FUTURE BILLING METHODOLOGY

MS12 Final Report on Field Trial Progress (SDRC 9.2)

Cadent Gas Ltd

Report No.: 114D803D-62, Rev. 1
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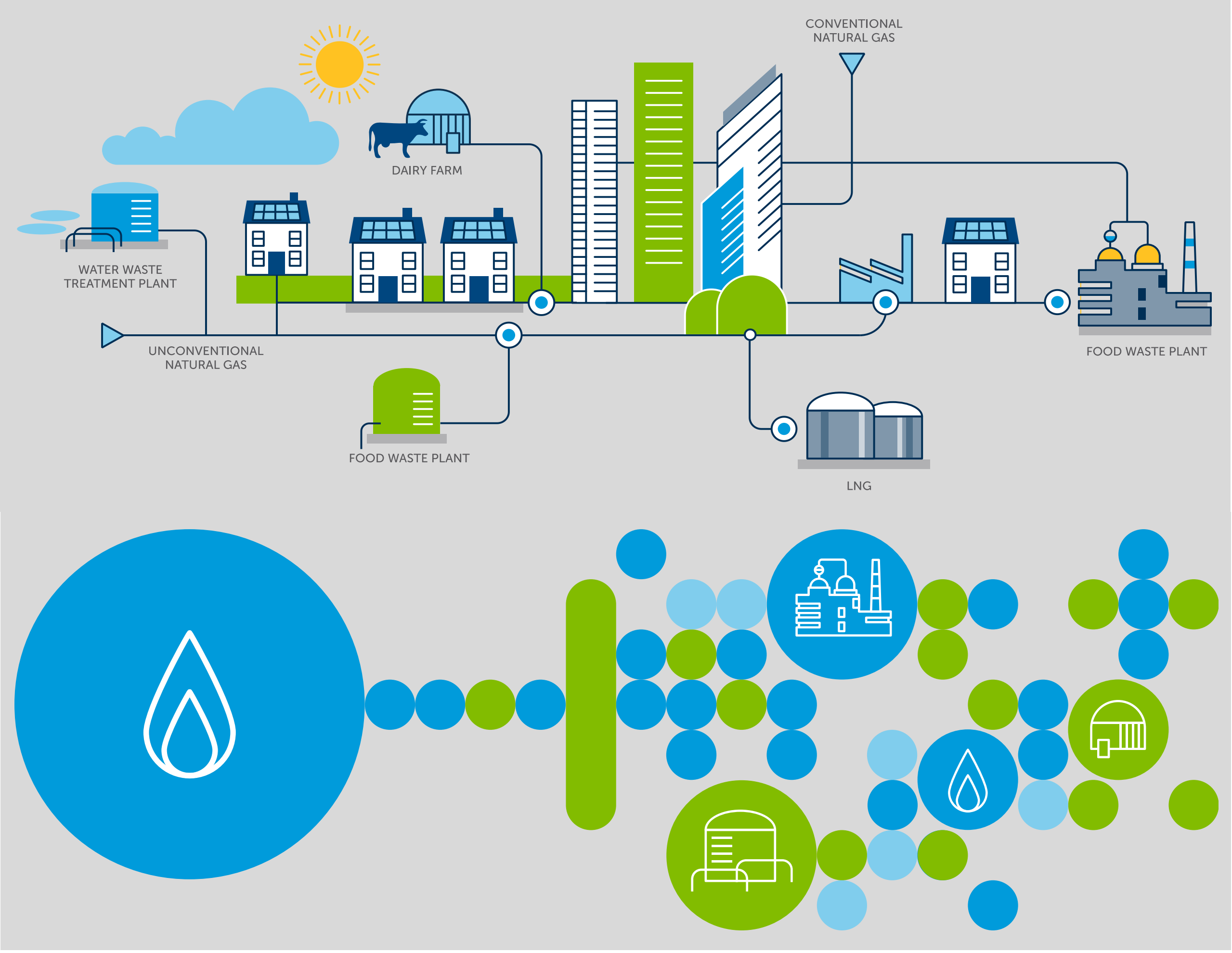

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Objective: Final progress report from the Chittering and Hibaldstow networks. The report will highlight any issues or successes that may impact on the project output.

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A	18/12/2020	Draft Report for Internal Review	HR	SK	
0	21/12/2020	Draft Report Issued	HR	SK	MS
1	24/12/2020	Final report, minor comments addressed	HR	SK	MS

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1 EXECUTIVE SUMMARY

The Future Billing Methodology (FBM) project is a proof-of-concept project which aims to identify the zones of influence around embedded biomethane injection points and to prove existing network models can be used to determine Calorific Value (CV) zones for billing purposes; this will unlock the potential benefits of decarbonisation of the existing gas grid. To verify that the existing network models could be used, sensors have been installed at 34 sites in the Hibaldstow and Chittering areas. These sites are a mixture of on-street locations and governor stations.

This final progress report covers the period from first site transmission to the end of data gathering on 31st October 2020 and aims to highlight any issues or successes that may impact on the project output. This report also supports the SDRC (Successful Delivery Reward Criteria) 9.2 "Novel tracking of unconventional gases by measurement". The first Site Acceptance Test (SAT) was completed on the 19th December 2019.

Issues and successes are highlighted below.

1.1 Site Installation

Although the number of sites was reduced from 55 to 34 sites, DNV GL was able to optimise the chosen locations for network analysis via a comprehensive site review.

Additional detailed hazardous area assessments carried out on governor stations involved in the FBM project will benefit any future work undertaken on these sites. During the FBM project it was identified that existing electrical design policy for gas installations had been developed principally to support high-pressure Gas Transmission sites. A proportionate and cost-effective approach to safe supply isolation had to be developed for the FBM Project installations and a formal policy deviation was authorised as a precautionary measure for the FBM Project. This knowledge will be beneficial for future projects.

1.2 Instrumentation

The GE OXY.IQ sensor has proven to be an effective and reliable instrument for measuring oxygen content and hence tracking biomethane through the test networks.

The FBM project has successfully trialled an innovative and low-cost gas flow measurement technique developed by Advantica (now part of DNV GL). This technology is likely to have wide ranging benefits across the gas network.

Already a proven technology for measuring CV under Ofgem Direction at biomethane network entry points, the GasPT data has been successfully incorporated into the smart meter laboratory trials, which began in November 2020.

1.3 Data Gathered

After overcoming the sensor installation challenges, the initial data analyses indicate that the project has a self-consistent, meaningful and novel set of measurements that track the flow of biomethane through the gas network.

