HyNet North West

Appendix B - Potential Economic Impacts of the HyNet North West Project

HyNet Carbon Dioxide Pipeline DCO

Planning Act 2008

The Infrastructure Planning (Examination Procedure) Rules 2010 – Regulations 8(1)(b)

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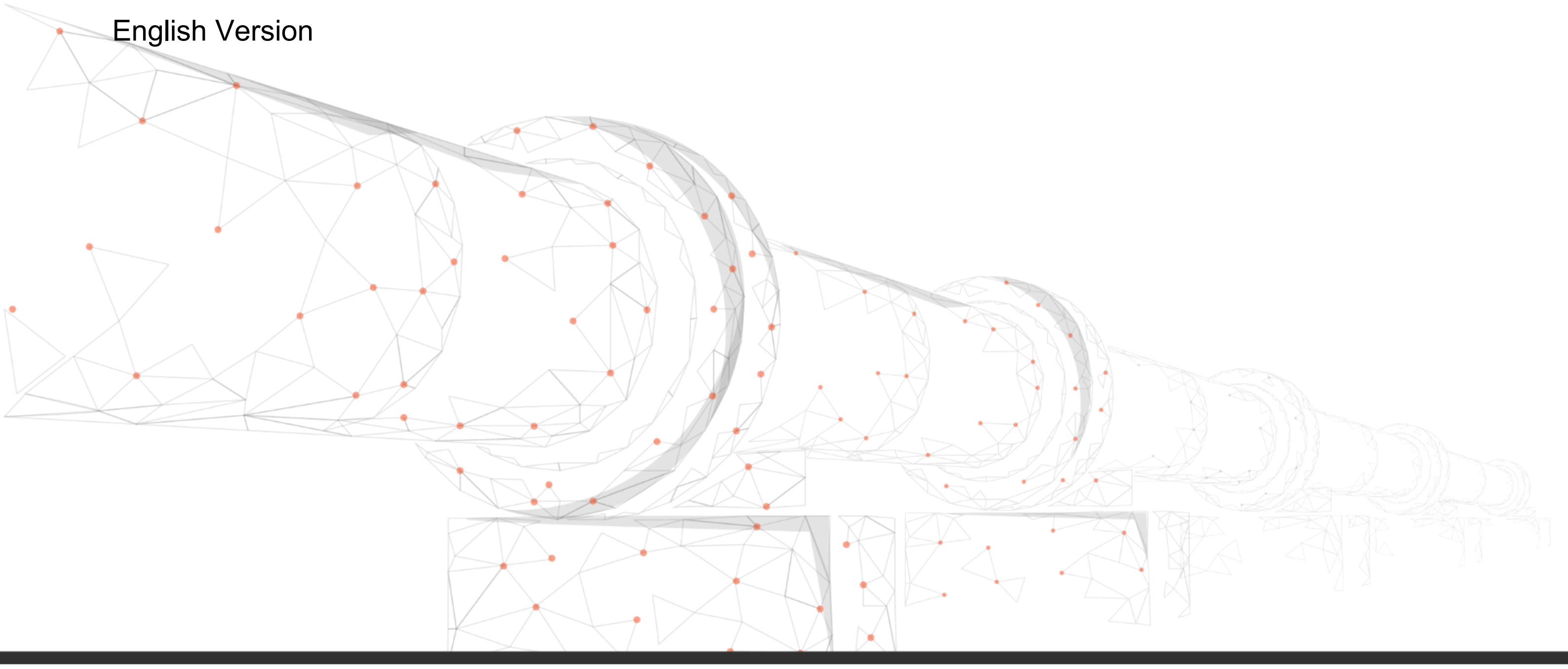

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Potential Economic Impacts of the

HyNet North West Project

AMION CONSULTING


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Contents

Executive Summary

Emissions from natural gas combustion/use are the largest source of greenhouse gas (GHG) emissions in the UK. Replacing natural gas with hydrogen was recognised by the Department for Business, Energy and Industrial Strategy (BEIS) Clean Growth Strategy (2017) as having the potential to deliver extensive decarbonisation of gas distribution networks thus helping to achieve compliance with the objectives of the 2008 Climate Change Act. There is therefore substantial potential scope for future investment in associated technology and infrastructure. This potential is reflected in the proposed HyNet North West (NW) Project.

AMION Consulting has assessed the likely economic impact of the development and operation of HyNet NW over the period to 2050 for both the North West of England and UK. The analysis has also included consideration of the potential impacts of inward investment attracted to the North West/UK in the wake of the Project.

The impact modelling used a 'multiplier' structure that takes into account not only direct and first-tier supplier spending/employment but subsequent supply-chain spend and the 'induced' spending of those in receipt of wages/salaries as part of this process

The investment in the Project will be substantial comprising capital expenditure of £17.7bn and operating expenditure of £29.1bn in the period up to 2050. The main capital expenditure items will include Autothermal Reforming (ATR) plants for production of hydrogen and capture of carbon dioxide (CO_2), Combined Cycle Gas Turbine (CCGT) stations and salt cavern hydrogen stores.

The largest operational expenditure will be on gas to service the ATR plants. Capital spend dominates the early period but is overtaken by operational spend in the late 2030's as more ATR and CCGT plants are constructed and come on stream.

In addition, it is assumed that twelve inward investments will occur as a result of the Project involving a further capital investment of some £0.87bn and operational expenditure of £3.5bn over the period.

