

## APPENDIX B

# DRAFT IMPLEMENTATION MANUAL FOR THE FY 2010-11 CALIFORNIA HYBRID OFF-ROAD EQUIPMENT PILOT PROJECT

DRAFT



*California Environmental Protection Agency*

**AIR RESOURCES BOARD**

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FOR THE CALIFORNIA HYBRID OFF-ROAD EQUIPMENT PILOT PROJECT**

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## 1 INTRODUCTION

In 2007, Governor Schwarzenegger signed into law the *California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007* (AB 118, Statutes of 2007, Chapter 750). AB 118 created the Air Quality Improvement Program (AQIP), a voluntary incentive program administered by the California Air Resources Board (ARB) to fund clean vehicle and equipment projects, air quality research, and/or workforce training. ARB's appropriation for AQIP projects in the FY 2010-11 State Budget is \$40 million. Based on projected revenues for the AQIP in FY 2010-11, ARB estimates about \$30 million will be available for grants.

In June 2010, ARB adopted the AQIP Funding Plan for FY 2010-11 (Funding Plan), which serves as the blueprint for expending FY 2010-11 AQIP funds. The Funding Plan focuses on supporting development and deployment of the advanced technologies needed to meet California's longer-term, post 2020 air quality goals.

The Funding Plan's \$2 million Off-Road Pilot Project helps achieve these long-term goals by helping accelerate deployment of commercialized hybrid construction equipment, as well as testing to determine this equipment's emission benefits. ARB anticipates emissions data and other information learned from this project could provide the foundation for a more comprehensive hybrid equipment voucher project in future AQIP funding years. Project data could also provide a mechanism for fleets to generate credits to demonstrate compliance with ARB's Off-Road Equipment (In-Use) Control Measure (Off-Road Rule). The Off-Road Pilot Project will be administered and implemented through a partnership between ARB and a Grantee or Grantees (Grantee), selected via this competitive ARB Grant Solicitation.

## 2 PROJECT IMPLEMENTATION

### 2.1 Project Timeline

The timeline for Of-Road Pilot Project development and implementation are identified in Table B-1 (below).

**Table B-1:  
Off-Road Pilot Project Development and Implementation Timeline**

Action Item	Date or Time Period
Solicitation for Project Grantee(s)	March – May 2011
Project Grantee(s) selected	June 1, 2011
Implementation Manual finalized. Grantee(s) begin funding and testing equipment.	Summer 2011
Status Report to ARB Project Liaison.	Mid-2011 – Project Completion

The timeline may be changed at ARB's sole discretion.

### 2.2 Equipment Deployment Element

The project deployment element provides funding for up to half the incremental cost of fully commercialized hybrid off-road equipment. This project element will help provide the foundation for growth in the hybrid off-road equipment fleet by spurring initial deployment of commercialized (but more expensive) hybrid equipment and providing fleets with experience using and maintaining this new technology. ARB, Grantee, and participating equipment fleet duties are described in Sections 3.1, 3.2, and 3.3, respectively.

### 2.3 Equipment Testing Element

The goals of the Off-Road Pilot Project testing element are to determine the oxide of nitrogen (NO<sub>x</sub>), particulate matter (PM), total hydrocarbon (THC), carbon monoxide (CO), and carbon dioxide (CO<sub>2</sub>) emission benefits of funded equipment relative to its non-hybrid counterpart. To achieve these goals, the project Grantee must complete the following four tasks:

- 1) Characterize Equipment Activity
- 2) Develop Equipment Test Cycles/Sequences of Operations
- 3) Perform In-Use Emissions Testing
- 4) Perform Data Analysis and Reporting of Results

The Emissions Testing Guidance included Attachment 1 of this Implementation Manual provides minimum requirements for completion of each of these four tasks. Grantee requirements for the Off-Road Pilot Project are included in this Implementation Manual, the Grantee funding application, and the executed Grant Agreement with ARB.

