DESCRIPTION OF THE SUBJECT OF THE CONTRACT

Customer:	**NAFTA a.s.**
Registered Office:	Votrubova 1, 821 09 Bratislava, Slovensko
Registered:	Obchodný register Mestského súdu Bratislava III, odd.: Sa, vl. č.: 4837/B
Company Identification No.:	36 286 192
Represented by:	Ing. Ladislav Goryl, CEO Ing. Martin Jarábek,UGS division director

Request

ASSMENT OF THE IMPACT OF 2% HYDROGEN IN THE MIXTURE WITH NATURAL GAS AND 100% HYDROGEN ON THE INDIVIDUAL PARTS OF UGS NAFTA (STUDY)

Description of the type and scope of required works/output:

Customer NAFTA a.s. (NAFTA), an operator of underground natural gas storage (hereinafter referred to as UGS), is interested in conducting an assessment of the UGS's capability to operate safely with 2% hydrogen in the mixture with natural gas and 100% hydrogen (H2).

1 List of UGS NAFTA facilities under the assessment

Under the assessment will be 7 facilities of NAFTA's UGS division:

- Centrálny areál PZZP Láb (CA PZZP),
- Centrálny areál Gajary (CAG),
- Zberné plynové stredisko Suchohrad (ZS1),
- Zberné plynové stredisko Suchohrad (ZS2),
- Zberné plynové stredisko Gajary (ZS3),
- Zberné plynové stredisko Gajary (ZS4),

whereby individual parts of the UGS will be reviewed, such as:

- **connecting and expedition pipelines and connections to wells**(form dimension DN80 to DN900; PN40 – PN250),
- **piping including valves** (gas coolers; heat exchangers; flanged joints; insulation joints; I&C – convertors of physical properties; shut-off, control and safety fittings; measuring lines; emergency depressurization of sites),
- **pressure equipment for NG treatment** (separators, drying columns, separators, filters),
- **equipment for NG treatment** (NG regulatory station, regulatory boards),

- **compressor units** (rotary compressors and their accessories),
- **equipment for NG consumption** (combustion turbines, gas heaters and burners of reconcentration boilers, burners of boilers and burners of NG heaters,
- **HSE facilities** (electronic fire alarm, gas detection system, fixed fire extinguishing systems).

The entire surface technology of the NAFTA UGS will be assessed, including connection to the distribution or transition network. A list of the facilities of which the NAFTA UGS Centers generally consist of is provided in the Annexes. As an example, the CA PZZP centers, CAG and ZS1 were selected.

2 Impact of 2% H_2 on infrastructure of UGS

The role of the Service Provider will be to prepare an assessment of the impact of 2% H_2 mixed with the NG on the parts of the UGS mentioned in Chapter 1. The impact of 2% H_2 mixed with NG on the process aspect has to be taken into account in the assessment. The assessment will be based on freely available credible information (e.g. relevant scientific articles, projects, statements from suppliers/manufacturers of the equipment concerned), not older than 5 years. The assessment will assume that the current process gas volumetric flow rates will be maintained even after the switch to 2% H_2 in the NG mixture.

Description of the assessment of the different parts of the UGS:

- When assessing the gas treatment technology, the analysis will include the impact of 2% H_2 on **the entire gas treatment process which must include at least:**
    - **Pipelines:**
        - **Recalculation of hydrodynamic conditions** gas flow in pipes.
        - Comparison of the change of physical properties of the transported medium on the transported amount of energy.
        - Design of dimensions and materials of new pipelines (if necessary)
    - **Compressor units:**
        - Assessment of existing compressor units at 2% H_2, blend with NG in case of unsatisfactory condition performance design of new compressor units, compressor, turbine (drive), separately, control system, support systems part compressor at current operating conditions (pressure, flow)
        - The required performance parameters for the recalculation of the equipment will be supplied to the winner of the tender
        - 10 units (10 CU) will be considered and the calculation will be performed for a mixture of 2% and 5% H_2 with natural gas
        - In case of unsuitability status, processing of a market survey to identify possible suppliers of individual components (compressor, turbine)

