Call for tender:

Entertain a feasibility study for use of petrol in a CI engine concept

Background
Under the EU H2020 research and innovation programme a project has been developed for which the European Commission (EC) and CEN have signed a contract (SA/CEN/RESEARCH/EFTA/000/2014-13) under the Framework Partnership Agreement with CEN-CENELEC (FPA). The project is titled: "Engine tests with new types of biofuels and development of biofuel standards". One of its objectives being to demonstrate the feasibility of a compressed ignition engine using ignition assist (spark plugs or glow plugs) to make high octane fuels ignitable and the combustion controllable over a wide operational window. The programme is executed by the Dutch Standardization Institute, NEN. To develop the technical work and to assess the bids, NEN has gathered a set of European experts from the refinery, automotive and biofuel industry in a taskforce, the H2020 TF2. That group will also act as the selection committee for the tender.

This project is a demonstration of a petrol in compression ignition concept running a fully instrumented single-cylinder bench engine, evaluating a series of fuels and running the optimum fuel as determined by bench engine tests and paper study.

Goal of the tender contract
The objective of this study is to construct a single-cylinder CI engine that is operable over a full-speed/load range on standard European grade petrol. This shall be achieved by running a series of test fuels in a pre-designed single-cylinder engine under standardized test cycles (including a range of speed and load conditions) measuring regulated emissions and fuel consumption in order to prove the concept of petrol use in a CI engine.

Deliverable of the project
The project consists of three parts which are preferably executed under the same contract. On each of the parts a report shall be delivered to the programme manager that presents the results of the study.

Tender basics
The project consists of several parts, preferably to be tendered to a single operator or a consortium, further contracted where appropriate. Alternatively, tenders can be made for each separate part of the activity.

1. Construction of two sets of specific cylinder parts based on a functional design provided by the programme manager.

2. Effective optimization of the engine design, consisting of the following:
   a. Building one set of the parts (as in 1) into a single-cylinder engine that is installed on a test rig and in a test cell.
   b. Executing a series of test runs with the rig at up to 15 different load points using a 95 RON petrol fuel supplied by the programme manager whilst measuring emissions and fuel consumption to optimize the test rig.
   c. Repeat step a) and b) with the second set of parts, after which the optimal setup is chosen in coordination with the H2020 TF2.

3. Executing a further set of test at set points using three different fuels, defined together with the H2020 TF2 and the programme manager.

A representative of NEN will act as programme manager. That person is to be informed of all decisions related to each of the project parts. That person is also responsible for the contracting, the payments and the effective acceptance of the final results, i.e. a written report.

In addition, a project manager is assigned by the H2020 TF2. That person will be the technical contact for questions on the design and the execution of the tendered work related to the test rig. Interaction with the
H2020 TF2 members on engine optimization and test programming, mostly by telephone, is part of the execution.

**Tasks for the construction Part 1:**
The main tasks of the tenderer during the contracting period are: Discussion of the design with the project manager and the TF2 on the basis of detailed drawings supplied by the programme manager;

i) Manufacture or model on the basis of a design supplied by the project manager the cylinder head (for a single cylinder engine with the valve train) and the piston bowl;

ii) Additionally supply of other further components required for operation in a single cylinder engine; e.g. a cylinder head gasket, an intake manifold and an exhaust manifold (in coordination with the project manager) that reflect the permissible compositions of the design;

iii) Construct a cylinder in line with the requirements set out in Annex A, in coordination with the project manager and the TF2;

iv) Compile a full report with technical explanations, a Power-point presentation with a summary of the executed work and conclusions and deliver detailed analytical results to project manager and the programme manager;

v) Should this part be contracted separately, deliver the developed cylinder or the specific components to the project manager or send it to an address the programme manager provides.

**Tasks for the engine design optimization Part 2:**
The main tasks of the tenderer during the contracting period are: **Part 2a, Engine preparation:**

i) If this work is contracted separately from the construction Part 1, to receive and inventorise the design specific components and check whether they are complete;

ii) Discussion of the testing plan with the project manager, TF2 and the programme manager;

iii) Construct a single cylinder engine that reflects the permissible parameters of the design in terms of bore, stroke, maximum cylinder pressure and maximum engine speed as in Annex A;

iv) Construct a test rig in line with the measurement requirements set out in Annex B, in coordination with the project manager;

v) After the first proving session as in Part 2b is finalised, (re)construct the test rig with the second set of components;

