



**CALIFORNIA  
ENERGY COMMISSION**



**California Energy Commission  
December 13, 2023 Business Meeting  
Backup Materials for Agenda Item No 03d:  
FirstElement Fuel, Inc.**

The following backup materials for the above-referenced agenda item are available in this PDF packet as listed below:

1. Proposed Resolution
2. Grant Request Form
3. Scope of Work

**STATE OF CALIFORNIA**  
**STATE ENERGY RESOURCES**  
**CONSERVATION AND DEVELOPMENT COMMISSION**

RESOLUTION: **FirstElement Fuel, Inc.**

**RESOLVED**, that the State Energy Resources Conservation and Development Commission (CEC) adopts the staff CEQA findings contained in the Agreement or Amendment Request Form (as applicable); and

**RESOLVED**, that the CEC approves agreement ZVI-23-004 with FirstElement Fuel, Inc. for a \$3,376,800 grant to develop a high-capacity, improved reliability liquid hydrogen pump system in Alameda County capable of 10 kilogram per minute fills for multiple applications, including light, medium- and heavy-duty on-road vehicles; and

**FURTHER BE IT RESOLVED**, that the Executive Director or their designee shall execute the same on behalf of the CEC.

**CERTIFICATION**

The undersigned Secretariat to the CEC does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the CEC held on December 13, 2023.

AYE:  
NAY:  
ABSENT:  
ABSTAIN:

Dated:

\_\_\_\_\_  
Kristine Banaag  
Secretariat



## GRANT REQUEST FORM (GRF)

### A. New Agreement Number

**IMPORTANT:** New Agreement # to be completed by Contracts, Grants, and Loans Office.

**New Agreement Number:** ZVI-23-004

### B. Division Information

1. Division Name: Fuels and Transportation
2. Agreement Manager: Daniel Siu
3. MS-27
4. Phone Number: 916-908-7483

### C. Recipient's Information

1. Recipient's Legal Name: FirstElement Fuel, Inc.
2. Federal ID Number: 46-4260718

### D. Title of Project

Title of project: High Capacity and Improved Reliability Liquid Hydrogen Pump System

### E. Term and Amount

1. Start Date: 12/13/2023
2. End Date: 10/31/2026
3. Amount: \$3,376,800

### F. Business Meeting Information

1. Are the ARFVTP agreements \$75K and under delegated to Executive Director? No
2. The Proposed Business Meeting Date: 12/13/2023
3. Consent or Discussion? Consent
4. Business Meeting Presenter Name: Daniel Siu
5. Time Needed for Business Meeting: 0 minutes
6. The email subscription topic is: Clean Transportation Program

#### **Agenda Item Subject and Description:**

**FirstElement Fuel, Inc.** Proposed resolution approving agreement ZVI-23-004 with FirstElement Fuel, Inc. for a \$3,376,800 grant to develop a high-capacity, improved reliability liquid hydrogen pump system in Alameda County capable of 10 kilogram per minute fills for multiple applications, including light, medium- and heavy-duty on-road vehicles, and adopting staff's determination that this action is exempt from CEQA.  
(General Fund Funding) Contact: Daniel Siu

### G. California Environmental Quality Act (CEQA) Compliance

#### **1. Is Agreement considered a "Project" under CEQA?**

Yes

If yes, skip to question 2.

If no, complete the following (PRC 21065 and 14 CCR 15378) and explain why Agreement is not considered a "Project":



Agreement will not cause direct physical change in the environment or a reasonably foreseeable indirect physical change in the environment because:

**2. If Agreement is considered a “Project” under CEQA answer the following questions.**

a) Agreement **IS** exempt?

Yes

Statutory Exemption?

No

If yes, list PRC and/or CCR section number(s) and separate each with a comma. If no, enter “None” and go to the next question.

PRC section number: None

CCR section number: None

Categorical Exemption?

Yes

If yes, list CCR section number(s) and separate each with a comma. If no, enter “None” and go to the next question.

CCR section number: tit. 14, sections 15301, 15303

Section 15301 provides that projects which consist of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, and which involve negligible or no expansion of use beyond that existing at the time of the lead agency’s determination, are categorically exempt from the provisions of the California Environmental Quality Act. The proposed project will add equipment to two commercial properties in Livermore and Oakland. The equipment will undergo functional and safety testing at the Livermore site before being moved to Oakland. There will be a 12-month demonstration period at Oakland to collect operational data on the equipment. The Livermore location is heavily industrial and is an approximately 4.5 acre site. The Oakland location is zoned as an “Exempt Public Agency” since it is on East Bay Municipal Utilities District property, and is approximately 4 acres. Construction will be limited to foundation work and piping at both the Livermore and Oakland sites. There will be minor modifications to the existing facilities that do not result in an increase of more than 2,500 square feet. With the equipment installation relatively small, the project falls within section 15301 and will not have a significant effect on the environment.

Section 15303 provides that projects which consist of construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure, are categorically exempt from the provisions of the California Environmental Quality Act. This project will install small new equipment on existing land; the estimated footprint of the test equipment is 14' W x 6' L x 10'H. Thus, only minor modifications are made, only small structures will be installed, and no new grading or paving is necessary. For these reasons, this project will have no significant



impact on the environment and is categorically exempt under 14 CCR Section 15303. The proposed project consists of installation of small new test equipment at an existing hydrogen facility with an estimated total footprint of less than 2,500 square feet, at the site. Therefore, the proposed project falls within section 15303 and will not have a significant effect on the environment.