While the majority of HyNet NW construction spend will be sourced in the North West (80-90% depending on type) and UK (90-100%), equipment spend will be more dispersed. For example, only 30% of ATR and CCGT related equipment costs are likely to be sourced from within the North West of England (50% and 80% respectively for the UK). Substantially higher levels of retention are assumed for operational spend.

The results of the modelling suggest that:

- spend on the HyNet NW Project will result in the creation of 144,287 job years for the North West and 289,377 for the UK to 2050. These equate to an average annual job creation of 4,509 jobs for the North West and 9,043 for the UK. The peak employment in any one year will be 11,522 in the North West and 23,167 for the UK. The implied employment multipliers are 2.0 for the North West and 2.6 for the UK;

- the Project spend will generate cumulative Gross Value Added (GVA) gains of £14.0bn for the North West and £25.9bn for the UK – equivalent to average annual gains of £439m for the North West and £811m for the UK with peak year gains of £1bn and £2bn respectively;

- leveraged inward investment will result in cumulative job year gains of 47,053 job years for the North West and 70,896 for the UK (annual average of 1,470 jobs for the North West and 2,215 for the UK and peak year employment of 3,771 jobs and 5,835 jobs respectively); and

- cumulative GVA gains from inward investment will be £2.8bn for the North West and £4.6bn for the UK (annual average £90m for the North West and £143m for the UK and peak year gains of £226m and £378m respectively).

In total combining the HyNet project and inward investment impacts some 191,340 person years of employment are forecast to be supported in the North West and 360,273 at the UK level up to 2050 (see Table ES1). Total GVA of £16.9bn and £30.5bn are estimated to be generated at the North West and UK levels respectively over the period.

Table ES1 Overall (HyNet project and Inward Investment) Employment and GVA Impacts (up to 2050)

Employment (Total Employment Years)	NW	UK (inc. NW)
HyNet NW	144,287	289,377
Inward Investment	47,053	70,896
Total	191,340	360,273
GVA (£m)	NW	UK (inc. NW)
HyNet NW	14,044	25,956
Inward Investment	2,836	4,584
Total	16,880	30,540

Overall, average annual job generation is projected to be 5,979 jobs for the North West and 11,259 for the UK. Average annual GVA generation for the North West is assessed at £528m and £954m for the UK.

Replacing natural gas with low carbon hydrogen has the potential to deliver extensive decarbonisation of gas distribution networks and contribute directly to GHG reduction targets at the same time as generating substantial and ongoing economic benefits. HyNet NW offers a very rare opportunity to achieve these ambitions with a development that builds on the strengths of the economic, industrial and energy infrastructure of the North West.

1. Introduction

1.1 Background

AMION Consulting was appointed by Progressive Energy Limited on behalf of Cadent Gas Limited to undertake an assessment of the potential economic impacts of the proposed HyNet North West (NW) Project. This document reports the results of the impact modelling.

Emissions from natural gas combustion/use are the largest source of greenhouse gas (GHG) emissions in the UK. As such, replacing natural gas with low carbon hydrogen has the potential to deliver extensive decarbonisation of gas distribution networks[1] . This perspective is reinforced through the Department for Business, Energy and Industrial Strategy (BEIS) Clean Growth Strategy (2017)[2] which examines three pathways (electricity, hydrogen, and emissions removal) designed to achieve compliance with the 2008 Climate Change Act and its objectives regarding reductions in GHG emissions.

While illustrative, rather than predictive, the fact that hydrogen is identified within the BEIS strategy as a key pathway for future decarbonisation planning implies substantial scope for future investment in associated technologies and infrastructure.

1.2 Objective

The objective of the analysis is to provide a robust assessment of the economic impact of HyNet NW over the period to 2050 across both the North West of England and the UK as a whole.

Impact is assessed through modelling of direct, indirect and induced effect frameworks:

- Direct effects – activities that directly accrue due to the construction and operation of the facilities;
- Indirect effects – the purchase of goods and services to facilitate construction/operation; and
- Induced effects – spending of wages and salaries generated directly and indirectly through construction and operation.

The approach taken is to define the capital and operating expenditure (CAPEX and OPEX) profiles of the Project investment as the basis of analysis, distinguishing where feasible between design, construction and equipment costs, and establishing the likely sourcing of these activities from within the North West, UK and overseas. Consideration is also given to the potential impacts of inward investment attracted to the North West/UK in the wake of the Project.

1. Progressive Energy Limited/Cadent (2017) The Liverpool-Manchester Hydrogen Cluster: A Low Cost, Deliverable Project.

2. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

The report does not:

- assess impacts related to the take-up of large transport, utility or domestic fuel cell electric vehicles (FCEVs)[3];
- consider the potential for the manufacture of FCEV engines/vehicles within the region;
- undertake any analysis of wider potential for import substitution of fuels (i.e. using hydrogen as an alternative to fossil fuels); or
- take into account any potential 'export' benefits for the region from providing CCS infrastructure for other regions.

As such, the study presents a relatively conservative perspective on impact.

