National Assembly for Wales
Environment and Sustainability Committee
EEFP 01
Inquiry into Energy Efficiency and Fuel Poverty
Response from: YnNi Llŷn Energy Survey

YnNi Llŷn

Hysbysu, Arbed, Cynhyrchu
Inform, Conserve, Produce

Community Energy Survey

A Study of Energy Use in Aberdaron, Botwnnog, Tudweiliog & Enlli

Cywaith

Prepared for Cywaith Cyf by Gritten mgmt, April 2012.

Contents

Summary

Headline Findings & Conclusions

i. 12% of households in Pen Llŷn[1] responded to a questionnaire sent to every address. The sample was sufficiently representative to make broad generalisations to the rest of the community.

ii. The entire sample's total energy consumption was 6,626 mWh per year, costing £639,870.

iii. Total annual demand for the domestic-only sample was 6,067 mWh/y, costing £612,396.

iv. Domestic demand ranged widely across households, between 4015 kWh and 93,075 kWh/y. Costs ranged between £556 and £14,350 per year.

v. For both the entire and domestic-only samples, electricity accounted for the smallest proportion of energy demand, followed by transport and then heating. However, the price of transport was significantly higher than heating.

vi. Extrapolating to the area suggested that the Pen Llŷn annual domestic energy demand is 7,698,215 kWh/y (costing £1,116,733) for electricity, 22,666,500 kWh/y (costing £1,366,091) for heating and 20,193,625 kWh/y (costing £2,620,475) for transport.

vii. On average, Pen Llŷn households appeared to be consuming 112 kWh of energy per day (compared to a national average of 94 kWh/d), costing £4,082 per year (compared to a national average of £2,478).

viii. The estimated annual demand for Ynys Enlli was 172,280 kWh, costing approximately £7,700.

ix. The median domestic electricity consumption was 13 kWh per day, costing £710 per year (compared to a UK median of 9 kWh costing £424/y). Almost 70% of the sample were Scottish Power customers.

x. The average domestic heating demand was 52 kWh/d, with a median annual cost of £1,178 (compared to a national average of 46 kWh/d costing £716/y).

xi. The most widely used heating fuel was oil and the average heating unit price was 6p/kWh (compared to a 3.67p/kWh average for gas mains households).

xii. Across Pen Llŷn, it was estimated that around £415,000 worth of heating fuel per year is being lost due to inefficiencies in heating systems.

xiii. The average domestic energy demand for transport was 45 kWh per day, costing £2,096 per year (compared to national average figures of 35 kWh/d costing £1,253).

xiv. Estimates suggested that Pen Llŷn spends approximately £860,800 on petrol and £1,646,250 on diesel each year.

xv. 9% of the sample's energy came from renewable sources, compared to 3.3% nationally

[1]The project area covered the wards of Aberdaron, Tudweiliog and Botwnnog and the island of Bardsey.

xvi. Rough estimates suggested that around a third of the sample's heating costs could be saved through draught-proofing and insulation.

xvii. Of those who supplied income data, 43% were classified as in 'fuel poverty', with a further 33% defined as 'at risk'. 69% of households were in 'transport poverty'.

xviii. Participants felt strongly about the environment, were overwhelmingly supportive towards the idea of a local renewable energy company and were particularly interested in solar power.

xix. The energy picture which emerged presented a unique set of circumstances not represented by national figures. There is a high level of dependence on unsustainable fuels and a critical vulnerability to rising energy costs.

xx. Strategic steps should be taken in order to increase the community's chances of becoming resilient to the issues of peak oil and climate change.

xxi. There is significant potential for addressing these issues as a community.

1.0 Introduction

This study was part of the YnNi Llŷn (Llŷn Energy) project (funded by the Department for Energy & Climate Change/Energy Saving Trust's Local Energy Assessment Fund) and took place between January and April 2012.

YnNi Llŷn was created by Cywaith Cyf, a regeneration initiative, and aimed to generate a picture of the sustainability challenge and lay the foundations for energy self-sufficiency on the tip of the Llŷn Peninsula - specifically in the wards of Aberdaron, Tudweiliog and Botwnnog and the Island of Bardsey (Ynys Enlli)[2]. One vision was to test the feasibility of setting up a local energy company which could supply the area with renewable electricity and use profits to benefit the community.

