Project Code/Version No:
NGNGN02/01

Gas Network Innovation Competition Full Submission Pro-forma

Section 1: Project Summary

1.1 Project Title:
T-Shale

1.2 Funding Licensee:
Northern Gas Networks

1.3 Project Summary:

There has been an increase in potential production of on-shore unconventional gas sources in the UK in recent years. This brings potential benefits in terms of security of supply, facilitation of the transition to a low carbon economy and direct customer benefit from access to the wider energy market. There are a number of challenges to address if these benefits are to be captured and maximised. Key amongst these is how the UK's gas transportation system and the associated commercial and regulatory framework can be most efficiently utilised, developed and operated to support these developments. To address these issues, the Project T-Shale will:

- Develop detailed scenarios that simulate the investment options that will be faced across a range of potential production capacities and geographical dispersion of unconventional sources of gas.
- Develop a system comprising several key elements – an economic model, a decision-tool, a simulation model and a scenario costing tool that together will allow modelling of the cost-benefit profiles for the full range of identified scenarios against a wider set of investment criteria that includes financial, economic, environmental, social and temporal factors. The system will also include new analysis that provides accurate estimates of low flow conditions on the distribution network.
- Identify and propose a regulatory and commercial framework which will be required to deliver any of the identified investment options that present the business case for development.

The project will deliver a new framework for identifying, assessing and implementing efficient infrastructure that maximises the net benefit associated with the development of shale gas production. This framework will provide policy makers, regulators, gas transporters and shale gas producers with the ability to directly assess the costs and benefits of alternative infrastructure development options and incorporate within the evaluation of the business case at both a policy individual project level. This framework will be developed in such a way that it will be accessible as a web based decision support tool, what will refer to as the T-Shale model, to be exploited by the industry to support the early stages of project development.

1.4 Funding

1.4.1 NIC Funding Request (£k):	£5,616,899
1.4.2 Network Licensee Compulsory Contribution (£k):	£624,100
1.4.3 Network Licensee Extra Contribution (£k):	£0
1.4.4 External Funding - excluding from NIC/LCNF (£k):	£0
1.4.5 Total Project cost (£k):	£6,240,999

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Section 1: Project Summary continued

1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more Projects which are interlinked with one Project requesting funding from the Gas Network Innovation Competition (NIC) and the other Project(s) applying for funding from the Electricity NIC and/or Low Carbon Networks (LCN) Fund.

1.5.1 Funding requested from the LCN Fund or Electricity NIC (£k, please state which other competition):

N/A

1.5.2 Please confirm if the Gas NIC Project could proceed in absence of funding being awarded for the LCN Fund or Electricity NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☒ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

- Addleshaw Goddard
- Aqua Consultants
- Environmental Resources Management (ERM)
- Enzen Global Ltd
- Leeds University
- National Grid
- United Kingdom Onshore Oil & Gas (UKOOG)

1.7 Timescale

1.7.1 Project Start Date:	1.7.2 Project End Date:
1 December 2014	31 December 2017

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title:	1.8.3 Contact Address:
Dan Sadler, Head of Investment Planning & Major Projects	Northern Gas Networks 1100 Century Way Thorpe Park Business Park Colton Leeds LS15 8TU
1.8.2 Email & Telephone Number: dsadler@northerngas.co.uk M: 07584 391466 ☎:0113 3975301	

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Section 2: Project Description

This section should be between 8 and 10 pages.

2.1 Aims and Objectives

A great deal of effort has been put into tackling social, economic, environmental and legal arguments currently preventing the development of shale gas in UK. Latest timelines for the development of shale gas, if at all, would suggest these arguments could be addressed and resolved in the next five to ten years.

To date, there has been little focus on UK gas transportation infrastructure development requirements. This is currently an essential, yet unexplored, challenge which will be a critical component to the successful introduction of shale gas into the UK energy mix.

The project addresses three questions:

1) What infrastructure development scenarios may be required to the UK gas transportation system to facilitate the development of the shale gas market?
2) What are the most efficient (cost and time), environmentally aware (reduced carbon impact) and socially responsible (e.g. jobs created) options for this transportation infrastructure development?
3) What are the potential regulatory implications arising from the transportation development program?

In order to answer these question the project has been divided into four core deliverables:

1) Creation of a broad range of scenarios, to provide a comprehensive overview of the options available for the development of the UK gas transportation system to facilitate the introduction of shale gas
2) Impacts assessment
   - A. Regulatory and legal impacts of the scenarios
   - B. Environmental impacts of the scenarios
   - C. Socio-economic impact of the scenarios
4) Technical and financial evaluation
   - A. Technically validate the existing network capacity models through flow trials to allow accurate analysis of low flow (summer) capacity
   - B&C. Develop a modelling software platform (S-Gas) to provide infrastructure development cost and carbon estimates (Capex/Opex) for each of the scenarios
5) Final report and development of the T-Shale web based decision support tool

a. The Problem(s) which need to be resolved

Currently a third of energy in the UK is provided by gas and this is expected to remain constant according to projected forecasts for UK gas consumption up to 2030. By 2025 the UK will be importing over 70% of its gas requirements. (Source: DECC Fracking UK Shale: Climate Change Report 2014).

In the light of what seems a strong case for the exploration and production of shale gas, there has been little, or no consideration as to the infrastructure development required to facilitate the development of this market.

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Project Description continued

NGN's experience in the biomethane market has identified a significant problem with the injection of alternative sources of gas into the current gas transportation system. The capacity of the existing infrastructure is often not sufficient to accept the flow rates that producers require. This challenge is magnified in the summer months when flows on the network are at a minimum, as gas consumption is relatively low. The challenge in the biomethane market is microscopic compared to the challenge that could face the shale gas market. This assessment is supported in the article 'Prospects on Shale Gas' which is available on the parliament website (the relevant section of this article has been added to Appendix 5).

As an example, if shale gas were to be extracted in the Yorkshire region there would be numerous implications for the infrastructure network. Questions arising from these implications have been listed below:

- How many wells may be established and what pressure and flow will each well produce and therefore, which mains pressure tier will be required for injection?
- Based on projected volumes, what is the impact on the National Transmission System (NTS) versus the local distribution network if NGN no longer required gas from the NTS?
- Can gas be transported through the NTS based on a geographically central UK injection point (i.e. North of England) as opposed to the current north to south configuration?
- Assuming all injections cannot be into the NTS, as the cost of the pipeline infrastructure would prohibit exploration at certain distances and/or if obstacles (roads, rivers, rail tracks) were in the way of the pipeline route. Based on the medium to long-term potential volumes, could there be a requirement for compression through the Local Transmission System (LTS) and injection back into the NTS at what may be an existing offtake?
- What are the timescales for the development of shale gas once the non-technical problems are addressed? How quickly could it grow and what infrastructure planning needs to be considered?
- Based on the latest gas transmission and distribution price control (RIIO), finishing in 2021 no allowance has been made in any GDN or NTS budget for transportation development to facilitate shale gas market growth. When the non-technical programs are aligned to the transportation development program will this position need to be reconsidered?
- Based on potential transportation challenges regarding both cost and time impact, should the government develop a policy for the introduction of shale gas in a staged release approach i.e. only releasing areas for development based on a transportation development program?
- Shale gas could be un-odourised – then transported through the LTS (odourised) into the NTS (which is un-odorised) and how does this impact the export of gas to Europe?
- What modifications will need to be made to the current UK regulatory framework and network code to which gas transporters currently operate?

The focus on the shale gas market to date has been on facilitating exploration and appraisal. This project will address the questions of time and cost for the associated pipeline and infrastructure development required to allow full-scale production to commence. At present, the expected timeline for production is anticipated to result in the UK's first productive wells coming on-stream within the lifetime of the next parliament. This is subject to exploratory well testing results, completion of necessary consenting processes

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Project Description continued

and site specific infrastructure being put in place. The key question is will the transportation system development be sufficiently advanced to meet this timeline? To date the answer is unknown, though highly unlikely, if a detailed review is not undertaken.

b. Solution

The business case for this project is based on addressing the questions set out in Section 2.1 and a successful project will provide a robust overview of the technical challenges for the UK gas transportation system for the development of the shale gas market, which through the T-Shale model provide an enduring web-based, decision support tool, for the industry.

A schematic of the T-Shale appraisal model is set out in the Diagram 1 below.

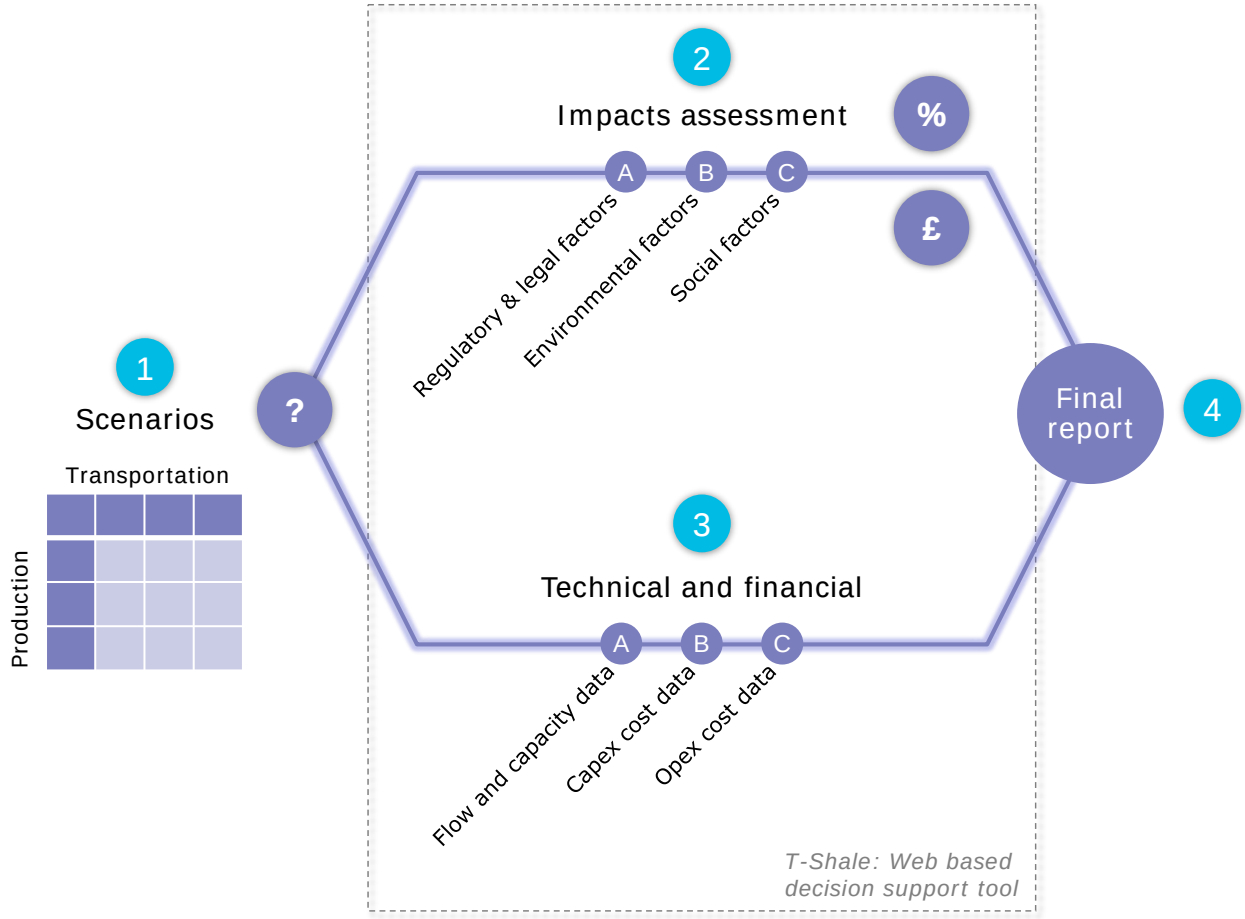

Diagram 1: T-Shale appraisal model

2.4 Technical Description of the project

The scope of this project is summarised below:

Deliverable	Sub-Deliverable	Within scope	Delivery Partner
1: Scenario Development	-	Scenario development: Information gathering on the various scenarios for shale gas development i.e. pressures, duration, flows, expansion predictions etc.	UKOOG/Various producers NGN System Control NTS System Control Enzen
2: Impacts assessment	2A	Regulatory and legal impact evaluation of scenarios	Addleshaw Goddard LLP alongside NGN in-house Legal Team
	2B	Environmental impact evaluation of scenarios	ERM
	2C	Socio-economic modelling and impact assessment	Consultant identified via competitive tender
3: Technical and financial	3A	Flow trial: Low flow trials using bolt on flow meters at multiple locations to revalidate the existing network analysis models	NGN Major Projects Team
	3B&C	S-Gas: Develop a modelling software platform (S-Gas) to provide infrastructure development cost and carbon estimates (Capex/Opex) for each of the scenarios	Aqua Consultants
4: Final report and T-Shale web platform	-	Final report and development of the T-Shale web based decision support tool	NGN (Core Team) Enzen

Out of scope	
I	Physical works associated with the exploration of shale gas
II	Consideration of gas sources other than shale e.g. remaining North Sea deposits etc.
III	Consideration of the future impact of the biomethane market
IV	Any physical transportation development works following the recommendations identified in the project
V	Actual changes to the regulatory framework or network code

The four deliverables are explained in more detail below.

Deliverable 1: Shale gas scenario development

In order to develop realistic scenarios for shale gas development it is critical to involve the exploration and production side of the industry. The project would begin with stakeholder meetings including UKOOG and multiple producers to establish realistic parameters for shale gas development. This will also form the basis of a university research paper, created in conjunction with our partner, the University of Leeds.

The project will develop a range of specific scenarios in the NGN region (including the Bowland Shale area), including but not limited to:

- Connection direct to the NTS
- Connection direct to the Gas Distributions Network (GDN)
- Compression through the LTS
- Regionalised 'stagger' infrastructure development
- Creation of new 'stand-alone networks'
- Extending associated connection infrastructure to facilitate connection of off-gas areas and alleviation of fuel poverty

For each scenario it is anticipated that a number of sub-options would emerge. An illustration of a scenario is shown in Diagram Appendix 5.

Once this stage of the project is complete the project team will look to generate the specific infrastructure requirements for each of the scenarios. These can be modelled to generate the cost, carbon and time impact on the development of the UK gas transportation infrastructure.

Development of the T-Shale model (Deliverables 2 and 3)

Deliverable 2 - Impacts assessment

The scale of the investment required to deliver the infrastructure to support UK shale gas could be at a level not seen in the UK gas industry since the conversion to North Sea Gas more than 30 years ago. Consideration of a set of potential distribution connection options highlighted a number of issues which indicated that including these within the analysis could provide a wider range of investment options, with a different cost profile but additionally the delivery of wider and longer term benefits when compared to current arrangements.

Project Description continued

Any consideration of these additional factors within the investment optimisation process must also consider whether any changes to the regulatory and commercial framework need to be made to facilitate the delivery of the wider benefits that may be identified.

In order to effectively address this problem NGN have selected Addleshaw Goddard (AG) working in conjunction with NGN's in-house legal team and ERM as the project partners. AG and ERM have experience in the emerging shale markets, recently providing UK wide workshops on the topic.

Deliverable 2A - Regulatory and legal impacts of the scenarios

The specific scope for AG will be:

- Provide an ongoing commentary and review of policy and legislative change over the lifetime of the project and consider how these impact on the projected timelines for delivery of both unconventional gas production and transportation infrastructure
- In conjunction with NGN's in-house legal team, propose any desirable changes to the legal and policy framework to facilitate coordinated delivery of production and transportation infrastructure to ensure the identified social, economic and environmental opportunities from domestic shale production are fully realised
- In conjunction with NGN's in-house legal team, review and report on the status of the UK regulatory environment for shale

Deliverable 2B – Environmental impacts of the scenarios

The specific scope for ERM will be:

- Investigate the environmental impacts of each of the scenarios

Deliverable 2C: Socio-economic impacts of the scenarios

The specified scope for successful tenderer will be:

For each scenario evaluate:

Direct impact: i.e. What is the boost to the UK Gross Value Added (GVA) and employment as a result of the expenditure to construct and operate the new infrastructure?

Indirect impact: i.e. What is the impact on UK GVA and employment as a result on the additional demands on the supply chain as a result of the new infrastructure?

Induced impact: i.e. What is the impact on UK GVA and employment as a result of the additional consumption of the workers who construct and operate the new infrastructure?

Deliverable 3: Technical and financial evaluation:
Deliverable 3A: Technically validate the existing network capacity models through flow trials to allow accurate analysis of low flow (summer) capacity

NGN's network analysis uses proprietary modelling software based on peak gas demand, which makes mathematical assumptions of both flow and pressure to calculate capacities at differing demand scenarios.

Proposals to introduce unconventional gas sources into the network has a significant impact upon the methodology used for modelling of the networks because of increased, and non-standard locations (i.e. not from the National Transmission Grid) of gas entry points and the change in the dynamics of the network in terms of flows at minimum demand.

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Project Description continued

NGN need to develop the existing network analysis methodology to establish the true network capacity to determine the safe, efficient and acceptable profiles for injection rates from unconventional gas producers in advance of sanctioning applications for network entry agreements. The flow trials that have been identified will allow effective recalibration of the model to ensure accurate modelling at peak and off-peak scenarios. This will enable accurate information to be provided to the unconventional gas market with the use of minimal over conservative assumptions.

In order to do this NGN have undertaken a detailed review of its existing network to ensure only a representative sample of trials is undertaken, from which the results can be extrapolated to provide meaningful results for the full network model. 12 of the 39 network models currently employed by NGN have been selected for investigation on the basis of complexity or similarity to other models or geographical areas within the network.

The flow trials require the installation of 53 ultrasonic flow meters which will be installed at key strategic points. This will determine actual flows under different demand conditions to encompass a minimum period of two summers. The networks identified are listed below.

Network	Type	Flow Meters	Notes
Scarborough MP	Coastal Town	2	Similar to a number of other location
York MP/IP	Small/medium urban town/city	4	
Wharf Valley	Small/medium rural villages	3	
Leeds MP	Complex multi nodal	5	Additional EP will significantly affect dynamics
East Coast Grid IP	Complex multi nodal	2	
South York's MP/IP	Complex multi nodal	4	
Northumbria MP	Complex multi nodal	5	
Thornaby MP	Complex multi nodal	6	
Bradford MP/IP	Complex multi nodal	5	
Calder Valley MP/IP	Complex multi nodal	7	
Hull MP/IP	Complex multi nodal	7	
Cumbria MP/IP	Complex multi nodal	3	
TOTAL		53	

The flow data will be collected in real time via mobile or fixed telemetry through a web interface from which the data can be downloaded for detailed analysis. NGN intend to develop this system to display real time flows to assist with future verification.

Following the first minimum demand period in summer 2015, the analysed data will be used to validate the network model outputs below peak demand, which are solely based on mathematical assumptions.

Models which do not demonstrate similar characteristics to the captured data will be remodelled to replicate actual recorded conditions.

NGN will then validate its newly developed low flow modelling system by using smart metering data, collected from alternative locations on the network, to robustly verifiy the revisions to the network analysismodels during low flows (see Appendix 9 for more detail on flow trials).

Enhanced confidence in the models will then allow detailed analysis of new proposed entry points. This will add significant benefit to current processes for analysing unconventional gas connections and provide invaluable experience prior to the onset of a shale gas market.

Deliverable 3B&C: Develop a modelling software modelling system (S-Gas) to provide infrastructure development cost, time and carbon estimates (Capex/Opex) for each of the scenarios

A key output for the project is to provide an enduring tool that can assess the impact of different UK gas infrastructure development scenarios would have on the UK economy. NGN recognise that a scenario modelling tool (S-Gas) would need to be developed to enable cost, carbon and time estimates to be produced for each of the scenario developed (Deliverable A). This will allow detailed programmes to be produced based on multiple alternative options.

Aqua Consultants (AC) have been chosen by NGN to produce infrastructure development cost, time and carbon estimates modelling system (S-Gas) based on comparable past experience in the water industry. AC have already delivered an engineering and cost model for Northumbrian Water (NWL). NGN have undertaken a review of the NWL modelling system and it is clear that this tool, redeveloped for the gas industry, would be the ideal option for Project-Shale. Once developed S-Gas will model scenarios quickly generating consistent technical, cost, carbon and time outputs. This S-Gas model would then be available to all networks to benefit from the ability to run scenario modelling to assist with future planning objectives.

The learning and development that AC gained in the water industry will significantly reduce the required time and costs for the development of a similar model for the gas industry. The S-Gas system will be held on a private cloud system which means that the models are held on a secure cluster of servers and they can be accessed by any organisation with appropriate login credentials and an internet connection.