### **3 DUTIES AND REQUIREMENTS**

#### **3.1 Air Resources Board**

ARB is responsible for:

- Selecting the Grantee.
- Development of the Off-Road Pilot Project Implementation Manual, in coordination with the selected Grantee.
- Participating in regular meetings with the Grantee to discuss project refinements and guide project implementation.
- Review and approval of project elements provided by the Grantee, such as Status Reports and fund disbursement requests.
- Distribution of project funds to the Grantee.
- Project oversight and accountability (in conjunction with the Grantee).
- Meet all applicable requirements of statute, the AQIP Guidelines and Funding Plan, the Off-Road Pilot Project Solicitation, the grant agreement with the Grantee, and the Off-Road Pilot Project Implementation Manual.

ARB shall also designate an ARB Project Liaison as the contact person for coordination with the Grantee. The ARB Project Liaison for the FY 2010-11 Off-Road Pilot Project is Mr. Joe Calavita. Mr. Calavita can be reached by e-mail at [jcalavit@arb.ca.gov](mailto:jcalavit@arb.ca.gov) or by telephone at (916) 445-4586.

#### **3.2 Grantee**

The Grantee has three primary project implementation responsibilities – implementation of the equipment deployment element, implementation of the equipment testing and data collection element, and project coordination with, and reporting to, ARB. These responsibilities include but are not limited to the following tasks:

- Develop and implement hybrid equipment deployment and testing as identified in the Off-Road Pilot Project Solicitation and as described in the selected Grantee's project application.
- Develop and implement hybrid equipment testing/data collection, in consultation with ARB, including:
  - Liaison with participating fleets, technology providers, and other partners identified in the Grantee application.
  - Project oversight.
  - Data quality assurance and quality control procedures.
  - Development of protocols describing stakeholder roles and responsibilities.
  - Data collection, evaluation, and reporting to ARB.
- Provide Status Reports to ARB detailing the following:

- Status of funds encumbered and expended for off-road equipment ordered and purchased, respectively.
- Status of off-road equipment monitoring, testing, and or data collection efforts as identified in the Grantee's funding application.
- Provide ARB with an Off-Road Pilot Project Final Report that summarizes and evaluates total fund expenditures (including match and in-kind funds), off-road equipment funded, monitoring, testing and/or data collection results and implementation challenges, and recommends potential project improvements.
- Provide ARB with all data, software or other intellectual property developed or purchased by the Grantee as part of the Off-Road Pilot Project (if requested).
- Ensure that it and its partners or subcontractors meet all applicable requirements of State law, AQIP Guidelines and Funding Plan, this solicitation, the Off-Road Pilot Project Implementation Manual, and the Off-Road Pilot Project grant agreement with ARB.

The project Grantee should have flexibility to refine project parameters in coordination with ARB in response to new information as needed to maximize project effectiveness.

#### Conflict of Interest

The Grantee may have no interest, and shall not acquire any interest, direct or indirect, which will conflict with its ability to impartially complete the project tasks described above. All applicants must disclose any direct or indirect financial interest or situation which may pose an actual, apparent, or potential conflict of interest with its duties at the time of the Off-Road Pilot Project Grantee solicitation. Although applicants are not automatically disqualified due to a potential or appearance of a conflict of interest at the time of the Off-Road Pilot Project Grantee solicitation, ARB may consider the nature and extent of any potential or apparent conflict of interest in evaluating the proposal. The Grantee must immediately advise ARB in writing of any potential new conflicts of interest throughout the grant term.

### **3.3 Participating Equipment Fleets**

California fleets receiving project equipment play a central role in the Off-Road Pilot Project's success. To receive Off-Road Pilot Project equipment, a fleet must:

- Be an individual, business, non-profit, or government entity which is based in California or has a California-based affiliate. An equipment leasing/rental agency based outside of California is also eligible if the equipment is leased/rented to an entity that will meet all applicable project requirements.
- Maintain insurance as required by law. If the purchased equipment is destroyed or otherwise permanently inoperable due to an accident or for any other reason, the Grantee must notify the ARB Project Liaison in writing within two weeks after the equipment becomes inoperable. The written notification must provide proof that the specific funded equipment has become inoperable, including photographs of the inoperable equipment with identifying markings, as well as any applicable insurance or police documentation.