A community steering group was set-up and three primary work streams were conducted:

i. A feasibility study of renewable energy generation options in the project area
ii. An appraisal of community-owned company models
iii. An energy survey of households and organisations

This report is the outcome of the third work stream. The survey was based on an energy audit piloted with 20 households across Snowdonia through EcoBro, a local environmental Community Interest Company (more details at http://ecobro.org/node/140). The EcoBro project worked with a self-selected group of households who were already engaged with environmental/energy issues. YnNi Llŷn took a step further by taking a whole-area approach.

The aims of the study were to:

i. Create a clear picture of where the community is now in terms of total energy consumption and costs which could be used as a benchmark for area-based energy reduction and sustainability initiatives.
ii. Provide data about energy demand within three primary categories (electricity, heating and transport) which could inform further initiatives - such as the required capacity of a renewable generator(s).
iii. Engage the population in energy and sustainability issues and understand local attitudes towards renewable power in order to move forwards as a community.

[2] The project area is referred to as 'Pen Llŷn' - the tip of the Llŷn peninsula

iv. Make households aware of any financial assistance they could receive towards energy efficiency measures and/or reducing energy costs and provide practical information about progressing towards sustainability.
v. Collect data about the area's housing stock which could inform energy efficiency measures.

Pen Llŷn is a staggeringly beautiful part of North West Wales. It has a small population, tight-knit community, vibrant culture and a high proportion of Welsh first language homes. Economically the area relies primarily on agriculture, tourism and travel to work in other areas. Ynys Enlli is a small island which has been a destination for pilgrims through the ages. The island has three permanent households and 12 short-let cottages.

1.1 Abbreviations

The following abbreviations are used in the report:

Organisations:

BRE - Building Research Establishment

DBERR - Department of Business, Enterprise & Regulatory Reform

DECC - Department of Energy & Climate Change

DEFRA - Department for Environment, Food and Rural Affairs

DfT - Department for Transport

EST - Energy Saving Trust

OFT - Office of Fair Trading

ONS - Office of National Statistics

WAG - Welsh Assembly Government

Units:

kWh - KiloWatt hours

kWh/d - KiloWatt hours per day

mpg - Miles per gallon

mWh - MegaWatt hours

Statistical:

M - Mean average

n - number

p - Significance value (the probability of obtaining a statistic at least as extreme as the one observed if there were actually no effect - social scientists tend to accept *p* values of .05 or lower as significant)

r - Pearson's correlation coefficient (values are between 0 and 1, higher values indicate a stronger relationship)

SE - Standard error of the mean

Z - Wilcoxon's signed-rank test statistic (similar to a *t* test but for non-parametric data)

2.0 Method

2.0.1 Measures

A questionnaire was developed containing 52 measures on five main themes:

i. Demographic characteristics
ii. Attitudes
iii. Financial situation
iv. Home energy efficiency
v. Energy consumption and costs (for electricity, heating[3] and transport[4])

The questionnaire was also available online at http://www.ynnillyn.org/ using a bespoke software package which generated interactive graphics corresponding to the energy data.

2.0.2 Procedure

Publicity was generated by distributing a leaflet (see appendix i), circulating information to the press, a large network of public sector, private sector and personal contacts and through direct contact with the public. The project received coverage through the Cambrian News, Caernarfon & Denbigh Herald, BBC Radio Cymru and Llanw Llŷn (the community paper).

The publicity invited householders, businesses and not-for-profit organisations to participate on a voluntary basis. As thanks for their participation residents were entered into a prize draw to win £200 and sent personalised feedback reports containing information on:

i. Eligibility for grants, benefits and other savings
ii. Energy use and expenditure
iii. Practical steps towards sustainability

The questionnaire was posted to every address in the project area 2.5 weeks after the publicity drive began. Householders had the option to complete the paper version or complete their survey online, whilst organisations were invite to take part through an interview adapted from the paper questionnaire.

---

[3] Including cooking and water heating

[4] Not including travel overseas

2.0.3 Participants

150 households, 8 businesses and 8 not-for-profit organisations took part in the study and an additional 4 households sent back largely empty questionnaires in the pre-paid envelopes provided.