S-Gas Model Development

Whilst working with NWL, AC generated over 120 data repositories of the most commonly used processes in water and waste water treatment, water and sewer networks and sludge treatment. Each model needs only minimal input data, such as a flow or population equivalent, to calculate the required size of each asset. The system then generates a fully engineered solution with a priced bill of quantity level output of the scope, Opex costs, Whole Life Costs (WLC) and carbon data. To generate all of these outputs the data repository contains numerous default values that are set to match industry standards. These values can be adjusted should the user wish to tailor the output to match site specific requirements. The automatic generation of fully costed outputs (bill of quantities) saves a significant amount of time compared with traditional engineering and estimating techniques,

whilst also improving consistency. In spring/summer 2013 AC and NWL used this estimating system to generate the PR14 business plan with over 300 projects/scenarios being modelled.

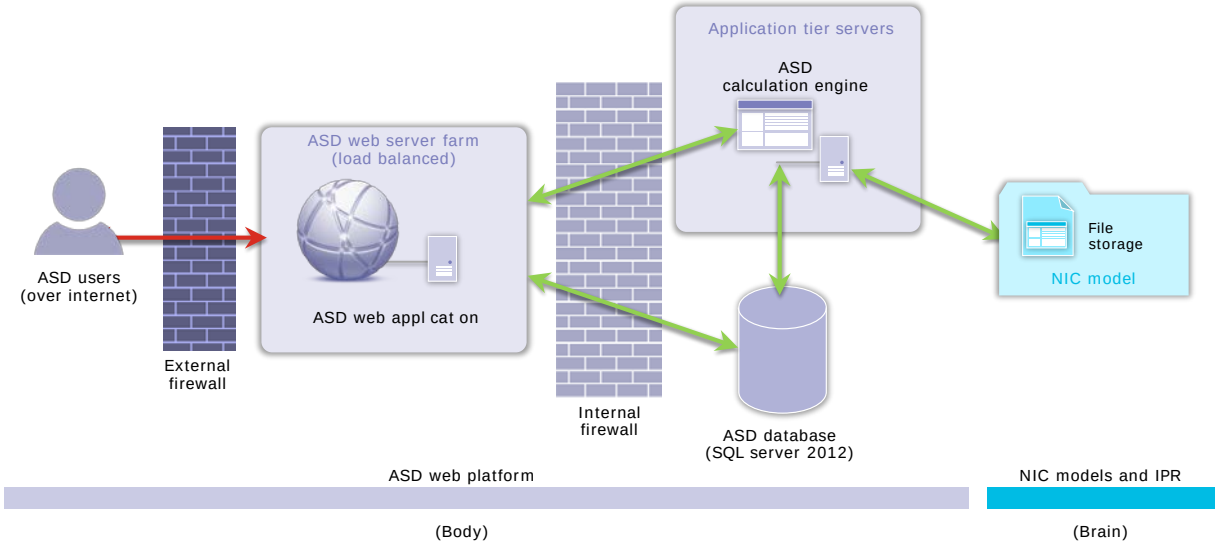

Diagram 2: S-Gas structure

The S-Gas system will be developed using the following stages.

1) Agree model scope and set boundaries of each asset
2) Capture data for use in model, including technical standards and details and supplier information
3) Develop engineering calculations to enable the scope to be costed
4) Develop component level models to allow assignment of Capex, Opex and WLC to the selected model result
5) Link component level models to the asset model to enable the generation of a bill of quantities, WLC, Opex and carbon data
6) Test model
7) Take model and link into the SQL user interface
8) Test system

The programme duration for the production of the S-Gas system will be 24 months. The S-Gas system will provide the following functionality:

- Intelligent engineering and estimating will generate the following outputs: scope of works; Capex cost; Opex costs; embodied and operational carbon; WLC; and programme
- The model will be used to engineer and cost multiple options/solutions with the flexibility to refine the detail to improve accuracy tolerances
- The models will enable NGN (and other GDNs) to validate, benchmark and challenge engineering and estimating outputs throughout the industry for similar types of solutions
- A user friendly web app which will allow multiple user access via an internet connection with helpdesk support

Deliverable 4: Final report and development of the T-Shale web based decision support tool

Final results and recommendations will be complied into a detailed final report. The report will include:

- A comparable set of programs for the non-technical challenges associated with shale gas development against a range of infrastructure development programs based on alternative viable scenarios
- Clear direction on the most economic, carbon efficient and realistic scenarios for the required development of UK gas infrastructure
- Clear recommendations on required reforms to regulatory arrangement around the UK gas transportation industry
- A list of technical challenges that need to be addressed before shale can be injected into the NTS and/or the LTS

Creation of T-Shale web based decision tool

The project will also provide the industry with a web based decision support tool, to enable regulators, producers, investors and networks to evaluate projects across the UK. The T-Shale model will provide:

- The UK gas industry with a detailed cost and time estimating tool for project development
- Risk and opportunity analysis, including impacts on employment, carbon estimate and indication of the capital cost and time of various risks on the proposed project(s)
- UK policy makers with the ability to undertake different weighted benefit options against the pre-defined scenarios that have been developed as part of the project, for example:
  - Which set of scenario have the least environmental impact
  - Which set of scenarios have the lowest impact on customer bills
  - Which set of scenarios have the highest social impact (e.g. jobs created)
  - A mixture of the above

The web platform should provide clear costs and pictorial representation of the infrastructure requirements in a user friendly understandable format

2.4 Challenges since initial screening process

Since the ISP submission all aspects of the project has been challenged and reviewed. The principle of what is to be achieved have remained fundamentally the same i.e. provision of a realistic picture detailing the requirements for the development of the UK gas transportation industry to facilitate the growth of shale gas.

NGN have worked tirelessly to ensure the correct mix of project partners are on board to enable successful project delivery and presentation of the whole picture. This has involved extensive workshops with all bid partners to ensure a common and universally supported vision of the project.

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

3.1 Background

The business case for T-Shale is based on answering three clear questions:

1) What infrastructure development scenarios may be required to the UK gas transportation system to facilitate the development of the shale gas market?
2) What are the most efficient (cost and time), environmentally aware (reduced carbon impact) and socially responsible (e.g. jobs created) options for this transportation infrastructure development?
3) What are the potential regulatory implications arising from the transportation development program?

Adding clarity to these questions will enable the industry to understand the full picture when considering the development of the UK shale gas market.

3.2 The Current Understanding of the Market / Work to Date

A recent industry commissioned study undertaken by EY looked into the potentials of shale gas in the UK. The study is useful for understanding the production element of the shale gas market. However, there would appear to be a lack of understanding when considering transportation and connection to existing infrastructure. The study is available at:

http://www.ey.com/UK/en/Industries/Oil---Gas/EY-getting-ready-for-shale-gas?utm_source=linkedin&utm_medium=sponsored&utm_term=20.5bn&utm_campaign=shale

The study states 'Connecting to the National Transmission System and UK gas distribution networks should be relatively straightforward'. NGN believe this is inaccurate and unrepresentative of our experience of biomethane (and other on-shore gas) connections which, by comparison, would be insignificant in scale compared to the onset of shale gas.

The study summarises the latest estimates on the impact of shale gas in the UK. The key findings are identified overleaf and are taken directly from the EY website. Other information on the key points from this report has been provided in Appendix 5.

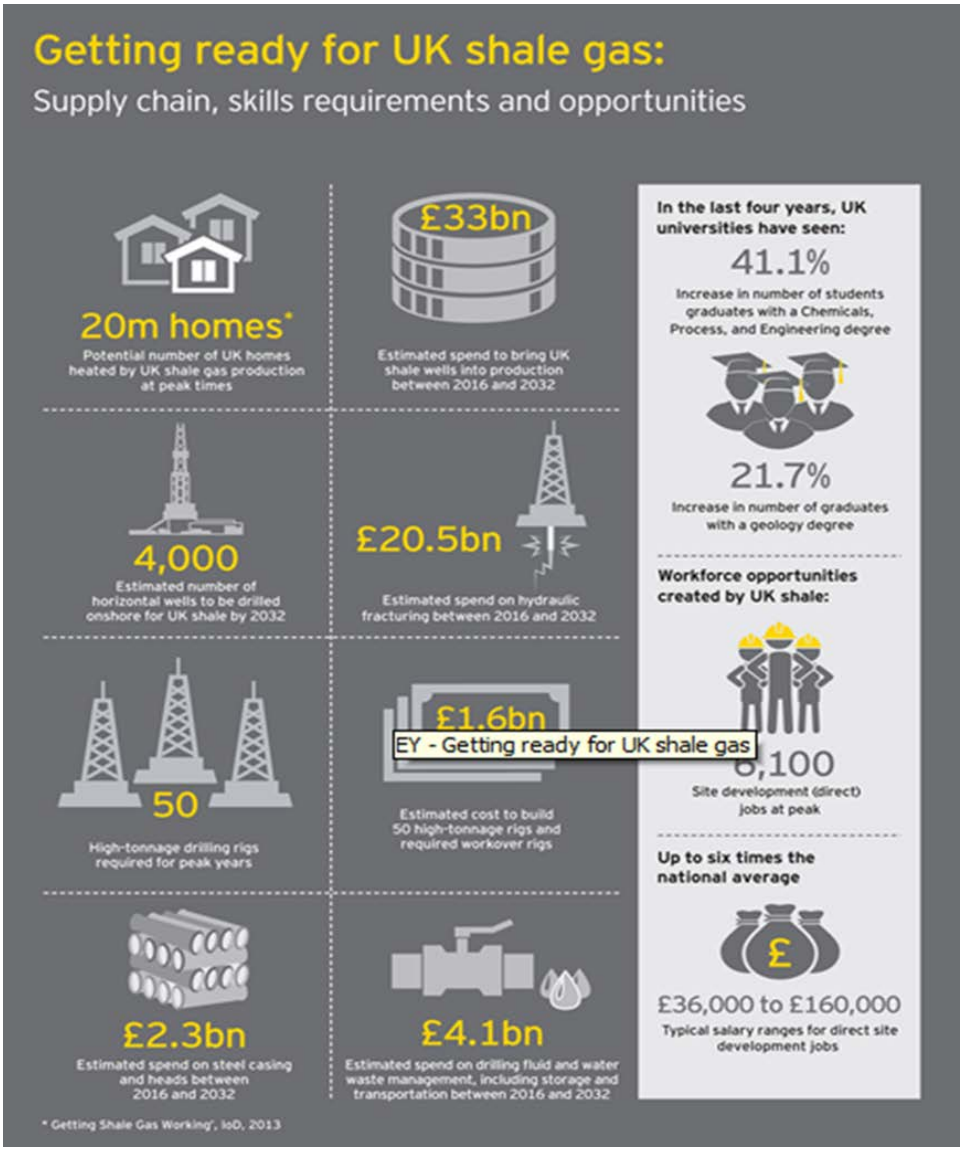

Diagram 4: 'The potential for shale gas' Source: EY website

When considering the scale of the potential shale gas market in the UK, the business case to understand the infrastructure transportation requirements appears simple to justify. T-Shale will provide a comprehensive overview of the transportational options available for shale gas development. It will add clarity in terms of cost, time, carbon and socio-economic impact of gas transportational development requirements.

3.3 Customer Benefits - Financial and Carbon Benefits from NGN activities

If this project is not undertaken the development of the infrastructure associated with the onset of the UK shale gas market will be at best random and inefficient, and at worst (but most likely), a significant obstacle to the introduction of shale gas to the UK market.

Failure to understand and design an appropriate transportation development strategy will lead to NGN, and the wider gas industry, facilitating connection requests based on ad hoc and uncoordinated connection enquiries. The costs and time associated with these

Project Business Case continued

connections would potentially be prohibitive and under current regulations and processes would be passed onto the producer. Following (and during) T-Shale an optimised and informed transportational development strategy can be developed which will provide the best customer benefit for UK plc taking into account cost, time, carbon and social considerations.

T-Shale will also provide an overview of required changes to existing regulatory policy which would currently obstruct the development of alternative transportation scenarios and would delay the growth of the shale market. For example, could a network with significant shale reserves ultimately become a shale gas only network? This would require isolation from the National Transmission System (NTS) and new network codes to cover shale gas quality and other operational parameters.

Financial and carbon benefits from UK Gas industry Activities

T-Shale will provide a transferable blueprint for the rest of the UK. It will consider the NTS and NGN's network and produce viable transferable information for use in other networks. The project will also produce a transferable scenario modelling package for the UK (S-Gas), as well as analysis and methodology for effective modelling of low flow scenarios.

Noting the most significant deposits of shale are currently identified in the North of England, NGN (with associated modelling of the NTS by National Grid), is best placed to address the issue. The output from T-Shale will allow UK wide consideration of the shale gas transportation challenges. This will directly benefit:

1) The UK Government, who will be able to design an optimised UK strategy considering all the variables of an economic model
2) Producers, through a clear understanding of the transportation options available and associated cost and risks
3) The UK gas transportation industry by providing an informed strategy for transportational development
4) The wider supply chain who will have visibility of the program for transportational development

3.3. Project Financial Analysis

To deliver a project which will address such a significant issue the organisational structure and the selection of partners is critical. The total costs for the NIC bid are summarised below. The NIC spreadsheet is attached separately (Appendix 1) with a further breakdown available in Appendix 2.

Funding Source	Funding Levels / Contribution (£K)
NIC Funding	£5,616.90
Northern Gas Networks contribution	£624.10
Project partners	No direct funding but a significant contribution through discounted rates. (See details in Appendix 2)

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Project Business Case continued

The overall structure for the project is represented diagrammatically below:

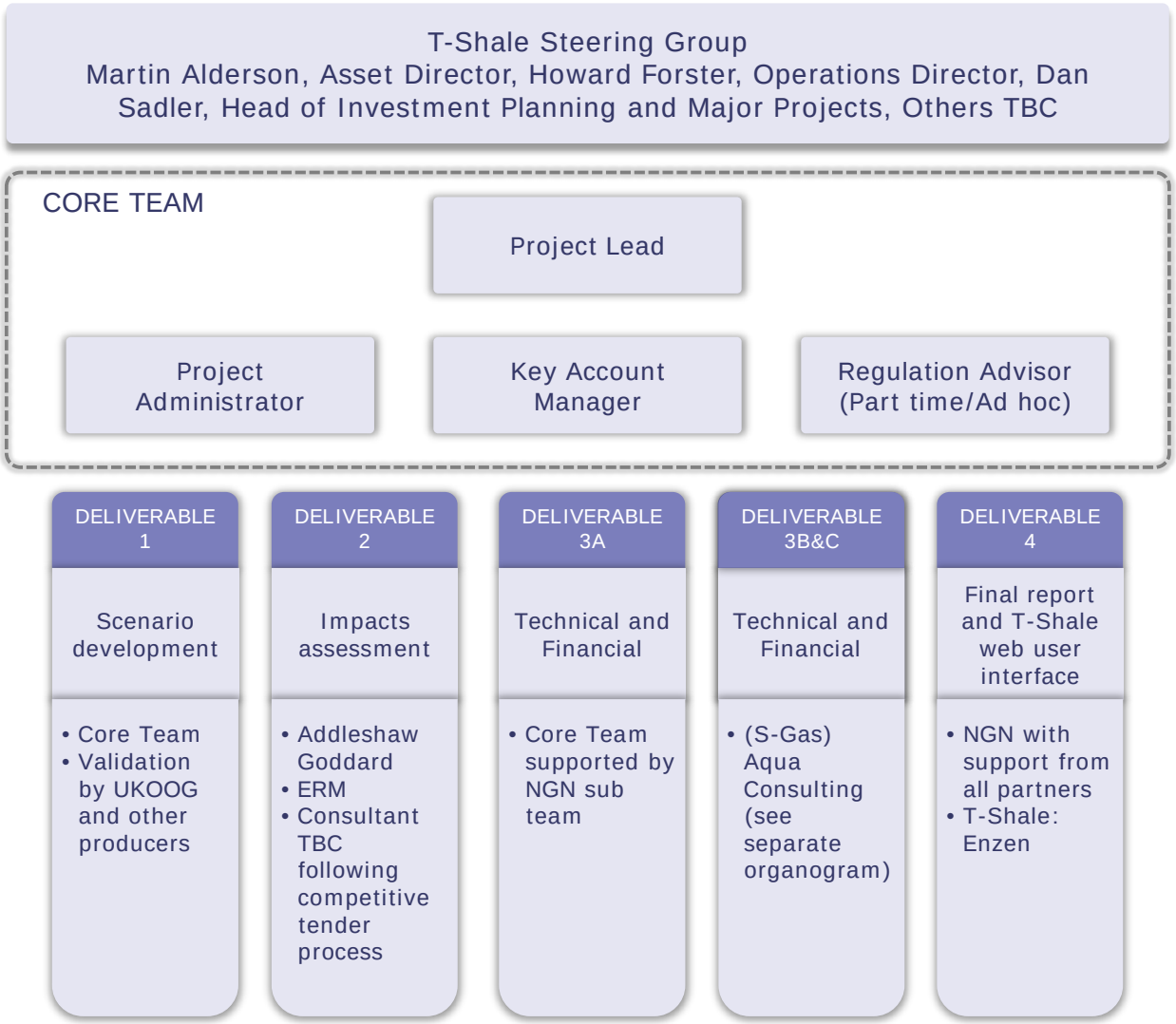

Diagram 5: T-Shale project structure

Core team (including T-Shale platform)

Reporting to the T-Shale Steering Group the Core Team will be engaged through NGN's professional services framework and will be responsible for the overall project delivery and the information sharing platform.

TOTAL COST FOR CORE TEAM:	[redacted]

Deliverable 1: Scenario Development

Information gathering on the various scenarios for shale gas development i.e. pressures, duration, flows, expansion predictions etc. This section will be led by the Core Team through a series of facilitated workshops involving all project partners and the members of the wider production and transportation industry. The additional costs listed below will be required for marketing, UKOOG and university support costs.

TOTAL COST FOR DELIVERABLE 1	[redacted]

Deliverable 2: Impacts assessment

The impact assessment element of the project will be managed using AG (2A), ERM (2B) and successful Consultant following competitive tender (2C). This includes production an impacts assessment of the shale gas position including legal, regulatory, environmental, and socio-economic aspects of the project.

	AG	ERM	TBC
Pre Award	[redacted]		
Preparation of Preliminary Report (6 months)	[redacted]	[redacted]	
Year 1 update report 'Running Draft'	[redacted]	[redacted]	
Year 2 update report 'Running Draft'	[redacted]	[redacted]	
Final Report (end year 3)	[redacted]	[redacted]	
TBC economic modelling costs			[redacted]
Sub Totals	[redacted]	[redacted]	[redacted]
TOTAL FOR DELIVERABLE 2:	[redacted]		

Deliverable 3: Technical and financial evaluation

3A - Flow trials

This is the most significant single element of cost for the project. The costs are split between a project management sub-team who will manage this element of T-Shale (including the analysis of results and remodelling) and the costs for design, procurement, and installation of the flow meters.

Item	Cost
Project management	[redacted]
Procurement / Installation	[redacted]
TOTAL COST DELIVERABLE 3A:	[redacted]

3B&C - S-Gas

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Project Business Case continued

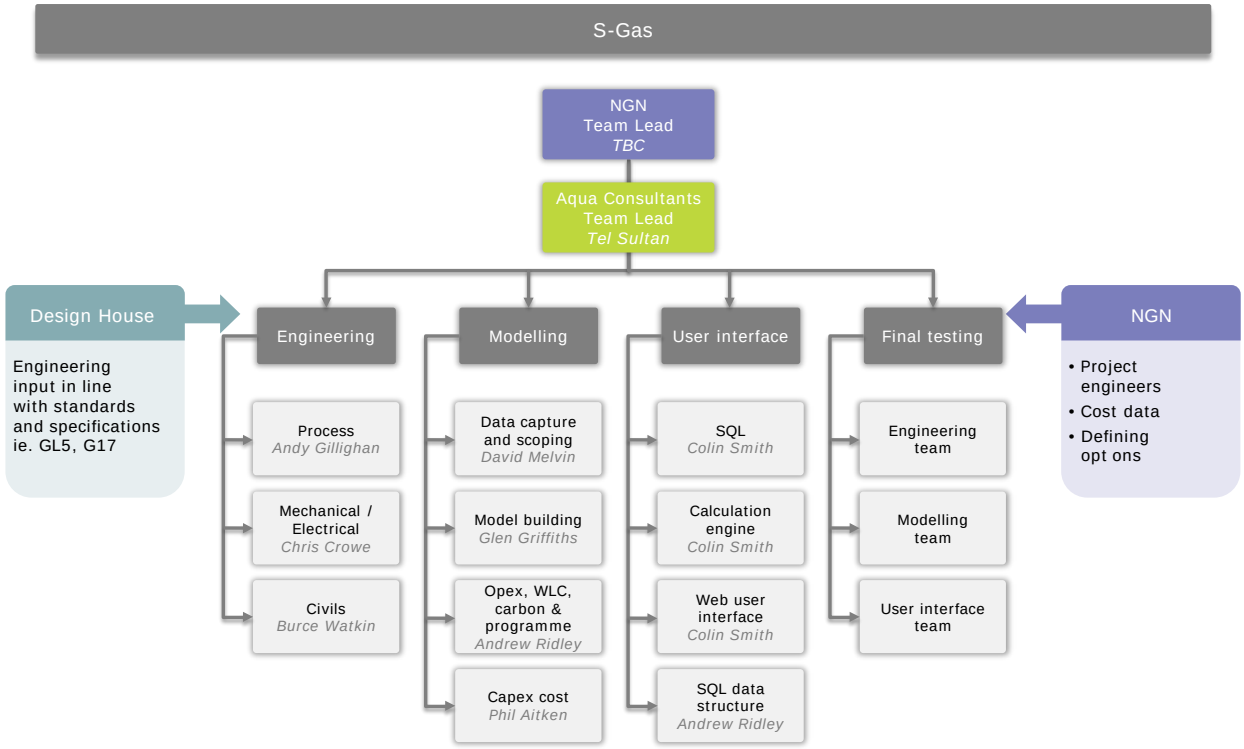

Diagram 4: S-Gas team structure

AC have provided a detailed cost breakdown for the above team using the NGN Professional Services tendered framework rates. The team would work on an ad hoc basis, as required, for various stages of the 24 month project delivery.