1.3 The HyNet NW Project

The scenario[4] examined in this document envisages HyNet project development across the North West through to 2050 that includes:

- construction of hydrogen pipelines:
  - extending along a corridor between Liverpool and Manchester with a series of spurs permitting hydrogen to be supplied directly to around 20 major industrial users and as a 'blend' to the existing natural gas network; and
  - supported by salt cavern stores in the later phases of network development.
- construction of carbon dioxide pipelines (alongside preparatory works) facilitating:
  - CO_2 storage in the Hamilton and (subsequently) Lennox gas fields in Liverpool Bay; and
  - subsequently storage in the South Morecambe field.
- construction and operation of a total of 14 hydrogen Autothermal Reforming (ATR)/Capture plants;
- development of six 'replacement' combined-cycle gas turbine (CCGT) facilities (at existing power generation sites) fuelled by hydrogen alongside two hydrogen-fuelled CCGTs on new power generation sites; and
- a series of transport refuelling stations.

1.4 Report structure

The report continues in four sections as follows:

- **Section 2** – reviews recent studies relating to the economic benefits of hydrogen and CCS projects in the UK;
- **Section 3** - defines the nature of the development scenario that is modelled in the assessment;
- **Section 4** - sets out the methodology used for the impact assessment and provides the results of the modelling exercise; and
- **Section 5** – presents an overview and conclusions.

3. Albeit, it does consider the impact of a limited roll-out of hydrogen vehicle refuelling stations

4. Details of the CAPEX and OPEX costs for HyNet NW were provided by Cadent Gas Limited

2. Recent studies of the Hydrogen Economy

2.1 Introduction

Analyses of the UK hydrogen economy are relatively few in number but are beginning to emerge as potential projects and investments crystallise. In this section we review a number of recent studies to provide a comparator for the impact modelling contained later in this report.

2.2 H21 Leeds City Gate

The 2016 H21 Leeds City Gate project seeks to determine the feasibility (technical and economic) of converting the existing natural gas network in Leeds to 100% hydrogen[5]. Designed to minimise customer disruption and to deliver heat at the same cost as current natural gas, analysis concludes that the gas network has sufficient capacity for such a conversion but that new energy infrastructure will be required involving steam methane reforming (SMR) and salt cavern storage.

Over a three-year period (2026-2029) CAPEX costs for work in Leeds is placed at some £1.05bn for appliance conversion, £395m for a SMR plant, £230m for hydrogen transmission (HTS) and £366m for salt cavern storage, totalling to £2.04bn. OPEX costs are placed at £139m per annum.

Alongside cost estimates for Leeds, estimates are provided for 16 other city areas in the UK (including Greater London). Total CAPEX for this scenario amounts to £50.6bn with OPEX of £22 bn per annum. The H21 analysis does not undertake any formal impact modelling and, thereby, no estimates of employment or Gross Value Added (GVA) gains[6] are provided.

2.3 East Coast UK Carbon Capture and Storage (CCS)

The 2017 Summit Power East Coast UK Carbon Capture and Storage (CCS) Study provides another investment perspective and does include a series of impact estimates[7] . The basis of the study is that successive investments in CCS projects and infrastructure evolve over time into a CCS network. The Study assumes CO_2 is captured from projects located at four industrial clusters along the East Coast, building to achieve a network capacity of 75MtCO_2 per year, some 85% of the required CCS contribution implied in the Committee on Climate Change (CCC) central scenario to meet the UK's 2050 GHG emissions reductions targets.

The methodology adopted in the study is that of a social cost benefit analysis (CBA) defining not only employment and GVA gains but benefits in the form of gains in health and well-being, CO_2 emissions avoided and the balance of trade[8]. As such, the scope of the Summit study substantially exceeds that of this report and generates a scale of benefit commensurate with the broad nature of the exercise.

5. http://connectpa.co.uk/wp-content/uploads/2016/07/H21-Executive-Summary-Interactive-PDF-July-2016.pdf

6. GVA is a measure of the increase in the value of the economy due to the production of goods and services. It is measured at current basic prices, which include the effect of inflation, excluding taxes (less subsidies) on products (for example Value Added Tax).

7. http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/

8. Projected balance of trade benefits are highly dependent on assumptions about the future price of traded carbon.

CAPEX and OPEX costs are defined between 2020 and 2060 and placed at £34bn, although there is no indication of the breakdown between the two. In addition, an early footnote in the report details that all 'amounts' shown in the report are discounted unless otherwise stated which does not permit assessment of the investment structure in current price terms.

Overall impacts are provided in terms of both CCS investments and associated impacts in 'linked economies'. The latter is defined as a combination of assumed economic activity that would otherwise be lost without a carbon solution, the avoidance of North Sea decommissioning and the development of new power plant[9]. There exists an additional reference to gains from inward investment though no details are provided.

On this basis, the CCS investments are reported to generate 7,600 jobs (defined as 10% of job years) by 2032 and 47,000 jobs by 2060 with multipliers of 2.5 in each instance. The linked economies analysis generates 4,860 and 178,600 jobs at the same points in time with multipliers of 2.7 and 3.6 respectively.

Whereas employment impacts are broken down into direct and indirect components, GVA impacts are defined solely in terms of discounted totals[10] with a 2032 value of £5bn and a 2060 value of £54bn. There is no additional information on the profile of these benefits.