Common Sense Exemption? 14 CCR 15061 (b) (3)

No

If yes, explain reason why Agreement is exempt under the above section. If no, enter "Not applicable" and go to the next section.

Not Applicable

b) Agreement **IS NOT** exempt.

**IMPORTANT:** consult with the legal office to determine next steps.

No

If yes, answer yes or no to all that applies. If no, list all as "no" and "None" as "yes".

| Additional Documents                   | Applies |
|----------------------------------------|---------|
| Initial Study                          | No      |
| Negative Declaration                   | No      |
| Mitigated Negative Declaration         | No      |
| Environmental Impact Report            | No      |
| Statement of Overriding Considerations | No      |
| None                                   | Yes     |

## H. Subcontractors

List all Subcontractors listed in the Budget (s) (major and minor). Insert additional rows if needed. If no subcontractors to report, enter "No subcontractors to report" and "0" to funds.

**Delete** any unused rows from the table

| Subcontractor Legal Company Name | CEC Funds | Match Funds |
|----------------------------------|-----------|-------------|
| TBD – Site Development           | \$0       | \$200,000   |

## I. Vendors and Sellers for Equipment and Materials/Miscellaneous

List all Vendors and Sellers listed in Budget(s) for Equipment and Materials/Miscellaneous. Insert additional rows if needed. If no vendors or sellers to report, enter "No vendors or sellers to report" and "0" to funds. **Delete** any unused rows from the table.

| Vendor/Seller Legal Company Name                                                | CEC Funds | Match Funds |
|---------------------------------------------------------------------------------|-----------|-------------|
| OZEN ENGINEERING, INC.                                                          | \$55,000  | \$0         |
| GO ENGINEER, INC., WHICH WILL DO BUSINESS IN CALIFORNIA AS GOENGINEER SOLUTIONS | \$10,000  | \$13,001    |



STATE OF CALIFORNIA  
CALIFORNIA ENERGY COMMISSION

Grant Request Form  
CEC-270 (Revised 10/2022)

|                                     |           |           |
|-------------------------------------|-----------|-----------|
| BOSCH REXROTH CORPORATION           | \$700,000 | \$130,000 |
| CRYOWORKS, INC.                     | \$160,000 | \$40,000  |
| Air Water America Inc.              | \$195,000 | \$60,000  |
| BG Mike, LLC                        | \$0       | \$120,000 |
| East Bay Municipal Utility District | \$0       | \$150,000 |
| TBD                                 | \$620,000 | \$50,000  |
| TBD                                 | \$310,000 | \$0       |
| TBD                                 | \$70,000  | \$230,000 |
| TBD                                 | \$0       | \$300,000 |

**J. Key Partners**

List all key partner(s). Insert additional rows if needed. If no key partners to report, enter "No key partners to report." **Delete** any unused rows from the table.

| Key Partner Legal Company Name |
|--------------------------------|
| No key partners to report      |

**K. Budget Information**

Include all budget information. Insert additional rows if needed. If no budget information to report, enter "N/A" for "Not Applicable" and "0" to Amount. **Delete** any unused rows from the table.

| Funding Source | Funding Year of Appropriation | Budget List Number | Amount      |
|----------------|-------------------------------|--------------------|-------------|
| General Fund   | FY 21/22                      | 601.129ZEV         | \$3,376,800 |

**TOTAL Amount:** \$3,376,800

R&D Program Area: Not Applicable

Explanation for "Other" selection Not Applicable

Reimbursement Contract #: Not Applicable

Federal Agreement #: Not Applicable

**L. Recipient's Contact Information**

**1. Recipient's Administrator/Officer**

Name: Stephen Hoffman

Address: 5281 California Ave, Suite 260

City, State, Zip: Irvine, CA 92617

Phone: (949) 933-5678

E-Mail: stephen.hoffmann@fefuel.com



## 2. Recipient's Project Manager

Name: Josh Adams

Address: 660 E. Dyer Rd.

City, State, Zip: Santa Ana, CA 92705

Phone: (609) 694 - 6754

E-Mail: josh.adams@firstelementfuel.com

## M. Selection Process Used

There are three types of selection process. List the one used for this GRF.

| Selection Process                      | Additional Information |
|----------------------------------------|------------------------|
| Competitive Solicitation #             | GFO-22-502             |
| First Come First Served Solicitation # | Not Applicable         |
| Other                                  | Not Applicable         |

## N. Attached Items

1. List all items that should be attached to this GRF by entering "Yes" or "No".

| Item Number | Item Name                                        | Attached |
|-------------|--------------------------------------------------|----------|
| 1           | Exhibit A, Scope of Work/Schedule                | Yes      |
| 2           | Exhibit B, Budget Detail                         | Yes      |
| 3           | CEC 105, Questionnaire for Identifying Conflicts | Yes      |
| 4           | Recipient Resolution                             | No       |
| 5           | Awardee CEQA Documentation                       | Yes      |

### Approved By

Individuals who approve this form must enter their full name and approval date in the MS Word version.