TOTAL COST FOR DELIVERABLE 3B&C	[redacted]

Deliverable 4 – Final Report and T-Shale web platform

The final report will be produced by the Core Team in conjunction with Stage 5 of the non-technical agenda. The costs for this deliverable have been accounted for in the Core Team and Stage 2 costs. This deliverable will also include the T-Shale platform.

3.4 Project Partners Contribution

The project partners are not contributing any cash up front into the project. However all partners have offered a significant reduction in rate which translates to a total indirect contribution to the project of:

Partner	Discounted Contribution (£K)
Aqua Consultants	[redacted]
Addleshaw Goddard	[redacted]
ERM	[redacted]
TOTAL	[redacted]

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Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

4.1 How does the project:

a. Accelerate the development of a low carbon energy sector

T-Shale is not starting from a perspective that the development of shale and/or other non-renewable forms of unconventional gas will deliver reductions in carbon. Instead, it is considering the potential for the facilitation of an efficient route to get from the current position to the longer-term requirement. Shale gas production provides an option, from a policy perspective, of a much cheaper short-term transition away from carbon intensive electricity generation (primarily coal). This creates space within the timeframe between 2020 and 2050 for new technologies and associated policies to be developed and implemented to achieve the UK's carbon targets.

Shale gas development means that a more rapid coal-to-gas switch is possible without significantly raising costs or reducing security of supply. When shale gas is used for electricity generation, the carbon footprint is likely to be in the range of 423–535g CO2e/kWhe, which is significantly lower than the carbon footprint of coal, which is 837–1,130g CO2e/kWhe (Source: MacKay and Stone, 2013). This is likely to result in a net reduction in carbon emissions for the electricity sector as a whole and would directly contribute to the UK government strategy to reduce GHG emissions as per the Carbon Plan.

The carbon impact of the full cycle of shale gas from production to consumption must also be recognised. Other energy sources, such as coal, have significant carbon impacts associated with both the production and transportation elements of the cycle. When considering shale gas it is therefore important to consider the carbon impact of both the development, construction and subsequent operation of the associated gas transportation networks. At present, there is no method or framework to assess carbon emissions related to transmission of shale gas from well heads to injection points. Roll-out of the proposed project across the UK would provide an efficient and structured tool to carry out such an assessment for quick decision making. T-Shale will provide a wide range of transportation options for shale gas from the well heads to the injection point. Each option has implications on carbon emissions based on several factors:

Distance to injection point: The extracted shale gas is, in most cases, likely to be conveyed through pipelines to the injection point. This could impact direct carbon emissions through fugitive releases including vented emissions during maintenance as well as possible flaring (combustion emissions). Distance, type of material and construction practices used for laying the pipeline will have a directed and proportional impact to the carbon impact of any infrastructure project. If shale gas from certain wells are transported by vehicles, carbon emissions would result from direct fugitive emissions during gas transfer processes as well as emissions from these vehicles.

Pipeline material, size and construction: The chosen gas transportation solution of any scheme will have a specific carbon footprint based on a wide range of factors including pipeline material, size, length and construction methods and practices.

Gas compression: Gas transmission from gas importation terminals along the coast is through large diameter high-pressure pipelines (up to 85bar). The NTS has over 7,600km of welded steel gas pipeline with 24 (mostly gas turbine driven) compressor stations (which keep the gas flowing through the system). Gas is transported through a number of reducing

pressure tiers (38bar, 17bar, 7bar, 5bar, 2bar, LP) until it is finally delivered to consumers. Injection of shale gas into the NTS or LTS may have a direct bearing on the energy needed to compress the shale gas prior to injection with implications for carbon emissions.

Network Operation: Transportation solutions may also involve alternative requirements and methods of operating the network that may be more or less carbon intensive.

The roll-out of Project-Shale across the UK would provide quantitative data on the carbon and environmental impacts of different shale gas transportation options with a single measure developed to compare these different options. This assessment would be useful to determine whether any single, or set of scenario options, would be the most suitable across different well locations and develop a UK wide framework for shale and unconventional gas transportation.

The project would provide guidance for selecting a scenario option for a particular well location based on carbon and environmental impacts. This is proposed to be integrated with the cost of the option to ensure that the recommended option would be the most optimal and efficient. Finally, the solution would make a significant contribution to the UK gas industry's carbon inventory by providing a framework for assessing carbon emissions in the transportation of shale gas. This would factor in uncertainties and provide direction for future research in emission monitoring.

b. Delivers wider environmental benefits

In addition to the carbon impacts of each of the transportation options of shale gas discussed above, other potential environmental impacts would be included in the assessment framework covering:

Physical impact on new infrastructure: The development of new gas transportation infrastructure inevitably has a direct and potentially significant impact on the local physical environment both during construction and subsequent operation. These network issues are not dissimilar to those currently faced by gas production facilities and must be considered within the evaluation if efficient solutions are to be identified. Factors such as proximity to heritage, archaeological or historical sites, settlements and communities and local urban or rural infrastructure are examples that will be included within the analysis.

Analysis of scenarios which include these specific factors provide a basis for defining efficient transportation infrastructure development that minimises or limits the impact on the local physical environment. The project will include the development of an approach to compare different injection options for a potential well location and estimate the carbon and environmental impacts of the transportation network.

4.2 Provides Value For Money to Gas Customers

The focus of the project is to provide a means by which the most efficient transportation infrastructure development associated with large scale unconventional gas production can be facilitated. The UK has significant potential for large scale production of on-shore unconventional gas sources in the next 10-20 years with potential benefits in terms of security of supply, the facilitation of a low carbon economy and direct customer benefit derived from greater access to the wider energy market.

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Evaluation Criteria continued

There are a number of key issues that the lack of consideration of the issues facing infrastructure development raises including:

- Will the current combined technical, regulatory and commercial framework deliver efficient production capacity and location decisions?
- Will the scale of infrastructure investment required deliver an optimal solution?
- Does the current combined technical, regulatory and commercial framework consider the full range of costs and benefits of large scale infrastructure development to deliver an optimal solution for the UK economy?

Under a range of indicative scenarios, it is possible to forecast significant levels of expenditure, potentially totalling hundreds of millions of pounds required to develop the necessary network infrastructure. Therefore, even viewing this problem in its narrowest form of attempting to identify a framework that delivers the lowest cost solution for developing the infrastructure required, the project has the potential to provide significantly lower energy bills whilst providing the additional macro benefits identified above.

However, current arrangements do not consider a wider range of issues that could better inform investment decisions and deliver additional benefits including:

- Socio-economic issues such as fuel poverty
- Economic/customer value benefits of extending access to wider energy market for off-gas energy users
- Carbon impact of investment options including carbon footprint of network investments and operations, the potential to facilitate greater connection of low carbon sources of gas, reduction in carbon footprint of gas customers who switch to using gas from higher carbon sources of energy
- Sustainability of energy supplies
- Operational impacts of alternative options

Extending the evaluation criteria to include these additional factors has the potential to drive further customer value in terms of environmental and social outputs for gas customers. The scale of the potential benefits for customers will be determined by the analysis and is a key objective of the project.

a. Outline how the Project has a potential Direct Impact on the Licensee's network or on the operations of the GB System Operator.

T-Shale is about optimisation of transportation for shale and unconventional gases and will have a direct impact on NGN, other gas network licensees and the GB System Operator. The following are some of the areas which will be impacted:

- A review of existing policy and regulation has the potential to impact the operations of all networks as well as the GB System Operator
- A review of current industry processes, including the nominations and commercial processes, could impact the operations of all networks as well as the GB System Operator
- Multiple injection points in the network could impact all network licences and the system operator as the physical balancing processes will have to undergo review and potential change. This will include a review of storage and intake planning considering new input sources on-shore and an assessment of the tools and processes used to balance the network

- The learning from this project will enable the UK to make optimal decisions on transportation options and injection points. These, in turn, will inform the network planning for future infrastructure requirements

b. Justify that the scale / cost of the Project is appropriate in relation to the learning that is expected to be captured.

The learnings from T-Shale will help in the evaluation of the viable options for the transportation of shale and other unconventional gases at a national and individual project level. It will support the decision making process at all levels including policy makers, regulators, transporters and producers. The learnings accrued will deliver the following industry wide benefits:

- The best value transportation options for the UK consumer
- Contribution to the Carbon Plan by helping select a transportation option which is the most carbon efficient as well as helping make other unconventional gases, such as biomethane, more economical to connect to the grid
- Socio-economic benefits by choosing a transportation option which considers the ability to connect off-grid customers and provide benefits for fuel poor customers

We have estimated the base cost of developing infrastructure to meet the requirements of the production capacities for unconventional sources of gas in the UK could be in the region of hundreds of millions based on current network configurations. This estimate is based on the extrapolation of industry data to estimate the number of pipelines, connection points, pressure reduction stations and compression facilities that could be required to efficiently facilitate the shale gas market. This figure will be quantified as a result of this project. This allied to the scale of investment needed to develop production capacity itself of £50bn illustrates the scale of the financial investment in this area. A small percentage saving on the transportation investment costs will derive a significant financial benefit for customers. This project will demonstrate this saving.

The cost of developing transportation infrastructure is fundamental to proving the business case for these projects, is therefore key to delivering the significant non-financial benefits. Taking a more holistic view, a benefits case for each scenario considered will quantify the potentially significant carbon, wider environmental and security of supply benefits can be generated for customers.

c. The processes that have been employed to ensure that the Project is delivered at a competitive cost

Throughout the development of this project and during NIC bid preparation, NGN have sought to ensure that the project will deliver good value for money for gas customers:

Efficient project costs: All large investment projects within NGN are managed and delivered via the Major Projects Team that employs an Integrated Management System (IMS) that is integrated with the ISO9001 quality system. This project will be delivered and managed using this system and will ensure that the project is managed efficiently, taking into account all relevant legislation, appropriate commercial strategies and quality management.

Wherever possible, the project will be delivered using NGN's approved framework partners for design and delivery. These partners have been identified and selected through a competitive tender and procurement process. To ensure that framework partners meet the requirements of NGN, these partners are regularly reviewed and performance evaluated.

Evaluation Criteria continued

Where project partners have been identified outside of NGN's approved framework, we have identified and selected them on the basis of the overall value that they can contribute to the project. This value is presented in a number of ways including relevant expertise and knowledge within the market, financial contribution to the project, in the form of discounted or pro bono services. Potential partners have also been assessed on their ability and willingness to identify and develop the core concepts and scope of the project.

Minimising project scale and scope: This project benefits from potential economies of scale and scope. As there is little information existing in the UK surrounding the issues identified within the project it has been important to clarify what is in and out of scope, as has been outlined in Section 2.2. This ensures that the project team can focus on the key issues, whilst not building in project risks from being over-ambitious has been a key element of forming the project in detailed discussion with our project partners. We have worked hard to identify the minimum size of project that can deliver these benefits.

d. Discuss the expected proportion of the potential benefits which will accrue to the gas network as opposed to other parts of the energy supply chain, and what assumptions have been used to derive the proportion of expected benefits.

The main beneficiaries of this project will be the UK economy and the UK gas consumers. However, the operational benefits of the project will accrue mainly to the gas network by allowing for a framework for decision making and governance, as well as optimisation of transportation costs.

Potential benefits to the UK economy and the UK consumer:

- The most optimised option for the transportation of shale and unconventional gases for the UK gas industry can be identified which in turn will foster the development of other 'green gases'
- Encouragement for the economic case for biomethane which is currently challenged by a lack of accurate capacity data based on low flow scenarios
- Contribution to the Carbon Plan by developing tools which will:
  - identify the most carbon efficient transportation option
  - Include of more off-gas consumers in the network. Over four million households in the UK are not connected to the mains gas grid and therefore use other fuel sources for their heating. These off-grid fuels include kerosene heating oil, liquefied petroleum gas, coal, wood and electricity, these large off-grid populations in the UK, both urban and rural. This project could facilitate an opportunity for off-grid properties to be connected to the gas network. By converting to a mains gas supply, these customers will make considerable savings on their fuel bills
- Minimising the impact of infrastructure development on consumer bills by optimising the transmission and distribution system development cost
- T-Shale, the web based decision support tool will enable policy makers to adopt the most appropriate transportation infrastructure strategy to optimise the various benefits e.g. social benefit selected will give an projected number of jobs created for UK plc

Potential benefits to the gas network:

- Providing the basis for rules and policy for shale gas in the UK which can help the development of the industry, as well as economic viability of the transportation network up to and beyond 2050
- A framework for decision making on transportation options and commercial implications

- A framework which fosters the development of biomethane and other unconventional gases and prepare the industry to deliver the gas network of the future
- Help the gas networks remain carbon efficient by helping them choose transportation options which are aligned to the Carbon Plan
- A re-evaluated, accurate analysis model for low flow prediction. (through Deliverable 3A)
- A scoping and estimating tool for future business plan development (S-Gas)

4.3 Generates knowledge that can be shared amongst all relevant network licensees

The project will provide a framework for the best transportation options for shale. In doing so, the project method will generate knowledge which enables the appropriate transportation decisions to be made. Examples of knowledge generated include;

- A model which enables the industry to calculate the economic costs of different transportation options
- A model which enables the industry to calculate the time required to develop different transportation options
- A model which enables the industry to calculate the carbon costs of different transportation options
- A framework to assess the socio-economic impacts of various transportation options
- A review of existing regulation and industry-wide processes and recommendations on changes required to fit to a future of onshore and unconventional gases

The project will be a collaborative effort with all relevant stakeholders including network licensees, the GB System Operator, on-shore gas producers, industry associations (such as IGEM and UKOOG) and universities to foster learning and knowledge.

The output of the project will be knowledge that can be shared, and of significant value to network licensees in considering the impact of the development of new sources of gas will have on transportation networks and outline how they will need to respond to these challenges. They will also be of equal value to policy makers, regulators and producers in considering the macro and micro level business cases, required changes to regulatory and framework and efficient investment levels needed by networks over the relevant period.

4.4 Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

NGN, and a number of project partners, have been following, and in some instances, driving the growing debate surrounding the potential large scale development of shale gas in the UK. It has become apparent that to date, there has been little discussion or consideration of the issues surrounding the efficient development of the transportation infrastructure required to facilitate this production capacity. The scale of investment required to deliver this infrastructure could be at a level not seen in the UK gas industry since the conversion of the UK to North Sea Gas.

There are a number of uncertainties associated with the development of large scale production of these unconventional sources of gas that provide a significant amount of risk.

The wider business case for the development of new unconventional sources of gas is partially dependent on the identification of an efficient infrastructure development framework. Key to this element of research and development being completed is external

funding via the innovation stimulus package provided by Ofgem. The primary drivers for this are:

Uncertainty: There remain some uncertainties around the timing and potential development of sources of unconventional gas.

Benefits: The majority of the outputs of the project will be of significant and direct value to parties other than the gas networks, and will include policy makers, regulators and producers.

Partners: The level of information required about network specific issues and access to expertise and modelling capabilities means that the project could not go ahead without network participation.

The NIC funding mechanism allows us to directly fund an area that has received little investment whilst addressing these key risks. However, for this project in particular, it will also allow us to accelerate the timescales for addressing these issues and provide a more timely evaluation of the business case and the any framework changes or funding arrangements.

4.5 Involvement of other partners and external funding

A project of this nature requires the involvement of a wide range of both project partners and stakeholders to fully address the key issues and deliver a successful outcome. We have worked hard to identify the correct partners for this project that provide both the correct level of knowledge, expertise and willingness to identify issues and develop a scope for how these can be addressed.

The key project partners are listed below along with their planned contribution to the successful delivery of the project:

Addleshaw Goddard: Provision of legal expertise including the detailed position on the current legal obstacles (for example mineral rights) and support in the identification of regulatory framework changes required.

Aqua Consultants: Provision of the S-Gas scoping, time and estimating platform.

ERM: Provision of environmental policy positions and the current status in terms of obstacles to shale gas exploration. Supporting the carbon assessment of scenarios as required.

Enzen: Provision of the T-Shale web portal.

National Grid Transmission: Remodelling of the NTS to understand the infrastructure requirements of different scenarios.

UKOOG: Facilitation of the initial scenario development stage of the project. Specifically bringing the potential producers together to understand the realist operational parameter from which to develop scenarios.

4.6 Relevance and timing

The current indications are that the first large scale development of shale gas sources will be complete and in a position to export from their facilities within a 10-15 year time frame. These timescales are consistent with those required for large scale transportation investment programmes which will be required to meet the production capacities of up to

five years. Therefore, evaluation of these requirements will need to be completed over the next 3-5 years to ensure that the industry is able to respond to these requirements in an efficient and timely manner.

This is particularly the case if it is found that to deliver the most efficient transportation infrastructure solution to meet these requirements, large scale changes are required to the commercial and regulatory framework of the gas industry. New solutions to technical and commercial challenges will need to be identified, scoped, agreed and implemented prior to facilities coming online. There is a significant risk that the timescales for the progression to production advance ahead of the infrastructure development requirements being implemented. This will lead to a sub-optimal solution with the potential for additional costs being met by gas customers and a missed opportunity by the industry to deliver the wider range of non-financial benefits for customers.

The timing is also relevant to ensure that investment decisions to accommodate new sources of gas can be made in an informed way by evaluating and setting regulatory allowances for the second RIIO regulatory period. With significant investment likely to occur in this period out to 2029, the project will provide the first sound basis for informing these requirements and their associated benefits.

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

5.1 Learning Dissemination

The key objective of this project is to fill the current knowledge gap that exists with respect to what the requirements are for the development of the transportation network to support the development of large scale production of shale gas.

It is clear that the knowledge and expertise required to address the issues presented by these developments do not reside with either a single, or even small group of stakeholders. Instead the project will require bringing together a wide range of parties to ensure that both background knowledge can be effectively shared and incorporated into the project from the outset. As the project progresses the joint learning can be used to direct both the key factors for consideration within the project and inform the outcomes and conclusions.

The knowledge generated from this project has the potential to positively impact upon decisions made at all levels including energy policy, regulatory and commercial framework, transportation investment and individual shale gas production investment decisions.

As such, the project requires that all of the learning generated is effectively disseminated for a wide range of stakeholders, including;

- Gas Distribution Networks
- Gas Transmission Networks
- Shale gas producers
- Ofgem
- Department of Energy and Climate Change (DECC)
- Academic institutions
- Local authorities

Management of the learning and knowledge will be an integral part of the project and this has been reflected in the structure, timescales and outputs of the project.

5.2 Categories of Data, Knowledge and Learning

The project will generate new and incremental learning in a number of key areas and will include:

Technical Knowledge: The project will generate valuable and necessary knowledge in a number of key technical areas relating to the investment in and operation of gas transportation networks. There is significant potential for the production and output characteristics of shale gas wells and fields to be significantly different from current input arrangements for gas transportation networks. Knowledge pertaining to how networks will need to adapt at a technical level will be key to ensuring efficient investment solutions.

Operational Knowledge: Knowledge relating how networks need to be operated with a larger and more varied portfolio of input points on the network with differing operating characteristics and timescales will again be key in determining efficient operating frameworks for networks.

Knowledge dissemination continued

Regulatory Knowledge: The current regulatory and commercial framework is linked very closely to the stable and well understood technical and operating characteristics of gas being transported. This is achieved using a relatively small number of very large production facilities, through the transmission networks and ultimately the distribution networks to end customers. The introduction of shale gas introduces the potential requirement to review current regulatory and commercial arrangements to both address new technical and operational challenges and facilitate potential investment options that are not relevant under the current arrangements. The project will also aim to provide the first indication of the efficient levels of gas network investment required under future network price controls.