**Part 2b, Engine proving:**

vi) Receive the reference fuel¹, supplied in containers, as provided by the programme manager (or procured in coordination with the project manager) and store them in a cool and dry environment for the period of testing and in line with the handling instructions provided by the project manager;

vii) Execute the tests on the rig in a test cell, which contains control of the ambient air temperature, air intake temperature and pressure, coolant and lubricant temperature, dynamic phase (engine start and transient) and external EGR with temperature control, and an emission and combustion pressure analyser;

viii) Ensure that the constructed single-cylinder engine test rig can be started whilst the controls installed as under vi) are measuring – in coordination with the project manager;

ix) Optimize engine operation on each of the test points by assessing the parameters as in Annex B using the reference fuel provided;

¹ An E10 market fuel in line with EN 228 with a RON of (95±0,2), containing an ester-based lubricity improver additive.
x) Repeat step vi) to ix) for the second set-up (see step v) ;

xi) Report the results to the project manager (preferably at a TF2 meeting) and advise regarding the optimal engine components and engine set-up that can be derived from the results;

**Tasks for the engine testing Part 3:**

The main tasks of the tenderer during the contracting period are:

i) If this work is contracted separately from the optimization part, receive the engine components constructed under Part 1 and the engine optimization details and instructions as developed under Part 2;

ii) Receive the test fuels, supplied in containers, as provided by the programme manager (or procured in coordination with the project manager) and store them in a cool and dry environment for the period of testing and in line with the handling instructions provided by the project manager.

iii) Construct a test rig in line with the measurement requirements set out in Annex B and using the engine components developed in Part 1 and the engine optimization settings developed under Part 2, in coordination with the project manager;

iv) Execute the tests on a rig in a test cell, which contains control of the ambient air temperature, air intake temperature and pressure, coolant and lubricant temperature, dynamic phase (engine start and transient) and external EGR with temperature control, and an emission and combustion pressure analyser;

v) Ensure that the constructed single-cylinder engine test rig can be started whilst the controls installed as under iv) are measuring and check, by using the reference fuel provided, if the engine operates as expected – in coordination with the project manager;

vi) Check – in coordination with the project manager - if the engine runs as expected by using two to maximum 15 test points to assess the parameters as in Annex B using the reference fuel provided;

vii) Execute the tests as indicated in Annex B using the test fuels and re-optimize injection timing;

viii) Compile a full report with technical explanations, a Power-point presentation with a summary of the executed work and conclusions and deliver detailed analytical results to project manager and the programme manager;

**All parts:**

a) Discuss on a regular basis, e.g. every two weeks, with the project manager and/or the H2020 TF2 in a (web)meeting on the next set points for the testing and report the results for a next discussion;

b) Return the drawings and single-cylinder engine components to the programme manager or send it to an address the contractor provides.
Execution of the work

The pre-selected contractor(s) will be invited to discuss his/their initial work plan and the technical part of the bid with the H2020 TF2. This exchange will take place via a face-to-face-meeting in a location in Brussels. This is a selection step that is required before the effective contract signature, but can be offered as a separate cost factor.

Construction, optimization and engine testing is to be executed at the premises of the contractor. Further detail on each construction or engine test requirements shall be discussed with the project manager and where necessary with the programme manager. The indicated numbers of fuels, tests points and measurements as in Annex A and Annex B are the foreseen maximum; they may be lowered in accordance with decisions by the relevant project manager or the programme manager.

The contractor will present a work plan to the project manager. The contractor may present suggestions for alternative fuels, quantities and alternative testing, providing there is agreement by the TF2 and the programme manager.

The contractor shall, where relevant, cooperate in evaluating the performance of the engine, the test rig and the test results reported.

Each contractor can, in coordination with the programme manager, be asked to join a TF2 meeting in person or via Webex to present the results and respond to questions. A representative of each contractor shall take part in the taskforce meeting where the final test report is being discussed (foreseen during the contracting period and to take place in Europe) in order to exchange information and cooperate in the advice to the EC regarding the feasibility of the concept.

The contractor shall report to the programme manager about the test progress and results. The programme manager or the project manager may visit the contractor facilities to check progress and discuss the work. The programme manager may require an interim written status report. Each contractor shall present a detailed report on the test execution and results. The test results and reports, as well as the constructed engine shall become (or remain) property of the programme manager.

The contractor shall at the end of the project and on request of the programme manager destroy or return the remaining test fuels in his possession.

General confidentiality around the fuels involved, test results, etc. shall apply and the contractor shall not distribute any results other than to those involved in the tender. The contractor for Part 1 shall sign a specific non-disclosure agreement as in addition to Annex A, detailed CAD drawings will be provided for the construction of the engine parts. These have to be returned by the end of the work.