2.4 Liverpool Manchester Hydrogen Hub

Distinct from the HyNet NW Project, Aqua Consultants (2017) provided an early, initial perspective on a Liverpool-Manchester Hydrogen Hub concept[11]. The approach modelled impact within the context of three different scenarios

Slow progression:

- very little uptake of hydrogen with decarbonisations primarily taking the form of electricity via renewable sources with substantive transfer away from natural gas;

NW Regional Hydrogen Hub:

- development of a hydrogen hub based around a pipeline between Manchester and Liverpool with hydrogen produced via SMR/ATR technologies, CO_2 stored in the East Irish sea, industry conversion from natural gas, surplus hydrogen, blended into local/national gas networks, no requirement for domestic conversion, switching of public transport and utility vehicles to hydrogen fuel use, provision of infrastructure for post 2040 motor vehicle production;

UK Wide Hydrogen Economy:

- a version of the H21 proposal discussed earlier with hydrogen storage in salt caverns, a network of hydrogen fuelling stations sustaining uptake of FCEVs and hydrogen fuelled micro combined heat and power (CHP) appliances but also large-scale domestic conversion of appliances.

Estimates of impact were based on a 2017 study by KPMG in which the GVA of the energy sector is assessed on the basis of a breakdown of a domestic dual fuel bill by Ofgem[12]. Impacts were assessed in terms of heating (conversion), transport and construction drivers.

The results were:

Slow progression:

- cumulative GVA impact is placed at £48.6m by 2050 and peak jobs of 70 in any one year;

NW Regional Hydrogen Hub:

- cumulative GVA impact is placed at £1.62bn by 2050 and peak jobs of 2,400 in any one year;

UK Wide Hydrogen Economy:

- cumulative GVA impact is placed at £12.8bn by 2050 and peak jobs of 14,000 in any one year but excludes additional impacts from domestic appliance conversion and broader impacts beyond transport and 'hydrogen related infrastructure'.

Although focussed on the North West, the scale of project envisaged in the Aqua study is relatively modest relative to the HyNet NW Project that forms the focus of this assessment. In particular, it does consider the benefits arising from the emergence of the proposed CCS cluster.

9. Percentages of direct job losses retained across industry sectors by 2060 are defined as chemicals (20%), iron and steel (60%), cement (60%), refining (33%), gas extraction (60%). These are adjusted for UK employment in the vicinity of the CCS project: chemicals (50%), iron and steel (45%), cement (10%), refining (50%), gas extraction (2%).

10. Our interpretation is that the term induced includes what in other studies would be referred to as both indirect and induced impacts though this is not explicit in the report.

11. http://www.aquaconsultants.com/wp-content/uploads/2017/10/Study-for-the-proposed-NW-Hydrogen-Hub-rev-11-Final-press-issue.pdf

12. https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/Energising-the-North_Economic-contribution_KPMG-final-report-to-NGN_Exec-summary.pdf

3. Development scenario

3.1 Introduction

This section provides further detail on the nature of the development process that underlies the primary HyNet project analysis, the profile of expenditure that drives overall impact and the set of assumptions made through which we evaluate impact. It also outlines the profile of inward investment that is used to consider potential wider benefits of HyNet project development.

3.2 HyNet NW: Development activity

Impact is assessed via a development model that reflects design, installation, construction and operation over a period to 2050. Table 3.1 outlines the CAPEX profile that underpins the modelling exercise. Total CAPEX investment is placed at £17.7bn (2018 prices) with 40% accounted for by construction of ATR/Capture plants, 32% by with CCGT stations and 19% by hydrogen storage.

Table 3.1: CAPEX Profile (2018-2050)

Year	Design (%)	Equipment (%)	Construction (%)	Cumulative Investment (£m)
ATR/Capture Plant	13	64	23	7,000
Industry Conversion	35	40	25	200
Refilling Stations	20	50	30	52
CCGT Station	13	64	23	5,600
Onshore Hydrogen Pipeline	15	40	45	320
CO_2 Pipeline	15	40	45	148
Offshore Facilities	48	34	10	507
Hydrogen Storage	30	20	50	3,360
Offshore Storage	35	22	42	511
Total CAPEX	**-**	**-**	**-**	**17,698**

The year-on-year CAPEX profile is 'saw-tooth' in nature reflecting ATR and CCGT plant construction across the period:

- ATR plants are assumed to commence construction in 2022, 2025 and 2028 with additional plant construction occurring every two years between 2030 and 2046. It is assumed that the two final plants commence construction in 2048. Unit costs are assumed to be in the order of £500m (for a plant producing up to 800MW of hydrogen)[13] ; and

- eight CCGT plants are assumed to be constructed in two-year tranches (2027/28, 2031/32, 2041/42 and 2047/48) increasing in capacity over the period. Six of the plants are assumed to be at existing power generation sites where suitable infrastructure is already in place and two are assumed to be built on new sites or sites which are already consented[14].

Other assumptions are that:

- around twenty industrial users convert to hydrogen feed at a unit cost of £100m;

- hydrogen vehicle re-fuelling stations are constructed at a rate of one per annum over the period at a unit cost of £2m;

- onshore hydrogen pipelines are required to service a blend of hydrogen injected into the natural gas network, industrial users/converters, CCGTs and salt cavern storage at a cost of £320m over the period. New stretches of CO_2 pipeline are necessary to link stretches of existing natural gas pipelines that are repurposed for CO_2. These new pipelines supply CO_2 to the Hamilton, Lennox and South Morecambe fields at a cost of £148m over the timespan;

- offshore facilities spend relates to preparation and modifying the Hamilton platform in the first instance, followed in turn via similar modifications to the Lennox and South Morecambe platforms and is placed at £507m. The cost of injection and storage infrastructure at all of the fields is placed at a combined additional £511m in total; and

- hydrogen storage costs (£3.36bn) relate to the preparation and delivery of salt cavern storage sufficient to accommodate diurnal/seasonal demand fluctuations from both CCGTs and the blend injected into the natural gas network.

