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Humshaugh Net Zero CIC

RCEF

Low Carbon Feasibility Study

Workstream 6 - Grid

Final Report

February 2021

d3associates

Third-Party Disclaimer

Document Revisions

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(REF: 1601)

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D3 Associates Ltd

Report for

Humshaugh Net Zero CIC

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Contents

1 Introduction

Humshaugh Net Zero CIC (HNZ) are engaged in the process of reducing the Parish's carbon footprint and tackling climate change and to achieving the Government and Northumberland County Council Net Zero targets. They have consulted with the local community to ascertain their views and are looking to identify a viable approach to low carbon energy generation, particularly electricity, in the Parish of Humshaugh.

The Rural Community Energy Fund (RCEF) is a £10 million programme to support rural communities in England to develop renewable energy projects. HNZ have been successful with a stage 1 application, the funds being used to deliver this feasibility study. Stage 2 grants are available to further develop identified feasible projects for business development and planning.

1.1 Description of the Brief

HNZ is seeking to understand the levels of electrical grid capacity available within the parish of Humshaugh as part of its overall plans to drive forward opportunities to reach a Net Zero Carbon level as targeted by Regional and National Policy.

HNZ required technical advice and assistance in reviewing the capacity of the local electricity grid to accommodate generation and increased demand within the Parish, now, and over the next few years. This will help the local community optimise its utilisation of local, low-carbon, energy resources, with the aims of supporting the Government Net Zero Target, in a cost effective manner for the local community and increasing employment opportunities in the locality.

HNZ identified possible renewable generation resources as solar PV generation systems installed on dwellings and farm buildings, a hydro-electric scheme and wind turbines. HNZ considered it unlikely that significant wind powered generation will be possible in the Parish due to the proximity to the Hadrian's Wall World Heritage Site. Small wind turbines may be an option. On the electrical demand side, use of electric vehicles may increase, and increased use of heat pumps and energy storage is considered likely. These options are considered in more detail in other workstreams.

1.2 Scope of Work

This report describes the results of a desktop study of available information and initial discussions with Northern Powergrid. It identifies at a very high level the possible local grid capacity, which can be used individually or collectively within the community.

Appendix A explains some basic aspects of grid connection.

Appendix B briefly discusses how the use of electrical energy can interact with carbon reduction measures.

2 Executive summary

HNZ is seeking to understand the levels of electrical grid capacity available within the parish of Humshaugh as part of its overall plans to drive forward opportunities to reach a Net Zero Carbon level.

This report describes the results of a high level desktop study which has reviewed the capacity of the local electricity grid to accommodate renewable generation and increased demand such as use of electric vehicles, heat pumps and energy storage within the Parish. The study considers the possible impacts on the local grid and the possible costs of mitigating these impacts. Available information from the local Distribution Network Operator, Northern Powergrid, was reviewed, and initial discussions were held with them to identify the implications of potential changes. Some basic aspects of grid connection are explained and there is a discussion of ways in which the use of electricity can interact with carbon reduction measures. On the one hand, improving building insulation performance, making use of energy-efficient products, and reducing travel can reduce overall energy use, including electricity demand. On the other hand, replacing high carbon (fossil fuel) forms of heating or transport with efficient alternatives that use low carbon electricity can also help to reduce the overall carbon footprint, even though electricity usage might increase.

The parish of Humshaugh and its surrounding area is served by a high voltage (20kV) electrical network operated by Northern Powergrid This network mostly comprises overhead lines, with some underground cabling. Transformers at key locations on this network convert the high voltage to low voltage customer supplies. Most transformers in the parish are single- or two-phase – only two existing three-phase LV supplies have been identified (at Chollerford South and Chesters).

Any new generation and demand connections, or increased power flows on existing supplies, need to be assessed and accommodated by the network operator. Unfortunately, it is not possible to identify easily and without guidance from the network operator whether a given section of the local distribution network can accommodate generation or additional load, or how much of either. This is because the network's capacity for new connections depends on a number of aspects which are very site-specific. The first question is whether there is any suitable grid infrastructure nearby, followed up by a number of technical design considerations. The network operator will carry out a detailed assessment of any significant additional connection (such as new generation, electric vehicle chargers or heat pumps) to establish the likely impact and any new infrastructure that may be needed.

- Detailed connections guidance is available from Northern Powergrid's website and their connections team.
- Typically the person or company requiring a new or upgraded connection will pay for all or some of any network infrastructure upgrades needed.
- An electric vehicle charger or a heat pump can be installed without first applying for a connection and without a connection charge if the installer assesses the property and its Maximum Demand is predicted to remain within 60 amps (~13.8kW). This is likely to be more achievable for properties which are not currently using electric cooking and heating (although replacing electric forms of heating with a heat pump is likely to reduce Maximum Demand).

- Some local network information from Northern Powergrid is included in the report. It indicates that four of the transformers in Humshaugh village could require upgrading if nearby electrical demand increases significantly. The responsibility for paying for those upgrades would depend on the process by which the total demand increases. It would not be impossible for Northern Powergrid to make anticipatory investment in its network to prepare for the impact of Net Zero developments, but it has to justify such investment to the electricity regulator, Ofgem.
- Locations with a single phase supply may not be able to accommodate large generation installations or fast vehicle chargers. Converting transformers to provide a three-phase supply or to increase capacity would need a replacement transformer and possible a cable or overhead line replacement. This would need to be included in the cost of any significant project.
- Small domestic renewable generation (less than 13 amps , or 3.68kW) can be installed without applying for a connection and without a charge. For example, a typical new roof-mounted PV solar installation will be within this limit.
- Any new renewable generation connections large enough to make a significant contribution to the parish's carbon footprint are likely to need network upgrades which the generator would pay for.
- Northern Powergrid have agreed to install some monitoring equipment on the ground-mounted transformers in the village, and to make the information available to HNZ.
- In order to obtain a better understanding of likely costs and timescales for potential low carbon projects, it is recommended that a budget offer / feasibility study is obtained from Northern Powergrid for some realistic demand and generation installations, in possible (if not necessarily exact proposed) locations.

3 Humshaugh electrical network

3.1 Infrastructure

The parish of Humshaugh and its surrounding area is served by a high voltage (20kV) electrical network which is connected to primary substations at Fourstones and Hexham. The parish is believed to be normally supplied from Fourstones substation (subject to confirmation from Northern Powergrid). This network mostly comprises overhead lines, with some underground cabling.