Commercial/Financial: The project will generate knowledge relevant to constructing and evaluating the wider business case for the large scale development of shale gas in the UK. It will also provide information that is vital for the assessment of the business case for individual projects.

5.3 Key Responsibilities for Knowledge Dissemination and Learning

The wider project team will be responsible for delivering the Data, Knowledge and Learning Strategy developed at the start of the project. This strategy will develop a set of overarching aims and objectives for the project and identify the necessary work streams with a responsible owner, associated project plan and timetable for each.

Given the central role of knowledge gathering, generation and dissemination as part of this project, all partners within the project will have a role and contribute to the dissemination of knowledge and learning from the project.

The dissemination of knowledge and learning internally within NGN will be coordinated via the Project Team in conjunction with NGN's Academy. NGN's Academy is the route by which all training and development is delivered across the business, including key contractors and direct service providers. This process will ensure that all learning is disseminated in a controlled manner and effectively delivered into business as usual processes.

5.4 Methods of Dissemination

The wide range of stakeholders in the output from the project dictates that our dissemination strategy must include a diverse range of methods that should be adaptable to the requirements of each particular audience.

Project Website: NGN will create an easily accessible website linked directly from its home page. This will form the hub of all its disseminated knowledge. It will provide stakeholders with access to site details, progress reports, photo and video galleries and lessons learnt in a live environment.

Workshops and Consultations: A large element of the project will involve data sharing between all primary stakeholders on the key interactions between shale gas production and the associated transportation requirements. The project plan shows the level of engagement envisaged between the project and stakeholders which will lead directly to wider consultation on findings before progressing to subsequent stages of the project.

Conferences and Seminars:

- Attendance at the NIC annual conference to update on progress and lessons learnt.

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Knowledge dissemination continued

- Providing a report on key project findings to meet wider utility needs, focusing on the socio-technical aspects of the project.
- IGEM Annual Engineering Update Conference to share analysis of the data and update engineering community.

Video, podcasts, Social Media: To increase the dissemination of knowledge to a wider audience, NGN will consider the use of video updates on YouTube and use our social media mechanisms (e.g. LinkedIn) to publish overviews of the project for other stakeholders.

Publications:

- Specific areas for wider communications, including gas and utility industry journals and periodicals, to ensure maximum coverage of the benefits of the whole project and some of the key lessons learnt.
- Publication of six monthly Project Progress Reports to Ofgem.
- Engagement with local and national media and trade press.

5.5 Intellectual Property Rights (IPR)

This project will conform to the NIC default IPR arrangements and a memorandum of understanding will be signed with all vendors and each project partner. NGN has worked closely with all partners in the project to ensure that all foreground IPR generated by the project, either planned or unexpectedly generated, will comply with the default IPR arrangements as set out in the Gas NIC Governance document.

Lessons learnt and network performance outcomes will be shared with other GDNs freely and non-redacted.

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Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%):

Requested level of protection against Direct Benefits that they wish to apply for (%):

6.1 Evidence of why the Project can start in a timely manner

NGN have spent a significant amount of time considering the most efficient delivery strategy for the T-Shale project; key to this has been the critical analysis and selection of partners, coupled with creating an achievable program of execution.

The project will be managed by the Major Projects Team and will be subject to the integrated Management System (IMS). The IMS is integrated with ISO9001 quality system and is successfully used to manage all NGN Major Projects including the Low Carbon Gas Pre-heating Project (NGN's 2013 NIC successful bid). It sets out clear processes and procedures to follow from the implementation of a project through to both the design and delivery phases, and so provides a robust framework for the management of this NIC project.

Setting up of framework agreements

All the project management for this project will be sourced via NGN's professional Services framework to ensure the best individuals are in place to ensure successful delivery and achievement of the NIC SDRC's.

The impact assessment non-technical partners for the project, AG, ERM and [redacted] have already agreed the scope of work, provided significantly discounted rates and will be engaged through NGN's standard terms and conditions managed by the networks procurement department. The procurement of the flow meters will be awarded though a competitive tender process with the award of installation tendered through the NGN delivery framework.

NGN's Procurement Team are aware of this potential procurement activity and have assigned the appropriate resources in their 2014/15 plan.

Preparation

The transportation challenges of the connection of non-conventional gas to the network is well understood through NGN's experience in the biomethane market. NGN have been developing a strategy for facilitation of biomethane connections and in doing so have found that connection location is one of the most significant obstacles to successful implementation. To try to explain the connection challenge to the biomethane market NGN undertook a 'gas to cash' stakeholder event in September 2013 which is still available online. NGN feel that in terms of both the market and our understanding of the industry issues, now is an opportune time to broaden our contribution from just biomethane to include the shale gas market.

Each stage of the T-Shale project plan has been robustly developed by the NGN team in conjunction with the framework partners. The project management requirements have

been developed through the Major Projects Team and are based on a lean delivery model which will allow support from the wider Major Projects Team to minimise costs.

Aqua Consultants (AC) have been chosen by NGN to produce a network engineering, construction, carbon and cost modelling system (Section 2: S-Gas) based on comparable past experience in the water industry. AC have already delivered an engineering and cost model for Northumbrian Water (NWL). NGN have undertaken a review of the NWL modelling system and it is clear that this tool, redeveloped for the gas industry, would be the ideal option for the T-Shale project. The learning and development that Aqua Consultants gained in the water industry will enable significantly reduced time and cost for the development of a similar model for the gas industry.

Deliverable 3A of the project (flow trials) has been developed following a network modelling exercise undertaken by NGN's Network Validation Team. The remit was to understand how many locations would be required for flow metering assessment in order to provide meaningful results that could be extrapolated. 53 specific locations have been identified on the network (see Section 3) based on providing data for multiple network configurations that can be extrapolated for the remainder of the NGN network model. Originally over 200 points were identified but these were reduced by a process of challenge and review to give the minimum number of meters, whilst achieving the correct remodelling result.

Project Programming

For all projects within NGN, cost loaded programmes are prepared in Primavera P6. Please see Appendix 6 for details of the T-Shale programme. The programmes are initially created by the Project Leader and developed as the project progresses and more information becomes available.

The Plan identifies the four deliverables (described below) of the project:

Deliverable	Sub-Deliverable	Within scope	Delivery Partner
1: Scenario Development	-	Scenario development: Information gathering on the various scenarios for shale gas development i.e. pressures, duration, flows, expansion predictions etc.	UKOOG/Various producers NGN system control NTS system control Enzen
2: Impacts assessment	2A	Regulatory and legal impact evaluation of scenarios	Addleshaw Goddard LLP alongside NGN in-house Legal Team
	2B	Environmental impact evaluation of scenarios	ERM
	2C	Socio-economic modelling and impact assessment	TBC

3: Technical and financial	3A	Flow trial: Low flow trials using bolt on flow meters at multiple locations to revalidate the existing network, results to be validated using smart meters	NGN Major Projects Team
	3B&C	S-Gas: Develop a modelling software platform (S-Gas) to provide infrastructure development cost and carbon estimates (Capex/Opex) for each of the scenarios	Aqua Consultants
4: Final report and T-Shale web platform	-	Final report and development of the T-Shale web based decision support tool	NGN (Core Team) Enzen

Financial management: Our Finance Team are familiar with the accounting requirements of an NIC project and are ready to support a project team with the additional requirements of T-shale.

6.2 Evidence of how the costs and benefits have been estimated

One of the core principles of the project is to identify the most efficient gas transportation infrastructure to facilitate the shale gas market in the UK. It is not feasible prior to this project to quantify the projected savings noting the shale gas agenda still has several moving parts.

What is clear is that infrastructure will need to be developed if the shale gas market is to reach the potential scale identified in the latest reports (for example the EY report). Noting the significant costs associated with any infrastructure projects e.g. pipeline, Pressure Reduction Stations (PRS), compressors, terminals any sub-optimised and / or uncoordinated program for such development will add potentially hundreds of millions to the costs.

To put the costs for infrastructure development into context some examples are provided below:

- A single 48 inch high pressure gas pipeline costs on average of £1.5m/km
- A single connection and associated PRS station to the NTS could cost in excess of c.£10m
- An above 7bar 10 inch pipeline costs on average c.£500k per kilometre

When considering these types of figures it is easy to see how transportation methods and costs can have a significant impact on the overall feasibility of shale gas. The development of shale gas production facilities needs to be considered alongside transportation options. In addition, the carbon footprint of these types of projects are significant, so the balance between cost, time and carbon impact needs to be understood to ensure an informed

decision can made on how to progress most efficiently. This project will support the industry in reaching a decision.

6.3 Evidence of the measures a network licensee will employ to minimise the possibility of cost overruns or shortfalls in Direct Benefits

This project will be subject to the IMS employed within the Major Projects Team. This management system will ensure that processes involving commercials, design, planning, risk and management will follow set and approved guidance. Problems arising will be regularly monitored and managed throughout this project to be sure that the project is delivered on time, safely, and within budget.

At the start of a project that involves commercial and delivery risk, a risk and opportunities workshop is held with all interested parties. The meeting follows a set format, which addresses all of the internal and external influences that could affect the cost and delivery of the project. The output of the risk review workshop is a risk factor which has been added to the project costings and programme.

The objective of the risk and opportunity workshop is to create a risk and opportunity register which lists the significant costs and schedule risks that may have an impact on the successful delivery of the project as well as identifying possible cost and schedule saving opportunities.

Specifically to this project, the list of risks and opportunities created and reviewed included:

- Project management costs
- Flow meter procurement and installation
- S-Gas external designer input requirements
- T-Shale portal development
- Impact assessment of non-technical input requirements (Addleshaw Goddard, ERM, [redacted])

Individual costs have been discussed relating to the minimum, most likely and maximum cost outcomes for each particular risk or opportunity. In addition to the cost spread that could result from any specific risk or opportunity, the range of delays that could result from these identified risks were also discussed and recorded. As with the cost impact, these ranges of delay have then been attached to the task or tasks that would be affected by each risk or opportunity. The probability of a risk / opportunity materialising has been based on a scale between 0% and 100%. These values, both cost and schedule impact and the probability, can be seen in more detail in Appendix 4. All costs identified in this workshop have been incorporated into the business plan.

Project progress review / governance

Once this project becomes a live project it will be managed closely for commercial performance, delivery and engineering quality assurance. Project partners will be engaged under Option A lump sum contracts (as per their provided costs) and the Core Team will be sourced from NGN's professional services framework.

Before a contract is awarded the expenditure and scope of work will be approved by the Investment Steering Group (ISG). The group is made up of NGN board and management. This group has already reviewed this project, evidence of which is can be found in Appendix 7 in EXP01 form which one of the IMS requirements. The signatures on this form also demonstrate the project readiness and support of senior staff within NGN.

If the NIC is awarded, a T-shale Steering Group will be set up to meet on a regular basis. This will be led by the Head of Investment and Major Projects. The T-shale Steering Group will review progress against programme and costs against the budget, as well as support with removing blockers and management of delivery risk.

To close the project a report will be produced and published in line with the information contained within Section 9.

6.4 A verification of all information included in the proposal (the process a network licence has in place to ensure the accuracy of information can be detailed in the appendices)

Figures contained in Appendix 2 have been produced by the Major Projects Team in conjunction with the project partners for their specific elements of work. Costs have been discussed and challenged and all partners have given a demonstrable reduction in normal rates in order to show support.

Regular internal meetings have been held within NGN in the preparation of this bid to ensure that the objectives proposed are achievable. Appendix 7 contains our EXP01 form signed by four senior managers to demonstrate that the bid has the full backing of NGN. More on the EXP01 form is explained below.

6.5. How the project plan would still deliver learning in the event that the take up of low carbon technologies and renewable energy in the Trial area is lower than anticipated in the full submission

To date there has been no consideration for the most efficient way to develop the UK gas transportation infrastructure to facilitate the shale gas market. Any project that begins to address this issue will provide significant benefit. (See program Appendix 6).

If the UK shale gas market did not materialise the outputs from this project will still add significant benefits, these include:

Flow trials: A recalibrated, accurate capacity modelling tool which would provide much more robust information for existing low carbon technologies i.e. biomethane. This would increase confidence and make projects more viable and investible. This work would also be applicable to other GDNs.

S-Gas: This scoping, estimating and programming tool will be made available to all of the gas industry. It will allow scenario modelling and business plan development for the UK gas industry and will increase efficiency whilst reducing carbon impacts of business as usual decisions.

T-Shale: This web platform will establish a blueprint for technical and economic modelling of future gas network scenarios.

This project will deliver learning regarding transportation of shale gas, but will be transferable to other forms of gas if shale gas extraction does not materialise. Furthermore, the T-shale tool will be suitable for national use, so if shale gas extraction does not go ahead in the Bowland area, the tool will still be useful to the gas industry.

6.6 The processes in place to identify circumstances where the most appropriate course of action will be to suspend the project, pending permission from Ofgem it can be halted

Another critical role of the T-shale Steering Group will be to support the Project Lead in assessing the project against the evaluation criteria in Section 9. If at any point it is apparent that the project is consistently falling short on the evaluation criteria then the steering group can suggest consultant with Ofgem to request halting the project.

The T-Shale project has been carefully designed to provide a 'full picture' in incremental steps. This allows the project to be terminated as specific points in time whilst still providing credible and beneficial learning. Considering the momentum around the shale gas market, NGN considers it unlikely that the project would require termination. In the coming years, there could be a substantial external non-technical event (for example legal milestone, parliamentary decision etc.) which may add significant uncertainty to the likelihood of shale being exploited in the UK.

If this were the case NGN would propose to remove the non-technical sections of the project (sub-deliverables 2D/E/F/G) whilst still completing the S-Gas and flow trial elements as these have other direct benefits for the UK gas industry.

Other than this type of external event, NGN would administer the project in line with the Major Projects IMS and internal NGN governance. The project would continue to completion unless it became clear that the outputs, costs or program, were becoming at risk. If this were the case the project would be re-evaluated and a decision made (pending permission from Ofgem) as to whether completing the project was in the best interests of the UK gas industry and its customers.

NGN have a highly experienced, mature project delivery capability coupled with the detailed due diligence the network has undertaken on the construction of this bid the above is considered highly unlikely.

Gas Network Innovation Competition Full Submission Pro-forma

Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

7.1 Regulatory Impact

It is not considered that the project will require any derogation, licence consent or licence exemption. Consequently, there are no regulatory hurdles to the project commencing or completing on the desired timescales.

7.2 Long-Term Regulatory Impact

The current regulatory and commercial framework in the UK is inextricably linked with the physical characteristics of the production techniques, gas quality and composition and the operation and configuration of the transmission and distribution networks.

The data, knowledge and learning derived from the project will have the potential to influence key elements of the regulatory framework for GDNs going forward. There are a number of areas that, even at this early stage of the evaluation, could be considered as likely to require changes to the regulatory framework to deliver alternative investment scenarios. Such areas include:

- Identifying possible scale and timings of transmission investment programmes required to facilitate development of shale gas. This will include key issues such as deep vs shallow connection charges and firm vs non-firm entry. Providing a robust basis for considering the impact on future price controls and customer bills.
- Delivering a number of the potential benefits from shale gas will require consideration of the applicable connections and transportation charging regimes required to deliver efficient investment and locational signals to producers and transporters. For example, the inclusion of social and environmental factors may be required to be incorporated in any methodology to ensure that benefits in these areas can be fully realised.
- Key areas of the Uniform Network Code (UNC) could be significantly impacted by new regimes required to facilitate efficient transportation of shale. The range from issues could include for example - allocation of Entry and Exit Capacity at both transmission and distribution level, Network entry requirements, Gas Composition and Calorific Value, Network Operational Planning and Maintenance.
- Gas Transporter Licence Obligations including regulatory allowances, incentive mechanisms and uncertainty mechanisms.
- Gas Safety Management Regulations surrounding composition and calorific value of gas and the associated impact on the wider regulatory framework

The project has identified that a key output must be a first indication of the regulatory framework changes that will need to be considered to facilitate any of the identified efficient investment options.

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Section 8: Customer impacts

This section should be between 2 and 4 pages.

8.1 Direct Customer Impacts

The project will not have a direct impact on customer's premises nor is it planned to cause any interruption to supplies. The project does not require any customer disconnections or interruptions during installation or operation of new equipment.

Safety and security of supply will have the highest priority throughout the whole of this project with existing safety precautions being maintained or improved during every operational change or engineering operation.

8.2 Risk of Interruption

Whilst there is always a small risk of unplanned customer interruptions when carrying work on the network due to unforeseen circumstances, the risk of such an occurrence happening is extremely.

Large elements of the project will not require physical works on the network. However, the installation of flow meters will require the installation of new kit at key strategic areas of the low pressure network. Whenever new equipment is installed there is a risk of faults occurring during the initial commissioning stages. The flow meters being installed are non-invasive technologies and installation or asset failure will have no impact upon the physical flow of gas and hence no impact on customers

8.3 Stakeholders in the trial area

It is considered that the risks associated with carrying out activities directly upon the networks will be managed to ensure that they are no greater than exist under business as usual processes. Consequently we do not see any requirement for alterations to our existing stakeholder strategy in this area.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

9.1 Completion of industry seminars with UKOOG – December 2015

Completion of industry seminars supported by UKOOG to establish viable scenarios for shale gas transportation.

9.2 Completion of scenario technical parameters – July 2016

Completion of NGN and National Grid modelling of identified scenarios to establish the technical parameters.

- Technical parameters developed for all scenarios on the National Transmission System (NTS)(National Grid). E.g. size of new compressor, size of new pipeline, operating parameters of PRS etc.
- Technical parameters developed for all scenarios on the Local Transmission System (LTS)(NGN). E.g. size of new compressor, size of new pipeline, operating parameters of PRS etc.

9.3 Installation of Phase 1 Flow Meters – June 2015

The installation of a minimum of 15 flow meters on the network recording flow data.

9.4 Installation of Remaining Flow Meters – May 2016

The installation of the remaining flow meters on the network as detailed in Deliverable 3A.

9.5 Workshops - flow meter information and evidence of accuracy – December 2017

Following the installation, data capture and subsequent validation of the network models in 2017. The updated models will be demonstrated to the wider industry through a series of open workshops. These workshops will:

- Provide a presentation on the strategy adopted for flow meter selection locations, including how results can be extrapolated to comparable networks.
- Provide a review of the project including lessons learnt, costs, final installation program and data capture processes.
- Overview of how the data was manipulated and incorporated into the models.
- A demonstration of the validation criteria and the accuracy of the updated models for capacity analysis.
- Any constrains that should be understood when undertaking future capacity and scenario modelling of low flow scenarios.

9.6 S-Gas Mobilisation – July 2015

Mobilisation of the S-Gas team with clearly defined parameters for system development.

9.7 S-Gas Models Available for Testing – July 2016

Models developed and available to the project team for detailed testing of price, time and carbon modelling of scenarios.

9.8 S-Gas Release via Web Platform – February 2017

S-Gas released for wider industry use via secure ‘login’ web platform

9.9 T-Shale web decision Tool

T-Shale web decision tool released via secure NGN portal. The platform will be interactive, allowing the user to identify preferable transportation development options based on different criteria e.g. jobs created versus minimal cost to customers' bills.