The 16 participating organisations included:

Public & Voluntary Sector	Private Sector
Community buildings (3)	Campsite (1)
Land trust (1)	Carpenter (1)
Primary schools (3)	Construction company (1)
Social enterprise (1)	Farm (1)
	Farming suppliers (1)
	Ferry/boat trip company (1)
	Holiday let cottage (1)
	Hotel (1)

2.0.4 Data Quality

Considering the length of the questionnaire and the need to retrieve information from fuel bills to complete it, the quality of the data was quite high, with the vast majority of participants answering every question. The most infrequently answered question was about income, with only 59% of households providing the information. The proportions of missing energy data were:

i. 8% for electricity
ii. 3% for heating
iii. 6.5% for transport
iv. 2.5% provided no useable energy data

The most frequently answered measures were the 0 - 100 scale bars (participants were asked to ‘put a mark on the line’ to indicate their agreement with a statement) used to rate subjective house temperature, draughtiness, proportion of low energy bulbs, concern for the environment and support for a local energy company.

3.0 Results & Discussion

3.1 Representativeness

The existence of data for the same wards in which the study took place enabled some comparisons to examine the representativeness of the sample.

3.1.1 Demographic

The 150 participating households housed over 337 people - 12.1% of the area's population of 2780 (ONS, 2010). Participants were well spread out over the project area with 45 households from Aberdaron (actual number: 454), 51 from Botwnnog (actual number: 419), 51 from Tudweiliog (actual number: 422) and one from Enlli[5] (CACI Paycheck, 2011).

141 households (housing 322 people) gave information about residents' ages. Figure (i) shows the goodness-of-fit of the sample's age distribution with that of the actual population.

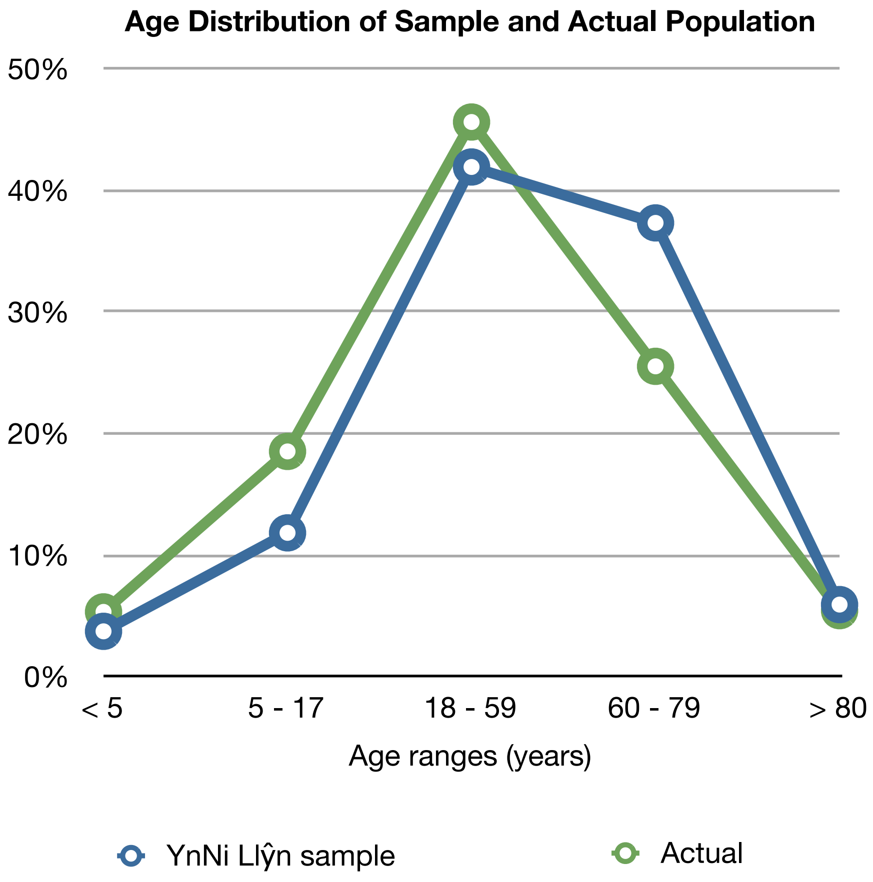

Fig (i). Comparison of age distributions - YnNi Llŷn sample with ONS estimates

[5] Two households participated anonymously and their location was unknown

The sample is slightly under representative for younger and working age people and slightly over-representative for people of 60 - 79 years. This could be due to more time constraints for working-age adults and therefore less likelihood of taking part in a survey. The likely impact on the results of more working aged adults taking part would have been slightly lower consumption figures for electricity and heating and slightly higher figures for transport due to this age group's tendency to be away from home during the day.

