This Project is supported by the BEIS funded Rural Community Energy Fund which is managed by the North East Yorkshire and Humber Energy Hub and administered by Tees Valley Combined Authority

BARNINGHAM ENERGY SURVEY

Produced by TEC Ltd on behalf of, and in association with, Barningham Net Zero Community Interest Company

Funded by the Rural Community Energy Fund (RCEF)

Report prepared by Ewan Boyd of Teesdale Environmental Consulting Ltd.
and Barningham Net Zero Community Interest Company

teclimited@btinternet.com info@barninghamnetzero.com

November 2020

Synopsis

The survey of energy usage in the Barningham area was the first step towards developing a community owned renewable electricity generation scheme and assisting in reducing environmental impacts associated with energy use. The survey of households, commercial premises, local village hall and church, achieved a very high response rate. Information returned was of good quality, enabling a thorough analysis of energy use and issues in the study area.

The survey was successful in the intended objectives of gathering key data and establishing a baseline energy usage pattern.

A positive finding of the survey is that a quarter of local energy is already supplied by wood products, which are sustainable and low in carbon emissions. There are also some individual households with renewable energy technologies fitted.

The high cost of electricity relative to the amount of energy provided was confirmed. However, we also identified opportunities for households to reduce their energy costs, including immediate savings by changing to a cheaper supplier or tariff. In addition, most properties would benefit from installation of additional energy efficiency improvements (e.g. thicker insulation, double glazed windows and modern boilers). These would reduce energy usage and costs over time. The Barningham Net Zero team will work on ways of supporting local people in making these changes.

The current electricity demand for Barningham and the surrounding area was determined to be 658,700 kWh per year. This provides the baseline needed for planning a renewable electricity generation scheme. Local electricity use is predicted to increase in the future and an additional income stream for the area would be beneficial. Therefore, a larger generation scheme will be put forward for community consideration as part of the Barningham Energy Project. The primary aim of the community-owned renewable generation scheme is to reduce electricity costs for local households and provide funds for energy efficiency improvements. It would also reduce greenhouse gas emissions equivalent to the local usage and contribute clean, renewable electricity to the national supply.

To achieve a “net zero” Barningham, it will also be necessary to eliminate or substantially reduce fossil fuel use: principally oil, which is the main heating fuel and responsible for over two-thirds of our greenhouse gas emissions. Solid fuel (e.g. coal) and LPG are also fossil fuels whose use will eventually be phased out. The survey highlights the importance of identifying alternative heating and cooking solutions. These will be investigated as part of the Barningham Energy Project.

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Disclaimer

The information contained in this report is accurate at the time of writing and has been checked by TEC Ltd and Barningham Net Zero for consistency and validity. Where assumptions have been made these have been stated, and a number of areas of uncertainty have been highlighted. The results contained in this report do not constitute guarantees of performance or cost, and TEC Ltd and Barningham Net Zero will not be liable for any losses arising from acting on the conclusions of this report.

1 INTRODUCTION

This report has been prepared under the Barningham Energy Project, a project supported by the Department for Business, Energy and Industrial Strategy funded Rural Community Energy Fund (RCEF) which is managed by the North East Yorkshire and Humber Energy Hub and administered by Tees Valley Combined Authority.

The baseline energy survey was commissioned by Barningham Net Zero Community Interest Company (hereafter referred to as Barningham Net Zero) to gather data on energy use and associated building factors in and around the village of Barningham, County Durham, and adjacent properties in the Parish of Newsham, North Yorkshire. The information collected will be used to inform the development of a community energy scheme for generation of electricity from renewable resources as well as evaluating sustainable household heating solutions. These are the first steps towards achieving the aspiration of Barningham becoming a net zero carbon emissions village.

The survey was conducted by Teesdale Environmental Consulting Ltd (hereafter referred to as TEC Ltd). Data was collated and analysed by TEC Ltd in accordance with Barningham Net Zero's Data Protection Policy. Data has been anonymised as far as possible, with individual household data not addressed within this report.

2 METHODOLOGY

2.1 Survey content

The residential energy survey was nominally divided into three sections:

- Household and house, which focused on occupants and descriptors of the buildings
- Heating and hot water, which was concerned with the nature of the heating systems and fuels used
- Energy consumption, primarily concerned with data on the cost and amount of energy consumed.

Additional questions covered existing energy efficiency measures, heating and condensation problems, plans for future energy efficiency improvements, interest in receiving further information and preference for method of contact (or no contact).

An adapted form was provided for non-residential properties.

Due to the incidence of Covid-19, respondents were asked to provide energy consumption data based on “normal” conditions, e.g. from 2019 if available or adjusted figures representing a future “normal” for the household.