- Commit to operate the equipment 100 percent within California for at least three years after the equipment purchase date.
- Not make or allow any modifications to the equipment's emissions control systems, hardware, software calibrations, or hybrid system. (Vehicle Code Section 27156)
- Be available for follow-up inspection if requested by the Grantee, ARB, or ARB's designee.

The project Grantee must keep written records of the equipment purchased or leased with Off-Road Pilot Project funds – including the equipment invoice, proof of purchase, and equipment lease contract (if applicable) -- for three years after the equipment purchase or lease transaction. The project Grantee must provide ARB or its designee with all requested information related to any equipment purchased with project funds within ten days of ARB's written request for such information. Requested information may include but is not limited to purchase orders or agreements, equipment payment information and related bank records, and purchaser fleet information. A Grantee that submit false information ARB or its designee may be required to return the full equipment funding amount to ARB, and may be excluded from future participation in AQIP projects. In addition, ARB may pursue other remedies available under the law.

## 4 PROJECT ADMINISTRATION

### 4.1 Background

This section defines the respective roles of the ARB and the Grantee in administering the Off-Road Pilot Project.

### 4.2 Disbursement of Project Funding

Funds for equipment deployment, equipment testing, and project administration are to be disbursed based on completion of project tasks as described in Table B-2 (below).

**Table B-2: Off-Road Pilot Project Disbursement Schedule**

<b>Milestone</b>	<b>Project Administration</b>	<b>Deployment Element</b>	<b>Testing Element</b>
1) Sign Grant Agreement	50 percent		
2) Purchase orders for 25 percent of deployment funds		25 percent	
3) Purchase orders for 50 percent of deployment funds		25 percent	
4) Purchase orders for 75 percent of deployment funds and 25 percent of deployment funds expended on delivered equipment		25 percent	
5) Purchase orders for all deployment funds and 50 percent of deployment funds expended on delivered equipment		15 percent	
6) Testing Element Tasks 1 and 2 complete			50 percent
7) Testing Element Tasks 1 and 2 complete AND 25 percent of deployment funds expended on delivered equipment	25 percent		
8) Testing Element Task 3 complete			25 percent
9) Testing Element Task 4 complete			25 percent
10) Final Project Report and fulfillment of all project commitments	25 percent	10 percent	
<b>TOTAL</b>	<b>100 percent</b>	<b>100 percent</b>	<b>100 percent</b>

Deployment element fund disbursements are based on specific hybrid equipment purchase orders and deliveries. For example, ARB will reimburse the Grantee at project start-up for purchase orders associated with the first 50 percent of project deployment funds (Milestones 2 and 3). However, additional disbursements will be made based upon additional purchase orders AND delivery of the vehicles initially ordered (as identified in Milestones 4 and 5). The project deployment and testing milestones identified in Table 2 do not necessarily have to be met in the order identified above. For example, the Grantee would be eligible to receive 50 percent of Testing Element funds once Testing Element Tasks 1 and 2 are complete (Milestone 6), even if all deployment funds have not yet been expended (Milestone 5).

With the exception of the initial 50 percent of administrative funding provided for project start-up, all funding provided to the Project Manager shall be on a reimbursement basis and cost summaries approved by ARB for completed tasks and/or eligible expenses.

Project administration funds are defined as follows:

- Deployment Element: Any funds not included as part of the direct equipment purchase price (including taxes), such as costs for labor, outreach, travel, consultant fees, and indirect costs, are considered administrative costs.
- Testing Element: Administrative costs include those associated with processing, tracking, and oversight, such as labor or consulting fees necessary to compile and submit status reports to ARB, request project funding, etc... Labor, travel, consultant fees, equipment purchase and other costs associated with data collection or evaluation are considered project costs.

Administrative cost summaries shall describe costs for work completed in the following categories: 1) labor expenses (including staff time and total labor costs); 2) external consultant fees for completed work (if applicable); 3) printing, mailing, travel, and other outreach expenses; and 4) indirect costs. Additional administrative cost categories may be provided to ARB if warranted. Documentation substantiating these costs must be maintained by the Grantee and provided to ARB upon request. ARB is required to expend 100 percent of the funds available through this solicitation prior to June 30, 2013.