With the exception of some minor gaps in the recorded data, data is being gathered and transmitted reliably from all sites which have undergone SAT. Unfortunately, site visit delays were incurred due to the Covid-19 pandemic in 2020. The data analysis and network modelling part of the project will use the data that is available and interpolate what would have happened during any periods of limited or no data. As the project progresses, the team will anticipate and address any questions and uncertainties that may arise due to the constrained period of data collection; this will be vital to achieving a successful and credible outcome for the FBM project.

1.4 Conclusion

The Future Billing Methodology project has overcome numerous issues and successfully deployed 34 sites at suitable measurement locations. Site-by-site evaluation, taking account of cost, complexity and timing was conducted with support from the network modelling team to ensure a robust optimisation of the field trial site population with respect to zones of influence.

The installed instrumentation is suitable and the GE OXY.IQ sensor has proven to be an effective and reliable instrument for successfully measuring oxygen content and hence tracking biomethane through the test networks.

With the exception of some minor gaps in the recorded data, data is being gathered and transmitted reliably from all sites which have undergone successful site acceptance tests (SAT). Unfortunately, site visit delays for service visits were incurred due to the Covid-19 pandemic in 2020.

The project has demonstrated the data gathered is compatible with the existing network models. The next step is for this data to feed into the development of modelling techniques for determining charging areas for Pragmatic and Composite options; this will be presented in MS13 report /6/

Further to this, an updated cost-benefit plan and industry recommendations will be delivered via the Future Billing Methodology project dissemination in late March 2021.

2 INTRODUCTION

The current billing regime uses Flow Weighted Average Calorific Value (FWACV) and an energy capping mechanism to ensure customers are not significantly over-charged. This requires alternative sources of gas such as biomethane, which typically have a lower energy content than natural gas, to have the energy content artificially increased by injecting propane. The addition of propane – a relatively carbon-rich fossil gas – to the biomethane stream negates the environmental benefit that would otherwise be realised.

FBM is a proof-of-concept project which aims to identify the zones of influence around embedded biomethane injection points using existing network models and unlocking the potential benefits of decarbonisation of the existing gas grid. To verify that the existing network models could be used, sensors have been installed at 34 sites in the Hibaldstow and Chittering areas. These sites are a mixture of on-street locations and governor stations.

This final progress report covers the period from first site transmission to the end of data gathering on 31st October 2020 and aims to highlight any issues or successes that may impact on the project output. This report also supports the SDRC (Successful Delivery Reward Criteria) 9.2 "Novel tracking of unconventional gases by measurement". The first Site Acceptance Test (SAT) was completed 19th December 2019.

3 SENSOR SITE INSTALLATION

3.1 Site Locations

The positions of the sensors within the network were selected through an initial network analysis modelling activity. For more detail on the site selection process and sensor selection, please see the Stage Gate Report FBM 1 /1/.

The initial selection process resulted in 40 governor stations within Chittering and Hibaldstow and 15 street locations within Chittering. However, for the following reasons the number of sites was reduced to 21 governor locations and 13 street locations.

- Electrical Power Source: After assessing power requirements during the detailed design stage, the solar PV panels would have needed to be significantly larger than originally determined, requiring expensive civil work and presenting visual impact and site security issues. It was therefore decided that power would be supplied via unmetered DNO supply (UMS) or battery power supply. Site selection was reassessed for feasibility of the new power supply due to:
    - Cost of laying the cables and the DNO connection.
    - Land access issues with the potential to introduce significant legal costs and where the need to gain third party agreements could effectively remove control over DNO connection delivery times.
    - Availability of space for a battery kiosk, as an alternative option.
- Land Re-use: Unfortunately, new buildings had been erected on one site following site surveys, meaning the FBM installation is now unfeasible.

Although the number of sites was reduced, DNV GL was able to optimise the chosen locations for network analysis via a comprehensive site review.

The variation in oxygen concentration levels is confirming the patterns predicted by the initial modelling. Biomethane at both Chittering and Hibaldstow has been flowing throughout this period.

Figure 1 and Figure 2 show the installations in the EM (Hibaldstow) and EA (Chittering) networks respectively.

