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## NIA Project Registration and PEA Document

### Date of Submission

Sep 2016

### Project Reference Number

NIA\_NGGD0085

## Project Registration

### Project Title

BioH2 Project: Production of hydrogen by the gasification of waste

### Project Reference Number

NIA\_NGGD0085

### Project Licensee(s)

Cadent

### Project Start

October 2016

### Project Duration

0 years and 9 months

### Nominated Project Contact(s)

NGGDx – Andy Lewis Progressive Energy Ltd – Chris  
Manson Whitten Advanced Power Plasma (APP) – Andy  
Cornell

### Project Budget

£519,437.00

## Summary

### Task 1

To produce a functional specification for hydrogen production, it will be important to engage with industry to understand the requirements for hydrogen, both in terms of volume and specification. Transport, industrial use, gas grid blending and 100% grid conversions are expected to have significantly different requirements. Furthermore the feasibility and specifications for CO<sub>2</sub> use/sequestration will also vary with plant scale and time horizon. The identified requirements will inform the target specification for production.

### Task 2

Demonstrating the feasibility of hydrogen production requires use of a small-scale plant, ordinarily costing millions of pounds. However, a unique opportunity is available to this project: the BioSNG Demonstration Plant project is scheduled to finish in Spring 2017. There will then be a fully functional facility, capable of gasifying waste, shifting the resultant syngas and removing CO<sub>2</sub>. This plant would require only relatively simple modifications to demonstrate production of high-purity hydrogen from waste, with CO<sub>2</sub> removal, providing a remarkably cost-efficient route to addressing the second barrier. This delivers further value for money from the existing plant and project.

### Task 3

Information from engagement with industry, along with results from the small-scale plant will be used as inputs to the engineering and commercial work of defining and evaluating future commercial plants, addressing the route to commercial deployment. Product purity, recovery and CO<sub>2</sub> quality must be optimised against process complexity/simplification and heat integration, and key process elements such as the type of shift, gas processing and contaminant removal and CO<sub>2</sub> removal require careful selection, optimised for the functional specification required. The conceptual design produced from this activity will be used to evaluate the carbon intensity and commercial performance of the process.

## Task 4

Definition of a larger-scale demonstration project will require searching out and engaging with potential funding sources, partners and investors. It is expected that this could be as part of a wider hydrogen system including new consumers.

### Nominated Contact Email Address(es)

Innovation@cadentgas.com

### Problem Being Solved

Hydrogen is seen by many as a key element of the UK's future green energy mix. More than one project is currently working to move hydrogen use forward: H21 in Leeds is researching the feasibility of converting the 7 bar and below gas network to pure hydrogen, and the HyDeploy project will trial use of up to 20% hydrogen mixed with natural gas in the gas networks.

An outstanding question is where the hydrogen comes from. It has been suggested that excess renewable power generation is used to produce hydrogen via electrolysis, but it is not immediately obvious how this would work commercially. Similarly, production of hydrogen from natural gas entails substantial additional financial and carbon costs from the conversion process, and relies entirely on establishment of Carbon Capture and Storage (CCS) infrastructure to deliver low carbon hydrogen. Production of hydrogen from biomass rich waste delivers low carbon and low cost hydrogen without CCS, and as shown in National Grid's 2015 Future Energy Scenarios report, the production of hydrogen using biomass gasification with CCS delivers the negative emissions necessary to offset emissions from sectors that cannot decarbonise.

National Grid, Advanced Plasma Power and Progressive Energy are currently engaged in a NIC-funded project ("BioSNG Demonstration Plant") which takes municipal waste and waste wood, gasifies it and uses the resultant syngas to produce methane. Inherent to this process are both the shifting of syngas to increase hydrogen content prior to methanation, and the separation of CO<sub>2</sub>, providing an obvious route to hydrogen production and CO<sub>2</sub> capture. Reconfiguring this technology to produce hydrogen rather than SNG would represent a simplification of the process, because no methanation would be necessary. In addition, because methanation catalysts are the most sensitive to impurities, the clean-up requirements for the syngas would be less stringent for hydrogen production.