9.10 Final Report and T-Shale platform launch

Produce a detailed final report to which will include:

- Details on the current position of the 'non-technical' shale gas program i.e. Mineral rights, NIMBY etc. and the latest timeframes for removal of any remaining obstacles
- Details of the scenario development process
- An overview of the T-Shale platform operation and logic of scenario selection based on specific criteria e.g. jobs created versus minimal cost to customers' bills.
- A written overview of each scenario summarising:
    - Cost
    - Timescales
    - Carbon impact
    - Regulatory changes required
    - Environmental constraints
    - Economic model results
    - Other considerations
- A summary of the most advantageous scenarios for specific criteria including:
    - Most environmentally friendly
    - Cheapest impact on customers' bills
    - Most jobs created for UK plc
    - Minimal regulatory changes required

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Section 10: List of Appendices

Appendix 1: Benefits Tables

Appendix 2: Financial Justification of Business Case

Appendix 3: Letters of Support

Appendix 4: Risk and Opportunity Summary Report

Appendix 5: Gas Industry Supporting Information

Appendix 6: Project Plan

Appendix 7: EXP01 Form

Appendix 8: T-Shale Cost Benefit Analysis

Appendix 9: Flow Trials Additional Information and Shale Gas Specific Information

Gas Network Innovation Competition Full Submission

Appendix 1: Benefits Tables

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Appendix 1: Benefits Tables

KEY

Method	Method name
Method 1	T-Shale

Gas NIC – financial benefits

Financial benefit (£m)								
Scale	**Method**	**Method Cost**	**Base Case Cost**	**Benefit**			**Notes**	**Cross-references**
				2020	**2030**	**2050**		
Post-trial solution *(individual deployment)*	Method 1						It is not possible, at this time, to populate this table. This NIC project aims to provide the base cost and subsequent financial benefits as a key deliverable. As an indication of potential financial benefits, a single 48'' high pressure pipeline costs c.£1.5m per km. Therefore any under optimised transportation development could incur additional costs amounting to hundreds of millions of pounds when mapped to the local and broader GB networks.	N/A
Licensee scale *If applicable, indicate the number of relevant sites on the Licensees' network.*	Method 1						*N/A – the scenarios developed as part of Deliverable 1 will identify the potential licensee scale.*	N/A
GB rollout scale *If applicable, indicate the number of relevant sites on the GB network.*	Method 1						*N/A - the scenarios developed as part of Deliverable 1 will identify the potential licensee scale. This can then be extrapolated to understand a GB network rollout scale.*	N/A

Gas Network Innovation Competition Full Submission Pro-forma
Appendix 1: Benefits Tables

Gas NIC – carbon and/ or environmental benefits

Carbon and/ or environmental benefit (MtCO2e)								
Scale	**Method**	**Method Cost**	**Base Case Cost**	**2020**	**2030**	**2050**	**Notes**	**Cross-references**
Post-trial solution *(individual deployment)*	Method 1						It is not possible at this time to populate this table. This NIC project aims to provide the baseline carbon and wider environmental impacts of the viable scenarios. For example if twice as many pipelines are built to facilitate shale gas as have been identified under an informed development program the carbon impact of the projects would double.	N/A
	Method 2							
	Method 3							
Licensee scale *If applicable, indicate the number of relevant sites on the Licensees' network.*	Method 1						*N/A – the scenarios developed as part of Deliverable 1 will identify the potential licensee scale.*	N/A
	Method 2							
	Method 3							
GB rollout scale *If applicable, indicate the number of relevant sites on the GB network.*	Method 1						*N/A - the scenarios developed as part of Deliverable 1 will identify the potential licensee scale. This can then be extrapolated to understand a GB network rollout scale.*	N/A
	Method 2							
	Method 3							

Gas Network Innovation Competition Full Submission Pro-forma
Appendix 1: Benefits Tables

If applicable, indicate any environmental benefits which cannot be expressed as MtCO2e.	**Post-trial solution:** The solutions identified by the T-shale project will allow policy makers to make informed decisions regarding the most beneficial way to develop the UK gas transportation infrastructure for UK shale.	*N/A*	N/A
	Licensee scale: Total avoidance of pipelines could be one option, avoidance of national parks could be another. In summary when the options are understood (i.e. scenarios developed) there could be multiple additional environmental benefits.		
	GB rollout scale: As above extrapolated to GB rollout.		

Appendix 2: Business Case Financial Support

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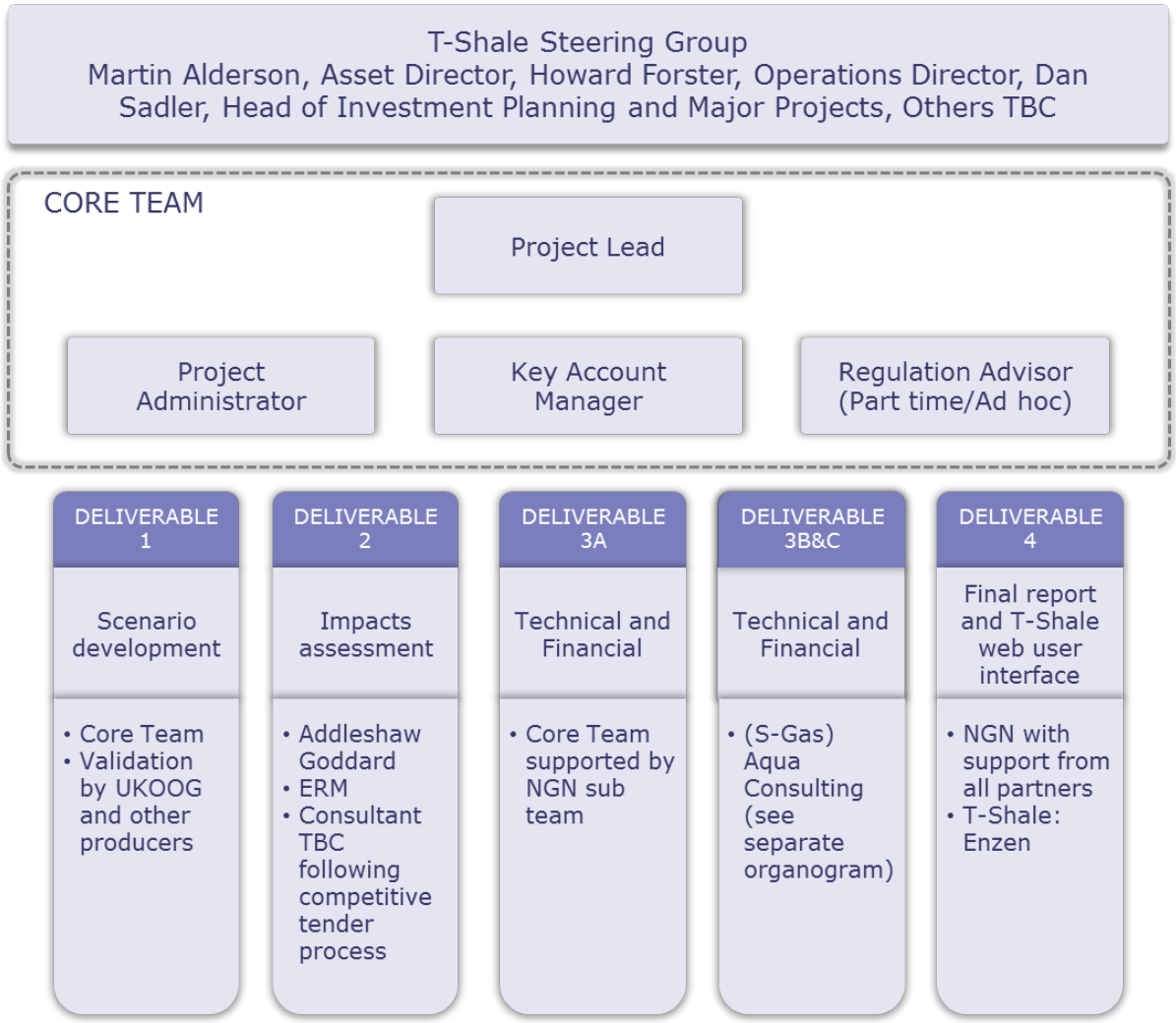
Appendix 2: Business case Financial Support

The following information provides additional detail behind the base cost estimates presented in Section 3 of the pro-forma document.

These costs are exclusive of risk (contingency) provision, which is detailed in Appendix 4: Risks and Opportunities Summary Report. Costs have been developed based on a Core Team with the 4 deliverable workstreams and the partners to support as detailed below:



Core Team:

Project Management Costs (Professional Services Team)

Please note all rates are taken from the average rate on NGNs Professional Services Framework.

Days per year full time are based on a five day week 45 weeks per year taking account of holidays and bank holidays etc.

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Appendix 2: Business case Financial Support

Core Team Costs

Role	Rate	Anticipated days over three years	Cost for three years
Project Manager	[redacted]	FT Jan 15 to Dec 17	[redacted]
Key Account Manager	[redacted]	FT May 15 to Dec 17	[redacted]
Administrator	[redacted]	FT Aug 15 to Dec 17	[redacted]
Office Facilities /IT Setup	[redacted]		[redacted]
CORE TEAM TOTAL			[redacted]

Deliverable 1: Scenario Development

The only additional costs associated with this deliverable other than the costs of the core team will marketing and meeting room / conference centre hire for the initial workshops.

DELIVERABLE 1: SCENARIO DEVELOPMENT TOTAL	[redacted]

Deliverable 2: Impacts assessment

2A – Legal and regulatory impacts assessment

2B – Environmental impacts assessment

Deliverables 2A and 2B of the impacts assessment of the non-technical agenda has been separated into five stages of the programme with a cost for each stage from Addleshaw Goddard (AG) and Environmental Resources Management (ERM). The stages include:

Stage	AG	ERM
Stage One: Pre Award	[redacted]	[redacted]
Stage Two: Preparation of Preliminary Report (6 months)	[redacted]	[redacted]
Stage Three: Year one update report 'Running Draft'	[redacted]	[redacted]
Stage Four: Year two update report 'Running Draft'	[redacted]	[redacted]
Stage Five: Final Report (end year three)	[redacted]	[redacted]
Sub Totals	[redacted]	[redacted]
DELIVERABLE 2A AND 2B TOTAL	[redacted]	

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Appendix 2: Business case Financial Support

2A - Addleshaw Goddard Team

Table of Rates

Name / Role	Standard Charge Out Rate (£)	NIC charge out rate (£)
Gary Sector, Legal Director, Energy Planning and Regulation	[redacted]	[redacted]
Guy Winter, Partner, Co AG Project Lead	[redacted]	[redacted]
David Shaw, Partner, Co AG Project Lead	[redacted]	[redacted]
Energy Planning / Regulation Associate	[redacted]	[redacted]
Energy Planning / Regulation Junior Associate	[redacted]	[redacted]
Trainee Solicitor	[redacted]	[redacted]

3A&B - Environmental Resources Management (ERM) Team

Table of Rates

Name / Role	Standard Charge Out Rate (£)	NIC charge out rate (£)
William Hazell, Principle Consultant (Project Manager)	[redacted]	[redacted]
Socio-Economic Consultant	[redacted]	[redacted]
Environmental Consultant	[redacted]	[redacted]
Graduate	[redacted]	[redacted]

3C – Socio-economic impacts assessment

Cost for this element of the work have been estimated at £75K by benchmarking against other consultant costs but will be formalised through a competitive tender process.

Gas Network Innovation Competition Full Submission
Appendix 2: Business case Financial Support

Deliverable 3: Technical and financial

3A - Flow Trials

The flow trial will require a small dedicated Project Management Team to manage a significant installation, data analysis and validation process. Costs have been broken down as per the table below.

Sub Team Project Management

Site works and Meter Procurement

Flow Monitoring	Start	Finish	Flow Monitors	Hired Flow Monitors	Total Cost	Locate, excavate, backfill with sand, remove risings	Purchase	Hire/week	Installation and Commission
Flow trials sub team project management	03/11/14	30/10/17			[redacted]				
Model analysis	01/01/16	01/12/16							
Identification of location points	03/11/14	01/06/15							
Location Surveys and Site Supervision	01/01/15	01/06/15							
Flow meter installation phase 1	01/04/15	01/06/15	[redacted]		[redacted]	[redacted]	[redacted]		[redacted]
Flow meter installation phase 2	01/06/15	04/12/15	[redacted]		[redacted]	[redacted]	[redacted]		[redacted]
Flow meter installation phase 3	01/01/16	01/05/16	[redacted]		[redacted]	[redacted]	[redacted]		[redacted]
Flow data capture	01/01/15	02/09/17			[redacted]				
Model development for low flow	01/09/15	04/04/17							
FLOW MONITORING TOTAL COST					[redacted]				

Gas Network Innovation Competition Full Submission

Appendix 2: Business case Financial Support

3 B/C S-Gas

Each element of the organisational chart has been broken down into constituent parts with a detailed estimate against each stage for time individuals will require.

Stages	Team Lead	Process Calcs	Mech Calcs	Elec Calcs	Civils	Data Capture	Scoping	Modelling	Opex / WLC / Carbon	Costs	Prog	Socio Economic Benefits*	Design House Input	NGN Input	System Goblin	Total	**Total by stage inc discount**
Name	[redacted]																
Day rate	[redacted]																
Stage 1 cost	[redacted]																
Stage 2 cost	[redacted]																
Stage 3 cost	[redacted]																5
Stage 4 cost	[redacted]																
Overall cost build up	[redacted]																

**Costs associated with calculating Socio Economic benefits not included at this stage*

Gas Network Innovation Competition Full Submission

Appendix 3: Letters of Support

ADDLESHAW GODDARD

Your reference
Our reference BURCM

7 July 2014

Northern Gas Networks
1100 Century Way
Leeds
West Yorkshire LS15 8TU

Dear Sirs

Gas Network Innovation Competition 2014 (Gas NIC):
Optimising the transportation of shale and other unconventional gases in the UK

Thank you for the opportunity to work with you on your submission for this year's Gas NIC.

As a leading UK law firm, we have participated in numerous workshops on the responsible development of shale and other unconventional gases in the UK, including hosting seminars in our London, Leeds and Manchester offices to facilitate debate around the key issues for stakeholders including local planning authorities, community and environmental groups, gas developers, the supply chain and water companies. Whilst there is clearly a wide spectrum of views on the merits or otherwise of shale gas development, the focus of almost all the discussion to date has been around the "upstream", exploration phase of unconventional gas developments- with very little consideration given to the critical issue of transporting extracted gas from the wellhead to the market. From our experience in other gas markets, including the analogous (but significantly smaller) biomethane-to-gas grid market, this "midstream" transportation infrastructure is an absolutely critical component of any gas production project, and can in itself determine the viability or otherwise of developing any gas reserves- however attractive they might otherwise appear on paper.

We therefore wholeheartedly welcome Northern Gas Networks' (NGN) initiative to establish a framework for the introduction of unconventional gas into the UK gas grid- and therefore its route to the market and end-users. Transportation logistics will make an enormous difference to the economics of shale gas development, and- crucially- to its carbon footprint. Wherever one stands on shale gas: in favour, opposed, involved in the industry or simply in the community, in order to determine the true public benefit or otherwise from the development of unconventional gas resources, it will be essential to understand the infrastructure requirements and related social, economic and environmental risks and rewards involved. In all gas infrastructure projects (including the capital-intensive pipeline and compressor construction they entail) the co-ordination of the upstream production timetable with the timetable for commissioning infrastructure is fundamental. Without NGN- or other GDNs in regions with significant contingent shale reserves- taking a lead and bringing their network expertise to bear on this issue well in advance of any significant onshore gas production coming on-stream, we believe that it will not be possible to co-ordinate this in a systematic fashion.

For our part, we continue to make a significant investment as a firm in the UK's energy future, including most recently working with Ofgem and with the Department of Energy and Climate Change on key energy projects and policies. This has included agreeing preferential fee rates for this important work, in a context where value-for-money for the taxpayer is crucial. Our proposal for this

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project is to use the same competitive fee structures for the ongoing work on the project. Benchmarked against the standard rates that apply to work for private sector participants in the energy sector, this represents an investment by Addleshaw Goddard in the project of over £100,000, taking into account our pro bono support for NGN in relation to your initial Gas NIC submission.

At the same time, we are excited about the opportunity to work with NGN to engage with the other GDNs and participants in the unconventional gas value chain, and we believe that (apart from the obvious commercial opportunities that will involve) we can make a real contribution to articulating the issues and bringing together stakeholders from across the UK public and private sectors. We are exploring similar opportunities in the "frackwater" treatment sector, and see the unconventional gas sector as a whole as one in which true collaboration between market participants at all levels of the value chain can unlock the greatest benefits for the UK economy and environment.

In conclusion, this is a vital area for research and investment to evaluate the potential viability of and requirements for a responsibly-developed UK unconventional gas industry, and one in which NGN, with its location, network expertise and innovative approach can be a genuine leader. We are fully committed to supporting that initiative in any way we can.

Yours faithfully

Monica Burch
Senior Partner
for Addleshaw Goddard LLP

Direct line +44 (0)20 7788 5155
Email monica.burch@addleshawgoddard.com

FAO Northern Gas Networks

June 18, 2014

Re: Network Innovation Competition 2014

Dear Sir /Madam,

We thank you for your invitation for 'Optimising the Transportation of Shale and Other Unconventional Gases in the UK' to work alongside Northern Gas Networks in the above competition. As a company focussed on the energy and utilities sector and well recognised in the UK gas industry, we fully support the main project objective to provide economical shale gas transportation and associated socio- economic benefits for the UK.

Please accept this letter as confirmation that we are delighted to be partnering with Northern Gas Networks as a supplier of services for review of regulatory and industry processes, development of tools such as an economic model for transportation of unconventional gas and associated project management and assurance services. We acknowledge that the knowledge gained from this project will be published on a website and will be freely available to the rest of the UK gas industry.

We are aware that value for money is vital if you are to be successful in obtaining funding for this project, and whilst we cannot provide our services free of charge, we acknowledge that we aim ultimately to benefit as a company from our involvement. As such, we confirm that our prices will be commercially reasonable, and we will assist the project with a contribution of resources including access to our innovation centre facilities, provision of hosting services to host simulation test infrastructure and provision of our specialist services at preferential rates to NGN.

Yours Sincerely,

Enzen Global Limited
Director

Enzen Global Limited, Blythe Valley Innovation Centre, Central Boulevard, Blythe Valley Business Park, Solihull, B90 8AJ, United Kingdom.
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Exchequer Court
33 St Mary Axe
London EC3A 8AA
Tel:+44 (0) 20 3206 5200
Fax: +44 (0) 20 3206 5440
www.erm.com

4 July 2014

Northern Gas Networks
1100 Century Way
Leeds
West Yorkshire
LS15 8TU

Dear Sirs,

Gas Network Innovation Competition 2014 (Gas NIC):
Optimising the transportation of shale and other unconventional gases in the UK

Energy industry leaders and the UK Government are currently considering the potential that unconventional gases have the potential to improve long-term energy security and support economic growth in the UK.

While much of the attention around unconventional gases to date has been around the actual development of unconventional resources, transportation of gases between supply and demand centres is clearly an area that needs to be considered and addressed in detail.

ERM is of the view that Northern Gas Networks' proposed project will provide an innovative approach to the appraisal of the transportation demands that could potentially be required by the unconventional gas industry, especially as it will involve proactive stakeholder dialogue. We are therefore fully supportive and delighted to be involved in this project.

Yours faithfully

Sabine Hoefnagel
UK & I Managing Partner

Faculty of Engineering
University of Leeds
Leeds LS2 9JT UK

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F +44 (0) 113 343 7665
E p.k.jimack@leeds.ac.uk

UNIVERSITY OF LEEDS

Dan Sadler
Head of Investment Planning and Major Projects
Northern Gas Networks
1100 Century Way
Thorpe Park Industry Park
Colton, Leeds
LS15 8TU

16 July 2014

Dear Dan

NGN T-Shale NIC Bid

I am writing this letter in my capacity as the Dean of the Faculty of Engineering at the University of Leeds. The Faculty is composed of five constituent Schools, including Chemical & Process Engineering, Civil Engineering and Mechanical Engineering, all of which have research strengths in areas relating to gas transportation, infrastructure, safety and modelling.

The University is therefore delighted to have the opportunity to be involved in the Northern Gas Networks 'T-Shale' project. We recognise the value of the project, especially considering the significant impact the potential shale market could have on the Yorkshire area. We believe this project will offer some fantastic opportunities for our students (both undergraduate and postgraduate) to undertake projects that will have a genuine research impact and will provide them with valuable practical experiences. The University is open to becoming involved in various aspects of the 'macro issue' bid and recognise that the precise opportunities for our engagement will become clearer if/when 'T-Shale' becomes a live project.

Please do not hesitate to contact me if you require further information.

Yours sincerely

Professor Peter Jimack
Faculty Dean

nationalgrid

National Grid House
Warwick Technology Park
Gallows Hill, Warwick
CV34 6DA

10th July 2014

Dear Mr Dallus

Re: NGN NIC Project Proposal

In response to your email dated 3rd July 2014, National Grid Gas Transmission welcomes the NGN NIC project proposal 'Optimising the Transportation of Shale and Other Unconventional Gases in the UK'. We believe that this project will be beneficial in understanding the potential and impact of unconventional gas on the gas transportation industry in the UK. We look forward to hearing more about this project and will keenly follow its development.

Yours sincerely,

M. D. Watson

Martin Watson
RIIO Strategy and Innovation Manager, Gas Transmission
National Grid

Aqua Consultants
Water and Environment Sector Specialists

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FAO Dan Sadler
Northern Gas Networks
1100 Century Way
Thorpe Park Business Park
Colton
Leeds
LS15 8TU

25th June 2014

Re: Network Innovation Competition 2014

Dear Sir / Madam,

Aqua Consultants would like to thank Northern Gas Networks for the opportunity to work side by side in the 2014 NIC competition. Please accept this letter as confirmation that our team would be delighted to produce a Gas Network Engineering and Cost Modelling system in partnership with Northern Gas Networks. We believe that the finished system will prove to be invaluable in ongoing efforts to assess future gas network infrastructure options. We acknowledge that the finished system will be available for use by the whole of the UK gas industry.

Aqua Consultants are fully aware that Northern Gas Networks must deliver value for money in order to be successful in securing the funding for this project. As a direct result of this we have reduced all of our rates to 10% below the previously agreed framework rates for this project. We feel that this demonstrates our commitment to this opportunity.