3.1.2 Housing

The average occupancy per house for the YnNi Llŷn sample was 2.24, compared with an actual occupancy of 2.39 (ONS, 2001). Figure (ii) compares the housing status of the sample with that of the actual population (ONS, 2001).

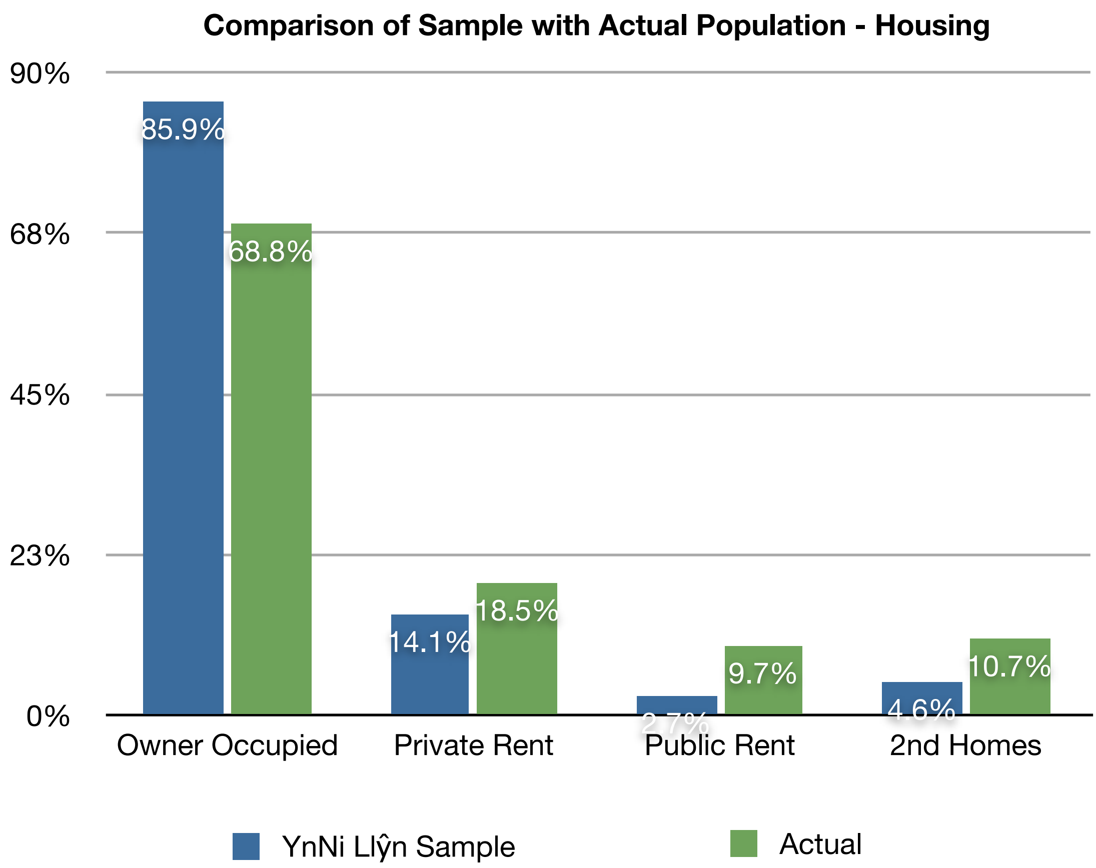

Fig (ii). Comparison of sample and actual populations for housing status.

The sample contains more home-owners than the actual population (as measured in 2001) and fewer renters. This could be explained by the over-representation of older people - who are more likely to be home owners (Hancock et al, 1999). There were fewer public renters in the YnNi Llŷn sample than reported in the 2001 Census. This may be due to a higher number of 'hard-to-engage' families living in social housing and/or a decline in the provision of rural social housing over the past decade (Milbourne, 2008). The sample also underrepresented households whose Llŷn home was a second residence - possibly due to a combination of these families' increased likelihood of being absent when the study was undertaken and/or lower interest in local affairs.

3.1.3 Economic Indicators

For the 89 households who provided financial data annual household income ranged between £5,200 and £100,000 with an average income of £25,594 (*SE* = £2,170.40) and a median income of £20,000.