**Agreement Manager:** Daniel Siu

**Approval Date:** 09/28/2023

**Branch Manager:** Elizabeth John

**Approval Date:** 10/06/2023



STATE OF CALIFORNIA  
CALIFORNIA ENERGY COMMISSION

**Deputy Director:** Melanie Vail

**Approval Date:** 11/2/2023

Grant Request Form  
CEC-270 (Revised 10/2022)

**Exhibit A**  
**SCOPE OF WORK**

**TECHNICAL TASK LIST**

| <b>Task #</b> | <b>CPR</b> | <b>Task Name</b>                                                                                                |
|---------------|------------|-----------------------------------------------------------------------------------------------------------------|
| 1             |            | Administration                                                                                                  |
| 2             |            | Engineering Design and Finite Element Modeling (FEM) (FEF Santa Ana Innovation Center)                          |
| 3             |            | Prototype Manufacturing and Assembly                                                                            |
| 4             |            | Hydrogen Safety Plan                                                                                            |
| 5             | X          | Livermore Skunkworks Testing (FEF Hub in Livermore, CA)                                                         |
| 6             | X          | Real HD Truck Fueling Testing (FEF HDV fueling station at East Bay Municipal Utilities District in Oakland, CA) |
| 7             |            | Data Collection and Analysis                                                                                    |
| 8             |            | Project Fact Sheet                                                                                              |

## KEY NAME LIST

| Task # | Key Personnel                                                    | Key Subcontractor(s)                                                                  | Key Partner(s) |
|--------|------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------|
| 1      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown                     |                                                                                       |                |
| 2      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown, John<br>McFarland  |                                                                                       |                |
| 3      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown                     |                                                                                       |                |
| 4      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown                     |                                                                                       |                |
| 5      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown, Gabriel<br>Sanchez |                                                                                       |                |
| 6      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown, Scott<br>Jennings  | TBD - Foundation, electrical<br>power, and H2 piping for test<br>unit at Oakland site |                |
| 7      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown                     |                                                                                       |                |
| 8      | Josh Adams,<br>Ghassan Sleiman,<br>Tim Brown                     |                                                                                       |                |

## GLOSSARY

*Specific terms and acronyms used throughout this scope of work are defined as follows:*

| <b>Term/<br/>Acronym</b> | <b>Definition</b>                   |
|--------------------------|-------------------------------------|
| AB                       | Assembly Bill                       |
| CAD                      | Computer-Aided Design               |
| CAM                      | Commission Agreement Manager        |
| CAO                      | Commission Agreement Officer        |
| CEC                      | California Energy Commission        |
| CFD                      | Computational Fluid Dynamics        |
| CTP                      | Clean Transportation Program        |
| CPR                      | Critical Project Review             |
| EBMUD                    | East Bay Municipal Utility District |
| FEA                      | Finite Element Analysis             |
| FEF                      | FirstElement Fuel, Inc.             |
| FEM                      | Finite Element Modeling             |
| FTD                      | Fuels and Transportation Division   |
| HDV                      | Heavy-Duty Vehicle                  |
| HRS                      | Hydrogen Refueling Station          |
| LDV                      | Light-Duty Vehicle                  |
| LH2                      | Liquid Hydrogen                     |
| OEM                      | Original Equipment Manufacturer     |
| Recipient                | FirstElement Fuel, Inc.             |
| SB                       | Senate Bill                         |
| TRL                      | Technology Readiness Level          |

### Background

The Budget Act of 2021 (Assembly Bill (AB) 128, Ting, Chapter 21, Statutes of 2021, as amended by Senate Bill (SB) 129, Skinner, Chapter 69, Statutes of 2021 and SB 170, Skinner, Chapter 240, Statutes of 2021) appropriated \$785,000,000 from the General Fund to support infrastructure deployments and manufacturing projects for zero-emission light-duty and medium- and heavy-duty (MDHD) vehicles.

On October 3, 2022, the California Energy Commission (CEC) released a Grant Funding Opportunity (GFO) entitled “Innovative Hydrogen Refueling Solutions for Heavy Transport.” This competitive grant solicitation was to develop and demonstrate innovative hydrogen refueling solutions to support the decarbonization of emerging MDHD on-road and off-road vehicle applications, reduce hydrogen delivery and refueling costs, improve reliability, enable higher fill rates, and minimize energy losses. In response to GFO-22-502, the Recipient submitted application #11 which was proposed for funding in the CEC’s Notice of Proposed Awards on May 24, 2023. GFO-22-502 and Recipient’s application are hereby incorporated by reference into this Agreement in their entirety.

In the event of any conflict or inconsistency between the terms of the Solicitation and the terms of the Recipient’s Application, the Solicitation shall control. In the event of any conflict or inconsistency between the Recipient’s Application and the terms of CEC’s Award, CEC’s Award shall control. Similarly, in the event of any conflict or inconsistency between the terms of this Agreement and the Recipient’s Application, the terms of this Agreement shall control.

#### **Problem Statement:**

Liquid hydrogen (LH2) pumping systems with 900 bar output are not available at the capacity required for heavy-duty vehicle (HDV) fueling. The LH2 pumping systems that are available for light-duty vehicle (LDV) fueling are not sufficiently reliable, and the reliability of high-pressure cryogenic pumping equipment deteriorates dramatically as it is scaled based upon FirstElement Fuel’s (FEF) experience. An increase of capacity factor of 4x is required, and an increase of reliability factor of 10x is required from currently available market solutions. The primary barrier to scaling is a precise and fundamental understanding of the following:

- Thermodynamic effects on performance such as volumetric and heat generation effect of two-phase compression and how to route heat transfer for added performance and reduced boil-off.
- Geometric effects and material choice on performance and reliability of dynamic sealing elements and structural elements.
- Process parameter effect on pumping efficiency and related boil-off.
- Multistage coupling effect in two-phase pumping.

These effects are not understood primarily due to limited available scientific knowledge of pumping thermodynamics at these pressures and temperatures, limited ability to instrument systems and test, and limited market availability of components and expertise due to the emerging nature of the industry. To advance the knowledge in this space requires a large budget or a very low-cost source of LH2.