- On the basis of the technical design of the plant, propose the necessary changes (if necessary) to modify the existing technology (box, inlet connection, discharge, etc.)
- Assessment of the impact of H_2 on the cooling performance of gas coolers after compression
- Risk definition
- Variation of compressor station design options + advantages and disadvantages of each solution

o **Gas drying technology:**

- **Gas drying process parameter change** (adsorption, absorption) and assessment of their suitability for drying 2% H_2 in mixture with NG in case of unsuitability of drying technologies proposal of an alternative drying method for a specific site.
- A variant solution for the design of a new technology for gas (hydrogen) treatment during production
- Calculating the impact of the Joule-Thomson effect
- **Measuring equipment:**
- Assessment of existing metering equipment for 2% H_2 in mixture with NG in case of unsatisfactory condition, **design of new metering equipment.**
- **Heat exchangers:**
- Assessment of existing heat exchangers at 2% H_2 in the mixture with NG in case of unsatisfactory condition, **design of new heat exchangers**.
- Variant solution for the design of new heat exchangers with optimization of heat consumption for gas (hydrogen) treatment.

– The assessment will also include a calculation of the impact of 2% H_2 in the mixture with NG on the injection-withdrawal performance of UGS Nafta (calculation of the change in energy output) - from the perspective of surface technology
– New parts of the technology are to be designed within the scope of the pre-feasibility study
– CAPEX and OPEX evaluation must be part of the study

3 Impact of 100% H_2 on infrastructure of UGS

The role of the Service Provider will be to produce an assessment of the impact of 100% H_2 on the parts of the UGS mentioned in Chapter 1. The assessment must take into account the impact of 100% H_2 on process aspects as well as on the actual metallic and non-metallic materials of the analyzed equipment of the technology. The assessment will be based on freely available credible information (e.g. relevant scientific articles, projects, statements from suppliers/manufacturers of the

equipment in question), not older than 5 years. The assessment will not address the commercial or legal implications of 100% H_2 storage. The assessment will assume that current process gas volumetric flow rates will be maintained after the transition to 100% H_2.

Description of the assessment of the different parts of the UGS:

- When assessing the gas treatment technology, the analysis will include the impact of 100% H_2 on **the entire gas treatment process which must include at least:**
    - **Pipelines:**
        - **Material assessment of the suitability of existing pipelines** (gas pipelines + pipeline yard) **for 100% H_2**
        - **Recalculation of hydrodynamic conditions** gas flow in pipes.
        - Comparison of the change of physical properties of the transported medium on the transported amount of energy.
        - Design of dimensions and materials of new pipelines (if necessary)
    - **Compressor units:**
        - Assessment of **existing compressor units at 100% H_2**, in case of **unsatisfactory condition performance design of new compressor units** (compressor, drive) at current operating conditions (pressure, flowrate)
        - **A variant solutions** of compressor station design options + advantages and disadvantages of individual solutions
    - **Gas drying technology:**
        - **Gas drying process parameter change** (adsorption, absorption) and assessment of their suitability for drying 100% H_2, in case of unsuitability of drying technologies proposal of an alternative drying method for a specific site.
        - Definition of limiting conditions for the operation of process gas drying plants - H_2 purity requirements for withdrawal
        - A variant solution for the design of a new technology for gas (hydrogen) treatment during production
        - Calculating the impact of the Joule-Thomson effect
    - **Measuring equipment:**
    - Assessment of existing metering equipment for 100% H_2, in case of unsatisfactory condition, **design of new metering equipment.**
    - **Heat exchangers:**
    - Assessment of existing heat exchangers at 100% H_2, in case of unsatisfactory condition, **design of new heat exchangers**.