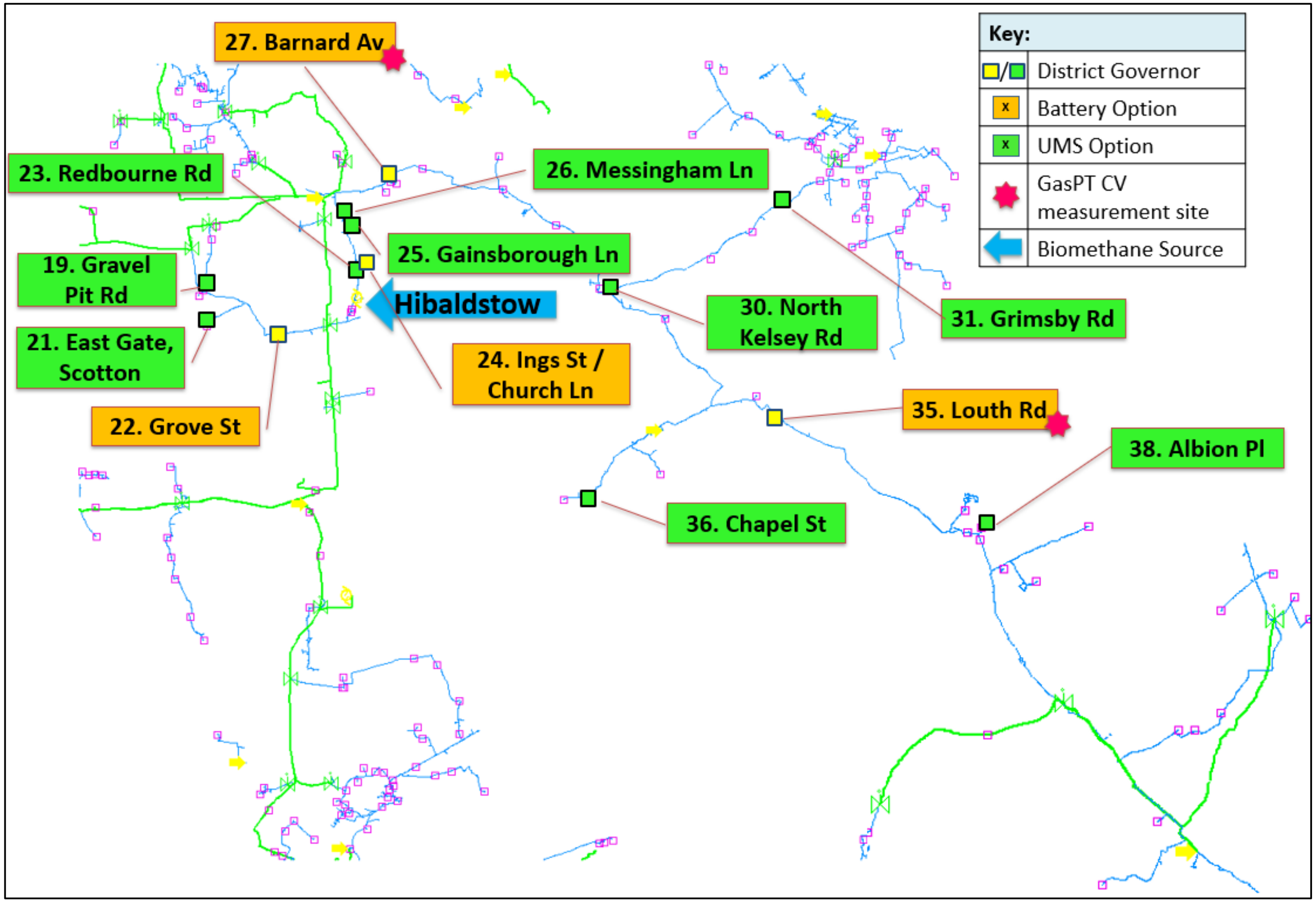

Figure 1: EM Hibaldstow site locations

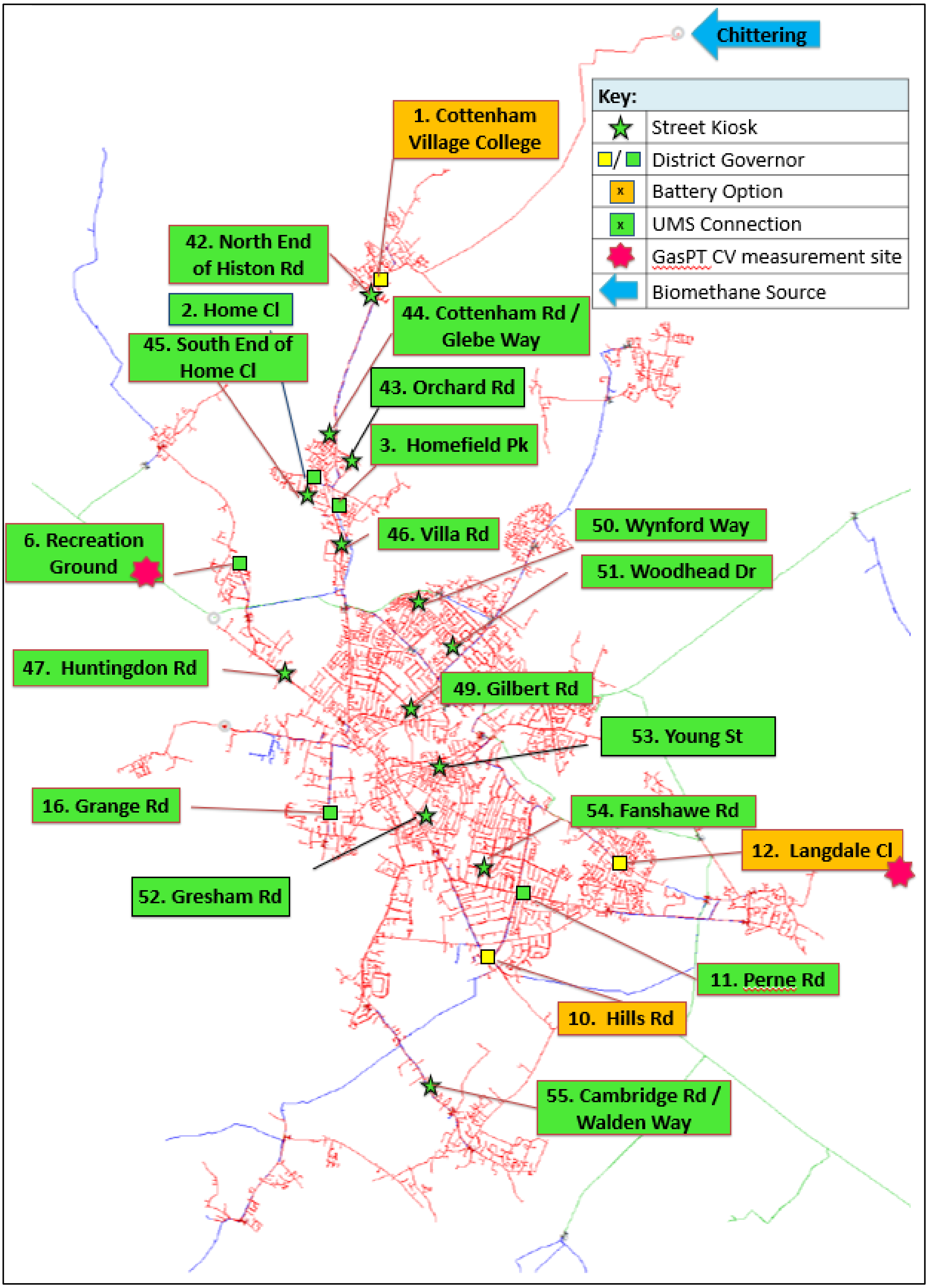

Figure 2: EA Chittering site locations

3.2 Site Location Issues

3.2.1 Electrical Power Supply

After assessing power requirements during the detailed design stage, the PV panels would be significantly larger than originally determined, requiring expensive civil works and presenting visual impact and site security issues. It was therefore decided that power would be supplied via unmetered DNO supply (UMS) or battery power supply.

3.2.2 Land Ownership

On receipt of the DNO quotations, site selection had to be reassessed for feasibility of the proposed power supply due to:

- Cost of laying the cables and the DNO connection.
- Land access issues with the potential to introduce significant legal costs and where the need to gain third party agreements could effectively remove control over DNO connection delivery times.
- Availability of space for a battery kiosk as an alternative.

3.2.3 Land Re-use

Unfortunately, new buildings had been erected on the Milton Road site following the initial site surveys, meaning the FBM installation became unfeasible due to hazardous area zone issues with the proximity of the new building construction site. Cadent commenced resolution of this issue with the construction organisation, but it would not be resolved within the project timescales.