Selection criteria for the tendering process
The offer shall be specific on the costs of each of the four parts of the project as described above, including the expected time. Complete offers for all Parts are recommended. Offers for provision of the construction separate Parts are treated individually. Consortium offers will also be considered. Offers can also be from a single person, which should however have a VAT number and a company registration.

Selection of contractors will be based on the following criteria:
1) **Documented experience** (maximum 50 points):
   - number of years working in relevant fields
   - demonstration of engine construction experience (Part 1)
   - demonstration of experience in rig testing and measurements for different fuels (Part 2)
   - technical knowledge of CI engine (preferably running in low-temperature combustion modes) and equipment behaviour
   - experience in development of test equipment and cooperation with OEMs and fuel suppliers
   - experience in running European or/and international test programs

2) **Organization**; demonstration of ability and understanding of the project (maximum 40 points):
facilities used for the actual testing
organization of the rig test development, evaluation and optimization
organization for the reporting to NEN and the TF2
established quality system

3) **Quotation price and detail** (maximum 10 points)

Additional points may be awarded if the tenderer can add additional value to the project.

Only offers that pass the selection criteria of scoring minimum 35 points under 1) and 25 points under 2) will be considered in the further evaluation. From those passing the minimum scoring a sensible pre-selection (based on the total of the short-list) will be made and the contractor(s) invited for further evaluation in a Q&A meeting session.

NEN considers that proposals requesting a budget in the range of 930k€ for all three Parts would allow this feasibility study to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

On the effective contract the “General Terms and Conditions for the Provision of Technical Services to NEN” shall apply. A copy of those can be delivered on request. The Contractor should also agree to the fact that the obligation of NEN to pay is subject to the normal functioning of the financing mechanisms of the Commission of the European Union and of the EFTA, through the order voucher(s) relative to the tasks under the Horizon2020 call under the Secure, clean and efficient energy programme: B.2.5. "Engine tests with new types of biofuels and development of biofuel standards" and/or through the Agreements between the Commission of the European Union and CEN on Action SA/CEN/RESEARCH/EFTA/000/2014-13.

**Replies to tender**

Tenders can be sent by e-mail to the programme manager, Mr. Ortwin Costenoble (energy@nen.nl) as soon as possible, at the latest at 15 February 2017. The tender shall contain a specified breakdown of tasks, costs and expenses for work, travel, consumables/market products and others where relevant and a first planning for the execution of the tasks, which will form the start of the selection/discussion regarding the tender contract.

If necessary, additional information can be obtained via the programme manager, O.M. Costenoble (T: +31 15 2690 330, e-mail energy@nen.nl) or via the TF2 leader, R.F. Cracknell (e-mail: roger.cracknell@shell.com).
Annex A – Model definition for the engine parts’ construction

As the engine is designed for a research project there is need for continuous exchanges with the TF for clarification and validation purpose.

The engine construction shall incorporate the following features:

Single cylinder engine base provided by the contractor:
  - Bore = 85 mm
  - Stroke = between 86 and 90 mm
  - Max Cyl Pressure >160bar
  - Max Engine Speed > 4500 rpm

An appropriate cooling system has to be realized for a 30kW engine.

The combustion system will be constructed according to a design specified by the TF for which detailed CAD drawings will be supplied following the award of the contract.

  - The 4 valves cylinder head including intake and exhaust pipes and the spark position
  - The piston geometry (several)
  - The camshafts (several)
Annex B – Testing requirements

As the engine testing is a research project there is need for continuous exchanges with the TF, so the testing is to be executed in parts.

Several testing conditions are expected in terms of static engine/cell temperature with limited transient phase testing.

The contractor shall be able to perform the engine starting phase, transient phase and stabilized engine operation measurements in hot and cold conditions. If the starting phase procedure is not reliable for the amount of tests, a way to assess it should be proposed.

The contractor is expected to describe its facility capability for the cold conditions: down to \(-x^\circ C\) for the oil/coolant/fuel/cell temperature for a reasonable amount of test per day.

The amount of engine test points to be tested for stabilised operation, and on which the offered price shall be based, is maximised at 15, from idle or very low loads to full load and from low to high engine speed, with the aim to cover the entire speed and load range of the engine. The test points selection will be provided by the TF.

The contractor will propose methodologies to perform the settings optimisation (Design Of Experiment) for each test points, to be decided by the TF members and for the selection criteria as well.