Figure (iii) compares economic indicators for the sample and the actual population.

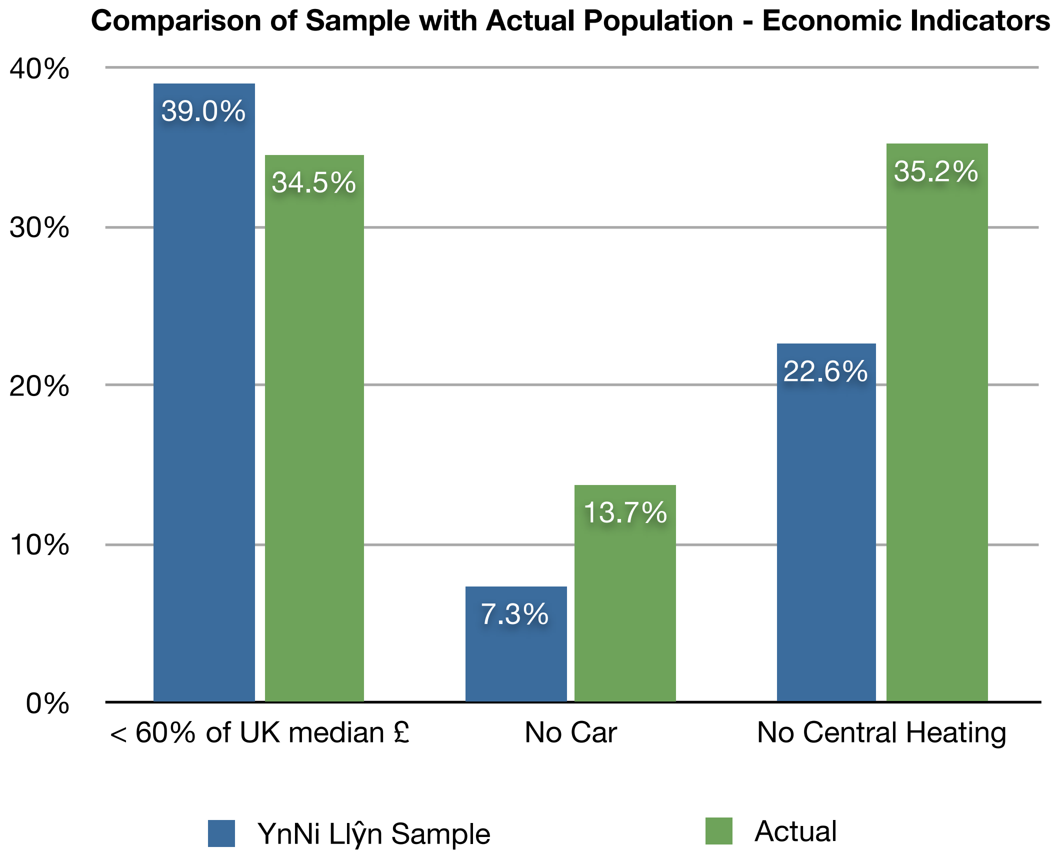

Fig (iii). Comparison of YnNi Llŷn sample with actual data for three economic indicators.

The sample had a slightly lower income than that of the actual population, with more households below 60% of the UK median income (CACI Paycheck, 2011), possibly due to the over-representation of older people. There were fewer households without a car in the YnNi Llŷn sample (ONS, 2001) which could be explained by a rise in car ownership since 2001 (the percentage of no car households in rural areas in the UK fell from 15% to 9% from 1995/7 to 2009/10) (DfT, 2011a). There were also fewer homes in the YnNi Llŷn sample without central heating than indicated by the 2001 Census, though this fits with the trend for this indicator to decline through increasing modernisation of the housing stock (Palmer, 2012).

3.1.4 Summation

Whilst there were some variations between the sample and the actual data, the general fit was good, with all ages and economic groups represented. It was, therefore, possible to generalise from the results to create a basic energy picture for Pen Llŷn.