Yours sincerely,

T Sultan

Tel Sultan
Managing Director

Appendix 4: Risk and Opportunity Summary Report

Gas Network Innovation Competition Full Submission

Appendix 4: Risk and Opportunity Summary Report (RESUBMISSION - 09/10/14)

This report details the results obtained from a Risk & Opportunity Workshop held to review the Northern Gas Networks submission to the Network Innovation Submission.

The meeting was held at the Northern Gas Networks Offices in Thorpe Park, Leeds, on Wednesday 16th July 2014. A further update meeting was held on at the same location on Tuesday 30th September 2014 as a part of the resubmission.

The objective of the meeting was to create a Risk & Opportunity Register which lists the significant Cost Risks that may have an impact on the successful delivery of the Project as well as identifying possible Cost saving Opportunities.

A list of Risks and Opportunities were created and reviewed in relation to the following:

- Current Risk / Opportunity Status (Open / Closed)
- Probability of Occurrence
- Basis of Cost Impact

Individual monetary values were discussed relating to the Minimum, Most Likely and Maximum Cost outcomes for each particular Risk and Opportunity. The Probability of a Risk / Opportunity materialising was based on a scale between 0% and 100%.

These values, both Cost and Schedule Impact and the Probability, were estimated by those present at the Risk & Opportunity Workshop.

Table 1 contains the full Project Cost Risk & Opportunity Results.

Gas Network Innovation Competition Full Submission

Appendix 4: Risk and Opportunity Summary Report

Table 1: Summary of Project Cost Risk & Opportunity Results

	Core Team / 1 Risk & Opp Total	2 - Non Technical Risk & Opp Total	3A - Flow Trials Risk & Opp Total	3B/C - S-Gas Risk & Opp Total	4 - T-Shale Risk & Opp Total	Overall Project Risk & Opp Total
P20 Risk Value	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
P50 Risk Value	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
P80 Risk Value	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Base Cost	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
P20 + Base Cost	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
P50 + Base Cost	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
P80 + Base Cost	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Also included within this report are:

- Risk and Opportunity Register
- Risk and Opportunity Result Histograms and Tornado Ranking Plot

Risk / Opp ID	Risk / Opp Name	Risk or Opportunity	Risk / Opp Status	Project Section	Risk / Opp Probability	Commercial Impact (£)					Risk Description / Risk Workshop Notes
						Minimum Cost	Most Likely Cost	Maximum Cost	Approx P50 Value	Approx P80 Value	
R-001	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-002	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-003	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-004	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-005	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-006	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-007	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-008	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted] - Base is 1 visit after 6months (£75k) - covers additional visit at £75k. Commercial impact set to £5/30/75k with a probability of 75%
R-009	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-010	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-011	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-012	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-013	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-014	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-015	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-016	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-017	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-018	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-019	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-021	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-022	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-023	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-024	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Risk / Opp ID	Risk / Opp Name	Risk or Opportunity	Risk / Opp Status	Project Section	Risk / Opp Probability	Commercial Impact (£)					Risk Description / Risk Workshop Notes
						Minimum Cost	Most Likely Cost	Maximum Cost	Approx P50 Value	Approx P80 Value	
R-025	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-026	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-027	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-028	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-029	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
R-030	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

NGN - Network Innovation Competition Submission Risk & Opportunity Results & Histogram

	Core Team / 1 Risk & Opp Total	2 - Non Technical Risk & Opp Total	3A - Flow Trials Risk & Opp Total	3B/C - S-Gas Risk & Opp Total	4 - T-Shale Risk & Opp Total	Overall Project Risk & Opp Total
P20 Risk Value	[redacted]					
P50 Risk Value						
P80 Risk Value						
Base Cost						
P20 + Base Cost						
P50 + Base Cost						
P80 + Base Cost						

[redacted]

Risk & Opportunity Tornado Ranking Plot

Northern Gas Networks

Risk / Opp ID	Risk / Opp Name	Probability	Minimum	Most Likely	Maximum	Approx P50	% of P50
R-030	[redacted]						
R-010							
R-002							
R-011							
R-013							
R-012							
R-007							
R-014							
R-029							
R-016							

[redacted]

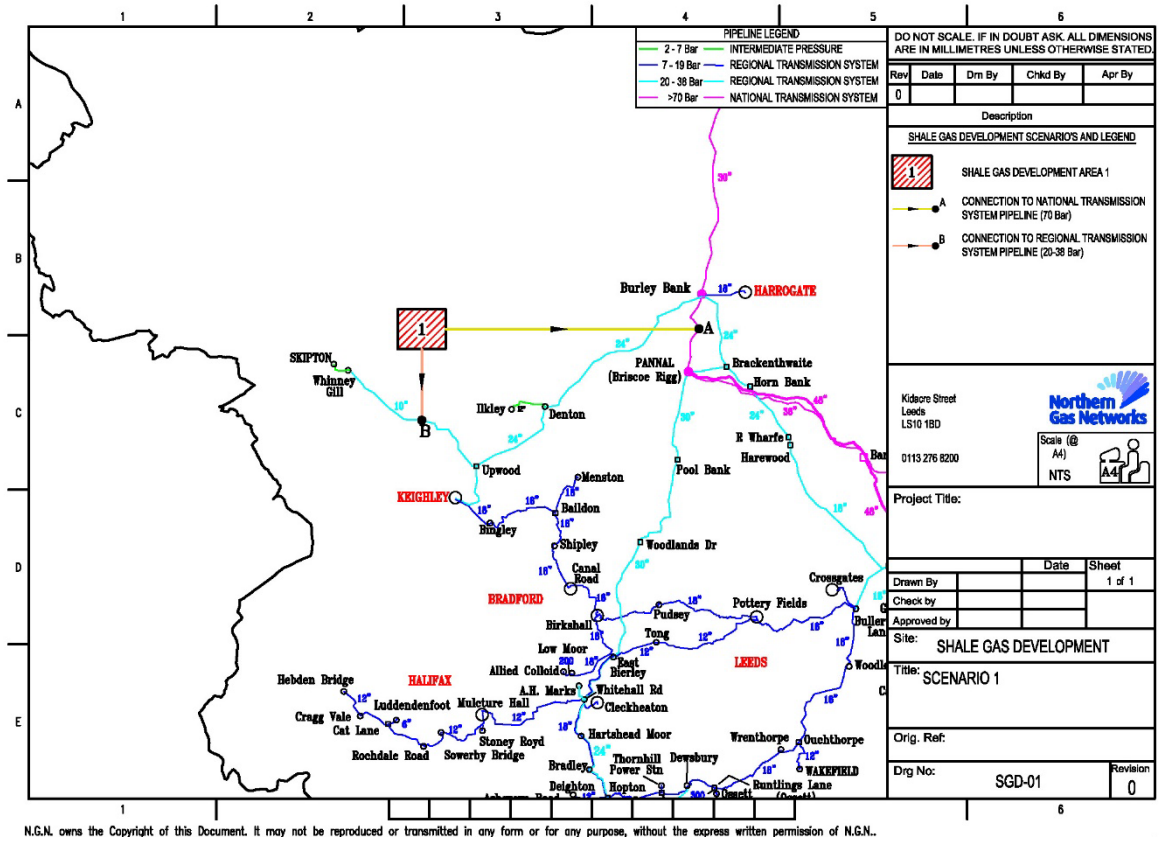
Appendix 5: Supporting Gas Industry Information

Gas Network Innovation Competition Full Submission

Appendix 5: Supporting Gas Industry Information

Scenario development examples:

Scenario One:



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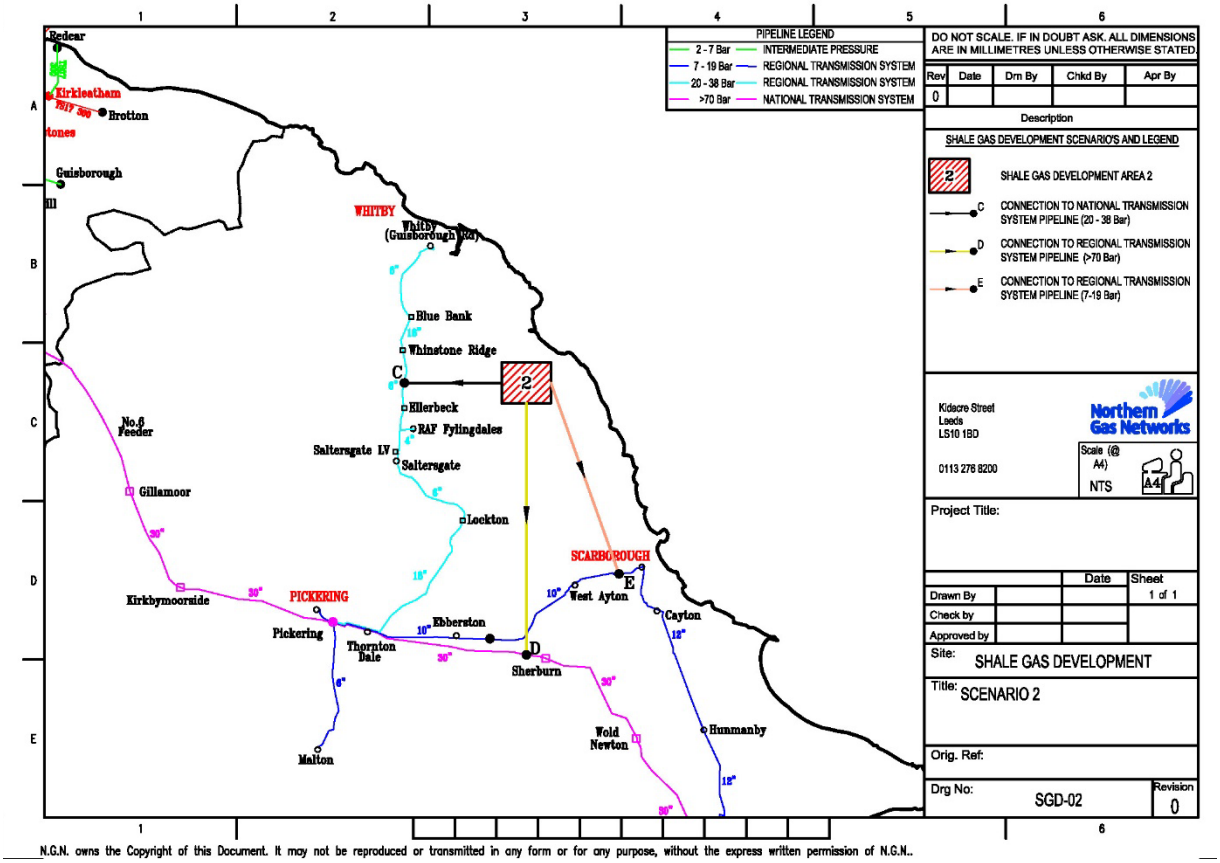
Appendix 5: Supporting Gas Industry Information

Scenario Two:



Gas Network Innovation Competition Full Submission

Appendix 5: Supporting Gas Industry Information

'The Myths and Realities of Shale Gas Exploration'

Ed Davey, Secretary of State, for Energy and Climate Change, recently stated in his speech (Source: www.gov.uk)

"Shale gas can be developed sensibly and safely, protecting the local environment, with the right regulation. And we can meet our wider climate change targets at the same time, with the right policies in place. Gas, as the cleanest fossil fuel, is part of the answer to climate change, as a bridge in our transition to a green future, especially in our move away from coal. Gas will buy us the time we need over the coming decades to get enough low carbon technology up and running so we can power the country and keep cutting emissions. We have to face it: North Sea gas production is falling and we are become increasingly reliant on gas imports. So UK shale gas could increase our energy security by cutting those imports."

EY Report: Getting ready for shale gas

This report, commissioned by UKOOG, provides valuable analysis and recommendations regarding shale gas. However, this is largely focussed on the upstream components such as hydraulic fracturing, drilling and waste disposal; it is assumed that connection to transmission and distribution networks 'should be relatively straightforward'. The scenarios and model that T-Shale will develop, seeks to provide data and information around that assumption.

Overview (Section 1 of report)
64,500 jobs (direct, indirect, and induced) will be needed at peak. These include highly-skilled direct site development roles with above-UK average salaries. The UK will need to standardise skill requirements and create a national institute of skills to address shortages and provide the right opportunities for already qualified personnel.

The oil and gas industry needs to act now to prevent shale gas supply chain and skills constraints. Our report recommends that industry groups, developers and government work together to:

- Define an investment case to develop required skills at pace.
- Define common pad and hydraulic fracturing standards, setting detailed specifications for UK suppliers.
- Encourage investment for UK-based capabilities in specialised areas like steel, rigs, and hydraulic fracturing equipment, as well as shared infrastructure for water treatment, waste disposal and gas processing.

Supply Chain and skills requirements (Section 3 of report)
Total spend could reach £33bn. The graphs below show the five main categories of supply chain spend:

- hydraulic fracturing (62%)
- drilling and completions (25%)
- waste disposal (8%)
- storage and transportation (4%)
- other, including items related to pad preparation, construction equipment, security services, and environmental impact assessments. (1%)

Defining the Supply Chain for shale gas
Given that the industry is in the very early stages of development, this study's primary focus is on the upstream elements of the value chain, where the majority of near term activity will take place.

These elements consist mainly of drilling and completions, hydraulic fracturing, waste management and storage and transportation activities.

Longer term, once production is in full flow, midstream and downstream activities (e.g., processing, transmission and distribution) are likely to be supported, for the most part, by existing infrastructure.

UK Opportunity Assessment / Other infrastructure: gathering and gas processing (Section 4 of report)
Connecting to the National Transmission System and UK gas distribution networks should be relatively straightforward, especially if a shale site is situated close to an existing entry point and/or entry points are minimised through the use of shared, centralised processing plants.

Recommended next steps

- UKOOG, with the support of Government and supply chain companies, should build an investment case, including finance options, for developing UK-based capabilities in shared gathering and gas processing infrastructure.

Prospects for Shale Gas

Source: www.parliment.co.uk
http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenergy/795/79506.htm

Gas Pipelines Transmission Networks

National Grid Gas (NGG)—owner and operator of the national gas transmission system throughout Great Britain and the Isle of Grain (Kent Coast) LNG import facility—says there are likely to be technical challenges surrounding the transmission of shale gas, "in particular the UK requirements for gas quality and for [network] entry capacity [requirements]".[94] SSE (formerly Scottish and Southern) stated that the UK's "existing gas distribution work, which is one of the most developed in the world" could offset the higher production cost of shale gas.[95] Chatham House's Professor Paul Stevens pointed out that access to the gas grid in the US is based upon "common carriage", which means "any gas supplier can gain access to the grid even if it is already operating at full capacity".[96] Whereas, in Europe, access is based upon "third part[y] access", which means if the system is operating at full capacity "there is no access unless dedicated new pipelines are built".[97]

Scotia Gas Networks (SGN) is the UK's second largest gas distribution company, with 5.7 million customers and 74,000 km of gas mains.[98] It believed that as shale gas wells will be distributed over a wide area across the UK, they were "likely to need large numbers of smaller scale connections to gas distribution networks than typical gas wells".[99] However, SGN also noted that "the [already] large scale and wide coverage of the gas distribution network could [...] increase the speed at which shale wells can connect to the system".[100]According to Shell, shale gas was likely to meet regional and national market demands in the first instance, as rapid growth in unconventional gas production was "likely to require new investment in European gas transport infrastructure" to facilitate pan-European sales.[101]

However, it is interesting to note the potential option to generate electricity on site at the shale well. An example of this is Cuadrilla's Elswick site, located near Blackpool, which we visited in March. The Elswick site was commissioned in July 1996, and is a natural gas to electric generation power plant, which means the power plant sits on top of the gas formation, negating the need for gas transmission (sometimes referred to as "gas-to-wire").[102] It has been producing natural gas and generating electricity since 1998, and originally produced 1MW of power.

The Minister told us he thought it was more likely that shale gas would be extracted and used for generating electricity on site than transported through pipelines: "I think Cuadrilla's interest has been their closeness to the electricity grid rather than their closeness to the gas grid".[103] As well as being input directly into the grid, the Minister suggested to us that electricity generated from shale gas could "be linked into a renewable resource [such as wind generated electricity] and, therefore you have the gas that is available to generate the electricity when the renewable resource is not there".[104]

During our recent visit to the US, we met with the Mayor of Fort Worth in Texas. There, the shale gas industry began by exploring in rural areas, but then encroached upon the city itself as it had identified "sweet spots" where the gas could be more easily extracted. "Sweet spots" were described by Nigel Smith of the BGS as "places where you

get higher productivity".[105] The Mayor told us that that pipelines—which transport the extracted shale to compressor stations before it is injected into the gas mains—had become a major issue, and one they wished they had dealt with at the outset. Each operator could have their own set of pipelines, leading to multiple sets across the city. They acknowledged that a lot of unnecessary duplication could have been avoided if companies had been made to work together and share pipelines.

There is a suite of environmental legislation, including Environmental Impact Assessment (EIA) that is applicable to pipelines for the onshore oil and gas industry in England, Scotland and Wales. The aim of EIAs is to determine the likely effects of new developments on the environment, and ensure these effects are taken into account before the development is allowed to go ahead. The Town and County Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 and the Environmental Impact Assessment (Scotland) Regulations 1999 require an EIA to be undertaken for "pipelines for the transport of gas [...] and a length of more than 40 kilometres". For smaller gas pipeline projects, an EIA is only required "if the development is likely to have a significant effect on the environment" as determined by the local authority. [106]

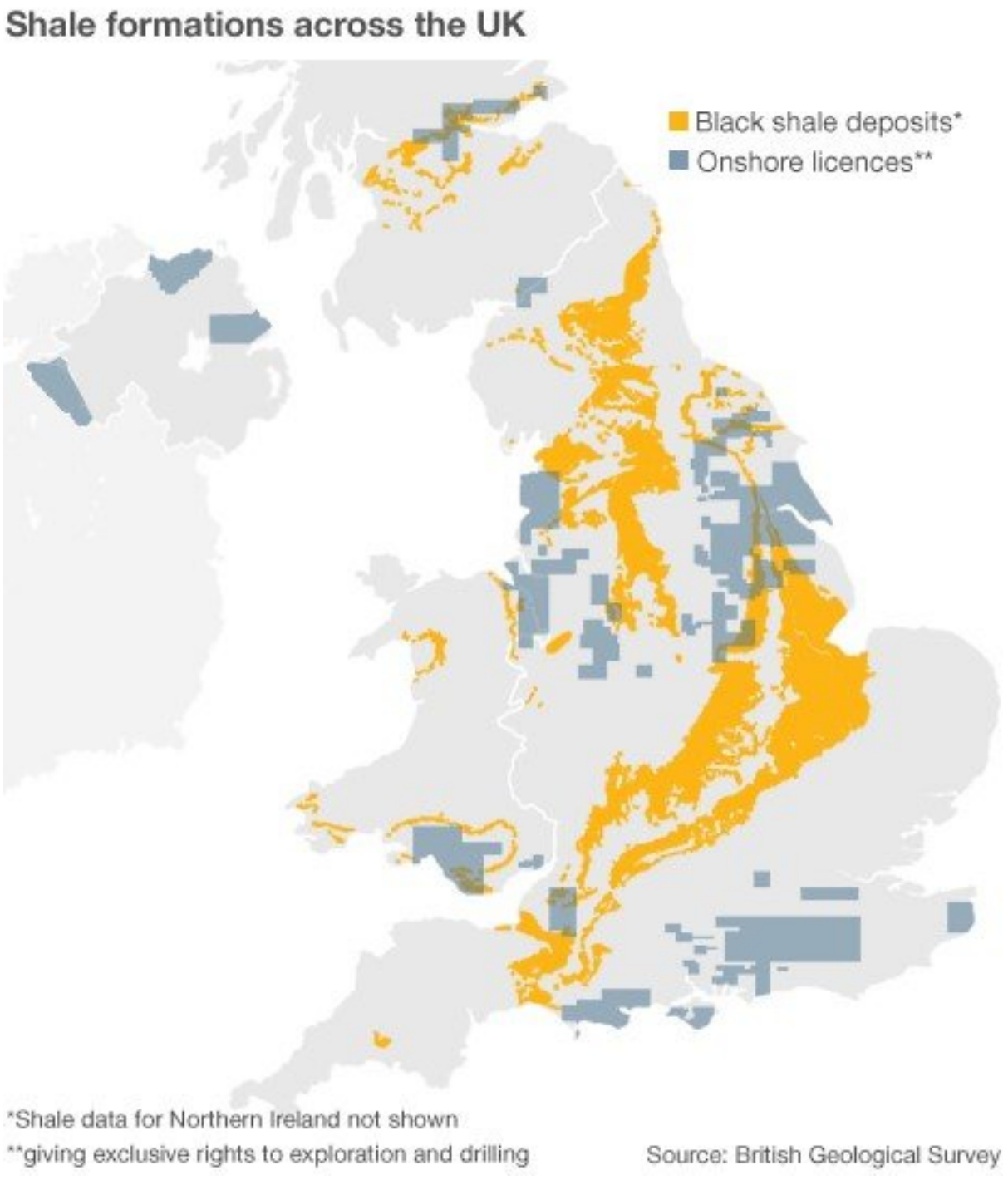
Planning for any new gas transport infrastructure required to exploit shale gas should take into account the opportunity to minimise disruption and costs by sharing pipelines between different companies operating near to each other. We recommend that the Government consider amending the Town and County Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 to require Environmental Impact Assessments for smaller gas pipeline projects, with the aim of avoiding unnecessary duplication of infrastructure.