3.2.4 Site Optimisation

The above activities triggered a comprehensive site-by-site evaluation, taking account of cost, complexity and timing. This was conducted with support from the network modelling team to ensure a robust optimisation of the field trial site population was achieved within budget.

3.3 Site Installation

3.3.1 Governor Sites

Measurements taken at governor sites are as follows:

- Oxygen
- Inlet and outlet pressure
- Governor regulator position giving an indication of flow rates
- Calorific Value (4 sites only)
- Pseudo gas composition (2 sites only)[1]

The installations at governor stations have been designed to have no impact on Cadent's operations and are contained within the footprint of the governor station. Instrumentation is connected using existing tapping points and all transmitters and communication equipment is held within a wall-mounted cabinet. Either a DNO connection or battery kiosk installation have been carried out for power supply.

[1] The gas composition measurement device GasPT2 uses correlative techniques to infer an equivalent five-component gas mixture (methane, ethane, propane, nitrogen and carbon dioxide) from which it calculates the gas properties using ISO 6976.

3.3.2 Street Sites

Measurements taken at street sites are as follows:

- Oxygen
- Network pressure

Street sites have been redesigned not to require a pit and instead involve a gas connection, kiosk installation and DNO power supply connection. The gas connection was carried out by excavating to expose the pipe, tapping into the gas supply, connecting a remote isolation valve, laying pipework to the kiosk, back-filling the whole excavation and restoring surrounding public highway land to original condition.

3.3.3 Site Overview

Table 1,

Table 2 and Table 3 give an overview of installation dates (not including the oxygen sensor cell), pre-commissioning dates (the site is powered on and the oxygen cell has been installed) and the site Acceptance Testing (SAT) completion dates (go-live). The oxygen sensor cells were installed closer to commissioning rather than with the rest of the installation, to preserve the cell life.

Table 1: EA Governor Sites

Site Number	Site Name	Power Supply	Installation Date	Pre-Commissioning Date	SAT Date
1	Cottenham Village College	Battery	06/12/2019	04/08/2020	12/08/2020
2	Home Close	UMS	15/11/2019	13/02/2020	17/02/2020
3	Homefield Park	UMS	22/11/2019	25/08/2020	03/09/2020
6	Recreation Ground	UMS	22/11/2019	23/10/2020	03/12/2020
10	Hills Road	Battery	13/12/2019	06/08/2020	16/10/2020
11	Perne Road	UMS	26/09/2019	14/10/2019	12/02/2020
12	Langdale Close	Battery	24/07/2020	06/08/2020	03/12/2020
16	Grange Road	UMS	29/07/2020	04/08/2020	11/08/2020

Table 2: EM Governor Sites

Site Number	Site Name	Power Supply	Installation Date	Pre-Commissioning Date	SAT Date
19	Scotter Gravel Pit Road	UMS	04/06/2020	06/07/2020	09/07/2020
21	East Gate Scotton	UMS	02/07/2020	07/07/2020	14/07/2020
22	Grove Street	Battery	17/01/2020	15/09/2020	17/09/2020
23	Redbourne Road	UMS	13/12/2019	11/02/2020	09/03/2020
24	Ings St and Church St	Battery	10/01/2020	14/09/2020	17/09/2020
25	Gainborough Lane	UMS	03/03/2020	11/03/2020	17/03/2020
26	Messingham Lane	UMS	03/03/2020	11/03/2020	16/03/2020
27	Brigg Barnard Avenue	Battery	07/08/2020	15/09/2020	18/09/2020

Site Number	Site Name	Power Supply	Installation Date	Pre-Commissioning Date	SAT Date
30	North Kelsey Road	UMS	17/10/2019	14/09/2020	16/09/2020
31	Laceby Grimsby Road	UMS	13/03/2020	04/06/2020	07/07/2020
35	Louth Road	Battery	02/07/2020	14/09/2020	16/09/2020
36	Chapel Street	UMS	13/03/2020	02/07/2020	06/07/2020
38	Louth Albion Place	UMS	15/11/2019	04/03/2020	10/03/2020

Table 3: Street Sites

Site Number	Site Name	Power Supply	Installation Date	Pre-Commissioning Date	SAT Date
42	North end of Histon Road	UMS	27/06/2019	27/01/2020	27/01/2020
43	Orchard Rd/Mill Lane	UMS	18/06/2019	21/01/2020	28/01/2020
44	Cottenham Rd/Glebe Way	UMS	18/05/2019	09/12/2019	22/01/2020
45	South end of Home Close	UMS	24/05/2019	11/12/2019	23/01/2020
46	Villa Road	UMS	18/06/2019	11/12/2019	19/12/2019
47	Huntington Road	UMS	07/06/2019	18/12/2019	18/02/2020
49	Gilbert Road	UMS	13/03/2020	03/06/2020	01/07/2020
50	Wynford Way	UMS	11/06/2019	06/01/2020	18/02/2020
51	Woodhead Drive	UMS	01/06/2019	18/12/2019	18/02/2020
52	Gresham Road	UMS	18/06/2019	18/12/2019	22/01/2020
53	Young Street	UMS	20/06/2019	18/12/2019	27/01/2020
54	Fanshawe Road	UMS	18/05/2019	21/01/2020	28/01/2020
55	Cambridge Road	UMS	04/06/2019	18/12/2019	18/02/2020

3.4 Site installation issues

Site installation commenced in May 2019 and was completed in July 2020. Following on from site location issues discussed in section 3.2, the FBM project also encountered and resolved a number of site installation issues.

3.4.1 Hazardous Area Assessments

The street kiosks are new self-contained sites and could therefore be designed so that electrical and communication elements remain in a safe zone with a standard site venting arrangement and hazardous area assessment. Initial surveys of the candidate gas governor sites for FBM however, highlighted the need for site-specific hazardous area assessments, as each site is unique and required specific site adjustments, e.g. to ventilation, to ensure that FBM installations could be installed and activated safely, as the sensors must be installed clear of existing hazardous areas and also require their own gas venting arrangement.

The FBM governor sites therefore required a bespoke assessment, which will benefit any future work undertaken on these sites.

3.4.2 Earthing and Electrical Design Policy

Electrical installations at gas sites require isolation. It was identified that existing electrical design policy for gas installations had been developed principally to support high-pressure Gas Transmission sites. A proportionate and cost-effective approach to safe supply isolation had to be developed for the FBM Project installations and a formal policy deviation was authorised as a precautionary measure for the FBM Project.