The range may have been due to the existence of a variety of potential motivations for taking part. These included:

i. Environmental reasons - to contribute to sustainability
ii. Support for local economic regeneration - to help lay the foundations for a community energy company
iii. Financial reasons - to receive information about eligibility for a range of grants and support and have a chance of winning a cash prize
iv. Personal interest - to receive information about how one's personal energy use compares to national average
v. To state an opinion - for example, to raise concerns about renewable technology

3.1.5 Organisations

It was not possible to obtain reliable data on the number of businesses in the project area, and that, along with the high level of variability in type and size within known organisations made it impossible to make any reliable generalisations about the energy use of this sector. The results, therefore, focus primarily on the domestic sample.

3.2 Energy Consumption & Costs

3.2.1 Demand Overview

3.2.1.1 Overall Demand (Organisations & Domestic)

The sample, including data from 162 cases, reported using a total of 6,626,575 kWh (6,627 mWh) of energy per year, costing £639,870[6]. Figure (iv) shows how these figures were distributed across the categories of electricity, heating and transport.

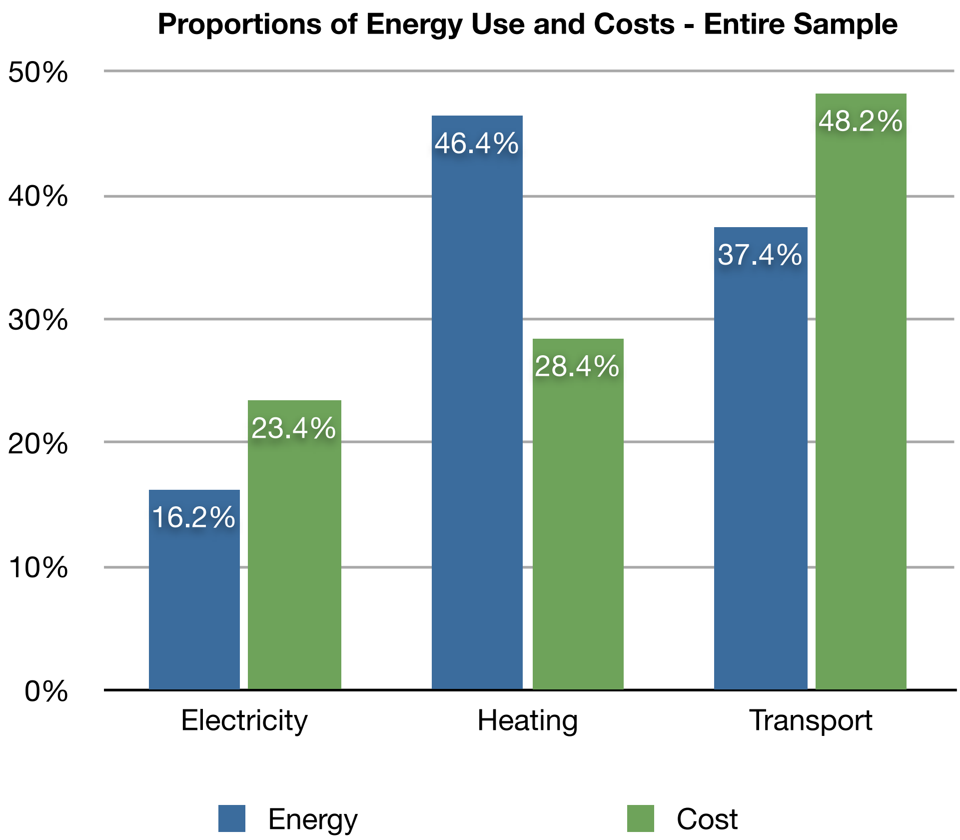

Fig (iv). Comparison of total energy and financial expenditure across electricity, heating and transport .

The average annual energy used heating *(M* = 19,071kWh, *SE* = 3.49) was significantly larger than that used for transport *(M* = 15,983kWh, *SE* = 2.51) (Z = - 2.01, $p < .05$), whilst the average cost of transport (*M* = £2,027.33, *SE* = £113.20) was significantly greater than the cost of heating (*M* = £1,128.80, *SE* = £68.85) (Z = - 6.85, $p < .001$).

