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ALPHARETTA, GA 30022
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www.crcao.org

May 3, 2011
In reply, refer to:
CRC Project No. CM-137-11-1

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for a **Review to Determine the Benefits of Increasing Octane Number on Gasoline Engine Efficiency** (CRC Project No. CM-137-11-1). A description of the project is presented in Exhibit A, "Statement of Work." This request for proposal is being issued in anticipation of funding being available in the near future.

Please indicate by letter, fax, or email by **May 13, 2011** whether or not you or your organization intends to submit a written proposal for this research program. CRC will answer technical questions regarding the Request for Proposal if they are submitted in writing. CRC will then return written answers to all of the bidders, along with a copy of the original questions.

A CRC technical group composed of industry and government representatives will evaluate your proposal. CRC reserves the right to accept or reject any or all proposals.

The reporting requirements will be monthly progress reports and a summary technical report at the end of the contractual period. The reporting requirements are described in more detail in the attachment entitled "Reports" (Exhibit B).

The proposal must be submitted as two separate documents. The technical approach to the problem will be described in part one and a cost breakdown that is priced by task will be described in part two. The cost proposal document should include all costs associated with conducting the proposed program. The technical proposal shall not be longer than 25 pages in length.

CRC expects to negotiate a fixed price contract for the research program.

Contract language for intellectual property and liability clauses is presented in Exhibit C and in Exhibit D, respectively. Bidders are also advised that government funds may be used to support the research, and therefore certain government contract terms and conditions may apply.

Important selection factors to be taken into account are listed in Exhibit E. CRC evaluation procedures require the technical group to complete a thorough technical evaluation before considering costs. After developing a recommendation based on technical considerations, the costs are revealed and the recommendation is modified as needed.

Thirty (30) copies of the technical proposal and three (3) copies of the cost proposal (or one each electronic-copy) should be submitted to:

Brent K. Bailey
Coordinating Research Council
3650 Mansell Road, Suite 140
Alpharetta, GA 30022

Phone: 678-795-0506
Fax: 678-795-0509
E-mail: bkbailey@crcao.org

The deadline for receipt of your proposal is **June 3, 2011.**

Yours truly,

Brent K. Bailey
Executive Director

EXHIBIT A

STATEMENT OF WORK

Review to Determine the Benefits of Increasing Octane Number on Gasoline Engine Efficiency

Background: There is increasing interest in energy use, greenhouse gas emissions (GHG) emissions and efficiency from the use of transportation fuels. A life-cycle or well-to-wheels analysis takes into account the actual production of fuels as well as the use of the fuel in the engine to estimate total GHG. This study and analysis will focus on understanding the response of light duty automotive spark ignition engine efficiency to changes to fuel octane number. In addition, the response of engine efficiency to the use of biofuels into gasoline beyond the octane number effect would be of interest as would other fuel properties. In addition to the efficiency response, changes in criteria emissions and engine hardware (etc...) should be noted. It is also of interest to identify how the change in octane number was obtained.

There exist previous studies and theories discussing the impact of changing octane number. The intent of this work is to compile and summarize all of this understanding as well as to include the effects of gasoline octane number as it may relate to advance engine technology used to increase efficiency. Efficiency is ideally being defined on an energy basis, that is, the energy delivered at the crankshaft of the engine divided by the energy of the fuel consumed. It is realized that this information may not always be available, so that other approximate measures of efficiency such as crankshaft energy per volume of fuel (for engines) or distance per volume of fuel (for vehicles) would be acceptable. Fuels containing increased levels of octane number have shown the ability to improve engine efficiency, leading to increased fuel economy and reduced need for enrichment. In addition, it is important to demonstrate the ability to incorporate in-house understanding of advanced engine technology response to increased octane number in gasoline.

Ultimately, assessing the impact of fuel octane number across the entire vehicle fleet will require the use of a modeling approach and the determination of average effects.

There is particular interest to understand the effects of gasoline-renewable fuel blends (oxygenates) on engine efficiency including effects that may be associated with other fuel properties. Since the passage of the Energy and Independence Act of 2007, there is increased pressure to use oxygenated renewable fuels, with ethanol presently being the biofuel of choice, to satisfy calendar year mandated volumes. According to recent fuel surveys, nearly every gallon of gasoline across the United States contains some amount of ethanol, typically at 10% by volume or E10. In addition, the U.S. Environmental Protection Agency (EPA) approved the use of 15% ethanol (known as E15) for model year vehicles 2001 and newer. Thus, incorporating an understanding of how gasoline-ethanol blends (oxygenates) can be best used to enhance or optimize gasoline formulations to achieve a synergistic improvement in engine efficiency would be seen to add value to this study.