### **4.3 Accounting of State Funds**

The Grantee must provide ARB with documentation accounting for the proper expenditure of State funds. The documentation must be provided in Status Reports submitted at least every three months to ARB and a Final Report submitted after all equipment and testing/data collection funding has been expended and prior to the Grantee receiving their last disbursement of administrative funding.

#### Status Report

The project Grantee must submit Status Reports to ARB at least every three months containing at a minimum the following information:

- Status of funds encumbered and expended for off-road equipment ordered and purchased, respectively.
- Status of off-road equipment monitoring, testing, and or data collection efforts as identified in the Grantee's funding application.
- Remaining grant funding available
- Identified problems or concerns

The Status Report provides a mechanism for the Grantee to justify a need for an additional project funding increment from ARB. The Status Report must be submitted at least every three months, but may be provided on a monthly or bi-monthly basis if

needed to justify additional funding from ARB. The first Status Report must be submitted three months after the grant agreement is fully executed or when requesting additional disbursement of funds, whichever is sooner.

#### **4.3.1 Final Report**

The Grantee must submit a Final Report to ARB after all project equipment and testing/data collection funding has been expended. This report must document all equipment funded by the program (which may be provided as summaries of previously submitted Status Reports), completion of all project equipment testing and data collection, and fulfillment of all project commitments.

#### **4.4 Intellectual Property**

Any data or other intellectual property developed by the Grantee in the course of administering or implementing the Off-Road Pilot Project are the property of ARB.

#### **4.5 Documentation of Administrative Costs**

Administrative funds shall only be used for costs associated with project implementation related tasks outlined in the AQIP Funding Plan, the project solicitation, the Implementation Manual, or grant agreement with the Grantee. Administrative funds shall be used for project administration and outreach including: Grantee staff time; consultant fees (if pre-approved by ARB); printing, mailing, and travel costs; project monitoring and compliance expenses; and indirect costs such as general administrative services, office space, and telephone services.

The Grantee must maintain documentation of project funds used for administration and outreach, including:

- Personnel documentation must make use of timesheets or other labor tracking software. Duty statements or other documentation may also be used to verify the number of staff and actual hours or percent of time staff devoted to project administration and outreach.
- Fees for external consultants must be documented with copies of the consultant contract and invoices. All external consultant fees must be pre-approved by ARB.
- Printing, mailing, and travel expenses must be documented with receipts and/or invoices.
- Any reimbursement for necessary travel and per diem shall be at rates not to exceed those amounts paid to the State's represented employees. No travel outside the State of California shall be reimbursed unless prior written authorization is obtained from ARB. The State's travel and per diem reimbursement amounts may be found online at <http://www.dpa.ca.gov/personnel-policies/travel/hr-staff.htm>. Reimbursement will be at the State travel and per diem amounts that are current as of the date costs are incurred by the Grantee.
- If indirect costs are used to document project administrative costs funded by the project, the Grantee must have an official written policy regarding calculation of

these costs. The Project Administrator must maintain documentation for all costs referenced in the indirect cost calculation formula.

The above documentation, records, and referenced materials must be made available for review during ARB, or its designee, monitoring visits and audits. These records must be retained for a minimum of three years after submittal of the final Off-Road Pilot Project invoice to ARB.

#### **4.6 In-Kind Services**

The Grantee is encouraged to contribute in-kind services to improve the project's effectiveness, or match funding to increase the number of equipments funded. Funds expended on in-kind services must meet all the requirements of Section 4 of this Implementation Manual and must be documented in the Off-Road Pilot Project Final Report to ARB.

#### **4.7 Match Funding**

Match funding can only be used to increase the number of pieces of project equipment funded, or to increase the direct funding available for project testing. All match funding or equipment funded with match funds must meet the following criteria:

- Funding from other state or federal revenue sources, such as the Carl Moyer Program or other AB 118 programs, may not be counted as match.
- Match funding must meet the same requirements applicable to non-match project funds, and equipments purchased wholly or in part with match funding must meet the same requirements as equipment funded with non-match project funds.

Documentation of match funding expended on eligible equipment or project testing must be retained for a minimum of three years after the match-funding has been expended.