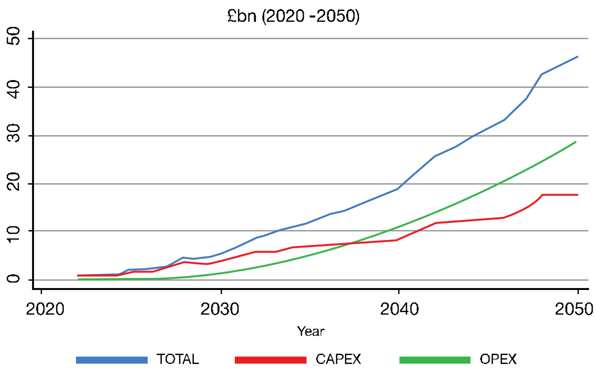
Table 3.2 OPEX Profile (2018-50)

Year	Cumulative Spend (£m)
ATR/Capture Plant O&M	3,178
Electricity	2,082
Gas	20,087
Compression	674
CCGT	1,320
Hydrogen Transportation	135
Onshore CO_2 Storage	48
Offshore Facilities	1,326
MMV	67
Financial Security	89
Well Workover	128
Total OPEX	**29,133**

Table 3.1 also details assumptions regarding the pattern of spending distributed across design, equipment and construction functions. Over 60% of ATR and CCGT expenditure is attributed to the cost of equipment with close to a quarter attributed to construction. Extensive equipment costs are also evident in a number of other investment categories.

Table 3.2 replicates Table 3.1 but references OPEX as opposed to CAPEX and shows that total OPEX costs over the period are placed at £29.1bn. By far the largest OPEX element is the use of gas to service ATR plants, reflecting the assumed profile of construction described earlier. Beyond this, OPEX spend by ATR/Capture plants, CCGT plants and provision for offshore facilities are the most notable.

Figure 3.1: CAPEX/OPEX Profile



[13] For the purposes of this exercise it is assumed that all builds are first-of-a-kind (FOAK) and that both design/consenting and construction take two to three years

[14] ibid

3.3
HyNet NW: Expenditure profiling

The core of the impact study lies in tracking the way in which the defined investments in the previous sub-section are likely to flow through the geographies of interest (North West and UK) and the extent to which they are 'retained', providing profit and employment opportunities for businesses and residents.

The CAPEX and OPEX profiles provide the starting point for the impact assessment. Both are phased to reflect differential timings and both are adjusted to reflect likely geography of spend. Not all CAPEX spend will necessarily occur in the North West or even the UK. Likewise, while much OPEX spend will, by definition, take place in the North West, some of the specialist labour providing services may operate from organisations located outside the North West. As such, the impact assessment requires a set of assumptions in relation to the location of CAPEX/OPEX investment and the location basis of labour supplying the associated services. Table 3.3 sets out the assumptions made in relation to the CAPEX investment.

Table 3.3 CAPEX Spatial Investment Profiles (as % of total spend)

North West	Design (%)	Equipment (%)	Construction (%)
ATR/Capture Plant	30	30	80
Industry Conversion	70	80	90
Refilling Stations	60	30	80
CCGT Station	70	30	80
Onshore Hydrogen Pipeline	80	40	90
CO_2 Pipeline	80	40	90
Offshore Facilities	70	60	80
Hydrogen Storage	70	50	90
Offshore Storage	30	40	80
UK (inc. North West)	**Design (%)**	**Equipment (%)**	**Construction (%)**
ATR/Capture Plant	50	50	90
Industry Conversion	90	90	100
Refilling Stations	90	70	90
CCGT Station	100	80	90
Onshore Hydrogen Pipeline	100	100	100
CO_2 Pipeline	100	100	100
Offshore Facilities	100	90	100
Hydrogen Storage	100	90	100
Offshore Storage	90	100	90

Development scenario CAPEX is dominated (72%) by costs associated with ATR/CCGT construction but, in each instance, equipment costs are assumed to account for just over 60% of defined costs. Advice provided suggests that we should assume that only 30% of ATR and CCGT related equipment costs are likely to be sourced from within the North West of England (50% and 80% respectively for the UK)[15].

Moderately low 'local' retention is assumed for the acquisition of pipelines and costs relating to offshore storage though higher retention rates for the UK implies some degree of sourcing from within the UK rather than internationally. As might be anticipated, design and construction retention is generally much higher.

OPEX retention profiles (Table 3.4) are significantly higher than for CAPEX. Much of the activity base required for normal operating of the plants/facilities is more readily available in the North West and UK[16].

Table 3.4 OPEX Spatial Expenditure Profile

	NW (%)	UK (inc. NW %)
ATR/Capture Plant	40	50
CCGT	40	50
Compression	100	100
Hydrogen Transportation	90	100
Offshore CO_2 Storage	90	100
Offshore Facilities	90	100
MMV	80	100
Financial Security	10	100
Well Workover	80	100

Each CAPEX and OPEX expenditure stream is modelled individually to allow for differentiation in the set of assumptions outlined and the next step in the modelling process involves decomposing expenditure streams into their primary labour, capital and intermediate components.

The categories used in setting out the development scenario enables us to directly integrate the investment and expenditure profiles with the UK Input-Output (IO)[17] Tables and to use the latter as the basis for assessing the nature and level of inputs. The IO tables provide the basis on which expenditure is allocated between labour and intermediate inputs.