Gas Network Innovation Competition Full Submission

Appendix 5: Supporting Gas Industry Information

Shale formations across the UK

Source: British Geological Survey

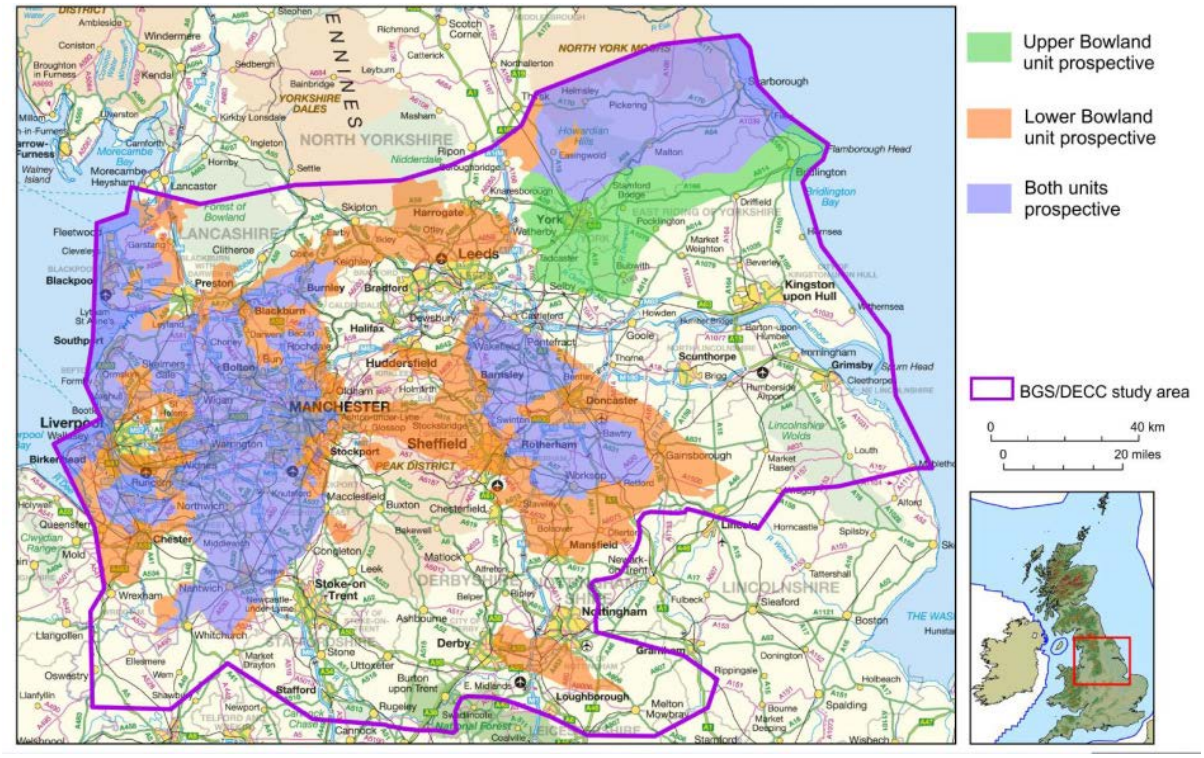


Gas Network Innovation Competition Full Submission

Appendix 5: Supporting Gas Industry Information

Bowland Shale

There is an estimated 1,329 trillion cubic meters of shale gas in the Bowland shale area (British Geological Survey Gas-in-Place Assessment of the Bowland Shale; 2013)

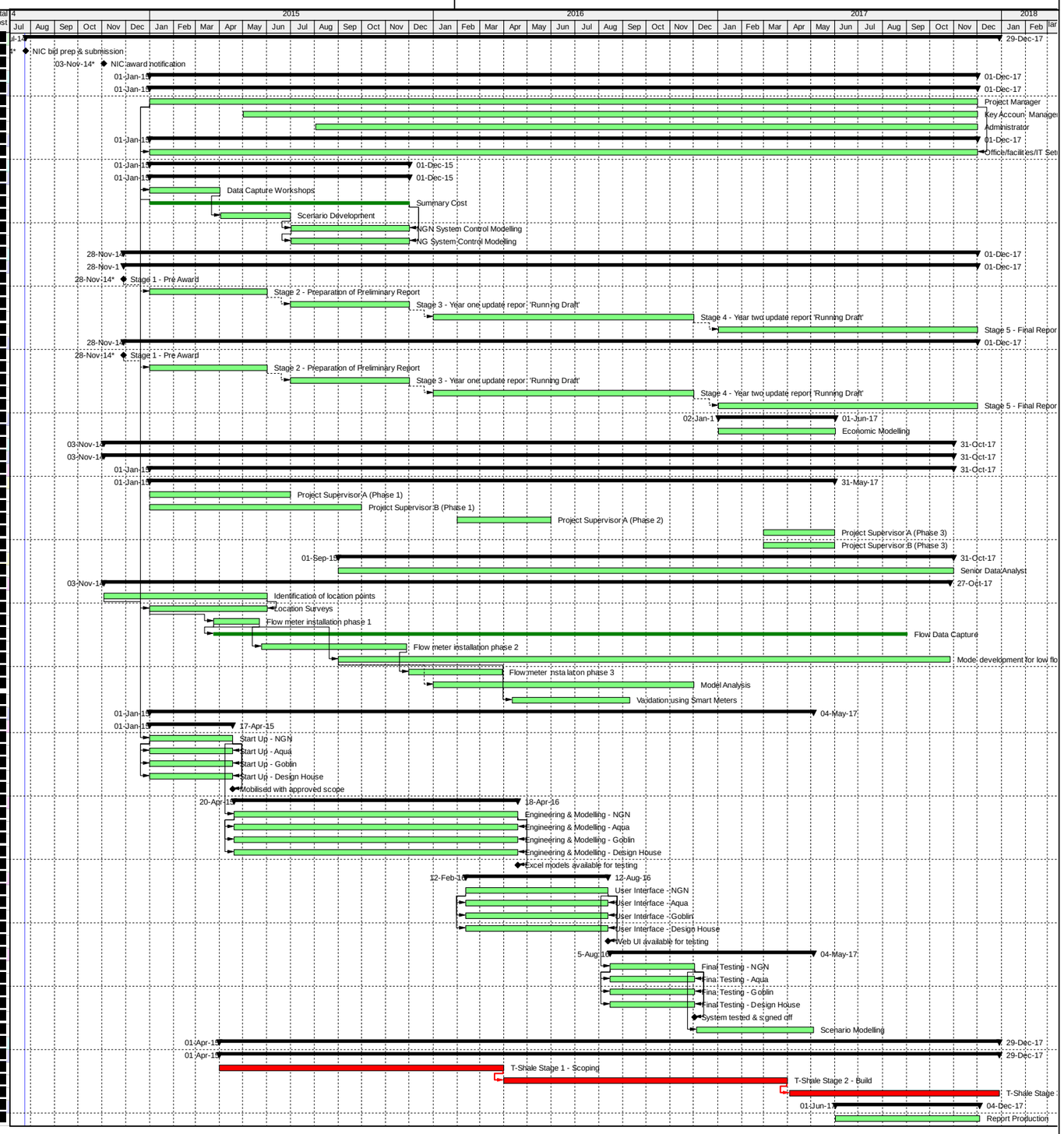


Gas Network Innovation Competition Full Submission

Project Code/Version No:
NGNGN02/01

Appendix 6: Project Plan

Activity ID	Activity Name	Start	Finish	Activity Status	Duration % Complete	Budgeted Total Cost	Remaining Total Cost	Actual Total Cost
T-Shale		25-Jul-14	29-Dec-17					
A1000	NIC bid prep & submission	25-Jul-14*						
A1010	NIC award notification	03-Nov-14*						
Project Management Core Team		01-Jan-15	01-Dec-17					
Project Management Team		01-Jan-15	01-Dec-17					
A1020	Project Manager	01-Jan-15*	01-Dec-17					
A1021	Key Account Manager	01-May-15*	01-Dec-17					
A1031	Administrator	03-Aug-15*	01-Dec-17					
Facilities		01-Jan-15	01-Dec-17					
A1030	Office/facilities/IT Setup	01-Jan-15	01-Dec-17					
Deliverable 1		01-Jan-15	01-Dec-15					
Scenario Development		01-Jan-15	01-Dec-15					
A1050	Data Capture Workshops	01-Jan-15	01-Apr-15					
A1045	Summary Cost	01-Jan-15	01-Dec-15					
A1060	Scenario Development	02-Apr-15	01-Jul-15					
A1070	NGN System Control Modeling	02-Jul-15	01-Dec-15					
A1080	NG System Control Modelling	02-Jul-15	01-Dec-15					
Deliverable 2 - Non-Technical		28-Nov-14	01-Dec-17					
2A - Addleshaw Goddard		28-Nov-14	01-Dec-17					
A1280	Stage 1 - Pre Award	28-Nov-14*						
A1290	Stage 2 - Preparation of Preliminary Report	01-Jan-15*	01-Jun-15					
A1300	Stage 3 - Year one update report 'Running Draft'	01-Jul-15*	01-Dec-15					
A1310	Stage 4 - Year two update report 'Running Draft'	01-Jan-16*	01-Dec-16					
A1320	Stage 5 - Final Report (end year three)	02-Jan-17*	01-Dec-17					
2B - ERM		28-Nov-14	01-Dec-17					
A1390	Stage 1 - Pre Award	28-Nov-14*						
A1400	Stage 2 - Preparation of Preliminary Report	01-Jan-15*	01-Jun-15					
A1410	Stage 3 - Year one update report 'Running Draft'	01-Jul-15*	01-Dec-15					
A1420	Stage 4 - Year two update report 'Running Draft'	01-Jan-16*	01-Dec-16					
A1430	Stage 5 - Final Report (end year three)	02-Jan-17*	01-Dec-17					
2C - TBC		02-Jan-17	01-Jun-17					
A1380	Economic Modelling	02-Jan-17*	01-Jun-17					
Deliverable 3 - Technical		03-Nov-14	31-Oct-17					
3A - Flow Trials		03-Nov-14	31-Oct-17					
Personnel		01-Jan-15	31-Oct-17					
Project Supervision		01-Jan-15	31-May-17					
A1176	Project Supervisor A (Phase 1)	01-Jan-15*	01-Jul-15					
A1177	Project Supervisor B (Phase 1)	01-Jan-15*	30-Sep-15					
A1187	Project Supervisor A (Phase 2)	01-Feb-16*	31-May-16					
A1207	Project Supervisor A (Phase 3)	01-Mar-17*	31-May-17					
A1217	Project Supervisor B (Phase 3)	01-Mar-17*	31-May-17					
Data Analysis		01-Sep-15	31-Oct-17					
A1178	Senior Data Analyst	01-Sep-15*	31-Oct-17					
Flow Trials		03-Nov-14	27-Oct-17					
A1180	Identification of location points	03-Nov-14*	01-Jun-15					
A1190	Location Surveys	01-Jan-15	01-Jun-15					
A1200	Flow meter installation phase 1	24-Mar-15	22-May-15					
A1230	Flow Data Capture	24-Mar-15	01-Sep-17					
A1210	Flow meter installation phase 2	25-May-15	27-Nov-15					
A1240	Model development for low flow	01-Sep-15	27-Oct-17					
A1220	Flow meter installation phase 3	30-Nov-15	29-Mar-16					
A1179	Model Analysis	01-Jan-16*	01-Dec-16					
A1250	Validation using Smart Meters	11-Apr-16*	09-Sep-16					
3B/C - S-Gas		01-Jan-15	04-May-17					
Stage One		01-Jan-15	17-Apr-15					
A1090	Start Up - NGN	01-Jan-15	17-Apr-15					
A1091	Start Up - Aqua	01-Jan-15	17-Apr-15					
A1092	Start Up - Goblin	01-Jan-15	17-Apr-15					
A1093	Start Up - Design House	01-Jan-15	17-Apr-15					
A1099	Mobilised with approved scope		17-Apr-15	Not				
Stage Two		20-Apr-15	18-Apr-16					
A1100	Engineering & Modelling - NGN	20-Apr-15	18-Apr-16					
A1101	Engineering & Modelling - Aqua	20-Apr-15	18-Apr-16					
A1102	Engineering & Modelling - Goblin	20-Apr-15	18-Apr-16					
A1103	Engineering & Modelling - Design House	20-Apr-15	18-Apr-16					
A1109	Excel models available for testing		18-Apr-16					
Stage Three		12-Feb-16	12-Aug-16					
A1110	User Interface - NGN	12-Feb-16*	12-Aug-16					
A1111	User Interface - Aqua	12-Feb-16	12-Aug-16					
A1112	User Interface - Gob in	12-Feb-16	12-Aug-16					
A1113	User Interface - Design House	12-Feb-16	12-Aug-16					
A1119	Web UI ava lable for testing		12-Aug-16					
Stage Four		15-Aug-16	04-May-17					
A1120	Final Testing - NGN	15-Aug-16	02-Dec-16					
A1130	Final Testing - Aqua	15-Aug-16	02-Dec-16					
A1140	Final Testing - Goblin	15-Aug-16	02-Dec-16					
A1150	Final Testing - Design House	15-Aug-16	02-Dec-16					
A1160	System tested & signed off		02-Dec-16					
A1170	Scenario Modelling	05-Dec-16	04-May-17					
Deliverable 4		01-Apr-15	29-Dec-17					
T-Shale		01-Apr-15	29-Dec-17					
A1370	T-Shale Stage 1 - Scoping	01-Apr-15*	31-Mar-16					
A1371	T-Shale Stage 2 - Build	01-Apr-16	31-Mar-17					
A1372	T-Shale Stage 3 - Testing and Release	03-Apr-17*	29-Dec-17					
Report Production		01-Jun-17	04-Dec-17					
A1360	Report Production	01-Jun-17*	04-Dec-17					



Remaining Level of Effort | Actual Work | Critical Remaining ...
Actual Level of Effort | Remaining Work | Milestone

TASK filter: All Activities

Gas Network Innovation Competition Full Submission

Project Code/Version No:
NGNGN02/01

Appendix 7: EXP01 Form

Northern Gas Networks

Exp-1 Expenditure Approval

Confidential
Issue 1 : 26/11/12

Business Strategy Record	NIC 2014 Submission	**Project Name**	T-Shale
Approval required	ISG		

Project Driver	This project will form NGN's network innovation Competition (NIC) 2014 submission. Recent years has seen increase in the potential for production of on-shore unconventional gas sources in the UK. These bring with them potential benefits in terms of security of supply, facilitation of the transition to a low carbon economy and direct customer benefit from access to the wider energy market. There are a number of challenges to address if these benefits are to be captured and maximised. Key amongst these is how the UK's gas transportation systekm and the associated commercial and regulatory framework can be most efficienctly utilised, developed and operated to support these developments
Deliverables	There are four key deliverable for this project: 1) Scenario Development information gathering on the various scenarios for shale gas development i.e. pressures, duration, flows, expansion predictions etc 2) Technical including 2A Flow trails to effectively model low flow scenarios, 2B/C S-Gas a scoping and estimating tool. 3) Non-Technical – an assessment of the legal, environmental and economic modelling implications of different scenarios and an overview of the overall shale gas development position. 4) Final Report and the T-Shale platform – a web based decision tool for scenario analysis.

Project Manager	**D Sadler**	**Delivery Partner**	See NIC submission document section 1.6

Start Date	Dec 2014	**Driver for timing**	NIC Submission 2014
P0 End Date	Dec 2017		
P50 End Date	March 2018		

Financial Summary	**Confirm Current year**	**Following Year**	**Remainder**	**Total**
Materials	[redacted]			
Labour				
Other				
Gross Total at P0				
P50 Risk				
Gross Total at P50				
Contribution				

Signatories	**Name**	**Date**	**Signature**
BSR Sponsor	**D Sadler**	24/7/14	
Finance	**D Waite**	24/7/14	
Delivery	**H Forster**	24-7-14	
Asset	**M Alderson**	24-7-14	

Finance (SAP) Codes	-

Appendix 8: CBA for T-Shale

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Appendix 8: CBA for T-Shale

In the expert panel sessions a request was put to NGN to try to include some form of CBA in the submission. In section 6.2 of the main submission the network has attempted to clarify the core principles of the T-Shale bid and put into perspective the impact on costs should an under optimised transportation network be developed.

For ease of reference section 6.2 of the bid is below:

6.2 Evidence of how the costs and benefits have been estimated

One of the core principles of the project is to identify the most efficient gas transportation infrastructure to facilitate the shale gas market in the UK. It is not feasible prior to this project to quantify the projected savings noting the shale gas agenda still has several moving parts.

What is clear is that infrastructure will need to be developed if the shale gas market is to reach the potential scale identified in the latest reports (for example the EY report). Noting the significant costs associated with any infrastructure projects eg. pipeline, Pressure Reduction Stations (PRS), compressors, terminals any sub-optimised and / or unco-ordinated program for such development will add potentially hundreds of millions to the costs.

To put the costs for infrastructure development into context some examples are provided below:

- *A single 48 inch high pressure gas pipeline costs on average of £1.5m/km*
- *A single connection and associated PRS station to the NTS could cost in excess of c.£10m*
- *An above 7bar 10 inch pipeline costs on average c.£500k per kilometre*

When considering these types of figures it is easy to see how transportation methods and costs can have a significant impact on the overall feasibility of shale gas. The development of shale gas production facilities needs to be considered alongside transportation options. In addition, the carbon footprint of these types of projects are significant, so the balance between cost, time and carbon impact needs to be understood to ensure an informed decision can made on how to progress most efficiently. This project will support the industry in reaching a decision.

To try to give some quantification of the types of CBA the T-Shale project will produce NGN have provided an example below:

Example: Development of an area of the Cleveland play (this is a theoretical example for illustrative purposes only)

If a small part of the Cleveland play were developed there may be an opportunity to connect direct to the NTS (20km away) or alternatively to connect to the LTS (2km away. If we assume the infrastructure needs to be in place prior to exploration and, for the purposes of this example, that the connection to the LTS is the optimised transportation option in terms of cost/carbon/jobs created etc.

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1. Connection to the NTS (pipeline only) = approximately £500k/km = £10,000K
2. Connection to the LTS (pipeline only) = approximately £500k/km = £1,000K

In this example the foresight (provided through the T-Shale project) to provide a connection and pipeline to the LTS would save £9,000K (1.5x the value of the project) this exclude the physical connection costs which would be significantly higher to the NTS when compared with the LTS option.

This is one example, for one group of wells, at one point on the network. When this is extrapolated to the entire Bowland shale area (and indeed further into the UK) this would equate to the 'hundreds of millions' identified in section 6.2.

The CBA above does not show the value T-Shale will provide by identifing required regulatory changes, advanced planning (see 'evidence form other sectors' below) and aligning the transportation infrastructure development program with the exploration and production programs.

Evidence form other sectors

When considering the merit in 'looking ahead' at the most effective gas transportation options required to facilitate the onset of the shale gas market NGN have drawn upon experience gained in the power sector. Currently the clyde and other wind farms have been built on the western coast of Scotland and are constrained until the Western power link transportation infrastructure project is completed. If a project like 'T-Shale' had been established prior to the development of these windfarms it may have had the following influence:

1. The windfarms and transmission infrastructure programs would have been delivered in tandem ensuring optimised operation of the windfarm and maximisation of the windfarms asset life.
2. The entire strategy for the Western power link may have been redesigned to consider localised isolation or other alternatives which may have offset the enormous cost of the Western power link project.

In appendix 5 (p7) NGN have provided some evidence from the US shale gas market form the Mayor of Fort Worth in Texas. After the development of the shale gas market in Fort Worth the mayor commented 'pipelines which transport shale gas to compressor stations before it is inject3ed into the gas mains had become a major issue which they wished they had addressed at the outset'. 'T-Shale' will provide this foresight.

Appendix 9: Flow Trials Additional Information

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Appendix 9: Flow Trials Additional Information

In the expert panel sessions NGN had significant challenge around the requirements to undertake low flow modelling as proposed in the submission. As a result the network felt it beneficial to include more detail to this element of the works as part of the appendices.

Before understanding the reasons for designing the flow trails in the manner they have been described in this submission it is first important to understand the fundamental requirements for the flow trails to be undertaken.