Transformers are installed at key locations on this network. They convert the high voltage to normal customer supply voltages – 230V for single phase supplies, and 400V for three-phase supplies. Low voltage cables and overhead lines distribute the supply to the properties near the transformer. Humshaugh village is served by three ground-mounted transformers and three pole-mounted transformers. Rural properties have mostly single-phase supplies, and are served by pole-mounted transformers, with the exception of a three-phase transformer serving the area around Chesters. Table 1 lists the transformers which supply Humshaugh village (information provided by Northern Powergrid).

Table 1: Transformers in Humshaugh village

Substation	Phases	Type	Capacity	Max Demand
Humshaugh East	Single	Ground Mounted	315kVA	75kVA
Humshaugh West	Single	Pole Equipment	150kVA	140kVA
Humshaugh South	Two	Ground Mounted	380kVA	157kVA
Humshaugh Linden	Single	Ground Mounted	150kVA	120kVA
Chollerford	Two	Pole Equipment	200kVA	200kVA
Chollerford South	Three	Pole Equipment	50kVA	33kVA

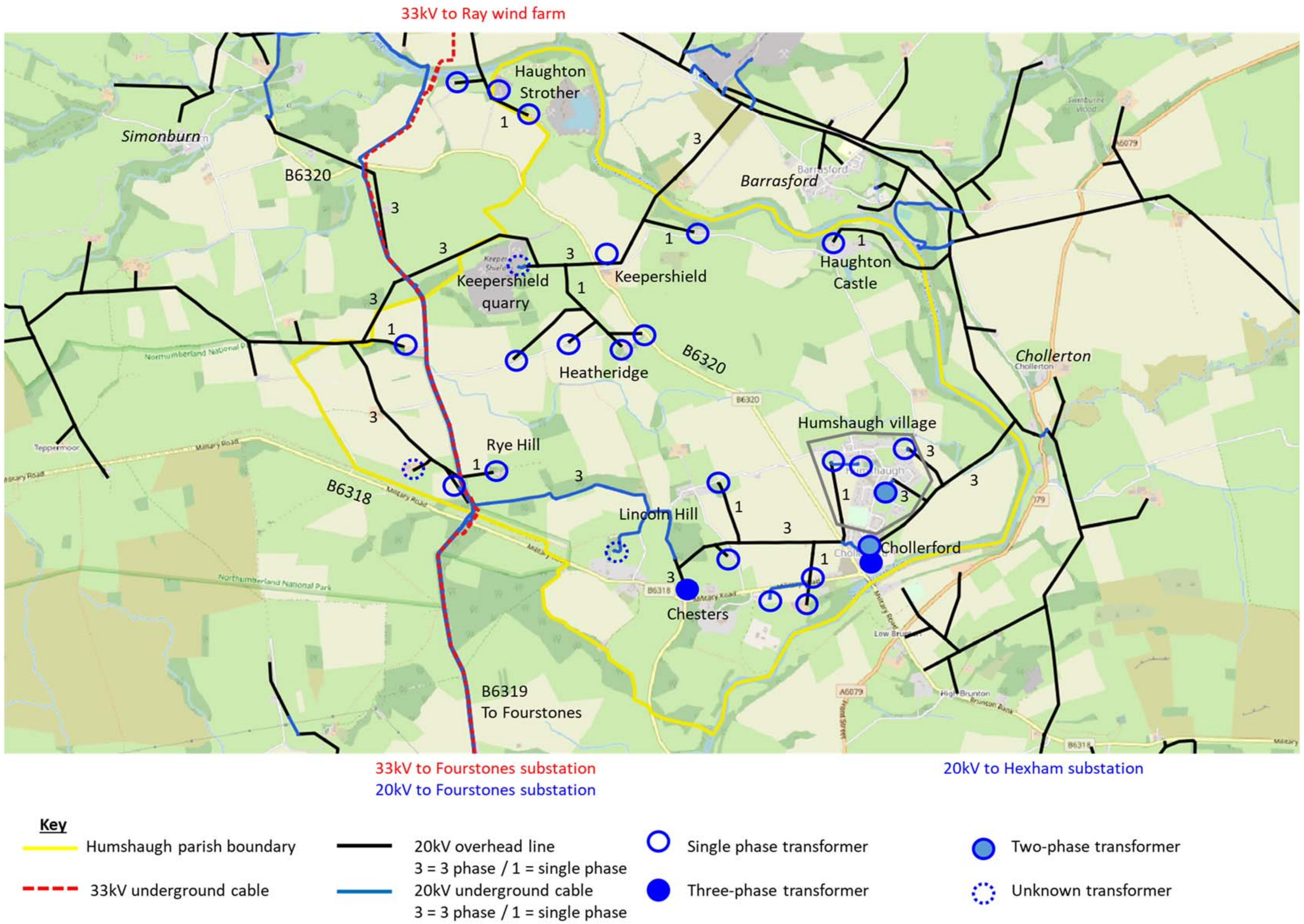
Notes: Humshaugh East and Chollerford are both three-phase transformers, connected as single phase and two phase respectively.

Northern Powergrid are obliged to publish circuit and transformer details for all circuits at and above 33kV, and this information is made available in their annual Long Term Development Statement. Unfortunately, this level of detail is not published for 20kV circuits. Northern Powergrid does make its Geographical Information System (GIS) data available for all its HV circuits, including 20kV, and this has been used to produce the maps below. This provides the location of the circuits, but not their electrical parameters. Circuit and transformer details need to be requested from Northern Powergrid where required.

3.2 System maps

Figure 1 shows the high voltage network in the whole parish, as explained above, mostly at 20kV. There is also a dedicated 33kV underground cable from Fourstones substation to Ray wind farm, which can be seen generally following the B6319 road. This is a double circuit, each rated at 54MVA. Figure 2 and Figure 3 show more detail in Humshaugh village itself.

Figure 1: Electrical high voltage distribution network in Humshaugh parish



Note: Based on Northern Powergrid network GIS information, available on request, and inspection of visible network infrastructure.