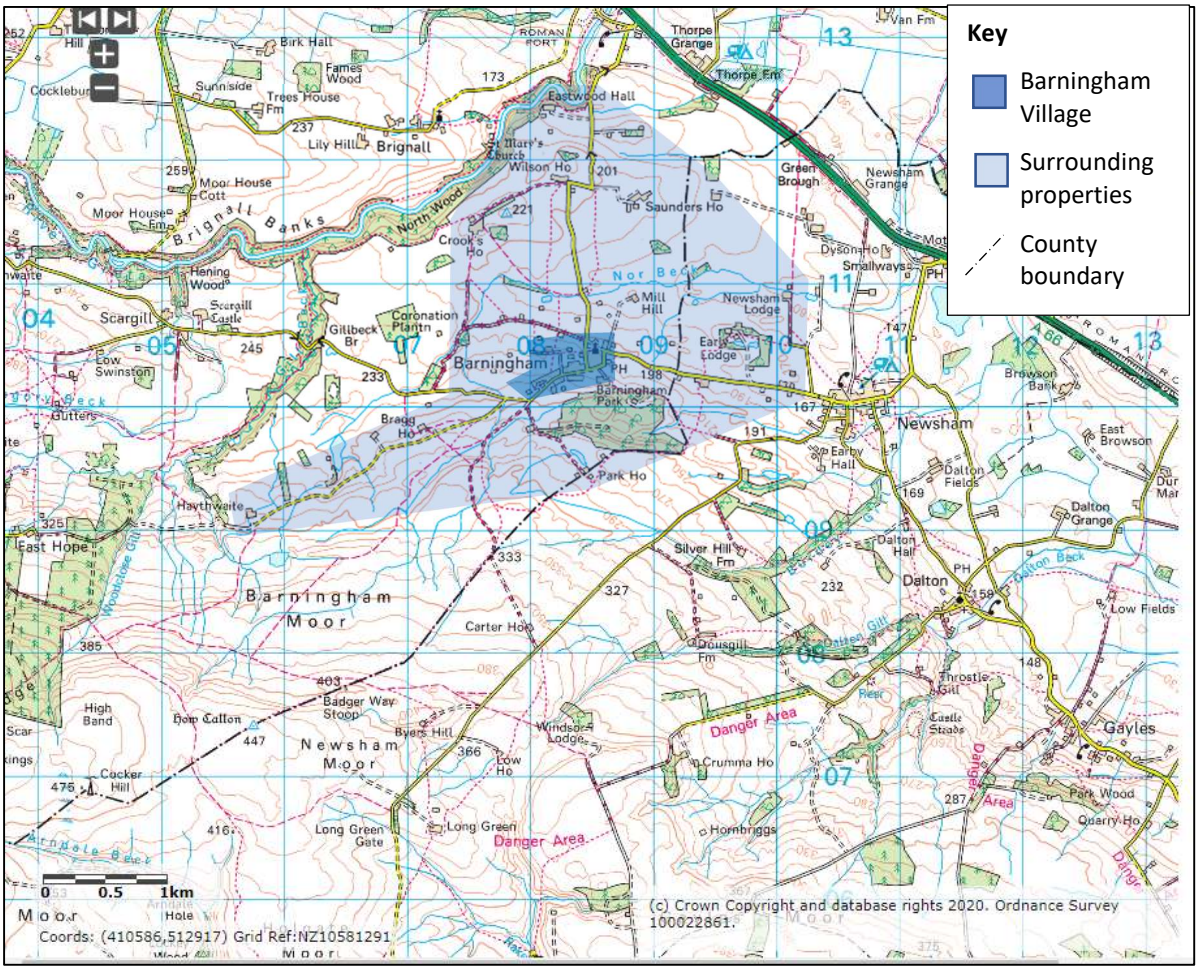
2.2 Survey area and distribution

The survey covered all properties in the village of Barningham, County Durham and additional properties in the surrounding area, as shown in Figure 2.1 below. All the properties included have a Barningham post code but some are located in North Yorkshire.

The energy survey was distributed in hard copy, delivered to all households in the participating area during August and September 2020 by Barningham Net Zero. An electronic version was also available for return by email. Surveys were returned to TEC Ltd directly in pre-paid envelopes by post or via email.

Ninety-two (92) surveys were distributed to the main village and surrounding areas. Of these, 84 were to occupied residential properties, 3 to owners of holiday cottages, 2 to owners of properties unoccupied at the time of the survey, and 1 each to St Michael and All Angels Church in Barningham and Barningham Village Hall. A single survey was provided to Barningham and Holgate Estates (hereafter referred to as Barningham Estate), the major local landowner, which returned data for a number of properties and businesses.

Figure 2.1 – Map of survey area



2.3 Data analysis and assumptions

Data from the returns was collated by TEC Ltd. The response information was anonymised as far as possible. Each return was assigned a unique reference number, with individual household data not addressed within this report.

The data was analysed to evaluate:

- How representative the response was relative to local census data and house types
- Energy and energy efficiency issues within the survey area
- Energy types used, their consumption and generation of carbon dioxide emissions which provides an indication of contribution to global warming

A number of assumptions have been adopted for the analysis and some of the calculations are based on assumed numbers of properties in the village or surrounding area.

A total of 63 properties were occupied in Barningham village at the time of the survey, with 5 properties unoccupied. The wider area included 24 occupied properties and 1 unoccupied property.

In addition to the properties described above, there are 6 properties in the village used as holiday lets and a further 1 holiday cottage in the outlying area. For the purposes of the energy analysis, where no data has been provided, it has been assumed that these consumed 50% of the energy of the domestic average calculated from the survey respondents.

New developments at Hill Top and Glebe Farm are projected to add 9 properties in total to the village. It is understood that these are being designed with heat pump technologies. For the purposes of calculating carbon emissions, it has been assumed that these properties will be 100% electric.

Where no cost data was supplied by respondents, typical costs were used based on local prices. These are shown in Table 2.1.

Table 2.1 - Typical energy costs for domestic users[1]

Fuel	Unit	Cost
Electricity	kWh	£ 0.16
Oil (for domestic uses)	litre	£ 0.33
LPG bottled	kg	£ 1.42
Solid fuel (e.g. domestic coal)	tonne	£ 240.00
Biomass (wood products including logs)	tonne	£ 350.00

For calculation of overall energy demand, the non-electric energy sources were converted to kilowatt hours (kWh). The conversion factors were back calculated from data provided by the Department for Business, Energy and Industrial Strategy (BEIS)[2] and the assumption that the bottled LPG used is propane.

The conversion factors and typical costs per kWh for each type of fuel used are shown in Table 2.2.

[1] Unit costs estimated by TEC Ltd based on local knowledge of Teesdale energy prices.

[2] Energy content and conversion factors from BEIS data 2019
www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

Table 2.2 - Energy equivalents in kWh and typical associated costs

Fuel	Unit	kWh / unit	Pence / kWh
Electricity	kWh	1	16.0p
Oil (for domestic uses)	Litre	9.78 kWh / litre	3.4p
LPG bottled	Kg	13.7 kWh / kg	10.4p
Solid fuel (e.g. domestic coal)	Tonne	7500 kWh / tonne	3.2p
Wood chips	Tonne	3776 kWh / tonne	9.3p
Logs	Tonne	4084 kWh / tonne	8.6p

Emissions of carbon dioxide (CO_2) were calculated using factors provided by BEIS for reporting of greenhouse gas emissions. It is standard practice to report greenhouse gas emissions in tonnes of CO_2 equivalents (CO_2e), which provides a measure of all greenhouse gases produced. Combustion of fossil fuels, for example, also produces significant emissions of methane and nitrous oxide, both of which are gases that cause global warming. The most recent conversion factors provided by BEIS for 2019 were used for oil, LPG, wood products and solid fuel. The factor for electricity has been changing significantly year on year as discussed below. For this assessment, data from 2016 to 2019 was reviewed and showed a substantial reduction. It was therefore assumed that there is a further 10% reduction in 2020 over the 2019 factor. The factors used for the data analysis are listed in Table 2.3 below.

Also shown in Table 2.3 are the CO_2e per kWh for each source of energy used in Barningham. This enables a direct comparison of the significance of the different energy sources used.

Table 2.3 - Carbon dioxide emission equivalents (CO_2e) from energy sources[3]

Fuel	CO_2e, kg / unit	CO_2e, kg / kWh
Electricity	0.230 / kWh	0.230
Oil (for domestic uses)	2.54 / litre	0.247 *
LPG bottled	2.93 / kg	0.214 *
Solid fuel (e.g. domestic coal)	2745 / tonne	0.345 *
Wood chips	59.0 / tonne	0.016
Logs	63.8 / tonne	0.016