By addressing these barriers and combining the knowledge with FEFs existing understanding of LDV hydrogen refueling station (HRS) and pump operation, FEF will be able to deploy a reliable and high-performing HDV scale HRS at the conclusion of the project.

## **Goals of the Agreement**

The goal of this Agreement is to enable deployment of reliable liquid supplied HRSs for HDVs and leverage the stored thermal energy of the LH2 to facilitate fueling of the gas into the vehicle. This allows for economically viable supply logistics, reasonable footprint of the equipment at the retail site, manageable energy consumption of the equipment performing the refueling, and improved air quality in the regions operating the vehicles.

## **Objectives of the Agreement**

The objectives of this Agreement are to:

1. Pump 30,000 kg of LH2 under real HDV fueling conditions to prove to automotive original equipment manufacturers (OEMs) that hydrogen is ready as a competitive trucking fuel.
2. Fuel 300 – 500 trucks with hydrogen, each in under 12 minutes.
3. Prove that hydrogen losses can be kept below 10% under the demonstration conditions for a 12-month period.
4. Pump at a rate greater than 10 kg/min during fueling.
5. Pump at a final fill pressure of 875 bar.

## **TASK 1 ADMINISTRATION**

### **Task 1.1 Attend Kick-off Meeting**

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement. The Commission Agreement Manager (CAM) shall designate the date and location of this meeting and provide an agenda to the Recipient prior to the meeting.

#### **The Recipient shall:**

- Attend a “Kick-Off” meeting that includes the CAM and may include the Commission Agreement Officer (CAO) and a representative of the CEC Accounting Office. The Recipient shall bring their Project Manager, Agreement Administrator, Accounting Officer, and any others determined necessary by the Recipient or specifically requested by the CAM to this meeting.
- Provide a written statement of project activities that have occurred after the notice of proposed awards but prior to the execution of the agreement using match funds. If none, provide a statement that no work has been completed using match funds prior to the execution of the agreement. All pre-execution match expenditures must conform to the requirements in the Terms and Conditions of this Agreement.
- Discuss the following administrative and technical aspects of this Agreement:
  - Agreement Terms and Conditions
  - Critical Project Review (Task 1.2)
  - Match fund documentation (Task 1.7) No reimbursable work may be done until this documentation is in place.
  - Permit documentation (Task 1.8)

- Subawards needed to carry out project (Task 1.9)
- The CAM's expectations for accomplishing tasks described in the Scope of Work
- An updated Schedule of Products and Due Dates
- Monthly Calls (Task 1.4)
- Quarterly Progress Reports (Task 1.5)
- Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
- Final Report (Task 1.6)

**Recipient Products:**

- Updated Schedule of Products
- Updated List of Match Funds
- Updated List of Permits
- Written Statement of Match Share Activities

**Commission Agreement Manager Product:**

- Kick-Off Meeting Agenda

**Task 1.2 Critical Project Review (CPR) Meetings**

CPRs provide the opportunity for frank discussions between the CEC and the Recipient. The goal of this task is to determine if the project should continue to receive CEC funding to complete this Agreement and to identify any needed modifications to the tasks, products, schedule or budget.

The CAM may schedule CPR meetings as necessary, and meeting costs will be borne by the Recipient.

Meeting participants include the CAM and the Recipient and may include the CAO, the Fuels and Transportation Division (FTD) program lead, other CEC staff and Management as well as other individuals selected by the CAM to provide support to the CEC.

**The CAM shall:**

- Determine the location, date, and time of each CPR meeting with the Recipient. These meetings generally take place at the CEC, but they may take place at another location or remotely.
- Send the Recipient the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. Prepare a schedule for providing the written determination described below.

- Determine whether to continue the project, and if continuing, whether or not modifications are needed to the tasks, schedule, products, and/or budget for the remainder of the Agreement. Modifications to the Agreement may require a formal amendment (please see section 8 of the Terms and Conditions). If the CAM concludes that satisfactory progress is not being made, this conclusion will be referred to the Lead Commissioner for Transportation for his or her concurrence.
- Provide the Recipient with a written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more product(s) that were included in the CPR.

**The Recipient shall:**

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other products identified in this scope of work. The Recipient shall submit these documents to the CAM and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

**CAM Products:**

- Agenda and a list of expected participants
- Schedule for written determination
- Written determination

**Recipient Product:**

- CPR Report(s)

**Task 1.3 Final Meeting**

The goal of this task is to closeout this Agreement.

**The Recipient shall:**

- Meet with CEC staff to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

This meeting will be attended by, at a minimum, the Recipient and the CAM. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the CAM.

The technical portion of the meeting shall present an assessment of the degree to which project and task goals and objectives were achieved, findings, conclusions, recommended next steps (if any) for the Agreement, and recommendations for improvements. The CAM will determine the appropriate meeting participants.

The administrative portion of the meeting shall be a discussion with the CAM about the following Agreement closeout items:

- What to do with any equipment purchased with CEC funds (Options)

- CEC request for specific “generated” data (not already provided in Agreement products)
- Need to document Recipient’s disclosure of “subject inventions” developed under the Agreement, if applicable
- “Surviving” Agreement provisions
- Final invoicing and release of retention
- Prepare a schedule for completing the closeout activities for this Agreement.

**Products:**

- Written documentation of meeting agreements
- Schedule for completing closeout activities

**Task 1.4 Monthly Calls**

The goal of this task is to have calls at least monthly between CAM and Recipient to verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement on time and within budget.