Figure 2: Electrical high voltage distribution network in Humshaugh village

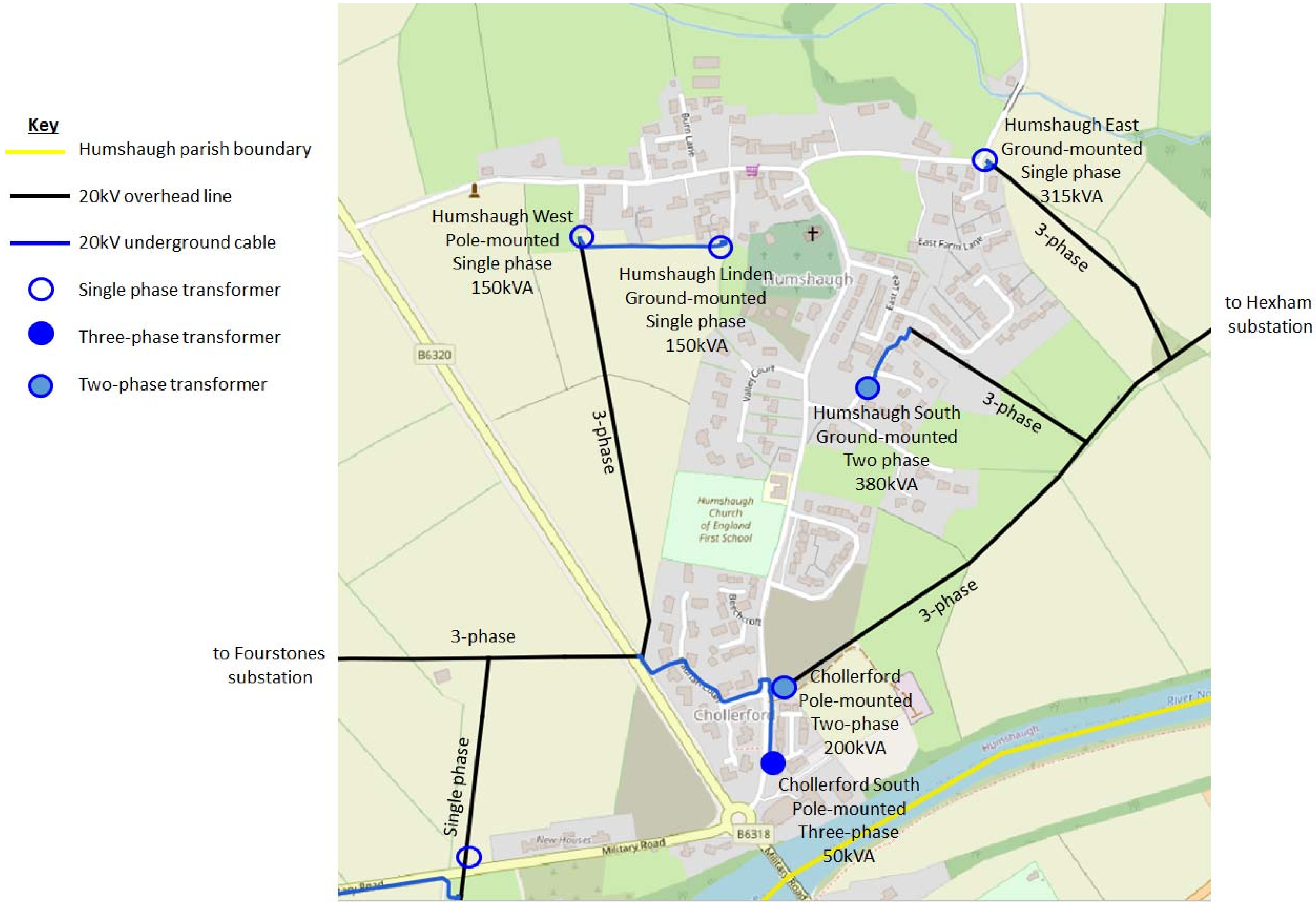
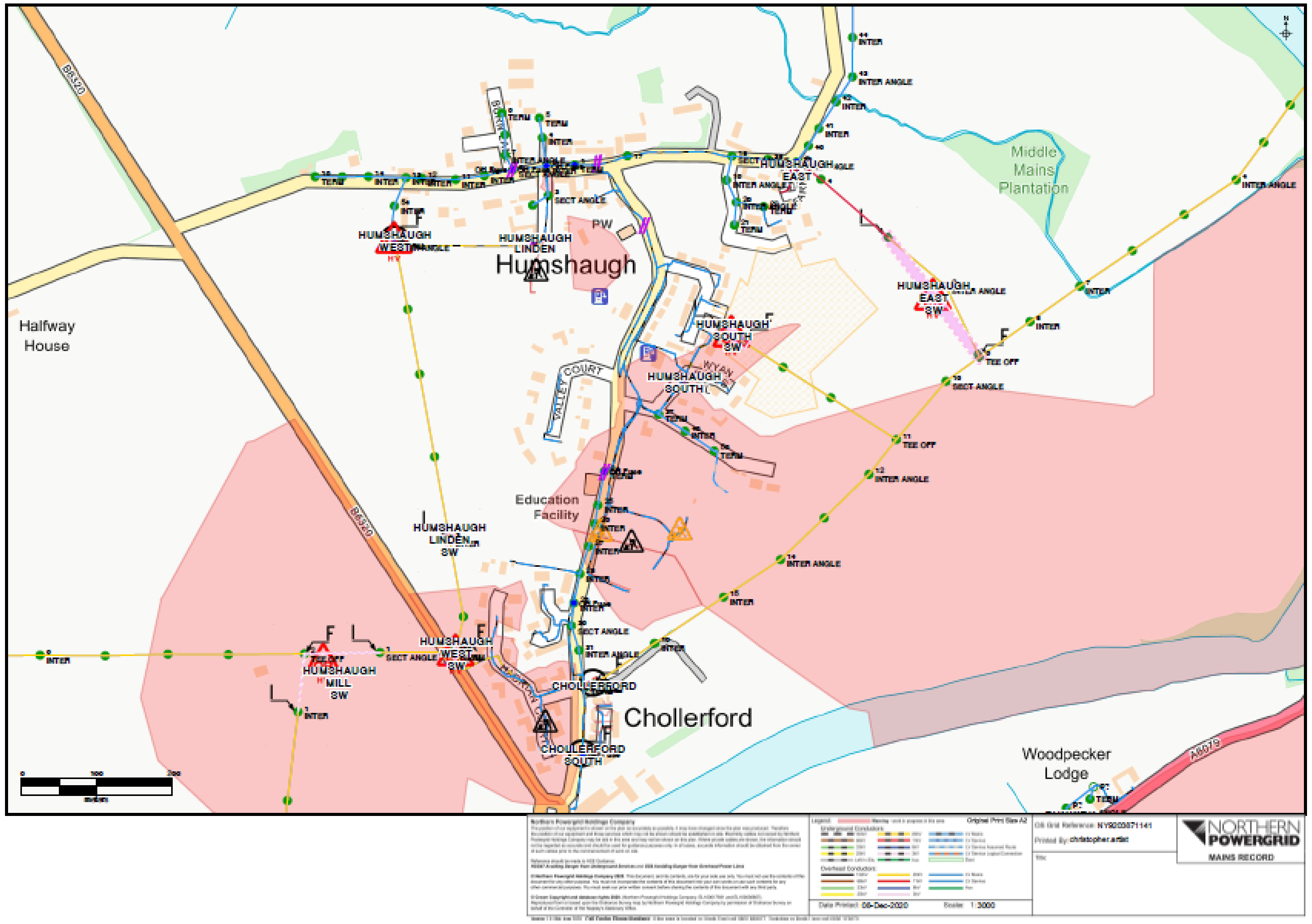
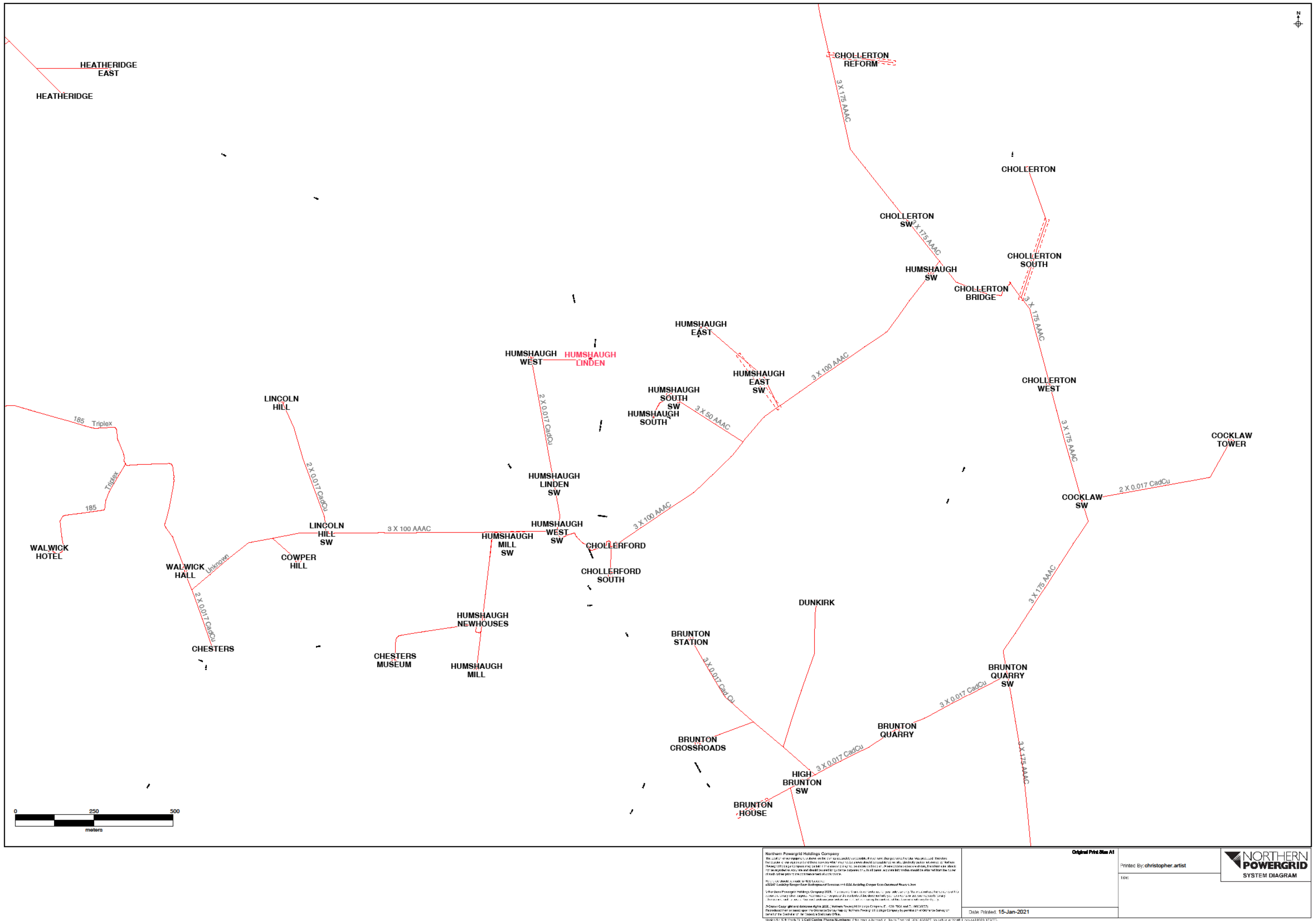