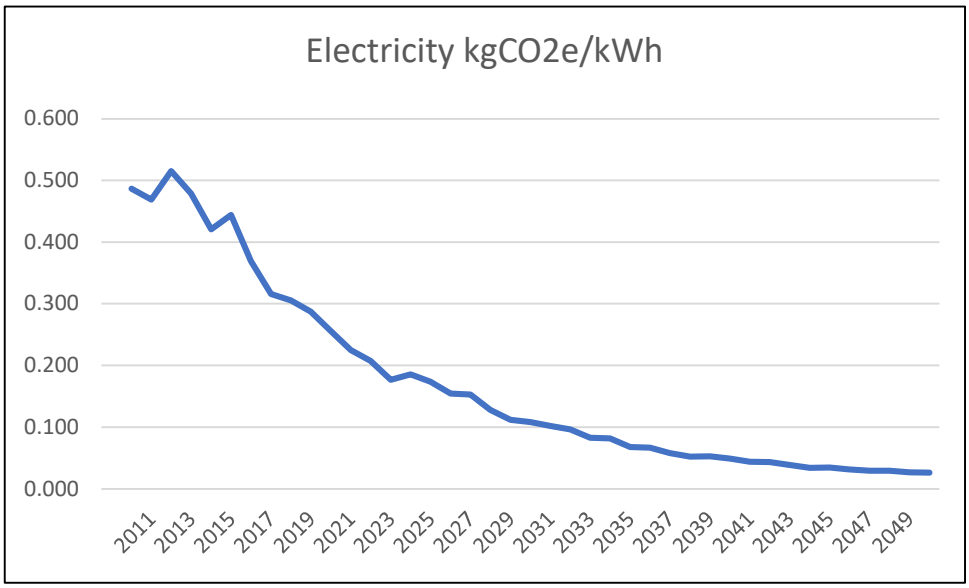
* Based on net calorific value

[3] Conversion factors from BEIS data 2019 www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019. Carbon emissions for UK electricity supply have been reduced by 10% to allow for anticipated decarbonisation in the current year.

It is notable that currently, there is little difference between CO_2e emissions from the use of electricity versus oil. This is because the current mix of sources used to generate electricity includes significant proportions of fossil fuels. Nevertheless, the mix is changing rapidly. Since 2011, the CO_2e emissions from electricity have almost halved due to reducing dependency on coal and increasing use of renewable generation sources. During 2020, the proportion of electricity generated by renewables is approaching 50%.[4]

Over the next 30 years, the government predicts further significant reductions in greenhouse gases from electricity generation. By the mid-2040s, CO_2e emissions are expected to be 1/10th of the current rate as shown in Figure 2.2.

Figure 2.2 – CO_2e emissions from UK electricity supply, 2011-2050[5]



2.4 Treatment of Barningham Park data

Barningham Park is a very substantial and atypical property, with a markedly higher energy demand than other residences. Although Barningham Park was included when calculating total energy data for the village and survey area, it was not considered appropriate to include it when averages were being calculated.

Where averages were required for extrapolation purposes, Barningham Park data was removed from the averaging calculation, then added back in to obtain the overall total.

[4] Source: UK energy statistics: statistical press release – September 2020 https://www.gov.uk/government/news/uk-energy-statistics-statistical-press-release-september-2020

[5] Source: https://www.gov.uk/government/publications/industrial-emissions-directive-derogation-cost-benefit-analysis-tool

2.5 Management of biomass data anomalies

Data was provided from Barningham Estate for point of use biomass (wood chip) consumption at the two district heating schemes currently operating in the village (at the Milbank Arms and the Barningham Park boilers). These serve several residential properties, holiday cottages, the pub, the church and Barningham Coach House, which is occupied by a restaurant, bakery and office units. The data on the amount of energy produced by the boilers (system input energy) was not divided between end users so it was not possible to accurately separate out the supply to the residences.

Some residences did provide consumption data but this is not strictly speaking comparable and could not be used to calculate the non-residential consumption.

The point of use energy data provided by Barningham Estate is the amount of energy produced by the boilers (system input energy), whereas the household survey data is for delivered energy (i.e. energy used at participating properties). The latter figure does not account for distribution system losses, typically 30% of the gross energy input.

Unless otherwise stated, the calculations in this study are based on the gross energy input figure, rather than the delivered energy measure. While this means a higher count of biomass energy, it is considered appropriate within the study to overestimate the usage. Firstly, this is because the delivery network is fairly small and losses may be less than the typical 30% stated. Secondly, if the biomass were to be replaced by an alternative energy source in the future (for example, by electricity), the higher energy value would be a more accurate measure of the supply required.

2.6 Energy content of wood products

Additional uncertainties are inevitable for wood products, given the widely differing energy content of different types of wood, varying moisture levels affecting energy output and different combustion regimes.

There is limited variation in the energy content of different woods at identical moisture content levels but different densities of tree species mean that the energy content from any given volume of wood can alter substantially. Hardwoods are typically around 30% denser than softwoods, at 700kg/m^3 compared to 500kg/m^3. As logs are generally purchased by volume, gathering accurate energy data is therefore difficult. Moisture content of wood also makes a substantial difference, with significant losses of energy output as the moisture content rises above 20%.

These issues are not resolvable within the context of this study, so the actual energy consumption from wood products remains one of the greatest uncertainties within this analysis. However, these sources are potentially sustainable with sufficient replanting and represent low CO_2e emission sources. Therefore, this uncertainty is seen as of less importance within the survey reporting and overall project objectives.

3 SURVEY RESPONSE

3.1 Returns

A total of 44 individual responses were received, from or on behalf of Barningham village residents, representing 70% of occupied houses. This is considered an excellent response rate for this type of household survey and much credit is due to the Barningham Net Zero team for this achievement. This highlights the benefits of engagement, prior discussion and briefing of local residents when such projects are being considered.

Barningham Estate provided data for several properties and buildings. Surveys were also returned for Barningham Village Hall and St Michael and All Angels church. Within the main village, 18 residential properties are owned by Barningham Estate, with 4 of these understood to be holiday lets. A total of 7 survey returns were provided from these properties, plus consumption data for the holiday lets from the Estate.

Eight responses were received from households in the surrounding area, representing 33% of occupied properties.

Additional data was provided by Barningham Net Zero for 26 properties in the main village area that did not return survey forms, including 4 properties which were unoccupied at the time and 2 used for holiday lets. No additional data was provided for 17 properties in the surrounding area that did not return surveys.

3.2 Data quality

The data quality provided by respondents is thought to be good. This is particularly so for the household and house data as well as for the heating and hot water section.

Most respondents provided reasonable quality data for fuel use by annual cost and approximately 50% provided consumption data. Overall consumption was derived from the cost data provided and cross referenced to typical unit prices where this was absent. This will inevitably lead to estimation errors for individual properties but given the sample size, such variations should largely average out across the sample.

Most respondents were able to name their utility company (only 6 could not) while 38 could name their tariff.

In general terms the survey has been successful in the intended objectives of gathering key data and establishing a baseline energy usage pattern.

4 DATA ANALYSIS FOR RESIDENTIAL PROPERTIES

4.1 Household residents and property details

The analysis of data from residential properties was limited to the main village only (44 properties), except where otherwise stated. The data from the outlying areas is not included within this analysis as the return rate was much lower and may not be representative.

The survey identified 84 residents within the responding properties at an average of 1.91 people per property (allowing for three non-responses to this question).