This approach offers the prospect of hydrogen production at parity with the cost of natural gas, and with the potential of negative carbon emissions where the separated CO<sub>2</sub> displaces fossil fuel derived CO<sub>2</sub> or it is sequestered

### Method(s)

Before this waste-to-hydrogen approach can be deployed commercially, several barriers must be overcome. Firstly, the commercial applications must be sufficiently well understood that a functional specification for hydrogen production can be produced. Secondly, the feasibility of hydrogen production from waste derived feedstock must be demonstrated to show that the concept is credible. Thirdly, the process must be optimised for commercial deployment, with designs produced, environmental impact understood and costs modelled. Fourthly, the chosen designs must be demonstrated at larger scale, with hydrogen supplied to end users.

This project will seek to push forward commercial deployment of hydrogen production from waste by systematically addressing each barrier.

### Scope

#### Task 1

To produce a functional specification for hydrogen production, it will be important to engage with industry to understand the requirements for hydrogen, both in terms of volume and specification. Transport, industrial use, gas grid blending and 100% grid conversions are expected to have significantly different requirements. Furthermore the feasibility and specifications for CO<sub>2</sub> use/sequestration will also vary with plant scale and time horizon. The identified requirements will inform the target specification for production.

#### Task 2

Demonstrating the feasibility of hydrogen production requires use of a small-scale plant, ordinarily costing millions of pounds.

However, a unique opportunity is available to this project: the BioSNG Demonstration Plant project is scheduled to finish in Spring 2017. There will then be a fully functional facility, capable of gasifying waste, shifting the resultant syngas and removing CO<sub>2</sub>. This plant would require only relatively simple modifications to demonstrate production of high-purity hydrogen from waste, with CO<sub>2</sub> removal, providing a remarkably cost-efficient route to addressing the second barrier. This delivers further value for money from the existing plant and project.

### Task 3

Information from engagement with industry, along with results from the small-scale plant will be used as inputs to the engineering and commercial work of defining and evaluating future commercial plants, addressing the route to commercial deployment. Product purity, recovery and CO<sub>2</sub> quality must be optimised against process complexity/simplification and heat integration, and key process elements such as the type of shift, gas processing and contaminant removal and CO<sub>2</sub> removal require careful selection, optimised for the functional specification required. The conceptual design produced from this activity will be used to evaluate the carbon intensity and commercial performance of the process.

### Task 4

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## Objective(s)

The work on each task will accomplish the following:

- 1) Definition of functional requirements for hydrogen production facilities
  - a. Definition of commercial applications for hydrogen
    - i. As a blend in the network
    - ii. For use in transport
    - iii. As a feedstock in the chemicals industry, e.g. ammonia production.
  - b. Resulting in a functional specification for each requirement:
    - i. Hydrogen purity requirements
    - ii. Allowable contaminants
    - iii. CO<sub>2</sub> purity requirements
    - iv. Project scale and operational requirements
- 2) Piloting of Hydrogen Production
  - a. Offline testing of hydrogen production using the BioSNG offline rig
  - b. Modification of the BioSNG demonstration plant for Hydrogen production
  - c. Physical demonstration of production of hydrogen production using this facility
  - d. Optimisation of the existing PSA for hydrogen and CO<sub>2</sub> separation
- 3) Commercial Plant definition and evaluation
  - a. Development of optimised Hydrogen production flow scheme
    - i. Selection of optimal CO<sub>2</sub> separation technique
    - ii. Hydrogen compression
    - iii. Heat integration
    - iv. Start-up requirements and turndown capabilities
    - v. Potential for and value of co-production of methane
  - b. Energy and Mass Balance
  - c. GHG assessment
  - d. Commercial assessment to give £/MWhr and evaluate against alternative hydrogen production routes
- 4) Definition of a hydrogen demonstration project
  - a. Evaluating Hydrogen demonstration opportunities in the UK
  - b. Definition of a demonstration project linked to end users

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

### Success Criteria

In achieving the objectives outlined above, the project will have addressed the barriers to hydrogen production by gasification of waste in a robust and cost-effective way, and laid the groundwork for future demonstration and commercial facilities. The project is also expected to show that this approach is a cost-effective route to bio-hydrogen, and to demonstrate the ability to capture carbon dioxide as part of the process.