Figure 3: Electrical distribution network in Humshaugh village (Northern Powergrid drawing)



Note: Yellow lines are 20kV; blue lines are low voltage

Figure 4: Electrical distribution network west and south of Humshaugh village (Northern Powergrid drawing)



3.3 Grid availability

Unfortunately it is not possible to identify easily whether a given section of the local distribution network can accommodate generation, or how much. This is because the network's capacity to accommodate new connections depends on a number of aspects which are very site-specific, including the key aspects listed in Table 2.

Table 2 – Typical challenges of installing new demand or generation on electrical networks

Issue	Problem	Solution / mitigation
Presence of grid	The location of the new plant may not be near existing grid infrastructure	Build new infrastructure.
Thermal capacity	Network infrastructure elements may not be able to carry increased power flows without overheating.	Upgrade infrastructure to increase rating (e.g. replace transformer; upgrade overhead line or cable from single phase to three-phase). Apply smart technical solutions to keep power flows within thermal limits.
Voltage limits	Operating the new plant may cause other properties to experience supply voltages above or below the permitted voltage range.	Upgrade infrastructure to reduce voltage impact or divert power flows to avoid problem. Apply smart technical solutions to manage power flows and regulate voltage.
Fault level	Installing the new plant may increase the amount of current that flows if there is a short-circuit somewhere on the network, which can damage switchgear and other plant.	Upgrade infrastructure (usually switchgear) to accommodate increased fault level. (Install fault-limiting plant – technology in early stages of development.)