Responses were heavily weighted to the over age 60 category, with 45 residents over the age of 60 in 28 properties and just 7 residents under the age of 16 across 5 properties. This suggests that 53.6% of the population in the survey area are over the age of 60 while just 8.3% are under the age of 16.

To determine how representative the respondent population is, the findings were compared with the 2011 census data for the area, as shown in Table 4.1. The Barnard Castle West E00105847 output area[6] covers a slightly bigger area of outlying properties but provides a valid benchmark for the comparison. While the survey area differs slightly from the census unit, the results suggest that the survey response may be weighted to an older population profile.

Table 4.1 – Comparison of survey response with 2011 census data

Statistic	Survey Response for Barningham Village	2011 Census Data for Barnard Castle West E00105847
Number of households	44	101
Average number in household	1.91 residents	2.41 residents
Over age 60	53.6%	33.2%
Under age 16	8.3%	18.3%

Additional information provided by Barningham Net Zero for the non-response list identified a further 9 residents under the age of 16 at 6 properties and 13 residents over the age of 60 at 8 properties. Overall, while the responding sample does appear to slightly under estimate households with children under the age of 16, the level of undercounting is not felt to seriously undermine the findings.

[6] See http://ukcensusdata.com/barnard-castle-west-e00105847

Most responding properties were owner occupied (35 or 80%) with 7 two-bedroom properties, 14 with three bedrooms and 11 with four, with the remainder with five or more. The majority of properties were detached or semi-detached (20 and 16 respectively) with the remainder split between mid or end terrace.

The majority of properties were pre-1900, with 35 being solid wall construction and the remainder more recently built houses being brick cavity construction.

While the ownership status of the non-responders is not known, the house types were very close to the responding sample, suggesting that extrapolation of results to the full survey population is valid.

From here on, unless specifically noted, the percentage description of responses should be read as the proportion of responding properties.

4.2 Energy efficiency measures

The survey included questions on energy efficiency measures, including presence and thickness of loft insulation and double glazing.

The responses to loft insulation questions suggest that this could be a significant area for improvement. It is also one of the cheapest and most cost-effective means to reduce heating consumption. Just 9 respondents indicated the presence of 300mm of insulation (the currently recommended standard) and only 9 households had added insulation within the last 5 years.

Around 43% of all properties reported 100% double glazing (19 in total). This is likely to be a second area where cost savings are possible, although there may be practical difficulties issues in listed buildings, of which there are 27 in the village, and a few more in the surrounding area.

4.3 Condensation and warmth issues

Over one third of properties (17 or 38.6%) reported condensation issues, which is high, but not unexpected, given the housing characteristics. A quarter of properties (12 or 27.3%) reported a desire to increase the general warmth level in their homes.

4.4 Residential heating and hot water

The majority of properties in the main village sample (33 or 75.0%) use oil as the primary heating fuel, with 11.4% (5 properties) using electricity, 15.9% (7 properties) using biomass and a single property each using solid fuel and LPG.

A substantial number of respondents (29 or 66%) also use logs as a secondary source of heat.

For those reporting the age of boiler, the average age of installation was 13 years, with only 11 of the boilers under 10 years old. This suggests that boiler age is likely to be a source of inefficiency in many properties.

Uptake of renewable and sustainable technologies was found to be low (22.7%, 10 properties). Of these, the majority (7 properties) were on biomass) systems with just 2 properties having solar PV and 1 with a solar thermal system.

The above does not account for properties on green electricity tariffs.

Most respondents answered the questions on boiler type, presence of hot water tank, and technical questions about the heating system(s), which provide useful background data but have not been summarised here.

4.5 Electricity suppliers and tariffs

A notable feature was the range of electricity suppliers and tariffs in use. Respondents listed 15 different supply companies with multiple tariffs evident. Nearly half of properties (19 or 43.2%) had changed supplier within the last three years. The majority of those that reported their tariff plan appear to be on fixed or discount plans. Eight properties (18.2%) are on standard variable tariffs which are generally poor value.

A more significant issue may be that over half of respondents (28 or 63.6%) did not report their tariff. Over half of these (15 of the 28) have not changed supplier recently, so it is possible that the number of properties on standard variable tariffs is much higher than 18.2%. A general finding is therefore that concerted action to secure the most appropriate tariffs and to encourage supplier switching may be an effective way to reduce costs.

4.6 Residential energy consumption and carbon budget

All but 5 respondents provided some cost data for energy consumption, with around half providing an assessment of actual energy consumption. In line with previous comments, errors from estimation of consumption for individual premises are likely to balance out and the aggregate figures can be taken to be reasonably accurate.

Where required, cost data was converted to estimated kWh usage by means of a standard assumed unit conversion (see Table 2.2 above) and vice versa. These conversions are potential sources of error but are still considered to be the most practical approach to calculating aggregate energy use.

In total, 40 respondents provided sufficient cost or consumption data for extrapolation purposes. The average household cost is £2,150 per annum for an average energy demand of 31,900 kWh (excluding Barningham Park as per Section 2.4). These figures are thought to be appropriate for estimation of the total domestic usage and spend in Barningham and surrounding area, as shown in Table 4.2.

Table 4.2 – Estimated total energy costs and consumption for domestic properties

	Total domestic energy spend	Total domestic energy use
Barningham village	£155,500	2,284,000 kWh
Full survey area	£212,500	3,108,000 kWh

The pie charts below illustrate the data provided by the 40 respondents on energy costs, energy provided by fuel type and global warming emissions. Figure 4.1 shows the energy spend by fuel type (from the responding properties); Figure 4.2 shows the proportion of energy provided from each fuel type (measured in kWh equivalent); and Figure 4.3 shows the relative contribution of each fuel type to greenhouse gas emissions (as carbon dioxide equivalents, CO_2e[7]).

In regards to the CO_2 emissions from electricity use, it assumes that all residents use electricity derived from the national mix of fuels and sources. This overestimates the greenhouse gas emissions from Barningham properties, as some residents purchase electricity from renewable energy suppliers or are on “green” tariffs offered by other suppliers. It is presumed that the latter are lower in carbon emissions than the national average.