As far as labour is concerned, we use industry specific wage costs as the basis for calculating employment numbers[18]. The data is sourced from Office of National Statistics (ONS) datasets and means that estimates of employment numbers not only reflect variation in spend across industry sectors but also variation in the costs of employment across industry sectors.

3.4 Inward Investment

Above and beyond the impact of CAPEX and OPEX, the assessment has also considered the impact of potential inward investment relating to the development of the HyNet NW Project. The basis of the analysis is that whereas it is unlikely that existing UK-based industrial operators outside the North West will choose to relocate into the region following development, it is feasible that international investors may opt to take advantage of the decarbonisation opportunity when they make investment decisions.

Analysis is based on an assumption that inward investment driven by HyNet NW results in twelve new plants locating within the North West through to 2050. These new plants are assumed to be split across the following sectors:

- paper/pulp;
- chemicals;
- glass;
- ceramics; and
- vehicle bodies.

We have assumed that the size of plant involved is typical of the UK parent sector as defined through ONS databases with construction and related costs based on standard reference tables relating to the development of industrial premises in the North West of England.

Taken together, CAPEX costs are placed at some £0.8bn. Investments are assumed to take place on a two-yearly cycle from 2030 onwards with annual OPEX of some £296m when all are operational (£3.5bn over period). Retention assumptions are marginally higher than those used for the primary impact analysis with labour sourcing broadly in line with the latter.

15. The residual difference at the UK level is attributed to imported equipment.

16. It is assumed that, on average, 85% of required CAPEX-related labour supply in the North West is sourced within the region with 93% for the UK. OPEX figures are defined as 93% for the North West and 99% for the UK.

17. Tables showing the relationship between components of value added, industry inputs and outputs, and product supply and demand.

18. With an appropriate adjustment for employer on-costs.

4. Impact assessment

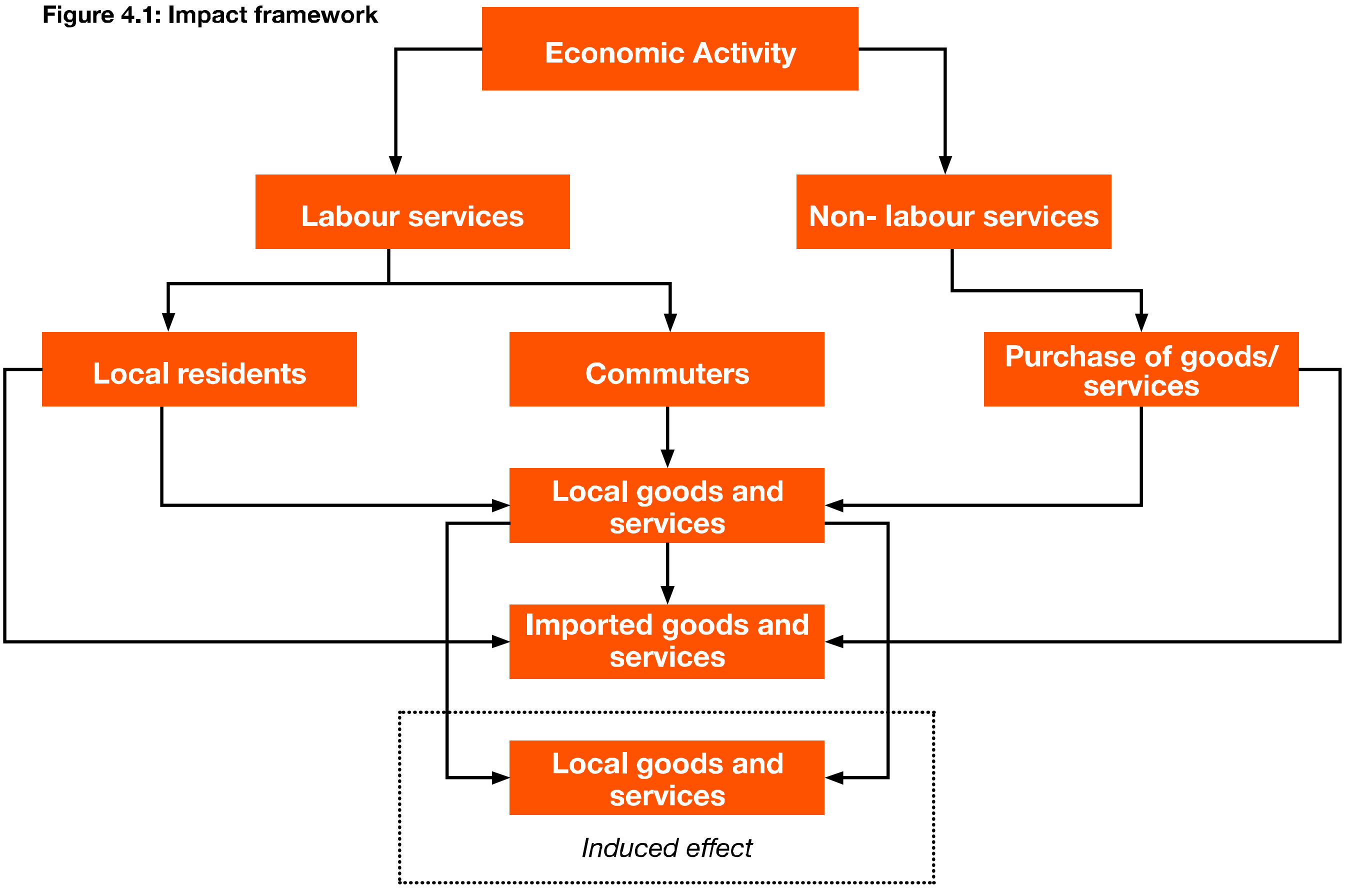
4.1 Introduction

In this section we summarise the findings from the modelling exercise undertaken. We outline the methodology adopted, illustrating the difference between direct, indirect and induced impacts, and report on the defined impacts of HyNet NW Project and associated inward investment