3.4.3 Asbestos

Some brick-built and GRP governors are known to contain asbestos, therefore detailed surveys were undertaken at all FBM Project sites to identify where asbestos-containing materials (ACM) were located, their condition and what remedial works might be necessary to ensure that the FBM installation could be undertaken safely. These assessments and implemented remedial actions have been recorded on Cadent's Asset Register and will benefit any future work undertaken on these sites.

3.4.4 Re-Design and Procurement Delays

Any substantial re-design work to ensure the success of the project as discussed in section 3.2.1 for power supply and 4.1.1 for oxygen sensor change, led to delays in procurement.

3.4.4.1 Electrical Power Supply

The requirement to change the design from solar PV panels to an unmetered DNO supply (UMS) or battery power supply (see section 3.2.1), resulted in significant design and procurement delays.

3.4.4.2 Oxygen Sensors

This component is central to the FBM project, as the presence or absence of biomethane at that point in the gas network is identified by measuring the level of molecular oxygen in the gas stream. At the point of Factory Acceptance testing of the first FBM test rig in October 2018 it became clear that the originally selected device was insufficiently accurate for the purpose of the FBM project and did not meet its own specification. This triggered an investigation, which led to procurement of a number of alternative devices for factory testing and selection. Initial testing of the alternative devices was completed in early January 2019 and procurement of the successful candidate device was completed by March 2019. Together with the associated redesign work, this resulted in a six-month delay, October 2018 to April 2019 inclusive and the requirement for an extension to the project completion date to the 31st March 2021.

See section 4.1 for more detail on the oxygen sensor re-design.

3.4.4.3 Pseudo Composition Measurement

The gas composition measurement device GasPT2 uses correlative techniques to infer an equivalent five-component gas mixture (methane, ethane, propane, nitrogen and carbon dioxide) from which the gas properties, such as CV, are calculated using ISO 6976.

This inferred composition data could be used in Synergi to model the molecular % composition of the gas in addition to the calculated CV value from the GasPT and could show how network analysis modelling can deal with different gas compositions.

It was initially proposed that each of the four CV measurement sites would also transmit the pseudo composition data, however due to software difficulties related to the different PLC model required, only two sites successfully transmitted this further data and incurred delays on the remaining two sites. This has not had a detrimental impact on the project, with the CV still being measured and transmitted at all four sites.

3.4.5 DNO Connection

The switch from the original solar PV power option discussed in section 3.2.1 to DNO unmetered connection required the procurement of connection quotations and subsequent revalidation of these quotations from the relevant DNOs, resulting in a two-month delay.

3.4.6 CompEx Requirements

CompEx is the Cadent recognised staff competency scheme for electrical work in potentially hazardous and explosive atmospheres; this involves safety training and certification for safe systems and processes of work on live gas sites.

A number of joint workshops were held in late 2018 and early 2019 for the FBM project team to walk through installation, commissioning and testing procedures in detail with Cadent Operations staff, however commissioning work on the first of the FBM gas governor sites highlighted a difference of views on a control issue around the activation and testing of instruments which had been installed by a CompEx-qualified technician. After detailed discussion, the agreed resolution required additional training and certification to be put in place before this work could continue at other gas governor sites, resulting in a four-month delay.

3.4.7 COVID-19 Delays

In late March, the UK was placed under lockdown as a result of the COVID-19 pandemic. As a result, Cadent undertook an urgent reprioritisation of resource deployment, with a focus on ensuring that network-critical activities could continue uninterrupted. This, together with a temporary prohibition on multi-party siteworks due to difficulties with maintaining social distancing on live gas sites where space is typically limited, meant that all FBM project site activity came to a halt for fourteen weeks, March 2020 to July 2020. Programmed installation activity resumed from the start of July 2020.

4 SUITABILITY OF INSTRUMENTATION

4.1 Oxygen Sensors for Biomethane Tracking

Biomethane contains a much higher oxygen content than natural gas and therefore using oxygen sensors is a simple way to track the flow of biomethane through the network.

Gas coming from the NTS should have an oxygen content of no more than 10 ppm (0.001 mol%). Cadent confirmed that the lowest oxygen concentration in the biomethane gas injected into the gas network from Chittering biomethane site and Hibaldstow biomethane site is 0.2 mol% which is based on data logged between April 2017 to September 2018. The maximum oxygen concentration allowed in biomethane gas is 1 mol%.

The GE OXY.IQ sensor has been used to measure oxygen content at each installation. Following initial testing of sensors prior to installation, the suitability and validity of oxygen tracking was assessed during Site Acceptance testing (SAT), long-term laboratory testing and follow-up site validations. The sensor has proven to be an effective and reliable instrument for measuring oxygen content and hence tracking biomethane through the test networks. The following section gives an overview of the testing carried out to determine this.

4.1.1 Enhanced Oxygen Cell Factory Testing

Initial testing of the Systech EC91 MkII oxygen sensor (as per the original design) showed that this sensor was not performing as per the specification and therefore enhanced factory testing was carried out with the Systech EC91 MkI, Systech EC91 MkII and the GE OXY.IQ sensors. Oxygen sensors were assessed for accuracy, response time, repeatability and drift. For detailed results, see the FBM Oxygen Sensor Testing Technical Note /2/.

Under the constraints of the further testing, the GE OXY.IQ was demonstrated to be suitable for measuring oxygen in the network for the FBM project. The Systech EC91 MkI, Systech EC91 MkII and AI GRP 1500 DN sensors have been demonstrated to be unsuitable for measuring oxygen in the network for the purposes and requirements specification of the FBM project.

DNV GL's technical recommendation based on these test results was to select the GE OXY.IQ sensor and undertake further testing of the sensor to clarify performance of the sensor over time, i.e. to assess measurement drift and cell lifespan, see section 4.1.3. Factory testing each individual sensor oxygen cell prior to installation was not recommended by the manufacturer as this could lead to cell damage. Instead the oxygen sensor cells were only assessed on site, see section 4.1.2. To combat this project risk, spare cells were taken to site installation and laboratory testing was carried out, see section 4.1.3.

4.1.2 Site Acceptance Testing

Site Acceptance testing is carried out during site commissioning and includes the use of three test gases for the "O2 Analyser QT001 – Function check":

- 0 ppm oxygen, 100% methane
- 10 ppm oxygen, 2% carbon dioxide, methane balance
- 20 ppm oxygen, 2% carbon dioxide, methane balance

Both the accuracy and response time of the oxygen cell was assessed for the three test gases. For all SATs completed as of mid-September, the oxygen cells passed.