The network operator will carry out a detailed assessment of a connection application to establish the likely impact of a requested connection and any new infrastructure that may be needed.

Northern Powergrid have made available an indicative online assessment tool which is currently aimed at low voltage demand connections only, which will be eventually expanded to include generation connections : https://www.northernpowergrid.com/auto-design. This can accommodate the following requests.

- Large single loads (up to 210kVA), including EV chargers, commercial or industrial properties;
- 100 general domestic properties with gas central heating;
- 40 electrically heated properties;
- 75 general domestic properties, each with a heat pump rated at 3kW;
- 30 general domestic properties, each with a 32A EV charger.

For HNZ to carry out its own high level first pass, it is easier to identify the limits of existing infrastructure, which can help to assess at what point it may be necessary for the network operator to carry out upgrades. These may or may not be charged to the customer (see section 5 and Appendix A).

3.3.1 Thermal capacity and power monitoring

The transformer ratings and maximum demand values shown in Table 3 indicate the possible maximum amount of available thermal capacity within the village. There appears to be very limited capacity for the transformers to accommodate increased demand at Humshaugh West, Humshaugh Linden and both the Chollerford transformers. Humshaugh East and Humshaugh South appear to have spare thermal capacity.

Northern Powergrid have agreed[1] to install monitoring equipment on the three ground-mounted transformers in Humshaugh village (Humshaugh Linden, Humshaugh East and Humshaugh South) as part of a current network innovation programme, subject to the LV distribution boards in the substations being suitable for connection. This is expected to provide information on power flows and energy demand at each transformer, and possibly voltage information. Installations should start to be rolled out early in 2021. The data will not be available real-time initially and will require processing. Methods to make the data generally available to customers are under consideration at present, but the Northern Powergrid Smart Grid engineer will be able to provide initial energy data for HNZ.

[1] Emails from Christopher.Artist@northernpowergrid.com, December 2020.

Table 3 – Estimated thermal demand and generation capacity in Humshaugh village

Substation Transformer type / phases / Supply cable phases	Capacity	Max demand	Estimated limit of additional demand	Estimated limit of generation capacity
Humshaugh East Ground-mounted / single / three	315kVA	75kVA	~216kW	~283kW
Humshaugh West Pole-mounted / single / single	150kVA	140kVA	~9kW	~135kW
Humshaugh South Ground-mounted / two / three	380kVA	157kVA	~200kW	~342kW
Humshaugh Linden Ground-mounted / single / single	150kVA	120kVA	~27kW	~135kW
Chollerford Pole-mounted / two / three	200kVA	200kVA	None	~180kW
Chollerford South Pole-mounted / three / three	50kVA	33kVA	~15kW	~45kW

Notes: Columns 1-3 are information provided by Northern Powergrid.
Figures are very approximate. Author assumes 0.9 power factor for both demand and generation (generally in line with Northern Powergrid), and no baseload demand (for estimating generation capacity).
Capacity may be limited by other factors – this is only the thermal limit on the transformer.

At present there is no specific information on transformer ratings for properties outside the village, or for any overhead lines or underground cables. Pending detailed information from Northern Powergrid, some inferences can be made from Northern Powergrid's Long Term Development Statement, which indicates the following standard arrangements.

- New distribution substations are normally equipped with a single 20/0.433kV or 11/0.433kV ground-mounted transformer, with a rating of up to 1000kVA for multiple or single customers and up to 1600kVA for a single customer only [and] …. a de-energised tapchanger. 25kVA pole transformers are the minimum size used for new installations.
- 20kV overhead lines are constructed from 100mm² aluminium alloy conductors with 175mm² aluminium alloy conductors used for highly loaded circuits and 50mm² aluminium alloy conductors used for lightly loaded spurs teed off a main line.
- 185mm² Al Triplex XLPE conductors are the minimum sizes for new cables at 20kV. 300mm² or 400mm² Cu conductor Triplex XLPE cables may be used where additional capacity for single customer connections is required or where the cables are to be installed in extensive duct runs.

Based on this and on typical cable properties, it can be suggested that:

- Rural supply transformers are likely to be rated around 25kVA.
- The smallest high voltage circuits are likely to have a thermal limit no lower than ~1.6MW, and three-phase circuits may have a limit of ~7.8-11.9MW.

3.3.2 Voltage rise and fault level

Northern Powergrid's area design manager has indicated that voltage management is a major consideration in long rural networks such as Humshaugh's and that it could well be a key issue in connecting any new renewable generation. Quantifying this would need detailed assessment of a specific generation proposal.

Experience with a wide range of generation connections suggests that fault level is less likely to be a problem in Humshaugh's network, because of its distance from major sources of fault current (significant other generation sources). Again quantifying this would need detailed assessment of a specific generation proposal.

4 Grid aspects of assessed generation sites

Some comments are made below on the grid connection aspects of sites and installation assessed within the other Workstreams.

4.1.1 Keepershield Quarry

The electrical supply to Keepershield Quarry is not known. The distance noted between its transformer and the possible PV site would add some cabling cost to a PV installation.

(Keepershield Quarry was not recommended for further consideration for PV generation for other reasons.)

4.1.2 Haughton Strother Quarry

Haughton Strother quarry appears to have a single phase supply from a pole-mounted transformer, which would limit the amount of generation that could be connected without increasing its transformer rating and/or upgrading its overhead line to three-phase.

(Haughton Strother quarry was not recommended for further consideration for PV generation for other reasons.)

4.1.3 PV on agricultural land

HNZ stated that solar farms on agricultural land were not to be included.

However, if a relatively large ground-mounted PV installation were to be considered by a landowner, it should be noted that most of the rural properties have single phase connections. An overhead line upgrade to three-phase might be necessary to connect a major installation. A significant generation capacity might be needed to make the business case for the cost of such an upgrade.

4.1.4 Residential properties – small roof-mounted PV installations

Approximately 80 houses have been identified under Workstream 1 as being potentially suitable for the installation of a G98 roof top PV installation up to 3.68kW.