[7] CO_2e or ‘carbon dioxide equivalent’ is used to denote all greenhouse gas emissions benchmarked against the equivalent volume of CO_2

Figure 4.1 – Barningham Village Respondents, Energy Spend by Fuel Type

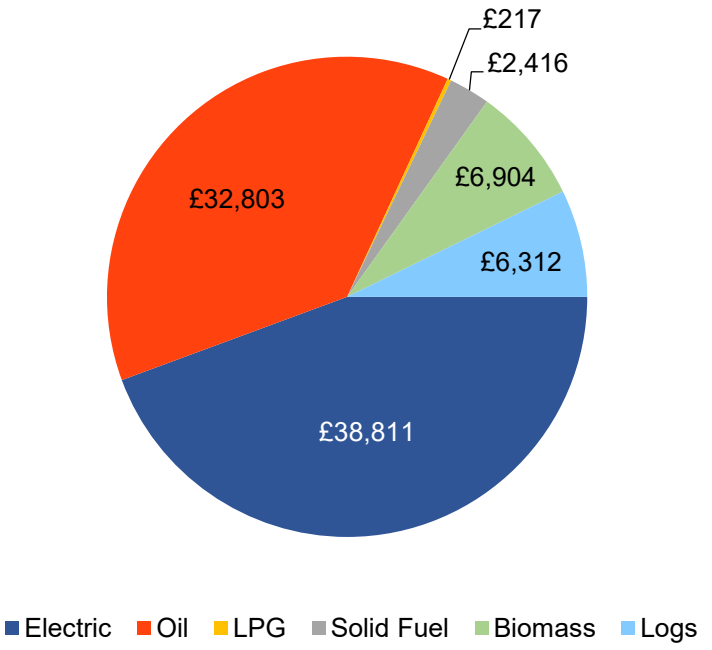


Figure 4.2 – Village Respondents, Energy Consumption (kWh) by Fuel Type

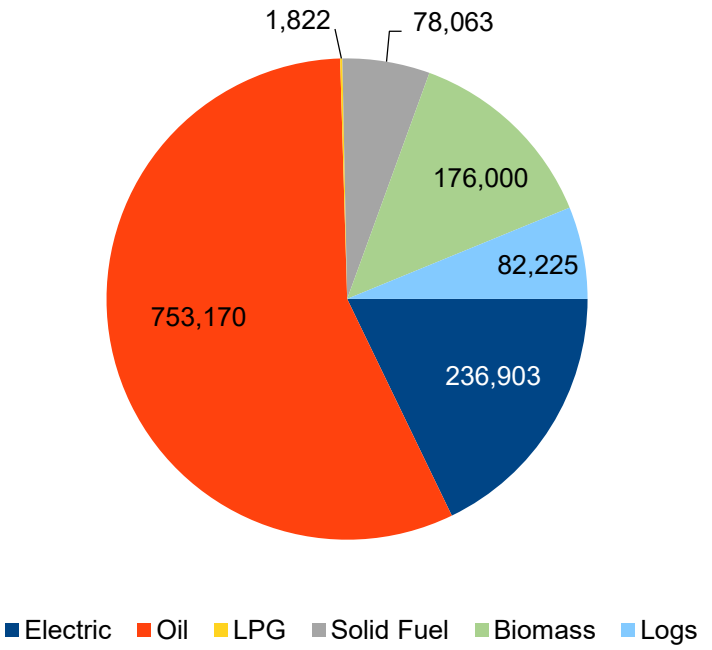
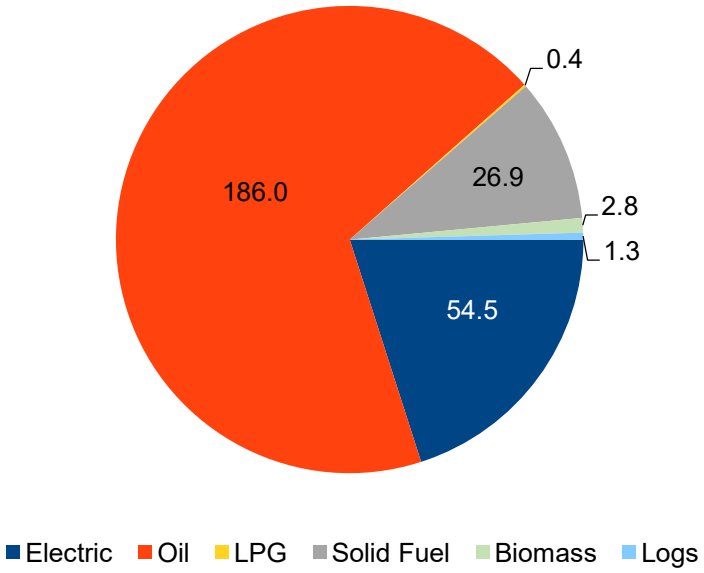


Figure 4.3 – Barningham Village Respondents, CO_2e (tonnes) by Fuel Type



To extrapolate data to the full survey area, the figures presented above were adjusted by removing Barningham Park data (as per Section 2.4) when calculating average values, then adding it back in for the final total.

A further adjustment to the aggregate data has been made with respect to the biomass usage. Within the village, there are two biomass district heating systems operated by Barningham Estate, serving 9 properties, and a system that serves an individual residence. Seven of these properties provided survey returns, but extrapolating these results to the remaining non-responding properties in the village and the wider area which are not on the biomass heating systems would overestimate biomass usage. Therefore, aggregated costs, consumption and CO_2e by fuel type data are based on the 33 non-biomass responding properties. The biomass data for properties on the two district heating schemes are returned into the calculations at the end and an uplift included for the additional household operating a self-contained biomass unit.

Table 4.3 below shows the resulting amounts estimated for energy spend, energy consumption and CO_2e emissions from domestic energy consumption aggregated across the full survey area.

Table 4.3 - Estimated annual domestic energy spend, usage and CO_2e emissions by fuel type, full survey area

	Electricity	Oil	LPG	Solid fuel	Biomass	Logs	Total
Cost	£95,100	£85,500	£600	£5,200	£9,400	£16,700	£212,500
kWh	580,400	1,930,600	5,000	171,100	203,000	217,700	3,107,800
CO_2e (tonnes)	133.5	476.9	1.1	59.0	3.2	3.4	677.1

4.7 Summary of residential household results

Overall, it is considered that the survey has achieved a good level of coverage and provided sufficient, representative data to be useful in planning the scale of a community owned renewable electricity generation scheme. The survey confirmed that there are a variety of energy efficiency issues within the housing stock surveyed some of which could be addressed by investing in improvements.

5 OTHER ENERGY CONSUMPTION

There is some additional energy consumption arising from commercial users and non-residential buildings, which was collected by an adapted survey form and meetings with representatives of the respective entities.

Data provided from Barningham Estate for point of use biomass consumption at the two district heating systems was evaluated to remove residential use. The remaining usage pertains to the Milbank Arms Pub, associated holiday cottages, St Michael and All Angels Church, and Barningham Coach House, the last of which is occupied by a restaurant, bakery and office units. The assessment suggests that an additional 474,000 kWh of biomass energy should be added to the overall aggregate village energy demands to account for supplies to these buildings.

An additional 78,370kWh of electrical demand has been added to the whole area domestic total to account for the electrical demand of the various Estate owned properties at the Coach House, the Milbank Arms as well as the Village Hall and the church and an independent business owner.

A small amount of LPG usage was also added in respect of some of the above properties.

6 AGGREGATE DATA FOR SURVEY AREA

This section presents the aggregate data of existing energy use for the full survey area, with breakdown by cost, energy provided and greenhouse gas emissions in Figures 6.1 to 6.3.

A number of key factors are illustrated by the breakdowns in the charts. Firstly, it is clear that while electricity is the most expensive fuel (in terms of both cost per kWh and overall spend per annum) it is less prominent in terms of the energy provided and CO_2e emissions data. Electricity accounts for 44% of energy costs but only 18% of the local energy supply and 22% of CO_2e emissions.

