of the 1 MWh system built under the Grid-Saver™ project, as installed into a temperature-controlled 45-foot trailer.

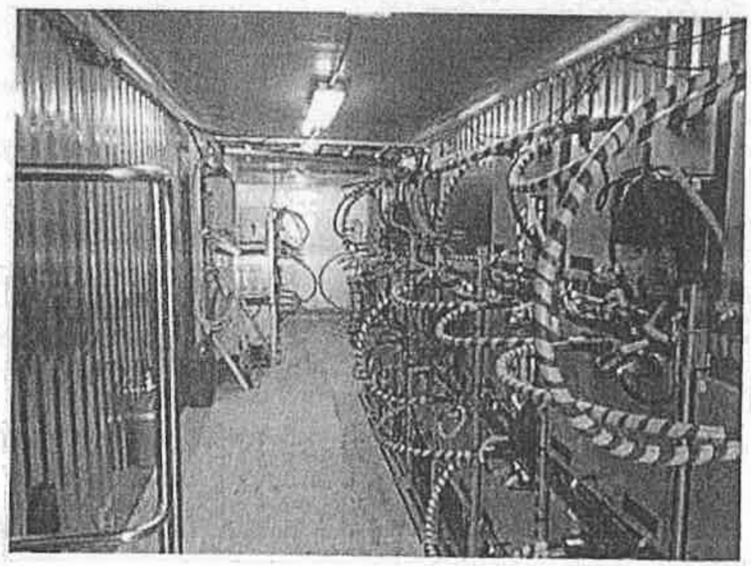


Figure 1. 1 MWh Grid-Saver™ system installed into a 45-foot trailer.

8. PROJECT COSTS

Table 1 is a breakdown of approximate GOT-EVs project costs, assuming deployment of seven vehicles, a 1 MWh stationary energy storage system, and vehicle charging infrastructure at ten different locations around Pasha's terminal. All costs are for turn-key delivery of electric vehicles except for the fork lift costs, which exclude the costs of the base vehicles to be converted (pending final definition of the vehicle models and pricing). For the shuttle bus, two options are provided – one for the retrofit of an existing 40-foot school bus owned by TransPower and one for delivery of a new bus using a higher end 40-foot transit bus chassis. These costs include two years of TransPower on-site support but do not include terminal operator vehicle operating costs such as driver salaries, electricity or natural gas purchases, or fleet operator maintenance costs. It is expected that these costs will be cost-shared by the terminal operator. These estimates are based on actual TransPower out of pocket costs and do not include any profit or fee for TransPower. The zero-profit offer is based on the expectation that TransPower will retain titles to the vehicles it builds and will have the opportunity to earn a profit after the demonstration if Pasha elects to purchase or lease the vehicles on a long-term basis. This cost information is for planning purposes only. Once a final decision is made on which items will be included in the GOT-EVs project, TransPower will refine the appropriate estimates and provide a more formal cost proposal.

Table 1. Preliminary project cost estimates.

Project Element	Non-Recurring Engineering	Recurring Manu-facturing	On-site Support	Total
Electric Yard Tractor #1	$150,000	$375,000	$50,000	$575,000
Electric Yard Tractor #2	0	$375,000	$25,000	$400,000
Electric Drayage Truck #1	0	$425,000	$50,000	$475,000
Electric Drayage Truck #2	0	$425,000	$25,000	$450,000
Electric High Tonnage Fork Lift – *Excluding Base Vehicle*	$100,000	$750,000	$50,000	$900,000
Electric Low Tonnage Fork Lift – *Excluding Base Vehicle*	$300,000	$250,000	$50,000	$600,000
Shuttle Bus – Option A, Existing School Bus Chassis	$100,000	$200,000	$50,000	$350,000
1 MWh Rated Battery Energy Storage System	$250,000	$1,000,000	$0	$1,250,000
Charging Infrastructure – 10 Installations	$100,000	$500,000	$100,000	$700,000
TOTALS (with Shuttle Bus Option A)	**$1,000,000**	**$4,300,000**	**$400,000**	**$5,700,000**
Shuttle Bus – Option B, New Transit Bus Chassis (Incremental Cost over Option A)	$300,000	$550,000	$0	$850,000
TOTALS (with Shuttle Bus Option B)	**$1,300,000**	**$4,850,000**	**$400,000**	**$6,550,000**

9. CONTACT INFORMATION

For additional information related to this proposal, please visit our website, www.transpowerusa.com, or contact:

Mike Simon
President & CEO
TransPower
13000 Danielson Street, Suites A-D
Poway, CA 92064
(858) 248-4255 (office)
(760) 504-3278 (cell)
mike@transpowerusa.com

Matthew Rodriquez
Secretary for Environmental Protection

Air Resources Board

Mary D. Nichols, Chair
1001 I Street • P.O. Box 2815
Sacramento, California 95812 • www.arb.ca.gov

Edmund G. Brown Jr.
Governor

April 12, 2018

Mr. Christopher Cannon
Director of Environmental Management
Los Angeles Harbor Department
425 South Palos Verdes Street
San Pedro, California 90731

Dear Mr. Cannon:

Enclosed for your signature you will find three copies of the Multi-Source Facility Demonstration Project Port of Los Angeles Green Omni Terminal Grant Amendment #2. Grant Number G14-LCTI-08-A2 modifies the project milestones and disbursements schedule along with project schedule, Exhibit B, Attachments I & II, respectively.

Work associated with these funds cannot commence until the grant amendment is fully executed, upon signature by CARB. Once executed, a signed original copy will be returned to the Los Angeles Harbor Department for your files. Please review and sign all three cover sheets and return them along with the grant amendment to:

Darren Nguyen
Cal. Air Resources Board
Mobile Source Control Division
Post Office Box 2815
Sacramento, California 95812

If you have any questions, please contact me at (916) 324-6745 or by email at Darren.Nguyen@arb.ca.gov.

Sincerely,

Darren Nguyen
Air Resources Engineer
Mobile Source Control Division
Enclosure(s) w/o

Cc: Lucina Negrete, Branch Chief
Peter Christensen, Manager