If the installation is compliant with Engineering Recommendation G98, no connection application or fee is required. The network operator must be informed after the installation.

4.1.5 Larger roof- and ground-mounted PV installations

The Workstream 1 report suggests that there are suitable buildings for installation of a larger, say 10kW PV array, including the school, and several farms, hotels and historic buildings. The Workstream 1 report also suggests that for those households with an increased electricity demand, a larger PV array could be beneficial, alongside battery storage, to make full use of the electricity generated. For the purposes of this study the potential total installation size was estimated at **~100kW.**

This type of installation would necessitate a planning application and a G99 application to Northern Powergrid to obtain a connection offer, both of which would incur a fee. The G99 application cost varies but would be £350+VAT for a 10kW LV connection. The network operator will review the network and make a connection offer which identifies the cost of connecting and an achievable timescale. The turnaround time is 45 working days.

4.2 Wind generation

At this stage, grid connections for possible wind generation options have not been assessed. Significant wind generation will need careful assessment by Northern Powergrid. The same considerations with regard to small installations apply as in the PV sections above (e.g. anything smaller than 3.68KW would fall under G98). Any installation above 190kW would need a high voltage connection to the 20kV network, and at some size, Northern Powergrid are likely to suggest a 33kV connection, which would probably entail a new 33kV substation and new circuits back to Fourstones. It would not be surprising if voltage rise issues are identified as a key issue which could trigger significant network upgrades or the need for a smart grid solution.

5 Approximate costs of upgrades and timings

5.1 Typical upgrade costs

No detailed costs or timings for network connections of potential generation installations have been obtained. Table 4 provides an indicative summary.

Table 4 – Typical costs and timescales for different types of grid connection

Domestic electric vehicle charger and/or heat pump, existing supply (Assessed Maximum Demand must remain below 60A, or 13.8kVA)	Installer must assess connection as suitable. No grid connection cost or delay; no DNO works required (any wider upgrades will be accommodated by the DNO at their cost.) DNO must be informed using Low Carbon Technology application form.
Domestic electric vehicle charger and/or heat pump, existing supply (Assessed Maximum Demand is above 60A, or 13.8kVA)	Installer must assess installation and apply for connection using Low Carbon Technology application form. 10 working days for DNO to assess if maximum demand <100A (~23kVA); standard connection timescales if >100A. Possibility of some cost or delay.
3.68kW PV installation (G98), existing supply (or 11kW three-phase PV installation)	No grid connection cost or delay (any wider upgrades will be accommodated by the DNO at their cost.) Inform DNO after installation using G98 process.
New supply for electric vehicle charger or heat pump	Application to DNO for a connection offer – costs and timescales to be assessed by DNO. (Autodesign software could indicate likely costs). Installation timescale likely to be weeks or months; costs maybe from £5k upwards.
Larger generation installation (G99 process)	Application to DNO for a budget offer, feasibility study or connection offer – costs and timescales to be assessed by DNO. Installation timescale likely to be at least several months, costs maybe minimum ~£10k depending on generation proposed. New HV circuits may be 1-2 years+.

1. Application form for the Installation of Low Carbon Technologies https://www.northernpowergrid.com/downloads/4738
See also www.northernpowergrid.com/heat-pump-and-electric-vehicle-installation-process and https://www.energynetworks.org/assets/images/Resource%20library/LCT_Combined%20EV%20&%20HP%20Process%20v5.5.pdf
2. https://www.northernpowergrid.com/get-connected/ G98 process
3. https://www.northernpowergrid.com/get-connected/ G99 process

In order to obtain a better understanding of likely costs and timescales, it is recommended that a budget offer / feasibility study is obtained from Northern Powergrid for some realistic demand and generation installations, in potential (if not necessarily likely or proposed) locations. For example, two 22kW Fast electric vehicle chargers at the Village Hall, 300kW of heat pumps in the village, a 1MW PV array in the fields at Linden, a 500kW wind turbine near Heatheridge, and a 190kW PV array at Lincoln Hill. Costs for this study may be in the region of £330-£520[2].

5.2 Anticipatory investment

HNZ has asked whether it might be more cost-effective for Northern Powergrid to carry out an anticipatory investment programme to upgrade the whole parish network to mitigate the impact of Net Zero Targets, rather than a more likely piece by piece response.

It is difficult to answer this without first having knowledge of the upgrade works that might be necessary to allow the network to deliver Net Zero targets. It is a considerable task to identify how Net Zero might be achieved in the parish and then to produce an outline design for the local electrical network to enable that.

It is possible that a piece by piece approach might install plant that would subsequently need a further upgrade to meet Net Zero targets, costing more overall, or it might deliver plant first time round that would be suitable over the long term. In the latter case, the cost of the equipment might not differ too much between the two approaches but there might be slightly higher overall mobilisation costs for the piecemeal approach.

Any anticipatory investment which could result in underutilisation or stranding of assets is subject to the need to justify it to Ofgem in their Business Plan for the next price control period (RIIO-2)[3].

7. Anticipatory investment
7.1. There may be items of expenditure that are not required to meet demands expected in RIIO-2, but where companies believe that investment now would reduce costs to consumers over time. In their business plan, we will expect companies to describe these types of investment in a separate section from their 'core' business plan proposals.
7.2. To support these proposals for anticipatory investment, companies should demonstrate:

- *The level of risk surrounding their assumptions on future demand, including clarity on government policy*
- *The benefits to network consumers that may flow from earlier investment*
- *The consequences of not making anticipatory investment*

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[2] Connection Offer Expenses Customer Guide Oct 2018.pdf available at www.northernpowergrid.com/connection-offer-expenses
[3] https://www.ofgem.gov.uk/system/files/docs/2018/09/riio-2_business_plans_-_initial_guidance.pdf

- *The justification for why network consumers should fund this work, including an examination of which other parties (including local authorities, national governments, and third parties) could fund the investment*
- *The balance of risk that is to be shared between consumers, the company and any third party.*

6 Potential risks and mitigation options

Connection of significant new electrical plant to the distribution network is always assessed thoroughly by the network operator. Any mitigation measures are designed and costed into the connection offer that is made. This means that once a system has been installed, there is minimal operating risk associated with the grid connection.