The objectives of this task are to verbally summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, to verify match funds are being proportionally spent concurrently or in advance of CEC funds or are being spent in accordance with an approved Match Funding Spending Plan, to form the basis for determining whether invoices are consistent with work performed, and to answer any other questions from the CAM. Monthly calls might not be held on those months when a quarterly progress report is submitted, or the CAM determines that a monthly call is unnecessary.

**The CAM shall:**

- Schedule monthly calls.
- Provide questions to the Recipient prior to the monthly call.
- Provide call summary notes to Recipient of items discussed during call.

**The Recipient shall:**

- Review the questions provided by CAM prior to the monthly call
- Provide verbal answers to the CAM during the call.

**Product:**

- Email to CAM concurring with call summary notes.

**Task 1.5 Quarterly Progress Reports**

The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the objectives of this Agreement on time and within budget.

The objectives of this task are to summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, and to form the basis for determining whether invoices are consistent with work performed.

**The Recipient shall:**

- Prepare a Quarterly Progress Report which summarizes all Agreement activities conducted by the Recipient for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Progress reports are due to the CAM the 10<sup>th</sup> day of each January, April, July, and October. The Quarterly Progress Report template can be found on the ECAMS Resources webpage available at <https://www.energy.ca.gov/media/4691>.

**Product:**

- Quarterly Progress Reports

**Task 1.6 Final Report**

The goal of the Final Report is to assess the project's success in achieving the Agreement's goals and objectives, advancing science and technology, and providing energy-related and other benefits to California.

The objectives of the Final Report are to clearly and completely describe the project's purpose, approach, activities performed, results, and advancements in science and technology; to present a public assessment of the success of the project as measured by the degree to which goals and objectives were achieved; to make insightful observations based on results obtained; to draw conclusions; and to make recommendations for further projects and improvements to the FTD project management processes.

The Final Report shall be a public document and is limited to 25-pages. If the Recipient has obtained confidential status from the CEC and will be preparing a confidential version of the Final Report as well, the Recipient shall perform the following activities for both the public and confidential versions of the Final Report.

In addition to any other applicable requirements, the Final Report must comply with the Americans with Disabilities Act (ADA) of 1990 (42 U.S.C. 12101 et seq.), which prohibits discrimination on the basis of disability; all applicable regulations and guidelines issued pursuant to the ADA; Cal. Gov. Code sects. 7405 and 11135; and Web Content Accessibility Guidelines 2.0, or a subsequent version, as published by the Web Accessibility Initiative of the World Wide Web Consortium at a minimum Level AA success criteria.

**The Recipient shall:**

- Prepare an Outline of the Final Report.
- Prepare a Final Report complying with ADA requirements and following the latest version of the Final Report guidelines which will be provided by the CAM. The CAM shall provide written comments on the Draft Final Report within fifteen (15) working

days of receipt. The Final Report must be completed at least 60 days before the end of the Agreement Term.

- Submit Final Report in Microsoft Word format or similar electronic format as approved by the CAM.

**Products:**

- Outline of the Final Report
- Draft Final Report
- Final Report

**Task 1.7 Identify and Obtain Matching Funds**

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. Although the CEC budget for this task will be zero dollars, the Recipient may utilize match funds for this task. Match funds must be identified in writing and the associated commitments obtained before the Recipient can incur any costs for which the Recipient will request reimbursement.

**The Recipient shall:**

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the CAM at least 2 working days prior to the kick-off meeting. If no match funds were part of the proposal that led to the CEC awarding this Agreement and none have been identified at the time this Agreement starts, then state such in the letter. If match funds were a part of the proposal that led to the CEC awarding this Agreement, then provide in the letter a list of the match funds that identifies the:
  - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
  - Amount of each in-kind contribution, a description, documented market or book value, and its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured. For match funds provided by a grant a copy of the executed grant shall be submitted in place of a letter of commitment.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the CAM if during the course of the Agreement additional match funds are received.

- Notify the CAM within 10 days if during the course of the Agreement existing match funds are reduced. Reduction in match funds must be approved through a formal amendment to the Agreement and may trigger an additional CPR meeting.

**Products:**

- A letter regarding match funds or stating that no match funds are provided
- Copy(ies) of each match fund commitment letter(s) (if applicable)
- Letter(s) for new match funds (if applicable)
- Letter that match funds were reduced (if applicable)

**Task 1.8 Identify and Obtain Required Permits**

The goal of this task is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track.

Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement. Although the CEC budget for this task will be zero dollars, the Recipient may budget match funds for any expected expenditures associated with obtaining permits. Permits must be identified in writing and obtained before the Recipient can make any expenditure for which a permit is required.

**The Recipient shall:**

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the CAM at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:
  - A list of the permits that identifies the:
    - Type of permit
    - Name, address and telephone number of the permitting jurisdictions or lead agencies
  - The schedule the Recipient will follow in applying for and obtaining these permits.
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the CAM.
- As permits are obtained, send a copy of each approved permit to the CAM.

- If during the course of the Agreement permits are not obtained on time or are denied, notify the CAM within 5 working days. Either of these events may trigger an additional CPR.

**Products:**

- Letter documenting the permits or stating that no permits are required
- A copy of each approved permit (if applicable)
- Updated list of permits as they change during the term of the Agreement (if applicable)
- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable)
- A copy of each final approved permit (if applicable)

**Task 1.9 Obtain and Execute Subawards**

The goal of this task is to ensure quality products and to procure subrecipients required to carry out the tasks under this Agreement consistent with the Agreement Terms and Conditions and the Recipient's own procurement policies and procedures.