Over decades as the gas industry has developed gas networks have been designed in order to meet the obligation to provide gas to all customers based on a 1 in 20 (1:20) day. Simplistically this means a network is designed to meet capacity requirements for peak demand conditions that may occur once every twenty years. In order to establish design parameters for this 1:20 scenario PEAK condition flow trials were undertaken over several years in order to establish a distribution correlation curve. This ensured the network was not overdesigned and could be sized appropriately. To put the significance of this work into perspective, if peak demand flow trails were not undertaken the network would have been designed based on the cumulative maximum flow of all loads taking gas simultaneously resulting in individual networks having on average five or six times more gas carrying capacity than they actually need. This additional size would have been funded by the UK customer.

Currently, virtually all gas is provided via the National Transmission System (NTS) at the highest pressure tier (i.e. up to 80bar). The input volumes from the NTS can be moderated for winter and summer demand to ensure the volume of gas that is allowed into a distribution network is proportional to the volume of gas that is required, i.e. used by customers. Today with the onset of the alternative gas sources (bio methane being the first significant contributor) networks are now faced with a totally different problem. Alternative gas sources can (theoretically) produce gas to be available for injection into any pressure tier, at a constant volume all year round. These alternative gas sources have business cases based on economic models as well as physical characteristics that demand constant gas flow all year round. Whilst the networks have good data to support injection and flows at peak demand (based on the detailed and validated models for the 1:20 conditions described above) they do not have any data to inform assumptions on flow rates and capacity for low flow scenarios i.e. in the middle of summer when there is minimal gas demand.

This lack of data to support low flow (summer) analysis has a significant consequence for the alternative gas injection industries as no clear commitment to available injection capacity can be provided. This problem is described in the example below:

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Example:
A typical bio methane plant of say 400scmh (standard cubic meters per hour) could request connection to the medium pressure system. The analysis for low flow (i.e. could this plant inject in summer) is currently based on 'expert' opinion of between 0.5%and 1.5% capacity. For a town of around 60,000 properties this could return a capacity of between 300 to 900scmh. Based on this analysis the network could advise the producer they either couldn't connect or in fact two bio methane facilities could connect.

Noting the bio methane industry is a tiny volume of gas in comparison to the onset of the shale gas market the lack of credible data in this area will have significant impacts on the successful development of the T-Shale project. For example, when the scenarios for T-Shale are developed based different volumes, pressures, timescales for market development etc. some credible scenarios could be discounted, based on modelling not enough capacity in the network. Whilst some non-credible scenarios could be included, based on an over estimation of capacity in the networks. As a result NGN consider the flow trials element of this project are critical for development of the overall T-Shale project.

Why Understanding Low Flow Modelling is Important for all Pressure Tiers:
In the expert panel sessions NGN felt there was a misunderstanding that low flow modelling was only relevant for injection into the low pressure network i.e. where most customers take gas. This is not the case, low flow modelling is critical to understanding injection at all pressure tiers, this is explained in the diagram below:

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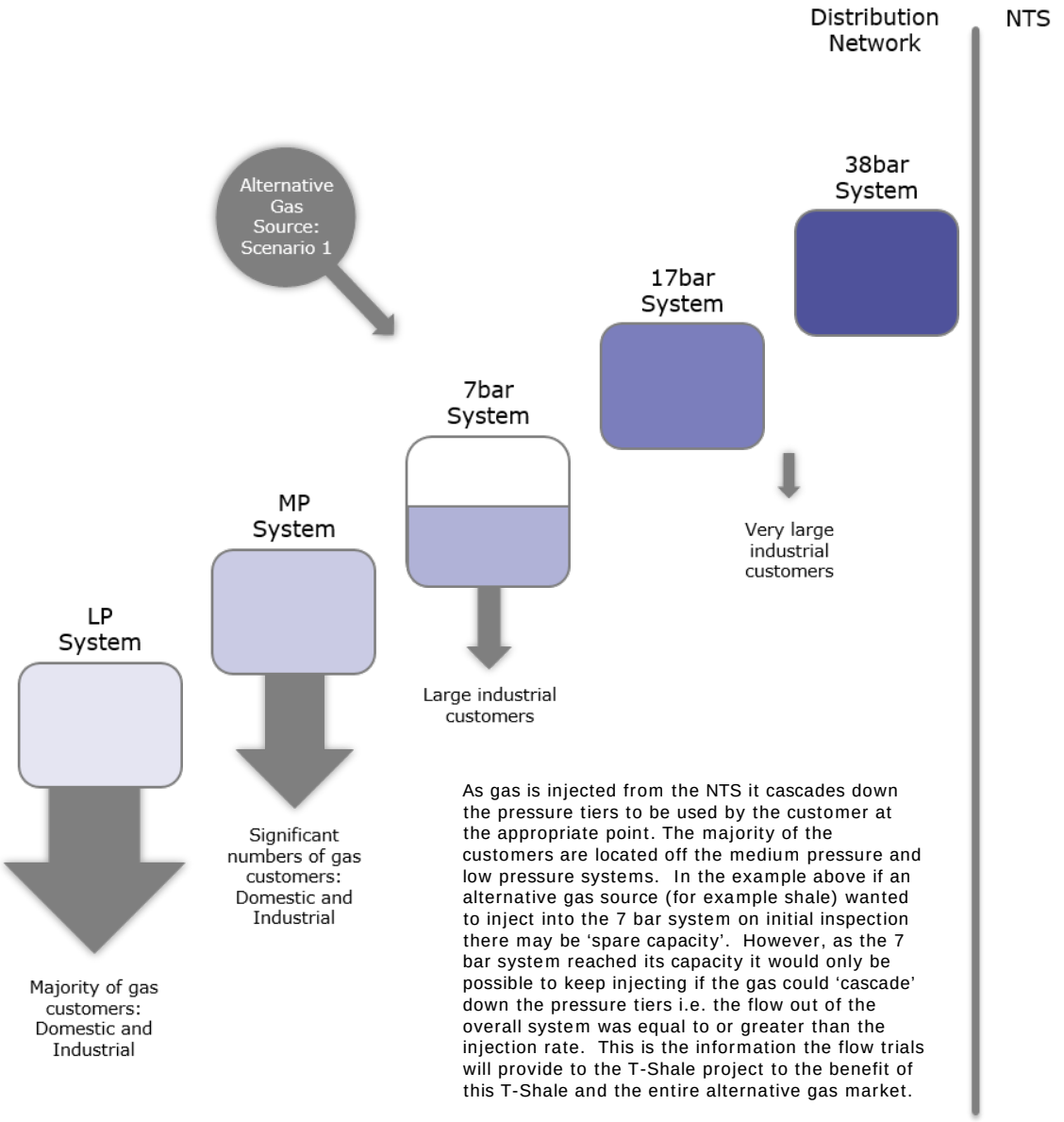
Appendix 9: Flow Trials Additional Information

Example: Typical gas network pressure tiers (very simplified)



Alternative Approaches to Low Flow Trials.

During the Expert Panel sessions there was significant debate concerning the use of alternative techniques to undertake low flow modelling. Specifically two areas were discussed firstly, using pressure differentials and secondly using smart metering. For completeness NGN has included the analysis of these alternatives below.

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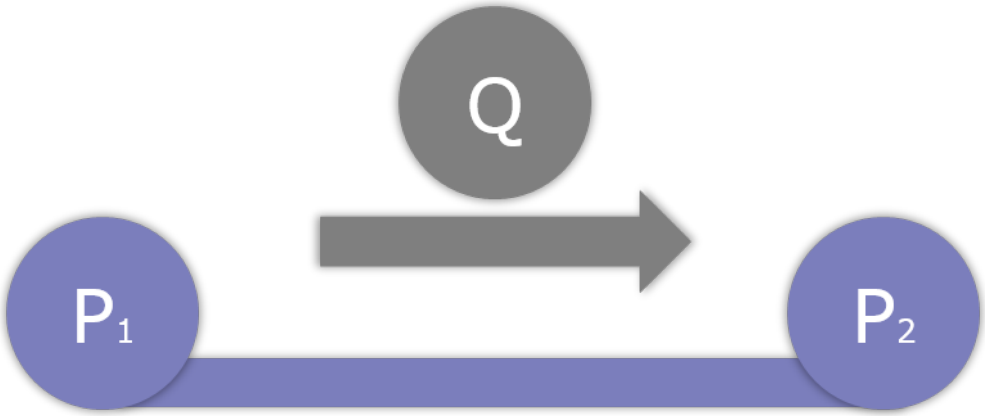
1. Using Pressure Differentials.

The relationship between pressure differential and flow rate of a gas through a pipe is well established and is the basis of our Network Analysis modelling tool.

In the simplest non-trivial form (a single pipe with gas flowing through it), the network analysis tool uses known parameters (upstream node pressure, flow rate, gas properties and known physical characteristics of the pipe such as length, diameter, material, roughness, etc.) to calculate the downstream node pressure.



Where

P2 is the downstream node pressure

P1 is the upstream node pressure

Q is the gas flow rate

In the model for a network, the initial conditions (source pressure at the district governor, gas demand (flow rate) for each node and all physical characteristics of the individual pipes within the network) are known. For a complex, interconnected network of multiple thousands of pipes, the network analysis model iteratively determines the pressure at each pipe node in order to balance the pressure drop / flow equation.

If (as is the case under low demand conditions where no demand diversity model exists) the individual pipe flows cannot be determined but potentially upstream and downstream pressures could be measured using dataloggers, the equation could be rewritten to express the unknown (flow) in terms of known upstream and downstream pressures

On first consideration, this appears to offer a solution whereby pressure dataloggers could be fitted at either end of a pipe unit and the pressure differential between the two then used to calculate the flow rate in the pipe.

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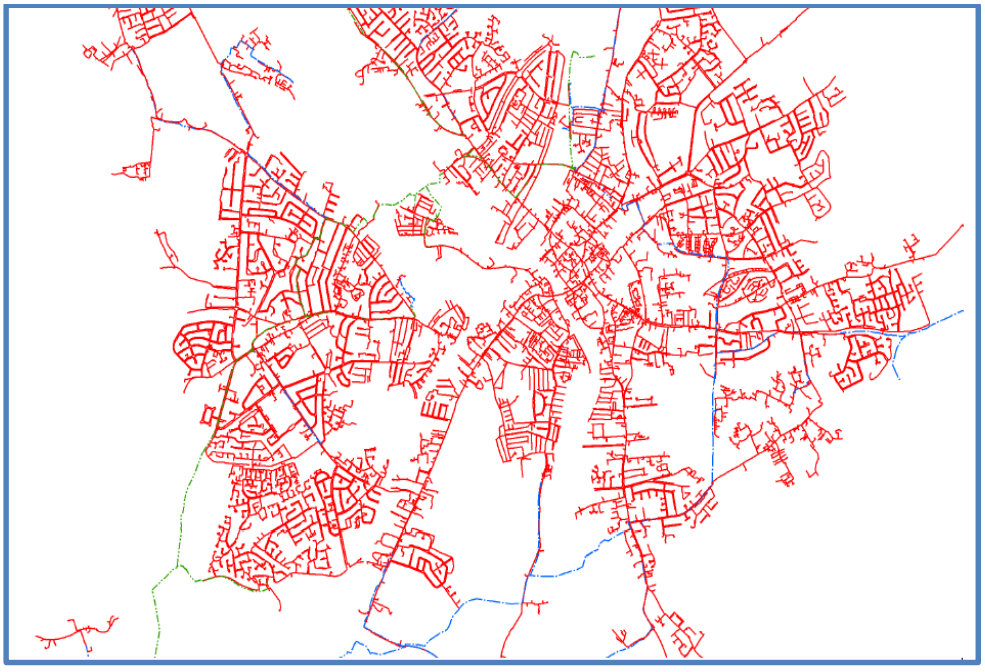
Unfortunately, it is not possible to do this practically. NGN uses good quality dataloggers fitted across the network and used for peak demand model validation. These instruments have a resolution which is sufficient and suitable for individual pressure measurements and for the purposes of validating the models under high demand conditions where there are large pressure drops across the network. However, under low demand conditions the pressure drop across an individual pipe unit (say, 100m in length) is extremely small – <<0.1mbar. This is far less than the basic resolution of the available instruments and so it would not be possible to utilise the differential across an individual pipe unit.

As an alternative, in order to increase the pressure differential between the dataloggers to a point it would be measurable, these could be placed at the source and extremities of a large network. Even in a very large network, the pressure differential between the source governor and the network extremities would be very small at times of minimum demand and so numerous high-precision instruments would be required throughout an individual network in order to collect any meaningful data. This would have to be repeated across each of the areas that we have identified as requiring flow data from.

Once collected, the problem would then remain as to how to convert this pressure differential data into flow. The simple calculation for an individual pipe could not be used as a network consists of very large numbers of interconnected pipes with different materials, diameters and flow characteristics. An example of part of a relatively small network (York) is shown overleaf.

Screen Shot: Part of York Gas Mains System



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A new network analysis computer model would need to be designed and developed to iteratively convert pressure differential information into flows. As well as the cost, time and technical complexity associated with this, major assumptions would need to be made as to how demand at low flow periods is shared across different constituent categories of the network. Once completed (if it is even technically possible), given the level of assumptions used it would still be necessary to validate the models by installing meters and collecting real flow data before they could be used to support any significant investment decisions.

In summary, NGN has given serious consideration to the possibility of installing pressure data recorders and using these to infer flow under low demand conditions rather than measure it directly. The conclusion reached is that this would not be cost-efficient, practicable or deliverable in a reasonable timescale and, even if possible, would require the installation of flow meters to validate the models produced before they could be used as part of the decision-making process.

An Alternative Approach: Using Smart Meters

NGN have considered the use of smart meter data to support the low flow modelling element of the T-Shale project. After numerous meetings with the networks representatives on the national working group, which comprises all the networks, Ofgem, DECC and the suppliers, NGN believe there are considerable obstacles to adopting this approach. These obstacles include but are not limit to the flowing;

1. Roll out:

a. From Dec 2015 there will be a mandatory rollout of smart meters across the UK (both Electricity and Gas). This will be a supplier-led rollout which will potentially see every domestic property in our network (c. 2.2m) visited by a smart meter installer between December 2015 and 2020. Smart meters are currently being fitted (primarily by British Gas), but this is known as the Foundation Stage, is non-mandatory and the final technical specifications for smart meters (called SMETS 2) whilst finalised, has not been put into large scale production of meters by manufacturers. Any meter fitted now will either have to have a firmware update, or be changed for a compatible meter once SMETS 2 meters are readily available. This could add delays to the program and ultimately the data provision.

b. The big six have indicated that they will be adopting customer-led rollout plans, which by definition will be difficult for them to forecast with any degree of accuracy. To undertake this rollout suppliers will need a significant ramp up in resource which, if not managed correctly, will add significant risk to delivery.

c. Roll out is being driven by customer footprint and not geography. Therefore, each supplier will be installing smart meters in their own customers' houses, wherever they are.

2. Data Availability: All data coming from Smart Meters will be communicated by a central body (DCC). Due to increasing concerns about security (both MI6 and GCHQ have got involved) all data will be encrypted and any organisation that wants to access this data will have to hold security keys, unique to that organisation, and loaded onto each meter on installation. With the current high-level rollout plans indicating that the vast majority of meters will not be installed before the second half of the rollout period, a 'tipping-point' (i.e. a point where enough meters have been installed for a network to get meaningful data) will not be reached until 2018, Until then it would be inefficient for the GDNs to become full DCC users. Recognising this the Smart Energy Code has introduced the concept of 'SMKI Lite' that allows a user to register with the DCC to allow them to fit the minimum security keys to the meters. This is it's a 'foot in the door' to the DCC without getting any data, until such a time that there is enough of a business case to justify the expense of a full DCC user gateway.

3. Data Clarity: There are still considerable amounts of uncertainty regarding data provision from smart meters. Data granularity is one of the main obstacles for the initial assessment of low flow modelling. Smart meters will only provide data in 30 minute intervals (as opposed to every minute from a flow meter). This will lead to uncertainties in modelling assumptions.

4. Other Technical Challenges:

a. Currently there is only one type of approved meter, the WAN hub hardware, firmware and software are not yet standardised, Funding streams for hardware are constrained and the subject of continual debate between Shippers.

b. The WAN is a separate network that is installed to support the meters. The positioning of the WAN, the electricity meter and the gas meter are now all the result of different sets of requirements in terms of proximity to electricity supply, telephone/broadband line, thickness of walls, upstairs/downstairs other WAN network constraints.

c. Purge and relight process on a smart meter has not yet been agreed.

d. The only approved meter design doesn't fit in semi-concealed or recessed boxes and can't cope with damp. When a service alteration is undertaken (or a back to front re-carcass) the gas meter will be re-positioned at the front of the house and potentially moved out of WAN range.

NGN's Proposed Solution

Taking into account all the challenges NGN has reassessed the original strategy to undertake the low flow modelling using only flow meters for upfront data and model revalidation. Instead the network is looking to adopt an approach of using flow meters for the upfront modelling requirements (i.e. 2015 & 16 monitoring of the 53 points

described in section 2 of the bid) followed by validation of the developed model assumptions using smart meter data if possible.

This approach should prove cost effective as well as technically robust to return an accurate low flow modelling analysis. NGN have retained the original costs for the validation of the low flow model using flow meters as part of the overall risk allowance. This is based on an awareness of the obstacles still to be addressed in the smart metering roll out program and recommendations from NGN's smart metering representatives. In effect this will allow the T-Shale project to successfully complete should there be delays or problems in smart meter data. It will also mean this allowance is returned to customers (via the NIC account) should the validation of the low flow model be achievable using smart meters.

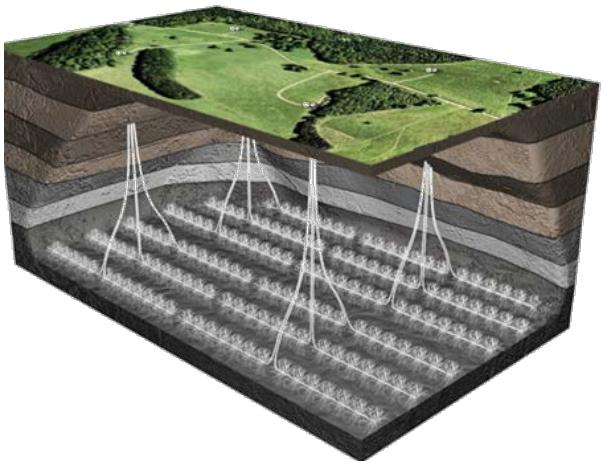
Shale Gas (Notes)

Regulation

The UK Shale gas industry is regulated by The Coal Authority, where the scope of their responsibilities extend to 'all minerals (at whatever depth they occur within the geo-structure).

Petroleum Exploration Development License (PED)

The UK Secretary of State grants Licence(s) exploration of land 'blocks' within the UK, applications under the 14th Round of Licencing are offered and subsequent applications administered by DECC.



Shale deposits within the UK typically occur within the geo-structure at a depths of 2-3 km, where shale gas is extracted by a process known as Fracking. The process of Fracking comprises the drilling of a vertical riser that will allow the maximum depletion of shale gas contained within the licensed geographical area. This depletion of shale gas deposits is achieved by the utilisation of optimised directional drilling techniques, where multiple 'horizontals' are established within the shale deposits from one vertical riser.

The process of Fracking (or Hydraulic Fracturing) utilises a mix of sand, chemicals and hydraulic pressure to 'shot blast' and fracture shale rock deposits, releasing the trapped shale gas. The gas rises up the water column to surface for collection or 'gathering', under natural buoyancy once the hydraulic pressure has been released. Each drilling may be repeatedly fracked at increasing pressures, to liberate additional volumes of gas.

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A Site with less than a designated threshold input <10,000scmh is designated as 'Small' and 'Large' being >10,000 scmh. This delineation is consistent with the approach taken by Ofgem/DECC and captured within ENA's document addressing proposed changes to calculation of Flow Weighted Average Calorific Value (FWACV). It is anticipated that most shale gas sites will have production rates in excess of 10,000scmh.

Shale Gas Gathering

A producer will normally sink multiple risers within the licensed area and gather the untreated 'raw' shale gas at low pressures via network of pipes transporting the gas to a central gas processing plant. The shale gas will be processed to meet with Grid entry requirements under GS(M)R and requires compression for injection to Grid.

T-Shale will develop scenarios which will cover all options available to the production and exploration side of the industry to efficiently transport the gas to the highest benefit to the UK. Initially, it will still be necessary to process the gas to meet with GS(M)R (Gas Safety management regulations) & CoTER (calculation of thermal energy Regulations) requirements. It may well be desirable to deliver un-propanated gas with a lower CV via a standalone network but as with 'conversion', there are appliance jetting and combustion considerations to overcome. The CoTER issues can be easily accommodated by the application of smart metering with the introduction of CV billing as opposed to the current volumetric assessment. Shale gas is primarily a wet gas due to the method of extraction through a liquid column, with a typical CV 37 mj/m3