4.2 Impact methodology

Impact analysis is designed to assist the process of identifying or quantifying the impact of any economic activity on local/regional and/or national economies. Over time, the methodologies used have tended to become more sophisticated but most approaches remain based on multiplier structures and have at their base the evaluation of what are called the direct, indirect, and induced effects of an economic activity. Figure 4.1 can be used to illustrate the basic concepts involved and outlines the underlying framework used in the study.

Figure 4.1: Impact framework



All economic activities attend to their business via the purchase of inputs with which to produce outputs. There are essentially two types of inputs, labour and non-labour (other goods and services) inputs. Analysis of these elements is important in impact studies since the extent to which inputs are sourced within an economy is a primary determinant of impact in that economy. The larger the proportion of staff that live within the economy, the greater will be the impact of the activity. Similarly, if inputs other than labour are sourced from outside an area, then such spending will bypass that economy.

These features broadly correspond to the notion of direct and indirect impacts. Direct effects are primarily the jobs and incomes that accrue to an economy due to the construction/operation of a facility and the employment they generate. The indirect effects relate to flows of income (other than labour income) to the economy arising from the construction/operation of the activity. In most cases, these latter effects reflect the purchase of goods and services and will cover items such as materials, supplies and business and professional services. The size of the indirect effect will be greater if such purchases come from within an economy rather than outside.

The final element in the impact structure focuses on the induced multiplier effect. This represents the process through which the spending of staff (i.e. both the direct and indirect income flows) helps to support other businesses in an economy, contributing to the wages and salaries of employees and covering material overheads. These employees and businesses, in turn, also spend a proportion of their incomes on goods and services and the process repeats itself over a number of rounds.

It is important to recognise, however, that not all of the money being spent in each round will find its way into the wages and salaries of the next group of workers and businesses in the chain. Income tax (direct taxation), national insurance and VAT (indirect taxation) will all disappear from the flow. Some of the money will be saved and not all that is spent will be spent on 'local' goods and services. One would therefore expect the impact to decline in magnitude at each stage of the process. In addition, and in general, the smaller the economy in question, the larger will be the proportion of any spending on imports to the economy.

The modelling procedure in this study follows the outline in Figure 5.1 and the above discussion[19]. More specifically, it accounts for:

direct effects:

- the scale of initial investment activity that is sourced within the North West and UK economies rather than elsewhere;
- the scale of everyday, ongoing ATR/CCGT/Storage operations that are sourced within the North West and UK economies rather than elsewhere;

indirect effects:

- the purchases of non-labour goods and services within the North West and UK economies stemming from construction and ongoing operations, including those at each subsequent supply-chain level; and

induced effects:

- spending of the wages and salaries generated directly and indirectly by construction/operations, again including subsequent round effects.

The critical issues are, therefore, the extent to which:

- available jobs are taken by NW/UK residents;
- supply-chain expenditure is won by NW/UK businesses; and
- spending by those local resident/businesses that do benefit from development activity is retained within the NW/UK as opposed to 'leaking' elsewhere in the UK or abroad.

As noted earlier, for the purposes of this exercise we have been provided with estimates from Cadent Gas Limited as to the extent to which labour supply is sourced from residents of the North West and UK. Assumptions regarding the location of first-tier suppliers are based on IO patterns of intermediate spend adjusted for local concentrations of sector activity.

To these elements must, as noted, be added the induced spending of workers and businesses. The structure employed to calculate these effects does not impose, assume, or 'borrow' multipliers; it constructs them as part of the modelling process, reflecting the specific set of circumstances under review.

[19] The impact estimates provided in this report are 'gross' rather than 'net additional' in nature. This is the same as the other studies reviewed in Section 2 of the report. Assessing the net additional impact would require detailed comparative analysis of the economic impact of a reference case future energy scenario for the North West and UK which would be highly complex and require numerous subjective assumptions.

Workers in each supply sector are subjected to a disposable income assessment calculated using information on average sector wages/salaries and on the tax and national insurance regimes in place, having taken account of personal allowances in the calculation of tax burdens.

Salaries are matched against profiles in the ONS Living Costs and Food survey (LCF) to estimate spend across consumption categories with the latter subsequently aggregated to match the consumer spend classifications contained in the UK National Accounts and IO tables. Leakage from the local area is based on consideration of local presence and relative concentration of employment in each supply sector.

This process establishes the parameters required to model 'first round' effects. A series of subsequent rounds are also modelled in much the same way except that parameters reflect 'average' local profiles.

4.3 HyNet NW Impact Assessment

Employment impacts are assessed via the methodological process outlined above. Table 4.1 details the resulting employment and GVA impacts of the modelling process.