**The Recipient shall:**

- Manage and coordinate subrecipient activities.
- If requested by the CAM, submit a draft of each subaward required to conduct the work under this Agreement to the CAM for review.
- If requested by the CAM, submit a final copy of the executed subaward.
- If Recipient intends to add new subrecipients or change subrecipients, then the Recipient shall notify the CAM.

**Products:**

- Letter describing the subawards needed, or stating that no subawards are required
- Draft subcontracts (if requested)
- Final subcontracts (if requested)

**TECHNICAL TASKS**

**TASK 2 ENGINEERING DESIGN AND FINITE ELEMENT MODELING (FEM)  
(FEF SANTA ANA INNOVATION CENTER)**

The goal of this task is to simulate the pump and integration concept by building and utilizing computer models to verify the assumptions around performance, followed by design and engineering of a two-stage decoupled high pressure cryopump for liquid to gaseous hydrogen fueling, which meets the project specifications and can be manufactured in the time and for the cost allotted.

**The Recipient shall:**

- Complete a dynamic simulation of the conceptual design. The results should include, but are not limited to pressure, temperature, and density plots at five varied process points in the spectrum of the potential interstage operating envelope. The results should include, but are not limited to heat generated from pumping work and flow friction as well as assumed mechanical friction and external heat ingress.
- Complete a configuration study of the pump and vessel integration. The results should include, but are not limited to detailed heat flow graphics at steady state operation of the pump stages and resulting boil-off.
- Complete computer-aided design (CAD) drawings of the pump stages, drives, structural elements, and connections.
- Complete a pump computational fluid dynamics (CFD) analysis of all relevant components. The results should include, but are not limited to velocity plots, temperature plots, pressure plots, and density plots throughout the flow path from inlet to full pressure discharge at steady state and at transient states.
- Complete a pump finite element analysis (FEA) of all relevant components. The results should include, but are not limited to peak mechanical stress in critical pressure bearing components at cryogenic conditions and full pressure combined with structural induced loading from assembly and operation. Fatigue analysis of relevant components is also required.
- Complete pump drive specifications and commercial quotation with terms. The results should include, but are not limited to load profiles, durability requirements, energy requirements, heat rejection rate and method requirements, documentation requirements, aftermarket parts and service availability requirements. The result should also include, but are not limited to a guaranteed cost of the units and a guaranteed availability of equipment for a period of 10 or more years.
- Complete pump materials compatibility and reliability analysis. The results should include, but are not limited to validated references of material usage in LH2 service under similar conditions, assertion of viability from accredited material scientists, and failure mode analysis of pumps and sub-assemblies.
- Complete safety and code compliance calculations.
- Complete pump manufacturability analysis/confirmation. The results should include, but are not limited to firm quotations for component manufacture, detailed process review documents from experienced manufacturers, re-deployment of existing component designs, or sign-off from manufacturing director for FEF.
- Complete field repairability analysis/confirmation. The results should include, but are not limited to sign-off from operations director for FEF cryopump driven HRS.
- Specify instrumentation and data collection methods for test pump.
- Develop controls and power plan for Livermore and Oakland test site.

- Develop pump test plan for Livermore and Oakland test site. The results should include, but are not limited to operating profiles and number of cycles to test, duration of tests in hours, worst case operating condition evaluation, and test to failure requirements.
- Complete a *Conclusion Report* summarizing the design, analysis, compliance calculations, instrumentation, and data collection specifications listed above, and provide a copy to the CAM.
- Finalize the designs entirely through dynamic iteration of all sub-tasks to completion. The results should include, but are not limited to a final bill of material and a final set of drawings for manufacture of the components for prototype. Provide a copy of *Final Bill of Materials and Final Set of Drawings for Prototype Pump* to CAM.

**Products:**

- Conclusion Report
- Copy of Final Bill of Materials and Final Set of Drawings for Prototype Pump

### **TASK 3 PROTOTYPE MANUFACTURING AND ASSEMBLY**

The goal of this task is to produce a complete prototype which can be tested, and produce multiple iterations of low risk elements to enable rapid exchange and continuation of testing of a new unit following a failure. In this way learnings from failed tests can be capitalized through redesign and manufacture in parallel with continued testing of another configuration which carries high probability of leading to further insight.

**The Recipient shall:**

- Procure material, specialized tooling, and prototype drive unit.
- Perform milling and forming operations on all parts at FEF Santa Ana Prototype Facility.
- Perform metrology and quality inspection at FEF Santa Ana Metrology Laboratory. The results should include, but are not limited to inspection documents and material certifications for all pressure bearing components. Prepare a *Metrology Conclusion Report* and submit a copy to the CAM.
- Perform assembly at FEF Santa Ana Repair and Assembly Works. The results should include, but are not limited to detailed notes on deviations and general observations.
- Complete bench testing and assembly verification of pump and drive at FEF Santa Ana Repair and Assembly Works. The results should include, but are not limited to bench test pass/fail or qualitative result recordings. Prepare a *Bench Testing Conclusion Report* and submit a copy to the CAM.
- Provide at least six (6) *high quality digital photographs* of pump and drive set assembled at FEF Santa Ana Repair and Assembly Works.

- Execute logistics to Livermore Skunkworks test facility.