4.1.3 Laboratory Testing

The manufacturer's guidelines regarding calibration and lifespan requirements were very limited, giving an estimated expected lifespan of the oxygen sensor cell of 6 to 18 months for the application of the FBM project and a requirement for recalibration every 3 months. The lifespan of the cell depends greatly on the exposure to oxygen.

In order to have a clearer and advanced view on the oxygen sensor performance over time, i.e. to assess measurement drift, cell lifespan and calibration requirements, laboratory testing was undertaken.

An oxygen sensor cell was tested in a laboratory for 17.5 months and was exposed to two different test gases:

- A main test gas with a target composition of 100 ppm. The purpose of this test gas is to expose the cell in the GE Oxygen sensor to a concentration of oxygen similar to an average value that is expected at the various installations for the FBM project. This gas is not UKAS accredited.

- A UKAS Test Gas with oxygen concentration of 20 ppm has been used in order to carry out spot checks on the sensor's accuracy and check for drift.

Throughout testing, all spot check readings were within the pass/fail tolerance of ±10% of reading +2 ppm, see Figure 3, and no noticeable drift in the measured values were observed for both spot check results and uncertified gas results.

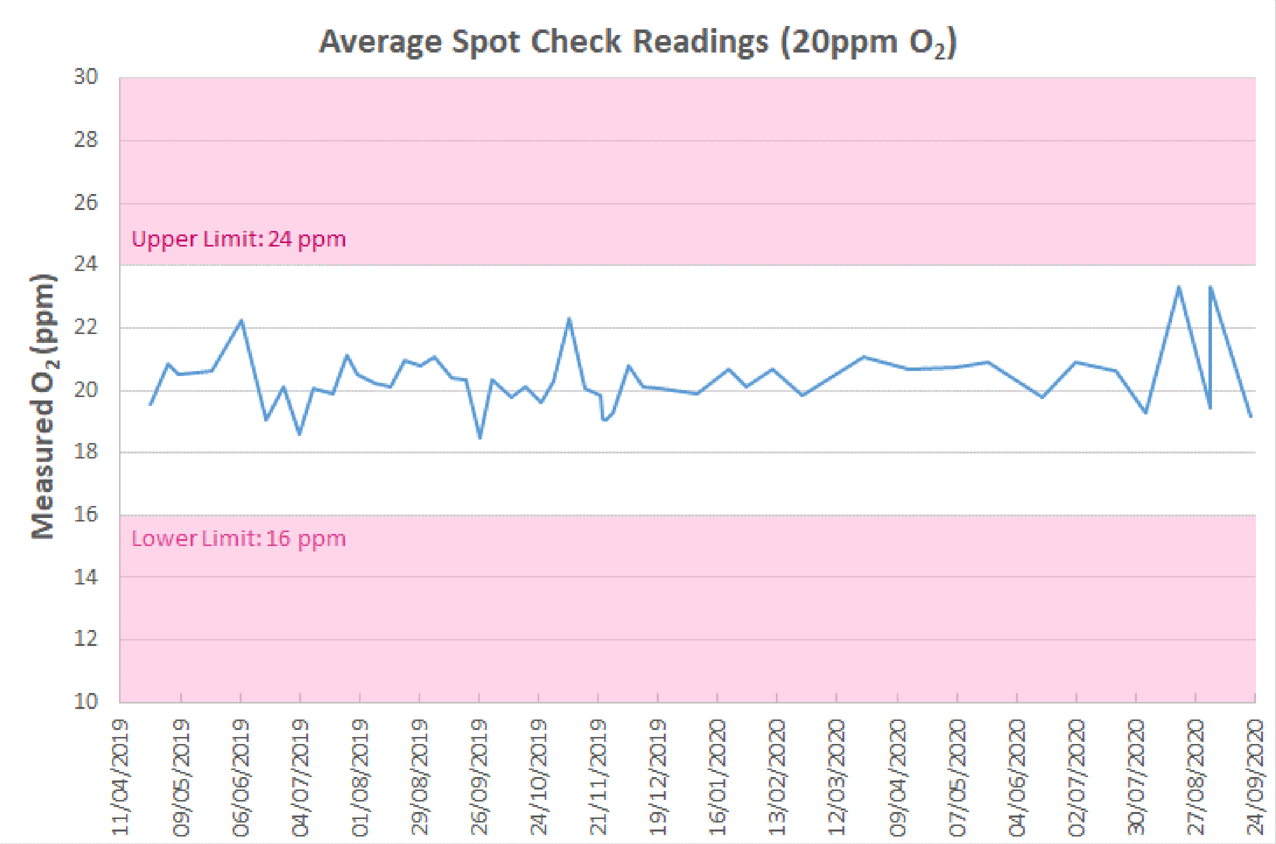

Figure 3: Laboratory Testing Average Spot Check Readings (April 2019 to September 2020)

The full testing specification is detailed in Appendix A. For more detail on laboratory testing, please see FBM Oxygen Sensor Lifespan Test Reports, 6 months, 12 and 18 months into testing /3//4//5/. This testing has continued for up to 18 months and the results will be included in an additional 18-month test report.

4.1.4 Re-Validation

A sample of sites were subject to re-validation to ensure the sensors are still operational. The oxygen cells in installations closer to the biomethane sites will most likely be exposed to higher concentrations of oxygen compared to the concentration (approx. 100 ppm) used in the 12-month test. Gas composition data from Cadent logged between April 2017 to September 2018 from the two biomethane sites closest to the FBM installations suggests that the minimum oxygen concentration is approximately 2,000 ppm which is 20 times the maximum oxygen concentration used during the long-term laboratory test. Therefore, several of these installations have undergone re-validations.

Several other locations furthest from the biomethane sites have not detected or only occasionally detected oxygen in the sample gas. A sample of these sites was re-validated to ensure that the oxygen cells at those installations are still operational.

The following six sites were selected for validations carried out in September to December 2020:

- Sites 23, 25, 26 and 42 were selected based on their close proximity to the biomethane site and therefore high level of exposure to oxygen.
- Sites 11 and 38 were selected as they are some of the furthest sites from a biomethane site and had also been installed for 14 and 6.5 months respectively at time of the validations.