The amount of CO_2e emissions from electricity consumption has changed markedly in recent years with the reduction in the carbon intensity of the national grid (as per Section 2.3 and Figure 2.2). Ten years ago, electricity contributed around 0.55kg CO_2e/kWh but has reduced to an estimated 0.23 CO_2e/kWh in 2020. At present, this places it slightly below oil, which generates 0.247kg CO_2e/kWh. Moving forward, the greenhouse gas emissions from electricity generation will steadily reduce to a near net zero carbon value by the mid-2040s, as the proportion contributed from renewable sources is maximised.

In contrast to electricity, oil is the main heating fuel, comprising 53% of energy demand, despite only contributing 35% of costs, but is by far the largest source of CO_2e emissions at 68% of the total. The contribution of oil to fuel costs reported in the survey is likely to be distorted by the abnormally low international oil prices following the Covid-19 pandemic.

A third notable feature of the results is the relatively high contribution from wood sources. Combining biomass and logs produces a total that accounts for 18% of energy costs and provides 24% of the total energy consumption. However, these sources only contribute 2% of local CO_2 emissions as wood is a very low carbon fuel. The considerable uncertainties associated with the biomass data are noted in Sections 2.5 and 2.6, yet the overall conclusions are considered valid.

Finally, the contribution of solid fuel (e.g. coal) is relatively limited. This accounts for 2.1% of costs, but 4.7% of consumption by kWh and 8.4% of greenhouse gas emissions. The phase out of solid fuels in the near future is discussed further in section 7.5.

Figure 6.1 – Total Energy Cost by Fuel Type, All Users

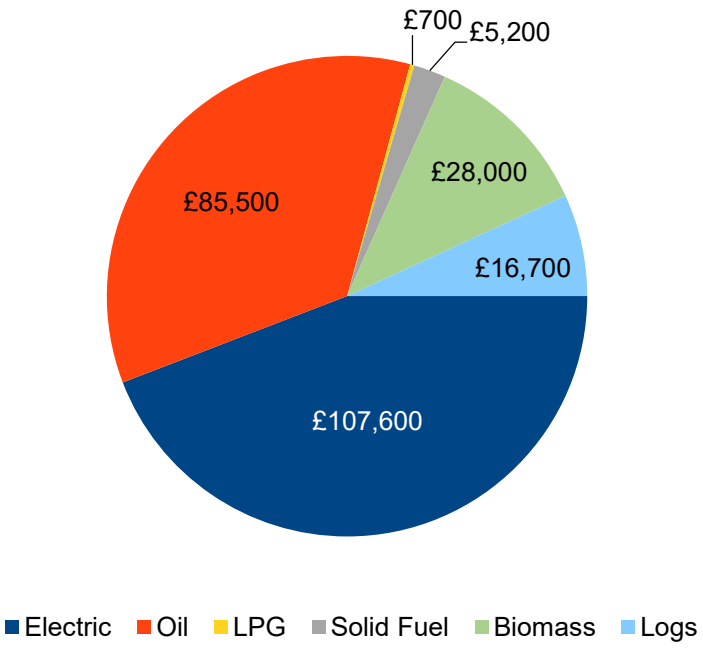


Figure 6.2 – Total Energy Use (kWh), All Users

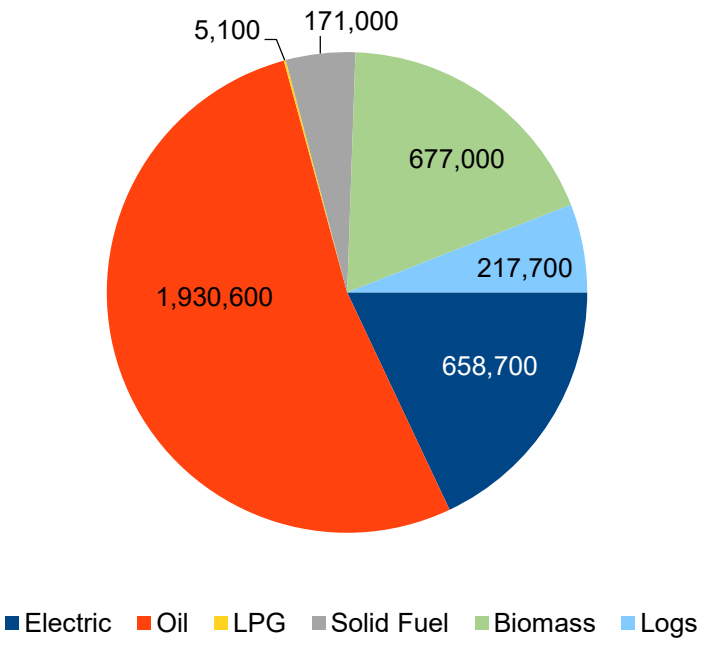


Figure 6.3– Total CO2e (tonnes) Emissions by Fuel Type, All Users

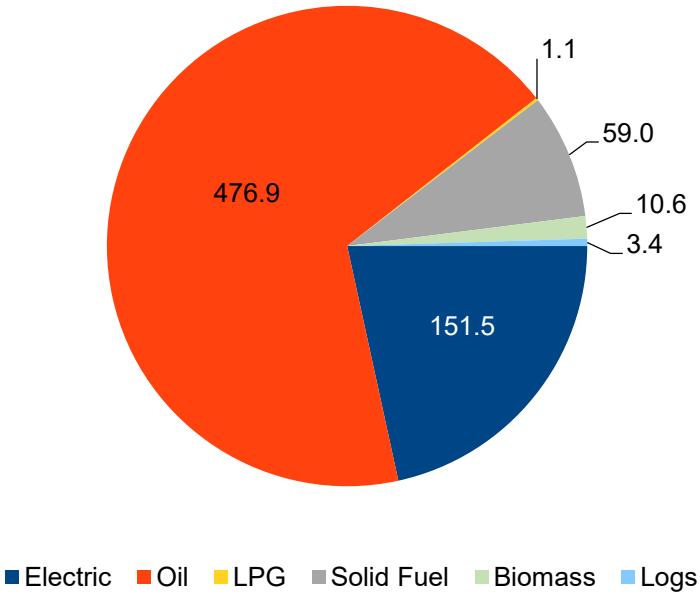


Table 6.1 provides the summary data of the aggregated estimated energy cost, consumption and CO_2e emissions for the survey area, including domestic properties and additional commercial enterprises.

From the table it can be seen that the survey suggests total annual energy consumption is around 3,660MWh, at a cost of £243,700 and with associated CO_2e emissions of 703 tonnes. To add some context to the greenhouse gas emissions, given the density of dry air of 1.2kg/m^3, the results suggest that Barningham and the surrounding area emits a volume of 585,000m^3 of CO_2 per annum, the equivalent of filling St Paul's Cathedral nearly four times.