- Variant solution for the design of new heat exchangers with optimization of heat consumption for gas (hydrogen) treatment.
- **Calculation of safety zones. SNV**

– The assessment will also include a calculation of the impact of 100% H_2 on the displacement and extraction performance of PZZP Nafta (calculation of the change in energy output)- from the point of view of surface technology.

–The impact of 100% H_2 on the **material composition** of equipment will also be assessed. **If the impact of 100% H_2 on any of the materials cannot be clearly determined, the Provider will need to determine the anticipated cost of testing these materials**, which will also be sufficient to demonstrate their compatibility with 100% H_2 under actual NAFTA UGS operating conditions. **If any of the materials are not 100% H_2 compatible, the Provider must determine an alternative material.**

- **If the material is not suitable or suitability cannot be proven, the study will propose replacement of the equipment - technical design + CAPEX and OPEX.**

– The Provider must determine **the cost to replace/upgrade portions of the equipment, piping, pipe yard, etc. to make the entire surface technology of the UGS 100% H_2 compliant.**

– The contractor will propose options for **a gradual transition to hydrogen**, i.e. **that part of the storage still runs on natural gas and part is gradually converted to H_2.** This will include a cost estimate as well as a schedule.

– New equipment must include the basic performance characteristics defined by the material with confirmation of its suitability for pure H_2 in the operating range.

– New parts of the technology are to be designed within the scope of a pre-feasibility study.

– The study must include a CAPEX and OPEX calculation

4 From of delivery of the assessment

The assessment will include analyses of the impact of 2% H_2 in the mixture with NG and 100% H_2 on parts of the UGS based on the description in Chapters 2 and 3 and will be produced in a digital version (PDF, MS Word, MS Excel and pictorial documentation).

The study also includes:

– **regular and operational meetings** (consultation and field verification of equipment) of the contractors to coordinate individual activities as required (online + physical site visit), - 2 week base (contractor must include in the price the necessary scope for the physical site visit)

– **presentation of the results of the assessment** or other activities under this specification, **their evaluation and explanation** in the form of a face-to-face meeting,

5 Requirement for the service provider

- **submission of references regarding experience with similar assessments**
- **submission of a quotation for an assessment of the impact** of 100% H_2 on selected parts of NAFTA's UGS technology
- **submission of a proposal for a procedure or methodological solution for the assessment**
- **submission of a schedule of works and a deadline for the delivery of the final assessment**

Annex 1: Facility CA PZZP

Maximum site pressure: 9.5 MPa

Equipment in direct contact with processed gas:

- ball valves
- measuring lines (flow meter)
- density gauge
- chromatograph
- water and hydrocarbon dew point gauge
- inlet liquid separator
- common separator
- test separator
- steam gas heaters
- indirect gas heaters
- absorption columns
  - low pressure separation
- TEG's reconcentration boiler
- steam condenser
- condensate separator
  - glycol degasser
- gas filter
- microfilter
- gas regulation station
- rotary compressor
- gas coolers
- mining water collection tank
- sludge tanks

Equipment in contact with gas as an energy medium:

- TEG's reconcentration boiler
- condensate separator
- medium pressure steam boiler
- hot water boiler
- rotary compressor

Annex 2: Facility CAG

Maximum site pressure: 22 MPa

Equipment in direct contact with processed gas:

- ball valves
- flow regulator
- pressure regulator
- measuring lines
- common collector
- test collector
- common separator
- test separator
- gas releaser
- gas heater
- adsorption gas drying
- preheating of regeneration gas
- commercial measuring
- chromatograph
- rotary compressor
- microfilter
- gas cooler

Equipment in contact with gas as an energy medium:

- gas regulation station
- heating boilers

Annex 3: Facility ZS1

Maximum site pressure: 6,5 MPa

Equipment in direct contact with processed gas:

- collector
- common collector
- test separator
- gas releaser
- indirect gas heaters
- absorption columns
- heat exchanger
- TEG's reconcentration boiler
- TEG degasser
- gas regulation station

Equipment in contact with gas as an energy medium:

- TEG's reconcentration boiler