#### **4.8 Earned Interest**

Interest earned by the Grantee or its designee on project funds must be reported to ARB. All interest income on project funds, including equipment, testing, and project administration/outreach funding, must be reinvested in the Off-Road Pilot Project to fund additional equipment or equipment testing. The Grantee is responsible for reporting to ARB on all equipment and equipment testing funded with interest earned on project funds.

The Grantee must maintain accounting records (e.g. general ledger) that tracks interest earned and expended on project funds, as follows:

- The calculation of interest must be based on an average daily balance or some other reasonable and demonstrable method of allocating the proceeds from the interest-generating account back into the program.
- The methodology for tracking earned interest must ensure that it is separately identifiable from interest earned on non-project funds.

- The methodology for calculating earned interest must be consistent with how it is calculated for the Grantee's other fiscal programs.
- Earned interest must be fully expended by June 30, 2013.

Documentation of interest earned on project funds must be retained for a minimum of three years after it is generated.

#### **4.9 Fidelity Bond Insurance**

ARB encourages the Grantee to maintain Fidelity Bond/Crime Insurance coverage for state-owned property or funding in the care, custody, or control of the Grantee. The policy should include as loss payee the California Air Resources Board and provide insurance against loss of Off-Road Pilot Project funding or property due to employee misconduct. Public entities and non-profit agencies may provide either proof of insurance or bond or a letter of self-insurance.

#### **4.10 Records**

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

- Establish an official file for the Off-Road Pilot Project which shall adequately document all significant actions relative to the project.
- Establish separate accounts which will adequately and accurately depict all amounts received and expended on the Off-Road Pilot Project.
- Establish separate accounts which will adequately and accurately depict all income received which is attributable to the Off-Road Pilot Project.
- Establish an accounting system which will adequately depict final total costs of the Off-Road Pilot Project, including both direct and indirect costs.

If the Grantee charges unallowable costs for project administration or outreach, it shall be required to substitute eligible administration and outreach expenses equal to the dollar amount found ineligible, or return the funds for the unallowable cost to the ARB.

#### **4.11 Oversight and Accountability**

ARB has found that project evaluations and program reviews are essential to ensure that incentive program funds are run in accordance with statutory requirements and that State funds are spent transparently and efficiently. The Grantee is responsible for working closely with equipment manufacturers, fleets and ARB to safeguard Off-Road Pilot Project funds from misuse as it implements the Off-Road Pilot Project.

ARB holds the overarching responsibility for Off-Road Pilot Project fund oversight and project accountability and has final authority regarding project parameters. As such, ARB is responsible for monitoring and reviewing the Grantee's implementation of the Off-Road Pilot Project. The Grantee shall allow ARB, the California Bureau of State Audits (BSA), Department of Finance (DOF), or a designated representative the right to review and to copy any records and supporting documentation pertaining to administration or implementation of the Off-Road Pilot Project. The Grantee must

maintain such records for a possible audit for a minimum of three years after final payment from ARB. The Grantee must allow ARB or its designee access to such records during normal business hours and to allow interviews of any employees who might reasonably have information related to such records.

Responsibilities for Off-Road Pilot Project oversight are as follows:

- ARB has primary oversight responsibility for the Off-Road Pilot Project to ensure transparent and efficient implementation, and that AQIP funds are spent consistent with the requirements of statute, the AQIP Guidelines and Funding Plan, the Off-Road Pilot Project solicitation and grant agreement with the Grantee, and this Implementation Manual. ARB reserves the right to conduct a site visit, evaluation, review, or audit the Off-Road Pilot Project for the life of the project grant.
- If the Grantee detects any potentially fraudulent activity by a fleet, partner or other project participant, they shall notify the ARB Project Liaison as soon as possible and work with ARB to determine an appropriate course of action.
- ARB staff or its designees have primary responsibility for conducting project reviews and/or fiscal audits of Off-Road Pilot Project administration and implementation.
- Project fleets, the Grantee, and its subcontractors shall allow ARB, BSA, DOF, or any authorized designee access, during normal business hours, to conduct Off-Road Pilot Project reviews and fiscal audits or other evaluations. Granting of access includes, but is not limited to, reviewing project records, site visits, and other evaluations as needed. Project evaluations or site visits may occur unannounced as ARB staff or its designee deems necessary.