Objective: Conduct a broad and comprehensive literature review to determine the effects of gasoline octane number on light duty spark ignition engine efficiency – create a comprehensive database using the collected information.

1. Primary Questions

(1) How much of a change in gasoline octane number would be required to raise a spark-ignited base engine compression ratio (CR) by one CR (CR/Octane Number) for the three levels of engine technology – "traditional," "advanced," and "future." *(Engine categories defined in Task 1.)*
    - From an assumed base CR level for each technology, report the Octane Number increase required to increase CR by 1, 2 and 3 units (Octane Number / CR)
    - What are these compression ratio changes worth in terms of engine efficiency (% BTE/CR)?
    - Consider any non-linearity in both the CR response to Octane Number and in efficiency to CR.

(2) Changing gasoline octane number may enable engine modifications other than increasing CR that could increase engine efficiency, such as more spark advance or increased boost pressure. Is there evidence of these other changes in the literature, either used alone or in combination with CR changes?
    - What are these alternative approaches worth in engine efficiency?

2. Furthermore, differentiate the octane number effects according to fuel formulation changes due to: hydrocarbon type, metallic additives and renewable fuel (e.g. alcohol type).
3. More generally, determine the effect of gasoline octane number on light duty spark ignition engine efficiency according to the Tasks outlined below.
4. Identify gaps and provide recommendations to improve the understanding of the engine efficiency effects from changing gasoline octane number. Include a determination of the relationship between octane number and engine technology which can maximize the engine efficiency.

Task 1 – Literature Review of Octane Number and SI Engine Efficiency Studies, including Compression Ratio Increases & Oxygenates

Scope: It is important to include "traditional", "advanced" and "future" engine configurations. Traditional would include PFI NA engines; Advanced would include Boosted and NA SIDI engines; Future would include Atkinson, Lean Burn and High rates of cooled EGR on Boosted SIDI.

Because there are numerous vehicle and powertrain design and calibration parameters that affect each vehicle's overall octane number requirement and therefore to answer the primary objective question, the information should be characterized in a fashion so that *(for example)* only base engine dynamometer studies conducted under highly controlled operating and environmental conditions can be extracted from the database – this ability to extract select portions shall also apply to other engine technologies, fuel types etc…

1. Provide an overview of the scope and effects in each study
    - include a basic description of the engine hardware and unique operating features
    - include a basic description of the fuels used in the study
    - include a description of changes made to the engine to enable changes in efficiency (eg, Compression Ratio, Advanced Spark Timing, Engine Boosting/Downsizing etc.)
    - include changes to criteria emissions, if available

    (for example, if an increase in octane number enabled an increase in compression ratio (CR) which in turn enabled an increase in efficiency which was accompanied by an increase in NOx emissions, both the magnitude of the CR increase and the change in NOx emissions should be noted.)

2. Summarize/interpret results from the studies
    - what engine technologies are included
    - distill information according to AKI, RON, MON, Octane Sensitivity, Energy Content
        - include engine technology
        - include the form of octane number: hydrocarbon, renewable, metallic and type (i.e. aromatic, ethanol Exx, lead x g/liter)
    - include auto-ignition and octane number rating determination (i.e. ASTM D2699, D2700 or DIN for octane number measurement), assess whether octane numbers were estimated or actually measured.
3. Identify gaps and describe limitations in the data
    - Are there engine technologies with insufficient data
    - Are there fuels (e.g. biofuels) with insufficient data
4. Assess sensitivity of results
5. Develop uncertainty analysis

Task 2 – Provide Assessment of Engine Technology and Octane Number Effects

1. Include in-house expertise
2. Include description of OEM query for engine efficiency responses – OEM input is to be a minor portion of the study and might be used as a way to fill gaps in literature information; however, OEMs may or may not provide input.

Task 3 – Summarize present understanding of engine efficiency and octane

1. Determine the relationship between octane number, engine technology and efficiency
    - Including Compression Ratio, Spark Advance, Downsize and/or Boosting, Down-speeding
2. Identify engine modifications needed to maximize efficiency in response to octane number
3. Determine average effects across the fleet based on a modeling approach

Task 4 - Based on literature review and analysis, the study is to offer expertise/views on proposing a potential maximum spark ignition engine efficiency improvement that is determined to be possible assuming specific (and identified) required changes to fuel properties

Task 5 – Provide recommendation(s) for future work to better understand engine efficiency response to changes in octane number

1. Propose the type of testing needed to fill gaps (if any) in the present literature
    - what experiments can add to the understanding of octane number effects.