Key indicators of a successful project will be:

Demonstration of hydrogen production from waste and CO<sub>2</sub>-separation using a modified form of the BioSNG Demonstration plant. This not only provides technical demonstration, but an important communication method about feasibility of hydrogen production from waste.

Preliminary definition of commercial facility, including robust understanding of economic and environmental benefits

Identification of partners, investors and site for larger-scale demonstration

A large driver for conducting the study at this point in time is the availability of the BioSNG Demonstration plant, which enables demonstration of hydrogen production from waste at remarkably low cost. Delivering the programme on budget will be important, in order to obtain maximum benefit from this opportunity

leveraging the £5M BioSNG Demonstration plant with a small additional programme, exploiting the existing equipment and mobilised team.

This project unlocks one of the key issues associated with the role out of hydrogen; how to deliver material quantities of low cost and low carbon hydrogen.

### Project Partners and External Funding

n/a

### Potential for New Learning

n/a

### Scale of Project

This project is being done on a single BioSNG demonstration facility in the UK. However, bioHydrogen production from a BioSNG plant can be scalable and replicated wherever a plant is located in the future. BioHydrogen can play a vital role in helping UK gas networks to meet the challenges of the energy trilemma and bring benefits to a range of stakeholders. BioHydrogen can help the UK meet the it's 2050 targets of reducing carbon emissions by 80% compared to 1990 levels by displacing natural gas.

### Technology Readiness at Start

TRL2 Invention and Research

### Technology Readiness at End

TRL3 Proof of Concept

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## **Geographical Area**

The project will be centred in Swindon, Gloucestershire.

## **Revenue Allowed for the RIIO Settlement**

**Not Applicable**

## **Indicative Total NIA Project Expenditure**

**Internal - £129,859.33**

**External - £389,578.00**

**Project Value Claimable under NIA (90% of total cost) - £467,493.60**

**Total Costs: £519,437.33**

## Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

### Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

#### How the Project has the potential to facilitate the energy system transition:

n/a

#### How the Project has potential to benefit consumer in vulnerable situations:

n/a

### Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

#### Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

A review of all other Network Licensees Innovation Funding Incentive annual reports has been performed and no similar Projects have been identified.

#### Please provide a calculation of the expected benefits the Solution

n/a

#### Please provide an estimate of how replicable the Method is across GB

This method of H2 will be replicable in any location where a BioSNG plant is present. Currently, there is only one BioSNG Plant which is a pilot plant in Swindon, Wiltshire.

#### Please provide an outline of the costs of rolling out the Method across GB.

n/a

### Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

- A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).
- A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)
- A specific novel operational practice directly related to the operation of the Network Licensees system
- A specific novel commercial arrangement

RIIO-2 Projects

- A specific piece of new equipment (including monitoring, control and communications systems and software)
- A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven
- A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)
- A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology
- A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution
- A specific novel commercial arrangement

## Specific Requirements 4 / 2a

### Please explain how the learning that will be generated could be used by the relevant Network Licensees

This could provide another route to H2 production which could then be injected into the UK's gas networks. H2 has the potential to deliver significant carbon and financial savings if it is injected into the gas grid.

### Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

Future proofing of the gas networks legislation to ensure they are able to work for the benefit of UK PLC going forward strategies of all Network Licensees.

- Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

### Is the default IPR position being applied?

- Yes

## Project Eligibility Assessment Part 2

### Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

### Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

n/a

### If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

n/a

## Additional Governance And Document Upload

### Please identify why the project is innovative and has not been tried before

n/a

### Relevant Foreground IPR

n/a

### Data Access Details

n/a

### Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

n/a

**Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project**

n/a

**This project has been approved by a senior member of staff**

Yes