#### Project Non-Performance

ARB or its designee has the authority to recoup Off-Road Pilot Project funds which were received based upon misinformation or fraud, or for which the Grantee or its subcontractors, a dealership, manufacturer, or participating fleet is in significant or continual non-compliance with this Implementation Manual or State law. ARB also retains the authority to prohibit any entity from participating in the Off-Road Pilot Project due to non-compliance with project requirements.

## 5 DEFINITIONS

**“ARB Project Liaison”** for the purposes of this program is the ARB staff person named in this Implementation Manual that serves as the point of contact for coordination with the Off-Road Pilot Project Grantee.

**“Earned interest”** for the purposes of this program means any interest generated from State AQIP funds provided to the Grantee and held in an interest-bearing account.

**“Expend”** for the purpose of this program means the payment of funds on an invoice for an eligible equipment.

**“Grantee”** for the purposes of this program means the entity or entities selected by ARB via competitive solicitation to administer the Off-Road Pilot Project. The Grantee is responsible for ensuring it and its project partners and subcontractors meet all project requirements.

**“Hybrid equipment”** for the purposes of this program means any equipment that can draw propulsion energy from both of the following on-equipment sources of stored energy:

1) consumable fuel, and 2) a rechargeable energy storage system.

**“Incremental cost”** for the purposes of this program means the difference in cost between the new hybrid equipment and the comparable new gasoline or diesel fueled equipment that would be purchased to perform the same function.

**“In-kind services”** for the purposes of this program means payments or contributions made in the form of goods and services, rather than direct monetary contributions.

**“Match funding”** for the purposes of this program means those funds contributed by the Grantee directly to the Off-Road pilot Project for the sole purposes of funding additional equipments or increasing the equipment voucher amount.

**“Non-profit agency”** for the purposes of this program means an agency or corporation that does not distribute corporate income to shareholders and is exempt from federal income taxes under Section 501 of the Internal Revenue Code (26 U.S.C.A. § 501).



**APPENDIX B, ATTACHMENT 1:  
HYBRID OFF-ROAD EQUIPMENT PILOT PROJECT  
DRAFT EMISSIONS TESTING GUIDANCE FOR EQUIPMENT TESTING ELEMENT**

**BACKGROUND**

The AB 118: Hybrid Off-Road Equipment Pilot (Off-Road Pilot) Project provides up to \$2 million to accelerate deployment of commercialized hybrid construction equipment, and for emissions testing to determine the equipment's air quality benefits relative to its non-hybrid counterpart. This Draft Emissions Testing Guidance discusses methods for evaluating hybrid equipment emissions benefits for the purposes of this project. Equipment emission benefits, if validated via the off-Road Pilot Project, may be used to justify a future Air Quality Improvement Program off-road equipment voucher or rebate project and/or extra credit under the Air Resources Board's (ARB's) In-Use Off-Road Equipment Rule.

**OVERVIEW**

The Off-Road Pilot Project consists of four key sequential tasks:

- 1) Characterize Equipment Activity
- 2) Develop Equipment Test Cycles/Sequences of Operations
- 3) Perform In-Use Emissions Testing
- 4) Perform Data Analysis and Reporting of Results

Project Grantee(s) specific emission testing protocol and types of data to be collected will be based upon the project solicitation requirements and the Grantees' project application.

**PROJECT TASKS FOR HYBRID EQUIPMENT EMISSIONS TESTING**

This section describes draft minimum Off-Road Pilot Project data collection and emissions testing requirements.

**1) Characterize Equipment Activity**

In-the-field ("in-use") emissions testing is essential to properly and accurately characterize and compare emissions from both the base case conventional equipment and the hybrid that would replace it. Accurate in-use testing must begin with an adequate characterization of how the equipment is used – its activity. This activity, when distilled and summarized, forms the basis for development of an equipment test cycles/sequence of operations described in Task 2.