The main risk to a renewable generation project is that the grid connection costs will be unaffordable, because of the network upgrades that are required to accommodate the connection. Sometimes, if a connection offer is made with a very high cost, working with the network operator to optimise the design can bring these costs down.

The main risks and mitigation measures have been mentioned throughout the report and are summarised in Table 5 below.

Table 5 – Grid connection risks and mitigation measures

Risk	Probability	Mitigation Measure
Network outages (power cuts) prevent generation from operating, reducing cost savings and/or revenue.	Low - Network operators have licence obligations to minimise "Customer Minutes Lost", and design and operate their networks very carefully to maintain supplies. If a network operator needs to provide supplies from a generator, then they may require local renewable generation to be disconnected during this period.	Allow for a reasonable number of power cuts and lost generation when calculating costs and benefits of a project.
Network outages (power cuts) prevent heat pumps from operating, resulting in cold buildings and additional costs for supplementary heat. (This also applies to other heating methods - even oil central heating will not work if the power is off.)	Very low - Network operators have licence obligations to minimise "Customer Minutes Lost", and design and operate their networks very carefully to maintain supplies. In an extended emergency, the network operator would be obliged to provide power from a generator.	Ensure alternative forms of heat are available for emergencies.
Network outages (power cuts) prevent electric vehicle chargers from operating, resulting in stranded vehicles and use of fossil fuel alternatives.	"	Buy a plug-in hybrid; operate a second car; find alternative transport solutions; install a domestic battery system.

Risk	Probability	Mitigation Measure
New heat pumps or EV chargers in existing properties might overload the local network.	Very low. Installing these in significant numbers could result in voltage or overload problems.	This is not the owner's problem if the property's total power demand is within its connection rating - the network operator may have to upgrade the network to maintain local quality of electrical supply.
Heat pumps or EV chargers in new properties, or a new EV connection might overload the local network.	Medium New connection requests will be assessed by the network operator. Any network upgrades needed will be included in the cost of the connection.	Where possible, locate new demand where there is surplus network capacity. Work with the network operator to optimise the connection cost.
New renewable generation below 3.68kW in multiple nearby properties might cause network problems.	Very low.	This is not the owner's problem if the generation falls under ER G98. The network operator may have to upgrade the network to maintain local quality of electrical supply.
New renewable generation larger than 3.68kW might cause network problems.	Minimal to Very High - dependent on size and location. New connection requests will be assessed by the network operator. Any network upgrades needed will be included in the cost of the connection.	Where possible, locate new generation where there is existing network capacity. Work with the network operator to optimise the connection cost.

7 Appendix A Electricity and renewable generation basics

7.1 Electricity supplier

Each household / customer can choose to buy its electrical energy from one of many electricity suppliers, who offer different tariffs and packages.

7.2 Electricity network operator (Distribution Network Operator, or DNO)

Northern Powergrid owns and operate the electricity network that supplies Humshaugh, including the overhead lines, poles and transformers that can be seen around the parish. These are supplemented by underground cables.

At each property, Northern Powergrid owns the low voltage cable that enters the building, as far as the electricity meter.

Beyond the meter, the electrical installation in the premises is owned by the property owner.

7.3 Network payments and losses

Each customer has to pay for their energy used (kWh, or units), plus their use of the distribution and transmission networks. All this is bundled into the supplier's tariff, and included in the bill from their electricity supplier. The supplier tariff also includes an allowance for energy lost due to transmission of electricity across the national electricity system.[4] The supplier may also offer a payment tariff for energy exported onto the grid from a home renewable energy installation.

7.4 Grid aspects affecting addition of electric vehicle chargers and heat pumps

Converting a heating system to electricity will increase the property's instantaneous electrical power demand (kW) at a property, and also increase its annual electrical energy usage (kWh) significantly. This increase will be greater if the property makes use of direct electric heat (e.g. storage heaters, an immersion heater), compared with the increase in demand if a heat pump of any type is installed (e.g. air source, ground source).

Adding an electric vehicle charger will also increase the property's instantaneous electrical power demand (kW) at a property, and also increase its annual electrical energy usage (kWh).

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[4] Public Domain, https://en.wikipedia.org/w/index.php?curid=9720869

However, converting to “domestic” electric heating or installing a home EV charger (3kW or 7kW) may not necessarily require any upgrade to the property’s electricity supply if it does not result in the property’s assessed Maximum Demand exceeding 60 amps (60A, 13.8kVA, or about 12.4kW). The installer must assess the property[5] and the network operator must be informed. Some EV chargers are able to control their power flow so that the Maximum Demand of the property will remain within the 60A limit.

Properties which use several of the following existing high-power electrical technologies are more at risk of their assessment identifying a high Maximum Demand:

- Electric cooker
- Electric storage heating
- Electric water (immersion) heater
- Electric shower

The Energy Networks Association publishes a flow chart outlining the process for connecting an electric vehicle charger or heat pump to the distribution network:
www.energynetworks.org/assets/images/Resource%20library/LCT_Combined%20EV%20&%20HP%20Process%20v5.5.pdf

7.5 Grid aspects affecting installation of renewable generation

Most standard “domestic” renewable generation products (PV and small wind turbines) need to be connected to the existing electrical network in order to generate. This applies even if the consumer only wants to use the renewable energy within the property and not export any energy to other consumers.

The network operator has to be informed if a consumer proposes to install any generation. For installations larger than a typical rooftop PV system, the consumer has to apply for network operator permission to connect, and may have to pay for the property’s grid connection to be upgraded.

[5] https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks “There is guidance in the IET Code of Practice for EV Charging Equipment Installation on supply adequacy (Maximum Demand) assessment. … There are different approaches to determining a site’s MD, including: Use existing information […or…] Determine loads installed […or…] an internet-connected monitoring device.”
“When the existing Maximum Demand of a premises is above 60A, i.e. prior to any new electric vehicle chargepoints or heat pumps being installed, network operators will permit a “Connect & Notify” installation for a new EV chargepoint or Heat Pump under the following conditions:

- No issues with the existing connection (i.e. no safety concern, looped supply, unknown cut-out capacity, unmetered supply, insufficiently sized cut-out, etc – see Notes 1-6 on combined flowchart)
- The installation of the new device (EV chargepoint or Heat Pump) is installed with an EV/HP curtailment scheme such that, whenever that device is activated (i.e. drawing current), the overall MD of the property is limited to 60A or less.”