**Products:**

- Metrology Conclusion Report
- Bench Testing Conclusion Report
- High quality digital photographs of pump and drive set

**TASK 4 HYDROGEN SAFETY PLAN**

The goal of this task is to develop a Hydrogen Safety Plan for the project's hydrogen fueling infrastructure at the Oakland site that will consist of a heavily instrumented and decoupled two-stage pumping system for testing. This Hydrogen Safety Plan will demonstrate that hydrogen safety has been incorporated into project planning and execution and ensure appropriate procedures are in place to safely operate hydrogen technologies.

**The Recipient shall:**

- Prepare the Preliminary Hydrogen Safety Plan. The Preliminary Hydrogen Safety Plan shall include, but is not limited to:
  - A description of the technologies to be operated
  - The Project Team's approach to ensure safe operation of all hydrogen technologies
  - Results of a functional hazard analysis to be conducted by the Project Team
  - A conformity plan for relevant codes and standards
  - The Project Team's safety reporting policies and procedures
  - A detailed description about how the Project Team will provide safety training for the hydrogen fueling infrastructure's initial operation and safety training for all operators
- Submit the Preliminary Hydrogen Safety Plan for review by the Pacific Northwest National Laboratory (PNNL) Hydrogen Safety Panel (HSP).
- Receive the *PNNL HSP's assessment* and provide a copy to the CAM.
- Evaluate the PNNL HSP's comments and determine how to address them in the final plan.
- Prepare a *memo* on how the PNNL HSP's comments will be addressed and provide a copy to the CAM.
- Incorporate feedback from PNNL HSP into the Final Hydrogen Safety Plan.
- Submit the Final Hydrogen Safety Plan to the PNNL HSP.
- Submit *written notification* of submission of the Final Hydrogen Safety Plan to the PNNL HSP to the CAM.
- Complete a hydrogen safety design review.
- Report unintended hydrogen releases to the Certified Unified Program Agency (CUPA) and the CAM.
- Report safety incidents.

**Products:**

- Copy of PNNL HSP's assessment of the Preliminary Hydrogen Safety Plan
- Memo describing how the PNNL HSP's comments will be addressed in the Final Hydrogen Safety Plan
- Written notification of submission of the Final Hydrogen Safety Plan to PNNL HSP
- Safety Incident Report(s) using the NREL Data Collection Tool (if and when applicable)

**TASK 5 LIVERMORE SKUNKWORKS TESTING (FEF HUB IN LIVERMORE, CA)**

The goal of this task is to operate the prototype units under the specified conditions for the specified duration, or until failure; record all operational data and thoroughly document failure conditions; and iterate on the design to facilitate successful operation at an accelerated rate by leveraging FEF internal design and manufacturing at Santa Ana, CA.

**The Recipient shall:**

- Complete CAD drawings of the pump test system including process, hardware, and site schematics. The results should include, but are not limited to a system level design which will enable safe pump operation at the specified conditions and duration specified in the test plan developed in task 2.
- Complete site preparation work at Livermore. The results should include, but are not limited to an area where the pump and vessel can be installed and connected to hydrogen lines and power.
- Complete mechanical and electrical installation. The results should include, but are not limited to the pump installed and connected to hydrogen lines, power, and instrumentation.
- Perform functional and safety tests on pump and local system. The results should include, but are not limited to a report with a completed checklist demonstrating thorough evaluation of relevant pump functions as well as safety functions and interlocks. Complete *Conclusion Report of Pump Functionality and Safety Tests* and submit a copy to the CAM.
- Provide at least (6) six *high quality digital photographs* of pump installed at FEF Livermore Skunkworks Test Facility.
- Execute the test plan and record the results. The results should include, but are not limited to a report showing pressures, temperatures, mass flow, power consumption, and boil-off during steady operation and transient periods. Complete *Conclusion Report of Pump Testing* that shall include but is not limited to key metrics of capacity, boil-off, electrical consumption, and longevity and submit a copy to the CAM.

**Products:**

- High quality digital photographs of pump installed at FEF Livermore Skunkworks Test Facility
- Conclusion Report of Pump Functionality and Safety Tests
- Conclusion Report of Pump Testing

**[CPR WILL OCCUR DURING THIS TASK. See Task 1.2 for details.]**

**TASK 6 REAL HD TRUCK FUELING TESTING (FEF HDV FUELING STATION AT EBMUD IN OAKLAND, CA)**

The goal of this task is to fuel heavy-duty (HD) trucks with the pump in under 12 minutes, or until failure and repeat for the duration of the 12-month demonstration period. Record all operational data and thoroughly document failure conditions. Iterate the design to achieve technology readiness level (TRL) 7 for the pump technology by the conclusion of the task while meeting the key performance metrics related to capacity, reliability and run time.

**The Recipient shall:**

- Complete engineering design of pilot pump HDV fueling installation. The results should include, but are not limited to a system level design which will enable safe pump operation at the specified conditions and duration specified in the test plan developed in task 2. Provide *CAD drawings* of the pilot pump test system including process, hardware, and site schematics to the CAM.
- Complete site preparation work at Oakland. The results should include, but are not limited to an area where the pump and vessel can be installed and connected to hydrogen lines and power.
- Complete mechanical and electrical installation. The results should include, but are not limited to the pump installed and connected to hydrogen lines, power, and instrumentation.
- Provide at least six (6) *high quality digital photographs* of pump set installed at Oakland EBMUD HDV Fueling Facility to the CAM.
- Perform functional and safety tests on pump and local system. The results should include, but are not limited to a report with a completed checklist demonstrating thorough evaluation of relevant pump functions as well as safety functions and interlocks.
- Execute the test plan over a minimum of 12 months in real fueling operations and record the results. Compare the performance results against the key metrics. The task results should include, but are not limited to a report showing pressures, temperatures, mass flow, power consumption, and boil-off during steady operation, transient, and idle periods.