4.1.4.1 Validation Results

Selected sites were validated at 0, 10 and 20 ppm as per the “O2 Analyser QT001 – Function check” from the Site Acceptance Testing (see section 4.1.2). Each site remained within the pass/fail tolerance of ±10% of reading +2 ppm ppm and there was an apparent trend to measure slightly higher oxygen content at the validation than the SAT. The differences in the two results could be explained by human factors as you need to wait for the readings to settle before taking the measurement – with only two repeats, this does not show any significant trend. However, these validations combined with the 18-month laboratory testing, it can be reasonably assumed that the sensor cells installed at all FBM sites remain operational and within tolerance throughout the duration of the project.

Figure 4 shows the SAT and validation results for each site. The maximum response time was acceptable at 50 minutes, 25 minutes and 24 minutes for 0 ppm, 10 ppm and 20 ppm tests respectively.

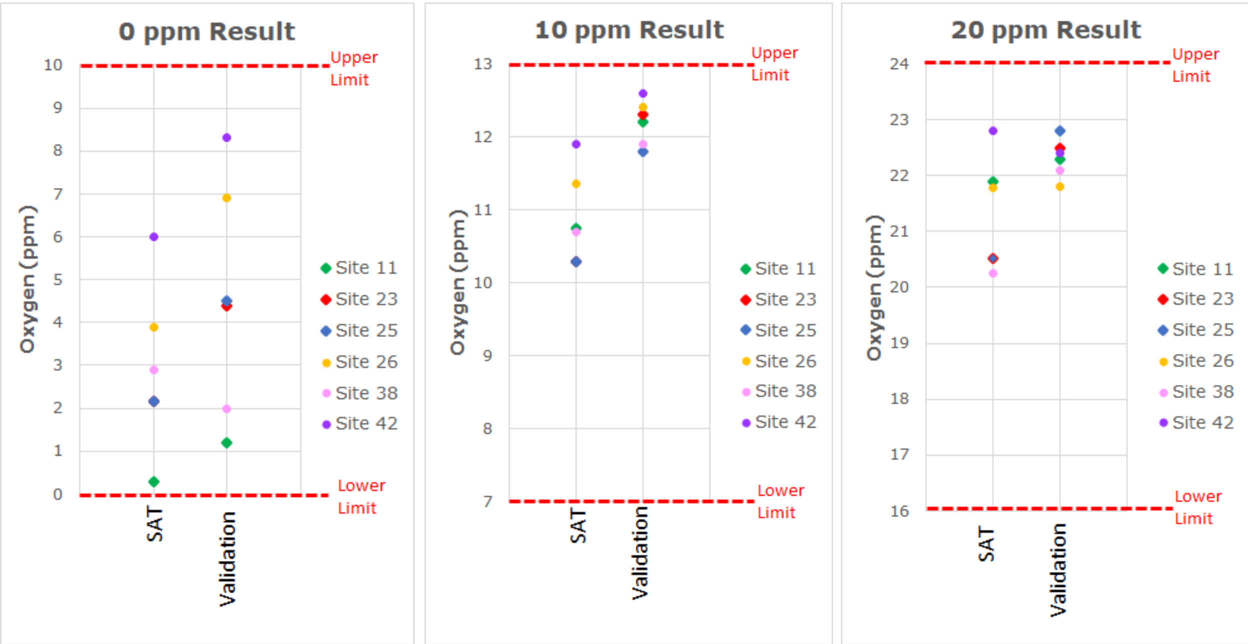

Figure 4: Oxygen Analyser Function Checks at Selected Sites

4.1.5 Initial Sensor Data

The initial oxygen sensor data is tracking the movement of the biomethane. In line with expectations the oxygen sensor data is indicating that as the demand drops off during the night the zone of influence of the biomethane gas extends further into the network. During the day, at periods of higher demand, the biomethane is absorbed by the demand more locally. For a more detailed look at data collection and modelling progress, please see the FBM Initial Data Review Report /7/.

4.2 Flow Measurement

An innovative and low-cost gas flow measurement technique was developed by Advantica (now part of DNV GL) in 2002 and is being trialled on governor stations as part of the FBM project. The inlet pressure, outlet pressure and governor regulator position (percentage of open/closed) is used to calculate the gas flow.

The valve travel is monitored by a transducer mounted through the regulator housing and in contact with the diaphragm. Part of the site selection criteria involved cross-checking the governors at Chittering and Hibaldstow against the existing database of categorised governor types.

The flow data estimated through these low-cost gas flow measurement devices has provided indicative regulator flows showing an expected diurnal profile of the downstream demand. The MS13 report /6/ covers a more detailed look at the application of this indicative flow data.

4.3 Gas Quality Measurement

Calorific value (CV) is being measured at four selected sites, two in each area (see Figure 1 and Figure 2) to demonstrate transmission to smart meters. The sites have been selected to provide additional validation information to the network models.

CV will be measured by the GasPT which is an inferential device; the GasPT is also an approved device for measuring CV under Ofgem Direction at biomethane network entry points. The GasPT determines the physical properties of natural gas:

- Calorific Value
- Wobbe Index
- Relative Density
- Compression Factor
- Methane Number (MN)
- Total Air Requirement (TAR)

Initial CV measurements have proven a useful addition to the network modelling. The GasPT data has been successfully incorporated into the smart meter laboratory trials, which began in November 2020.

Two of the four CV measurement sites are also transmitting pseudo composition data. The gas composition measurement device GasPT2 uses correlative techniques to infer an equivalent five-component gas mixture (methane, ethane, propane, nitrogen and carbon dioxide) from which it calculates the gas properties, such as CV, using ISO 6976.

This inferred composition data could be used in Synergi to model the molecular % composition of the gas in addition to the calculated CV value from the GasPT and could show how network analysis modelling can deal with different gas compositions.

5 RELIABILITY OF THE DATA GATHERING AND TRANSMISSION

Each site undertakes a SAT during the commissioning stage to ensure the validity of measured data and to confirm that the data is transmitted and stored as per specification to the DNV GL Cloud.

The measurements are transmitted at a suitable frequency to the DNV GL secure data cloud using GPRS mobile communications. With the exception of some minor gaps in the recorded data, data is being gathered and transmitted reliably from all sites which have undergone SAT. Unfortunately, site visit delays for service visits were incurred due to the Covid-19 pandemic in 2020.

6 COMPATIBILITY OF THE DATA WITH THE NETWORK MODELS AND DEVELOPMENT OF MODELLING TECHNIQUES

Detailed analysis is being undertaken as more data becomes available from all sensors across both networks. Initial results confirm that the network models provide results in line with those experienced in the physical network. If this initial finding is substantiated with the increase in data, this should provide the foundations to allow the development of charging areas in line with the pragmatic and composite solutions.