Table 6.1– Estimated annual total energy costs, consumption and CO_2e emissions for the full survey area

	Electricity	Oil	LPG	Solid fuel	Biomass	Logs	Total
Cost	£107,600	£85,500	£700	£5,200	£28,000	£16,700	£243,700
	44.2%	*35.1%*	*0.3%*	*2.1%*	*11.5%*	*6.9%*	
kWh	658,700	1,930,600	5,100	171,000	677,000	217,700	3,660,100
	18.0%	*52.7%*	*0.1%*	*4.7%*	*18.5%*	*5.9%*	
CO_2e (tonnes)	151.5	476.9	1.1	59.0	10.6	3.4	702.5
	21.6%	*67.9%*	*0.2%*	*8.4%*	*1.5%*	*0.5%*	

7 DISCUSSION

As a general comment, it should be noted that the survey provides a single snapshot in time. Energy consumption, particularly heating loads, vary from year to year dependent on prevailing weather patterns. Moreover, changes and improvements to properties in the area will alter energy consumption in the future. Nevertheless, the data collected and estimates of energy demand in the Barningham area, provide a useful benchmark for planning the community renewable electricity project as well as highlighting the need for sustainable solutions to household heating.

Comments on the findings follow, including an exploration of potential future steps to achieving a “net zero” Barningham.

7.1 Potential to reduce energy use and costs

The Barningham energy survey has identified a number of areas to consider for future reductions in energy costs and use. Respondents on standard variable tariffs from a long-standing supplier could probably reduce their bills by changing to a discount plan from the same supplier or seeking an alternative supplier. Energy costs could also be reduced by improving energy efficiency through increasing the use of and / or thickness of loft insulation, as well as installation of double or triple glazed windows and doors.

As part of the Barningham renewable energy project, a series of information factsheets will be provided on all aspects of energy use and improvements in home energy efficiency. This may be helpful to assist households in reducing energy use and associated costs.

Further comments on potential improvements in energy use are provided below by fuel type.

7.2 Wood products

The high level of biomass and log consumption within the survey area is positive, with 24% of energy consumption already supplied from sustainable, low carbon sources.

Increasing the use of wood products in the fuel mix would improve sustainability and reduce carbon emissions. Currently the economics of retrofit district heating schemes are difficult to justify and there are some additional issues of air quality that are becoming an increasing concern with regards conventional heating stoves.

The use of individual biomass systems for home heating and cooking in the Barningham area will be evaluated in early 2021 under the Barningham Energy Project. A factsheet about the use of such systems will be produced on conclusion of the study.

In the meantime, anyone who wants to reduce emissions from wood burning devices or increase energy efficiency should consider the following steps:

- Purchase and burn only hard woods with less than 20% moisture
- Consider replacement of existing wood stoves or fires with a newer model that meets the 2022 regulations set out in the Clean Air Act and is approved as compliant by the Stove Industry Alliance. New models have 90% lower particulate emissions than open fires and 80% less than older stoves. They are also significantly more efficient in regards to fuel use.

7.3 Electricity and the potential for generation from renewable sources

In the Barningham area, electricity accounts for only 18% of total energy consumption, comprising a total of 659MWh [8] based on existing use. It is also the highest cost fuel: 44% of current energy costs. Installation of a community owned renewable electricity generation scheme has the potential not only to reduce costs but also to eliminate the greenhouse gas emissions associated with its generation.

Prior to the installation of a local renewable electricity scheme, anyone who wants to reduce costs and / or emissions associated with electricity use should consider the following steps:

- Contact your energy supplier to see if you can move to a cheaper tariff
- Use an electricity switching site to identify alternative suppliers who may be cheaper, see for example:

  https://www.citizensadvice.org.uk/consumer/energy/energy-supply/get-a-better-energy-deal/switching-energy-supplier/
- Reduce electricity consumption by adopting improved management of home energy and installation of energy efficiency measures
- If you want to reduce greenhouse gas emissions from electricity use, consider switching to a 100% renewable electricity supplier. All electricity for public use is fed into the national grid and thus, all of us receive electricity generated from a mix of fuels and sources. By purchasing a 100% renewable supply, you can help to increase the contribution from renewable sources and acceleration of the decarbonisation of the UK electricity supply.

[8] 1 MWh = 1,000kWh or 1,000 units

7.3.1 Meeting current electricity demand

The two technologies most suitable for generation of renewable electricity in the Barningham area are solar photovoltaic (PV) panels and wind turbines. Hydropower is not an option as the supply of run-off water from nearby moorland is not sufficient.

Use of combined technologies could offer optimal utilisation of renewable sources on a year-round basis, as well as spreading the risk associated with single technology operation and performance. To give an indication of scale, if approximately half of the existing electricity demand was generated from each technology, an area of 1.5 acres of PV panels and two small 50kW 25m hub-height turbines would be required.

To generate sufficient electricity to meet the current demand from photo voltaic as a sole technology would require around 700kW of installed PV panels, occupying approximately 2.8 acres of ground coverage.

Alternatively, utilising wind energy as a sole technology to meet the entire demand, would entail installation of five 50kW 25m hub-height turbines operating at a typical capacity factor[9] (CF) of 30% to generate 131MWh each (655MWh in total).

Putting aside issues of matching supply to demand, in theory at least, local generation of sufficient electricity to meet 100% of the current total fossil fuel demands from all sources would be possible from a relatively small commercial PV array comprising of 2 or 3 medium size fields, or from a combination of local PV arrays along with one larger medium scale (500kW, 50m hub height) wind turbine. It is unlikely that the conversion of all energy sources to electricity would be desirable or economical, as the use of electricity for heating is generally more expensive than other sources. Furthermore, the current planning policy for the Barningham village area considers it suitable for wind turbines up to 25m hub height only.

7.3.2 Meeting future electricity demand

It could be advantageous for Barningham to consider installation of a renewable energy generation scheme that provides for future increases in electricity demand. This would account for the proposed housing developments at Hill Top and Glebe Farms, as well as some take up of electrical heating solutions and electric vehicles within the local area.

[9] Capacity Factor is the proportion of output produced compared to the theoretical maximum output if the generation equipment was running at full capacity throughout one year

The 9 new properties proposed by Barningham Estate are anticipated to be heated via heat pump technology systems. Current government data [10] suggests new build Energy Performance Certificate A rated properties use 113kWh/m^2 per year, of which 75% is heat energy. The total new development floor area proposed of 1,375m^2 would have an average demand of 17,260kWh per year per new property, approximately half the average of existing Barningham houses at 31,900kWh.

As the new properties would use ground or air source heating, the energy input demand would be lower, at around 4,270kWh, assuming a heat pump efficiency factor of 3. Overall, this suggests potential new demand of around 8,600kWh per property or 77,300kWh in total, adding a further 11.7% to the electricity demand and 2.1% to the overall total energy demand.