The measurements channels to be provided are mainly concerning the fuel consumption, engine torque, cylinder pressure measurement, combustion noise and emissions. They are listed in the following table:

<table>
<thead>
<tr>
<th>Engine speed</th>
<th>Air Flow</th>
<th>Particles</th>
<th>CA50 - CA10</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMEP</td>
<td>EGR Flow</td>
<td>Noise</td>
<td>CA90 - CA50</td>
</tr>
<tr>
<td>Equivalence ratio</td>
<td>EGR Rate</td>
<td>IMEP</td>
<td>Cell Temperature</td>
</tr>
<tr>
<td>Intake Pressure</td>
<td>EGR Temperature</td>
<td>IMEP stability</td>
<td>Cell atm Pressure</td>
</tr>
<tr>
<td>Intake Temperature</td>
<td>Fuel flow</td>
<td>Gross IMEP</td>
<td>Fuel Temperature</td>
</tr>
<tr>
<td>Exhaust Pressure</td>
<td>Raw HC</td>
<td>LP IMEP</td>
<td>Fuel Flow</td>
</tr>
<tr>
<td>Exhaust Temperature</td>
<td>Raw CO</td>
<td>Max Pressure</td>
<td>Air Flow</td>
</tr>
<tr>
<td>Rail Pressure</td>
<td>Raw NOx</td>
<td>Max Pressure covariance</td>
<td>Computed Fuel Flow</td>
</tr>
<tr>
<td>total quantity</td>
<td>Raw CO2</td>
<td>Max Pressure Angle</td>
<td>Computed Air Flow</td>
</tr>
<tr>
<td>Pilot2 timing</td>
<td>Raw O2</td>
<td>Max deltaPressure</td>
<td>Equivalence Ratio</td>
</tr>
<tr>
<td>Pilot2 duration</td>
<td>Spec (indicated) HC</td>
<td>Max deltaPressure covariance</td>
<td>Air/Fuel Ratio</td>
</tr>
<tr>
<td>Pilot2 quantity</td>
<td>Spec (indicated) CO</td>
<td>Max deltaPressure Angle</td>
<td>Equivalence Ratio (sensor)</td>
</tr>
<tr>
<td>Pilot1 timing</td>
<td>Spec (indicated) NOx</td>
<td>Max Pressure Max</td>
<td>Equivalence Ratio (3 gas)</td>
</tr>
<tr>
<td>Pilot1 duration</td>
<td>Spec (indicated) CO2</td>
<td>CA5</td>
<td>Volumetric efficiency</td>
</tr>
<tr>
<td>Pilot1 quantity</td>
<td>Spec (indicated) O2</td>
<td>CA10</td>
<td>Crankcase Pressure</td>
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<tr>
<td>Main timing</td>
<td>Intake CO2</td>
<td>CA50</td>
<td>Oil Pressure</td>
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<tr>
<td>Main duration</td>
<td>5 gas compatibility</td>
<td>CA90</td>
<td>Inlet Coolant Temperature</td>
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<tr>
<td>Main quantity</td>
<td>ISFC</td>
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<td>Outlet Coolant Temperature</td>
</tr>
<tr>
<td>Split timing</td>
<td>High pressure ISFC</td>
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<td>Inlet Oil Pressure</td>
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<tr>
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<tr>
<td>Split quantity</td>
<td>Combustion efficiency</td>
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<td>Outlet Oil Temperature</td>
</tr>
<tr>
<td>Spark timing</td>
<td>Smoke</td>
<td>CA90 - CA10</td>
<td></td>
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</tbody>
</table>

An engine results template will be proposed by the TF to the selected supplier to ensure matching the project requirements. Alternatively, the contractor can propose an appropriate results template and the TF will decide if it meets the requirements of the project.

Detailed combustion analysis will be required with a methodology to compute the heat release rate (heat transfer models, the number of cycles in the acquisition) to be documented by the proposed contractor.
For the purpose of making the TF able to compare the tender offers, the duration to perform a typical EGR sweep on a fixed engine test points with up to 4 parameters (injection, air loop and spark parameters) to be optimised should be proposed. With this duration in mind, a typical cost for one week of testing and the amount of measurement points performed related should be provided in the offer for the different testing conditions (hot or cold, stabilised, starting or transient phase).

The possibility to test several piston/ camshaft/ spark plug options is required. The duration and cost related to these modifications should be described in the offer.

**Fuels to be tested**

EN 228 compliant (RON 95) E10 fuel – summer grade. This is the main reference fuel for testing. Up to six other fuels for later testing will be variants on this reference fuel with changes to ethanol content, octane and volatility. However all of the fuels will have octane levels that are broadly in the range of pump gasoline with RON ranging between 91 and 99. All fuels will be supplied by the programme manager (or procured by the tenderer in coordination with the project manager) and will contain an appropriate level of ester-based lubricity improver additive.

The contractor will be asked to define how much time is required to switch between fuels and how much fuel is required for each test, taking into consideration the requirements to purge the system.