Table 4.1: HyNet NW Employment and GVA Impacts (up to 2050)

Employment (Total Employment Years)	NW	UK (inc. NW)
Direct	71,240	110,394
Indirect/Induced	73,047	178,983
Total	144,287	289,377
GVA (£m)	NW	UK (inc. NW)
Direct	7,594	11,144
Indirect/Induced	6,450	14,812
Total	14,044	25,956

Employment:

- is defined in terms of cumulative years of employment over the impact horizon and NOT the number of jobs created. In total, some 85,000 years of employment are forecast to be created in the North West up to 2050 and 130,000 in the UK;
- average annual job generation is defined as 4,509 jobs for the North West and 9,043 for the UK;
- peak employment in any one year is defined as 11,522 for the North West and 23,167 for the UK; and
- the implied employment multipliers are 2.0 for the North West and 2.6 for the UK.

GVA:

- is defined in terms of cumulative GVA over the impact horizon and equates to £14.0bn for the North West and £25.9bn for the UK;
- average annual GVA generation for the North West is defined as £439m and £811m for the UK;
- peak GVA in any one year is defined as £1bn for the North West and £2bn for the UK; and
- the implied GVA multipliers are 1.9 for the North West and 2.3 for the UK.

4.4
HyNet NW Inward Investment Impact Assessment

Impact estimates relating to inward investment are generated in the same way as for the HyNet project scenario. Table 4.2 details employment and GVA impacts of the modelling process.

Table 4.2: Inward Investment Employment and GVA Impacts (up to 2050)

Employment (Total Employment Years)	NW	UK (inc. NW)
Direct	26,479	27,804
Indirect/Induced	20,574	43,092
Total	47,053	70,896
GVA (£m)	NW	UK (inc. NW)
Direct	1,470	1,725
Indirect/Induced	1,356	2,859
Total	2,836	4,584

Employment:

- again, this is defined in terms of cumulative years of employment over the impact horizon and NOT the number of jobs created. Overall, some 47,000 years of employment are expected to be generated in the North West and 71,000 in the UK up to 2050;
- average annual job generation is defined as 1,470 jobs for the North West and 2,215 for the UK;
- peak employment in any one year is defined as 3,771 for the North West and 5,835 for the UK; and
- the implied employment multipliers are 1.8 for the North West and 2.5 for the UK.

GVA:

- is defined in terms of cumulative GVA over the impact horizon and equates to £2.8bn for the North West and £4.6bn for the UK;
- average annual GVA generation for the North West is defined as £89m and £143m for the UK;
- peak GVA in any one year is defined as £226m for the North West and £378m for the UK; and
- the implied GVA multipliers are 1.9 for the North West and 2.3 for the UK.

5. Summary of results and conclusion

Cumulative CAPEX for the Project is £17.7bn, while that for OPEX is £29.1bn, much of which is accounted for by gas costs. Total GVA impact in the North West is calculated to be £17bn to 2050, with total employment years created at 191,000 for the period.

In terms of the HyNet project development, cumulative job year gains are defined as 144,287 job years for the North West and 289,377 for the UK. Average annual job generation is defined as 4,509 jobs for the North West and 9,043 for the UK with peak year employment of 11,522 jobs and 23,167 jobs respectively. Likewise, cumulative GVA gains are defined as £14.0bn for the North West and £25.9bn for the UK. Average annual GVA gain is defined as £439m for the North West and £811m for the UK with peak year gains of £1bn and £2.0bn respectively.

The pattern for inward investment is that cumulative job year gains are defined as 47,053 jobs years for the North West and 70,896 for the UK. Average annual job generation is defined as 1,470 jobs for the North West and 2,215 for the UK with peak year employment of 3,771 jobs and 5,835 jobs respectively.

Likewise, cumulative GVA gains are defined as £2.8bn for the North West and £4.6bn for the UK. Average annual GVA gain is defined as £89m for the North West and £143m for the UK with peak year gains of £226m and £378m respectively.

Results combining the HyNet project and inward investment impacts are summarised in Table 5.1.

Overall, average annual job generation is projected to be 5,979 jobs for the North West and 11,259 for the UK. Average annual GVA generation for the North West is assessed at £528m and £954m for the UK.

Table 5.1: Overall (HyNet project and Inward Investment) Employment and GVA Impacts (up to 2050)

Employment (Total Employment Years)	NW	UK (inc. NW)
HyNet NW	144,287	289,377
Inward Investment	47,053	70,896
Total	191,340	360,273
GVA (£m)	NW	UK (inc. NW)
HyNet NW	14,044	25,956
Inward Investment	2,836	4,584
Total	16,880	30,540

It is important to note that the modelling exercise does not consider impacts related to the take-up of large transport, utility or domestic fuel cell electric vehicles (FCEVs)[20]. It does not consider the potential for the manufacture of FCEV engines/vehicles within the region, does not undertake any analysis of potential for import substitution of fuels and does not take into account any potential 'export' benefits for the region from providing a source of CO_2 storage. As such, the impact estimates may prove conservative.

Ultimately, replacing natural gas with low carbon hydrogen has the potential to deliver extensive decarbonisation of gas distribution networks and contribute directly to GHG reduction targets at the same time as generating substantial and ongoing economic benefits. HyNet NW offers a very rare opportunity to achieve these ambitions with a development that builds on the strengths of the economic, industrial and energy infrastructure of the North West.

[20]. Albeit, it does consider the impact of a limited roll-out of hydrogen vehicle refuelling stations