Project Schedule

The project technical effort, including preparation of the draft final report, should be completed nominally within 3 months, it is expected that additional technical staff are to be included to contain the schedule within the specified timeframe. An additional two months will be allowed for review, comments, and revisions to develop an approved final product. Periodic conference calls with the

sponsors, especially at the beginning of the project may be scheduled to assist the contractor with questions of direction on data handling or interpretation.

Deliverables
The project deliverables will include brief monthly progress reports, a draft final report, comprehensive database, and the final report and database. See Exhibit B for additional details.

Quality Assurance and Quality Control
The individual responsible for quality assurance should be identified in the proposal statement on quality assurance and quality control.

EXHIBIT B

REPORTS

MONTHLY TECHNICAL PROGRESS REPORTS

The contractor shall submit a monthly technical progress report covering work accomplished during each calendar month of the contract performance. Thirty-five (35) hardcopies or one electronic Microsoft® Word compatible file (<1 MB) of the monthly technical progress report shall be distributed by the contractor within ten (10) calendar days after the end of each reporting period. The report shall contain a description of overall progress, plus a separate description for each task or other logical segment of work on which effort was expended during the reporting period.

FINAL REPORT

The contractor shall submit to or distribute for CRC thirty-five (35) hardcopies (or one hardcopy and one electronic pdf-compatible copy transmittable via email) of a rough draft of a final report within thirty (30) days after completion of the technical effort specified in the contract. The report shall document, in detail, the test program and all of the work performed under the contract. The report shall include tables, graphs, diagrams, curves, sketches, photographs and drawings in sufficient detail to comprehensively explain the test program and results achieved under the contract. The report shall be complete in itself and contain no reference, directly or indirectly, to the monthly report(s).

Within thirty (30) days after receipt of the approved draft copy of the final report, the contractor shall make the requested changes and deliver to CRC fifty (50) hardcopies including a reproducible master copy of the final report. The final report shall also be submitted as an electronic copy in a pdf or pdf-convertible file format. The final report may be prepared using the contractor's standard format, acknowledging author and sponsors. An outside CRC cover page will be provided by CRC. The electronic copy will be made available for posting on the CRC website.

EXHIBIT C

INTELLECTUAL PROPERTY RIGHTS

Title to all inventions, improvements, and data, hereinafter, collectively referred to as ("Inventions"), whether or not patentable, resulting from the performance of work under this Agreement shall be assigned to CRC. Contractor X shall promptly disclose to CRC any Invention which is made or conceived by Contractor X, its employees, agents, or representatives, either alone or jointly with others, during the term of this agreement, which result from the performance of work under this agreement, or are a result of confidential information provided to Contractor X by CRC or its Participants. Contractor X agrees to assign to CRC the entire right, title, and interest in and to any and all such Inventions, and to execute and cause its employees or representatives to execute such documents as may be required to file applications and to obtain patents covering such Inventions in CRC's name or in the name of CRC's Participants or nominees. At CRC's expense, Contractor X shall provide reasonable assistance to CRC or its designee in obtaining patents on such Inventions.

To the extent that a CRC member makes available any of its intellectual property (including but not limited to patents, patent applications, copyrighted material, trade secrets, or trademarks) to Contractor X, Contractor X shall have only a limited license to such intellectual property for the sole purpose of performing work pursuant to this Agreement and shall have no other right or license, express or implied, or by estoppel. To the extent a CRC member contributes materials, tangible items, or information for use in the project, Contractor X acknowledges that it obtains only the right to use the materials, items, or information supplied for the purposes of performing the work provided for in this Agreement, and obtains no rights to copy, distribute, disclose, make, use, sell or offer to sell such materials or items outside of the performance of this Agreement.

EXHIBIT D

LIABILITY

It is agreed and understood that _____ is acting as an independent contractor in the performance of any and all work hereunder and, as such, has control over the performance of such work. _____ agrees to indemnify and defend CRC from and against any and all liabilities, claims, and expenses incident thereto (including, for example, reasonable attorneys' fees) which CRC may hereafter incur, become responsible for or pay out as a result of death or bodily injury to any person or destruction or damage to any property, caused, in whole or in part, by _____'s performance of, or failure to perform, the work hereunder or any other act of omission of Contractor in connection therewith.

EXHIBIT E

PROPOSAL EVALUATION CRITERIA

1) Merits of proposed technical approach.
2) Previous performance on related research studies.
3) Personnel available for proposed study – related experience.
4) Timeliness of study completion.
5) Cost.