- Maintain multiple prototype pumps so as to with best effort enable continued fueling operations for the entire 12 months period. Pumps can be swapped within 24 hours if a replacement is available.
- Generate detailed root cause failure reports, and iterate the design to mature the pump technology to TRL 7 during the 12 months of operation.
- Complete Conclusion Report of Pump Testing including key metrics of capacity compared to fueling requirements, boil-off, electrical consumption, and longevity. Conclude pass / fail conclusion on key metrics:
  - Capacity > 10 kg/minute continuous capability
  - H<sub>2</sub> losses < 10% during 24 hours of operation in real HDV fueling
  - Run time without rebuild > 100h or 30,000kg pumped in real fueling
- Provide a copy of the *Conclusion Report of Pump Testing* to the CAM.

#### **Products:**

- CAD drawings of the pilot pump test system including process, hardware, and site schematics
- High quality digital photographs of pump set installed at Oakland EBMUD HDV Fueling Facility
- Conclusion Report of Pump Testing

**[CPR WILL OCCUR DURING THIS TASK. See Task 1.2 for details.]**

### **TASK 7 DATA COLLECTION AND ANALYSIS**

The goal of this task is to collect operational data from the project and to analyze that data for economic and environmental impacts.

#### **The Recipient shall:**

- Develop data collection test plan and/or submit the *NREL Data Collection Tool* (Exhibit XX) once the hydrogen refueling station becomes operational and continue to do so every quarter until the end of the agreement.
- Perform and submit results of purity using hydrogen collected, at the nozzle for each hose at each open retail station. Purity tests for the station will be performed:
  - at the time the station becomes operational
  - every six months after the station becomes operational during the approved term of this agreement; and,
  - as needed when the hydrogen lines are potentially exposed to contamination due to maintenance or other activity.
- Hydrogen purity readings shall be collected according to CCR Title 4 Business Regulations, Division 9 Measurement Standards, Chapter 6 Automotive Products Specifications, Article 8 Specifications for Hydrogen Used in Internal Combustion Engines and Fuel Cells, Sections 4180 and 4181.

- Troubleshoot any issues identified.
- Collect and provide the following data:
  - Number, type, date and location of hydrogen refueling stations installed.
  - Nameplate capacity of the installed equipment, in kg/day for hydrogen.
  - Location type, such as street, parking lot, hotel, restaurant or multi-unit housing.
  - Total cost per refueling station, the subsidy from the CEC per refueling station, federal subsidy per refueling station, utility subsidy per refueling station, and privately funded share per refueling station.
- Collect and provide 12 months of throughput, usage, and operations data from the project including, but not limited to:
  - Number of refueling sessions
  - Average refueling station downtime
  - Average session duration
  - Average kg dispensed
  - Types of vehicles using the refueling equipment
  - Applicable retail price for hydrogen fuel
  - Payment method for public refueling, if applicable
  - Maximum capacity of the new fueling system
  - Normal operating hours, up time, downtime, and explanations of variations
  - Gallons of gasoline and/or diesel fuel displaced (with associated mileage information)
  - Expected air emissions reduction, for example:
    - Non-methane hydrocarbons
    - Oxides of nitrogen
    - Particulate Matter
    - Formaldehyde
  - Duty cycle of the current fleet and the expected duty cycle of future vehicle acquisitions
- Identify any current and planned use of renewable energy at the facility.
- Identify the source of the hydrogen using the Renewable Hydrogen Report (Exhibit XX) template.
- Comply with the Petroleum Industry Information Reporting Act (PIIRA) and complete the [CEC Form A15](#) on an annual basis for submission to the CEC's PIIRA Data Collection Unit (<https://a15.energy.ca.gov/>).

- Describe any energy efficiency measures used in the facility that may exceed Title 24 standards in Part 6 of the California Code Regulations.
- Provide data on potential job creation, economic development, and increased state revenue as a result of expected future expansion.
- Provide a quantified estimate of the project's carbon intensity values for life-cycle greenhouse gas emissions and explain the approved Low Carbon Fuel Standard pathway used.
- Compare any project performance and expectations provided in the proposal to CEC with actual project performance and accomplishments.
- Provide a *Data Collection and Information Analysis Report* that lists and analyzes all data and information described above that is not provided in another specified product.

**Products:**

- Quarterly NREL Data Collection Tool
- Initial, biannual, and as needed hydrogen purity test results
- Biannual Renewable Hydrogen Report
- Data on refueling events will be submitted electronically in Quarterly Progress Reports
- Data Collection and Information Analysis Report

## **TASK 8 PROJECT FACT SHEET**

The goal of this task is to develop an initial and final project fact sheet that describes the CEC-funded project and the benefits resulting from the project for the public and key decision makers.

**The Recipient shall:**

- Prepare an *Initial Project Fact Sheet* at start of the project that describes the project and the expected benefits. Use the format provided by the CAM.
- Prepare a *Final Project Fact Sheet* at the project's conclusion that describes the project, the actual benefits resulting from the project, and lessons learned from implementing the project. Use the format provided by the CAM.
- Provide at least (6) six *High Quality Digital Photographs* (minimum resolution of 1300x500 pixels in landscape ratio) of pre and post technology installation at the project sites or related project photographs.

**Products:**

- Initial Project Fact Sheet
- Final Project Fact Sheet
- High Quality Digital Photographs