For a more detailed look at data collection and modelling progress, please see the FBM Initial Data Review Report /7/ and subsequently the MS13 report /6/ alongside the Future Billing Methodology Recommendations report due at the end of March 2021. The identification of the Cost Benefit Analysis (CBA) associated with the charging area methodology will be covered in Milestone 15.

7 DECOMMISSIONING

Decommissioning of field trial sites will commence April 2021, details of this process are to be agreed between all parties.

8 PROJECT SUCCESSES

Successes for the FBM project are highlighted in this section.

8.1 Suitability of Instrumentation

8.1.1 Biomethane Tracking

The GE OXY.IQ sensor has proven to be an effective and reliable instrument for successfully measuring oxygen content and hence tracking biomethane through the test networks.

Limited guidelines regarding the calibration and lifespan of the oxygen sensors was provided by the manufacturers. The 18-month testing and the field validations carried out by DNV GL has provided invaluable insight into the long-term performance of the oxygen sensors. This data will prove highly useful for determining the practicality of similar oxygen sensors being installed across the network.

8.1.2 Flow Measurement

The FBM project has successfully trialled an innovative and low-cost gas flow measurement technique developed by Advantica (now part of DNV GL). The inlet pressure, outlet pressure and governor regulator position (percentage of open/closed) is used to calculate the gas flow. This technology is likely to have wide ranging benefits across the gas network. The flow data estimated through these low-cost gas flow measurement devices has provided indicative regulator flows and proven to be suitable.

8.1.3 Gas Quality

Already a proven technology for measuring CV under Ofgem Direction at biomethane network entry points, the GasPT data has been successfully incorporated into the smart meter laboratory trials and proven to be suitable. The smart meter laboratory trials commenced in November 2020 and results will be detailed in the MS11 report.

8.2 Hazardous Area Assessments

Detailed hazardous area assessments carried out on governor stations involved in the FBM project will benefit any future work undertaken on these sites. See section 3.4.1.

8.3 Earthing and Electrical Design Policy

Electrical installations at gas sites require isolation. It was identified that existing electrical design policy for gas installations had been developed principally to support high-pressure Gas Transmission sites. A proportionate and cost-effective approach to safe supply isolation had to be developed for the FBM Project installations and a formal policy deviation was authorised as a precautionary measure for the FBM Project. See section 3.4.2.

8.4 Data Gathered

After overcoming the sensor installation challenges, the initial data analyses indicate that the project has a self-consistent, meaningful and novel set of measurements that track the flow of biomethane through the gas network.

Whilst the observation of peak and minimum demand conditions cannot be guaranteed within any set time frame, the key aim is to demonstrate that the network model can reflect the behaviour of the physical network across a range of demand conditions and can therefore be used to determine how the network will perform at any demand level, including peak day. Early indications are that the field trial measurements confirm the predictions of the network model across a range of demand conditions. The data analysis and network modelling part of the project will use the data that is available and may apply interpolation to any data gaps, to achieve a coherent project output. As the project progresses, the team will anticipate and address any questions and uncertainties that may arise due to the constrained period of data collection.

9 CONCLUSION

The Future Billing Methodology project has overcome numerous issues and successfully deployed 34 sites at suitable measurement locations. Site-by-site evaluation, taking account of cost, complexity and timing was conducted with support from the network modelling team to ensure a robust optimisation of the field trial site population with respect to zones of influence.

The installed instrumentation is suitable and the GE OXY.IQ sensor has proven to be an effective and reliable instrument for successfully measuring oxygen content and hence tracking biomethane through the test networks.

With the exception of some minor gaps in the recorded data, data is being gathered and transmitted reliably from all sites which have undergone successful site acceptance tests (SAT). Unfortunately, site visit delays for service visits were incurred due to the Covid-19 pandemic in 2020.

The project has demonstrated the data gathered is compatible with the existing network models. The next step is for this data to feed into the development of modelling techniques for determining charging areas for Pragmatic and Composite options; this is presented in MS13 report/6/.

Further to this, an updated cost-benefit plan and industry recommendations will be delivered via the Future Billing Methodology project dissemination in late March 2021.

10 REFERENCES

/1/ Cadent, Stage Gate Report FBM 1, September 2017.

/2/ FBM, FBM Oxygen Sensor Testing Technical Note, Rev 1, January 2019.

/3/ DNV GL, FBM Oxygen Sensor Lifespan Test (6 month Report), Rev 0, December 2019.

/4/ DNV GL, FBM Oxygen Sensor Lifespan Test (12 month Report), Rev 1, June 2020.

/5/ DNV GL, FBM Oxygen Sensor Lifespan Test (18 month Report), Rev 2, December 2020.

/6/ DNV GL, FBM Report on Validation of Network Modelling for Embedded and Network Charging Areas, Rev 1, December 2020.

/7/ DNV GL, FBM Initial Data Review, Rev 1, May 2020.

Appendix A Oxygen Sensor Long Term Testing Specification

Oxygen Sensor	GE OXY.IQ
Number of Cells	1
Duration	18 months (or until cell fails or the UKAS test gas is depleted)
Cell Range	0 - 200 ppm
Sample Gas Flowrate	15 l/h
Non UKAS Test Gas	Target Composition is Natural Gas with 100 ppm oxygen
UKAS Test Gas for Spot Checks	20 ppm oxygen
Frequency & Duration of Spot Checks	Start at every 2 weeks but this may increase/decrease depending on results. Duration should be long enough for readings to settle. Spot checks changed to once every 3-4 weeks after the 6-month results indicated that oxygen cell's performance was still within acceptable limits.
Data	Oxygen concentration will be recorded at 10 second intervals This was changed to 20 seconds interval for month 7 and onwards. The 6 months results showed that the response time of the cell is sufficiently low to allow the new sampling rate to capture the change in oxygen concentration. Decreasing the sampling rate also allowed Orbital to reduce the frequency of data download from the logger. Downloading data from the logger disrupts the data logging process and creates large gaps in the data.
Pass/Fail Criteria	Accuracy: ±10% of reading + 2 ppm at calibration temperature (i.e. 16 – 24 ppm.); 0 ppm must read < 10 ppm. Response time: No more than 1 hr but less than 30 min on average. (as observed during the oxygen sensor selection tests for the GE sensor). Drift: Spot checks (certified gas) should be within the accuracy stated above. The results for both the spot checks (certified gas) and the main test gas (uncertified gas) should not show a general upward or downward trend.

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