Equipment activity data should describe how project equipment typically operates in California. This data can be obtained in two ways – by data-logging project equipment in-the field, and via submission of previously-collected equipment activity data. Data should reflect at least one month of equipment usage during the peak of the usage

season. Monthly downloads of this data from in-use equipment would help substantiate project duty cycle characterization. Generally speaking, the more extensive, comprehensive, and representative the equipment activity data set, the more confidence in the resulting equipment test cycle/sequence of operations.

## 2) Develop Equipment Test Cycles/Sequences of Operations

Development of a reproducible/repeatable test cycle is essential for any type of emissions comparisons. For the purposes of this project, the test cycle is comprised of a structured series of equipment operations, as opposed to the more typical engine speed and torque schedules used for conventional engine dynamometer testing. This contrived test cycle/series of operations must be based upon the actual, typical, in-use, real-world operations ('activity') for that particular equipment category identified in Task One (above). The test cycle/sequence of operations must be demonstrated to be equivalent in terms of the amount of the total amount of work done by the conventional and hybrid equipment to ensure an 'apples to apples' comparison.

ARB staff recognized that this real world testing is inherently not as controlled or repeatable as dynamometer testing. However, sequences of operations (such as amount of dirt moved under certain conditions) can be relatively controlled and, if repeated enough times, can be useful in validating equipment emission reduction benefits. For example, if data indicates project equipment typically pushes dirt forty percent of the time, digs trenches thirty percent of the time, idles ten percent of the time and does a variety of other activities the remainder of the time, the equipment test cycle/series of operations could be based on the three primary equipment functions and the percent of time each is conducted.

## 3) Perform In-Use Emissions Testing

Utilizing the test cycle developed during Task 2, pollutant emissions and engine parameter data must be collected for a total period of at least ten hours. Testing must be conducted in-the-field utilizing an on-board portable emissions measurement system (PEMS) to collect real-time (1 Hz minimum) gaseous and particulate matter (NO<sub>x</sub>, THC, CO, CO<sub>2</sub>, and PM<sub>2.5</sub>) emissions data. On-board PEMS that have been approved for on-road heavy-duty diesel engine in-use compliance purposes (or equivalent) should be utilized for gaseous and PM emissions data collection. While utilization of these 'compliance quality' PEMS is not required, the most responsive bidders will utilize such PEMS. For PEMS that have not been evaluated and/or approved for compliance purposes, supporting information such as comparative data, journal papers, reports, etc. shall be provided to demonstrate the veracity of measurements made with these other systems compared to the federal reference methods.

The ideal comparison would be between hybrid and otherwise identical non-hybrid equipment (i.e., same manufacturer and engine size, horsepower rating, certification tier, etc.) operating simultaneously, side-by-side, performing identical operations over multiple repetitions. At the other extreme would be comparison of dissimilar engines/equipment tested over different operations performed at different times. The former approach would represent a more controlled experiment, while the latter

approach would be considered a random field test and thus be non-responsive to the goals of this project.

ARB recommends that project participants utilize in-the-field procedures that are based upon engine dynamometer testing procedures (i.e. utilizing engine parameter data). Reporting of engine parameter data provide a means of validating that hybrid and base case equipment have been exercised in a similar/comparable manner, and can help to account for differences attributable to the hybrid technology. For example, load factor data can serve as a check to ensure/verify that the base case and hybrid are experiencing approximately the same loads (with the understanding that engine loads are not expected to be identical because of the impacts of energy transfers that result from the use of capacitors, etc.). Project participants should provide real-time (e.g., 1 Hz) engine electronic control unit (ECU) data, such as engine speed and torque/load, fuel rate, etc., as well as fuel delivery rate. In any case, project proposals must explicitly address the questions of determining test-to-test variability for the same piece of equipment, and determining 'equivalency of operations' for the hybrid versus non-hybrid equipment. Both variability and equivalency are critical for making meaningful comparisons. If project participants utilize test methods that deviate significantly from engine test procedures (such as collection and use single data points, no load factors, etc.), they assume sole liability for emissions results that are either ambiguous, and/or problematic to analyze.

During emissions testing, different types of equipment operations must be distinguished from each other (e.g., idling, trenching, moving materials, etc.). Ideally, an observer would record information and data about the different operations using a video recording that could then be paired with emissions data to aid in subsequent data analyses (particularly if in-use ECU data is not collected and provided).