Existing properties may also consider switching to electric heating, either through heat pumps or through the recent development of direct electric boilers. Heat pumps have high capital costs and may not be suitable for retrofitting in older properties, particularly those which do not have a high level of energy efficiency. Direct electric boilers are less expensive in capital and servicing costs terms than conventional boilers, but currently significantly more expensive in terms of ongoing fuel costs. Both technologies will be evaluated in early 2021 under the Barningham Energy Project. A factsheet about the use of such systems will be produced on conclusion of the study.

Northern Powergrid estimates that by 2028, more than 5% of households will have installed a heat pump.[11] Due to the nature of the housing stock in the Barningham area, the take up of heat pump technologies in existing houses is likely to be lower. For the purposes of this report, it is therefore estimated that only 2 or 3 properties within the survey area will install electrical heating within 10 years. The electricity demand is estimated to be consistent with that used for the new houses, suggesting an additional demand of 8,540kWh, assuming 2 houses.

Finally, a significant additional electricity demand from take up of electric vehicles in the local area is considered likely. Based on an average consumption of 305Wh/mile, an annual use of 12,000 miles, and assuming 75% of charging is done at home, the addition of each electric vehicle would increase electrical demand by around 2,750kWh per annum.

[10] See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/853067/energy-consumption-new-domestic-buildings-2015-2017-england-wales.pdf

[11] https://engage.northernpowergrid.com/static/Emerging_Thinking_Overview-d90326b0030707edce1849c8f8515c74.pdf

Northern Powergrid estimate that by 2028, 19% of households will have an electric vehicle. Take up in Barningham may be higher than the average and a take up rate of 25% is considered possible, equating to 23 properties. This would add 63,250kWh to the total electrical demand, representing a 9.6% increase in electricity demand, and a 1.7% increase in total energy demand.

Adding the aforementioned additional electricity demand to existing demand results in an overall increase of 23% as shown in Table 7.1. This does not take into account potential decreases in demand through improvements in energy efficiency, nor other unspecified increases in demand. Nevertheless, the projected increase is probably in the right order of magnitude given the nature of the housing stock and limitations on uptake of electrical heating solutions due to energy efficiency constraints.

Table 7.1 – Estimation of potential future electricity demand (by 2028)

Electricity Demand	kWh per year	% increase over current
Current Barningham & vicinity usage	658,700	
New houses (1,375m^2)	77,300	11.7%
Electric heating solutions in existing houses (2)	8,540	1.3%
Electric vehicles (23)	63,250	9.6%
Total:	**807,790**	**22.6%**

Following consultation in the local area, the development of a larger capacity may be considered desirable in order to maximise the potential income stream arising from a community owned electricity generation scheme. This approach is in line with many other community energy projects.

Activities included in Stage 1 of the Barningham Energy Project will address issues of local acceptability, grid connection, planning and commercial viability.

7.4 Oil

Oil is currently the main heating fuel, comprising 53% of energy demand and the largest source of greenhouse gas emissions (68%). Available options for replacement of oil are currently limited in off gas grid areas like Barningham but they are developing. Within the Stage 1 energy project, a number of home heating options have been highlighted for further evaluation.

The options to be considered include:

- Locations within the village where another small district heating scheme is possible, including an assessment of connecting some existing properties to a ground source heat pump system currently being proposed for the new build properties.

- Options for switching to non-fossil fuel heating oil for existing central heating systems. There is a developing market for non-fossil fuel heating oil, typically with blended mixtures that offer the opportunity for reduced emission heating fuels. Issues to be explored here are costs, compatibility with existing boilers and any additional servicing issues.

- Feasibility of replacing individual existing oil-fired systems with electrical heating systems (including heat pumps) or wood product-fired systems (options already discussed in Section 7.2).

Prior to replacement of fossil fuel heating oil or an oil-fuelled heating system, anyone who wants to reduce usage and emissions in the short term should consider options for adopting improved management of home energy and installation of energy efficiency measures.

In the medium to longer term, it is to be expected that sale of fossil-fuel based heating oil will be prohibited, although a transition period for existing systems is likely.

7.5 Solid fuel

Solid fuel, including coal, provides 4.7% of total energy consumption but contributes 8.4% of emissions. A simple switch from solid fuel to wood-derived fuels would represent a significant emissions reduction. However, solid fuel purchases reported in the survey only represent 2.1% of fuel costs, suggesting that any such switch would lead to higher household costs.

As the sale of house coal is being phased out (bagged coal by February 2021 and loose coal by February 2023[12]), users of this fuel will either need to replace it with wood-based fuel or replace the combustion appliances involved within the next two years.

[12] https://www.gov.uk/government/news/government-takes-action-to-cut-pollution-from-household-burning

7.6 LPG

LPG fuel represents a very small proportion of energy use, energy costs and emissions of greenhouse gases. Nevertheless, as a fossil fuel, sale is likely to be phased out at some point in the future. As with other non-renewable source fuels, consideration should be given to replacing it and any appliances that use it, with a sustainable, renewable solution.

7.7 Final comments

Not only was the energy survey a snapshot in time but also the range of improvements that are currently a possibility are “interim” technologies in the evolution of no and low carbon energy solutions. Many technologies are in development and at different stages of commercial viability. Nevertheless, adoption of interim solutions will facilitate the transition to decarbonisation of energy supply. There will not be a single or perfect solution. Rather it will be through the adoption of evolving, stepwise solutions that we will achieve a “net zero” village and eliminate our contribution to climate change.

8 CONCLUSION

The survey of energy usage in the Barningham area was the first step towards developing a community owned renewable electricity generation scheme and assisting in reducing environmental impacts associated with energy use. The survey of households, commercial premises, local village hall and church, achieved a very high response rate. Information returned was of good quality, enabling a thorough analysis of energy use and issues in the study area.

The key findings of the survey are as follows:

- Energy costs could be reduced for some households by changing the tariff of supply or the supplier, as well as by additional installation of insulation, double glazed windows, modern boilers and other energy efficiency improvements.
- Combustion of wood products provides 24% of energy in the study area but only accounts for 18% of energy costs and 2.0% of CO_2 emissions, as wood is a very low carbon fuel.
- Electricity accounts for 44% of energy costs but only provides 18% of energy consumption and 22% of CO_2e emissions. The aims of a community-owned renewable generation scheme is to reduce costs and reduce or eliminate greenhouse gas emissions from electricity use. To give some idea of scale, a hypothetical option to meet *current* electricity demand might comprise 1.5 acres of PV panels and two 25m turbines. Such a scheme may provide optimal utilisation of seasonal resource and reduce operational risks. A larger scheme would be necessary to meet future growth in electricity demand (e.g. from electric vehicles and heating technologies) and also provide an additional income stream to the area from surplus electricity generation.
- Oil is the main heating fuel, comprising 53% of energy demand, despite only contributing 35% of costs. It is by far the largest source of greenhouse gas emissions at 68% and as its use will eventually be phased out, alternative heating solutions are needed. Further investigation under the Barningham Energy Project will include:
    - Extension of a ground source heat network associated with new build properties to nearby existing properties in the village.
    - Options for switching to non-fossil fuel heating oil.
    - Replacement of oil-fired systems with electrical or wood-product fired systems.