7.6 Type of electricity connection – using existing connections

A property with an existing electricity supply can install and connect a limited amount of renewable generation without needing to upgrade the supply.

The details of the existing electricity supply will affect the amount of administration, new infrastructure and cost that will be needed to connect any on-site renewable generation to the supply.

7.6.1 Low voltage (LV) single phase supply

Most households will have a low voltage (LV) single phase supply at 230 volts (230V).

Up to 3.68kW of type-tested renewable generation can be installed at these properties without needing to obtain prior permission from the network operator.

If space allows, up to 60kW might be installable (subject to Northern Powergrid confirmation) at one of these premises without needing to upgrade to a high voltage connection. It is probable that an upgrade of the distribution transformer and LV switchgear would be needed.

Collectively, in the parish, a total of approximately 320kW of roof-mounted PV might be installable at domestic premises without the property owners needing to upgrade any supplies. An additional total of ~100kW of PV might be installable on further properties, subject to network operator connection offers being applied for and accepted. (These estimates are explained in the Workstream 1 report.)

7.6.2 Low voltage (LV) three phase supply

Larger properties and small commercial enterprises may have an LV three phase supply (400V).

Up to 11kW of type-tested renewable generation can be installed at these properties without needing to obtain prior permission from the network operator, under Engineering Recommendation G98.

Up to ~190kW might be installable at each of these premises, subject to network operator assessment of the local network infrastructure, without needing to upgrade to a high voltage connection. It is probable that an upgrade of the distribution transformer and LV switchgear would be needed.

7.6.3 High voltage (HV) three phase supply

Premises with greater electrical demand may have a high voltage (HV) three phase supply. In Humshaugh this would be at 20kV. (It is possible but unlikely that a property would have a single phase HV connection.)

Large renewable generation installations (in the hundreds of kW range) are likely to need a new dedicated HV network connection. This will be designed by the network operator and/or an Independent Connection Provider. A large MW-scale installation might need a connection at 33kV or higher.

7.7 Distributing and using renewable generation – other options

The lowest cost way to distribute low carbon electricity is to connect it to the existing network.

However if this is not possible, or too expensive, other cost-effective enabling options could be explored. This might include:

- wider network upgrades;
- an Active Network Management system;
- a private wire network;
- energy storage.

8 Appendix B Electricity and carbon footprint

In theory it could be possible to achieve Net Zero in Humshaugh by installing enough renewable generation to offset its entire carbon footprint and then export any surplus energy to the wider UK network. In practice this could be limited by a number of local constraints.

The first step is to understand the possible amount of electrical power and energy that might need to be connected and distributed, and the capacity of the existing electrical network. Future electrical demand could be greater than the current local electrical demand, in part because low carbon electricity could replace other forms of fossil fuel energy used (as mentioned in the Newcastle University study).

The next step is to consider how the proposed generation sites could be connected and matched to the community's electrical load and identify the possible cost and practical implications of achieving that.

8.1 Available information

Electricity consumption could account for ~8% of the total carbon footprint of Humshaugh Parish, according to the report on the findings from an online survey of the households within Humshaugh Parish in 2020, which had a 30% response rate. The total electrical annual energy usage for the households in the survey was 498,040kWh, with properties varying from 1262kWh to 19467kWh – this shows how difficult it is to generalise about household electricity usage.

8.2 Reducing electricity consumption

For individual households, there is a considerable variation around this ~8% average figure. Size of dwelling, level of insulation, number of people in household and use of electricity as the main source of heating are the main factors accounting for this variation.

The survey also suggests that there may be scope to lower Humshaugh's carbon footprint from domestic electricity consumption, because just 35% of households surveyed have a smart meter and less than half of households (46%) have mostly 'low energy' light bulbs.

8.3 Reducing carbon footprint of grid electricity

In general, as Great Britain moves towards a lower-carbon generation mix, the carbon footprint of even "ordinary" electrical energy is reducing[6]. Green electricity tariffs supply consumers with low- or zero-

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[6] https://electricityinfo.org/real-time-british-electricity-supply/

https://carbonintensity.org.uk/

carbon electricity. However, from the Newcastle University survey currently only around 37% of Humshaugh households may be on some form of green low carbon tariff.

Households can easily convert to a low carbon electricity supplier without any change to their electrical network connection – it is merely a change of electricity supplier which can be done online[7]. Of course, a new supplier offer needs to be affordable.

8.4 Reducing carbon footprint by using more grid electricity

A significant amount of Humshaugh's carbon footprint is from transport and heating. The Newcastle University survey found that over three quarters (77%) of households surveyed rely on the direct burning of some form of fossil fuel to provide the main source of heating for their home, with 58% of households using oil for their main form of heating. Overall, home heating accounted for 28% and car transport accounted for 26% of all household CO2 emissions.

Transferring away from using fossils fuels, and using electric vehicles and electric forms of heat, could reduce overall carbon emissions, because grid electricity is relatively low carbon, and becoming more so. So increased electricity usage could in fact indicate that Humshaugh's carbon footprint is reducing, rather than increasing. Assessing whether a change in electricity consumption upwards or downwards is beneficial overall would need careful and broad-ranging energy use assessment.

8.5 Renewable generation – how much would be needed

Balancing out Humshaugh's electrical energy demand with low carbon generation needs the amount of renewable power and energy that will be required to be calculated, or at least estimated.

This can be based on:

- current electricity usage
- forecast "normal" growth (or reduction) in electricity usage as a result of changes in the electricity use of existing customers
- possible increased usage as new properties are built in the parish
- possible reductions in electricity usage due to energy efficiency measures
- possible increased electricity demand as households convert to electric heating and vehicles.

[7] https://www.ofgem.gov.uk/consumers/household-gas-and-electricity-guide/how-switch-energy-supplier-and-shop-better-deal

8.6 Improving understanding and gathering more information

At the moment, the only concrete information available is the Newcastle University survey which provides a snapshot of about a third of the parish.

Discussions with Northern Powergrid have led to them offering to install monitoring on the ground-mounted substations in the village, and making the results available to HNZ. This is part of an ongoing monitoring rollout.

Improved and more detailed measurement of the different types of energy use in the parish will be an essential feature in enabling HNZ to understand and implement its progress towards Net Zero.