Finally, new engines utilize, or will soon be utilizing, exhaust after-treatment, including diesel particulate filters (DPFs; aka 'periodic trap oxidizer') that require periodic regeneration. For on-road, 2007-compliant engines, regeneration PM emissions can be significant, so in-use emissions testing should capture regeneration event emissions for equipment utilizing a DPF that requires regeneration.

#### 4) Perform Data Analysis and Reporting of Results

This task encompasses both data analyses and reporting of methods, results, and conclusions. The project should identify 'amount of pollutant emissions per amount of material moved', or some other such 'operations-based' metric as well as 'amount of pollutant per unit of time' (g/hour). Other units, such as grams of pollutant per gallon of fuel burned (e.g., g/gal) may also be proposed. The project goal is to determine air pollutant emission benefits (on a percentage basis) of the hybrid equipment relative to its non-hybrid counterpart. These benefits may be identified as a range as needed to reflect uncertainties in the underlying data.

Emissions averages, together with confidence intervals, must be calculated and compared using standard statistical techniques. Emissions comparisons must be demonstrated to be of sufficient statistical-analytical rigor to substantiate the reported

emissions differences between conventional and hybrid equipment - this is a critical requirement.

As mentioned earlier, in-use engine parameter data provides for a more thorough comparison of emissions data. See the graphs below which illustrate real-time, second-by-second engine parameter data collected on-board a wheel loader being operated in the field (Figure 1) and a laboratory engine dynamometer transient test schedule meant to represent engine operation for a skid steer loader (Figure 2). Note that different engine/equipment operations, as inferred by engine speed, can be readily observed, for both the highly-controlled, prescribed laboratory engine speed and torque test schedules, as well as for the less-controlled 'operations defined' in-the-field data. This type of emissions evaluation would be considered "most responsive" to the goals of the Off-Road Pilot Project.

Figure 1: Wheel Loader - Percent Load and Speed

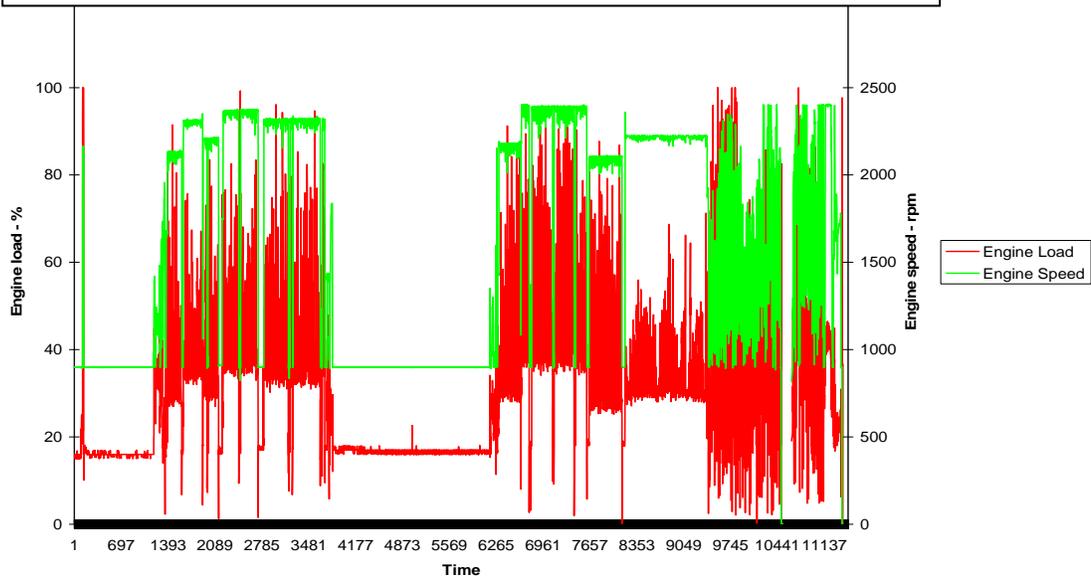


Figure 2: Skid Steer Loader Typical Operation Cycle