---

[6] Actual consumption and costs would be higher due to a small percentage of data being missing for each category. Missing data treatment for this analysis:
i.Electricity - where no kWh or costs figures were provided use was recorded as missing
ii.Heating - where no fuel costs/quantities were provided, usage was extrapolated from fuel type and frequency of use based on the sample means if this information was provided (see *Appendix ii* for figures)
iii.Transport - data was recorded as missing where no mileage figures were provided

3.2.1.2 Overall Demand in Domestic Sample

The total annual energy demand for the domestic sample was 6,067,030 kWh (6,067 mWh) costing £612,396[7]. There was a great deal of variation within the sample: Total energy use ranged between 4015 kWh/y for the lowest user and 93,075 kWh/y for the highest, with household energy costs ranging between £556 and £14,350 per year. The mean annual usage was 39,749kWh (*SE* = 1496.5) with a mean cost of £3903.30 (*SE* = 167.58).

Figure (v) shows the proportion of energy and costs across the three use categories for the modelled data.

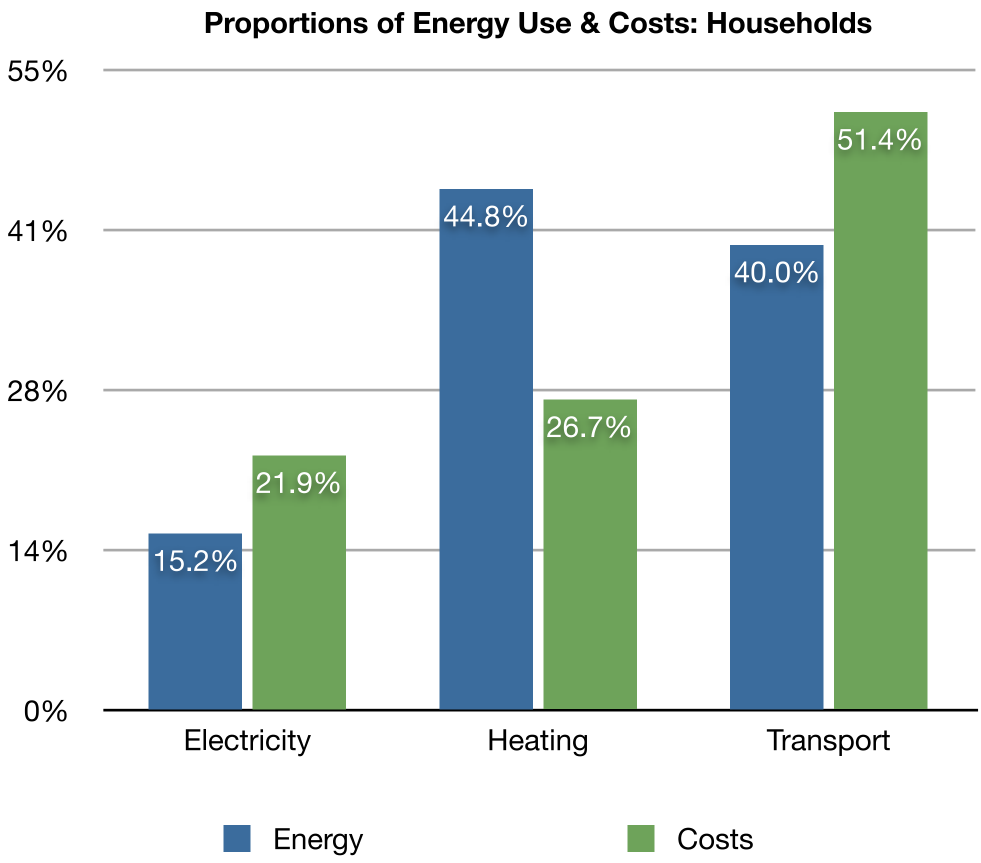

Fig (v). Percentages of energy use and cost across electricity, heating and transport for domestic participants.

The same interaction between heating and transport energy use and cost was seen in the domestic figures, with the effect slightly more pronounced for costs.

[7] Where data was missing, figures were substituted by the mean to model the total.

3.2.1.3 Extrapolating to the Local Population

Extrapolating from the results suggested that the domestic residents of Pen Llŷn have a total annual domestic energy demand of approximately 50,558,340 kWh (50,558 mWh), costing £5,103,299. Per category, the energy and costs broke down as follows:

i. Electricity = 7,698,215 kWh/y (£1,116,733)
ii. Heating = 22,666,500 kWh/y (£1,366,091)
iii. Transport = 20,193,625 kWh/y (£2,620,475)

3.2.1.4 Pen Llŷn & National Total Energy Expenditure

Figures (vi) and (vii) compare the average consumption and costs for the sample to comparable national figures [8].

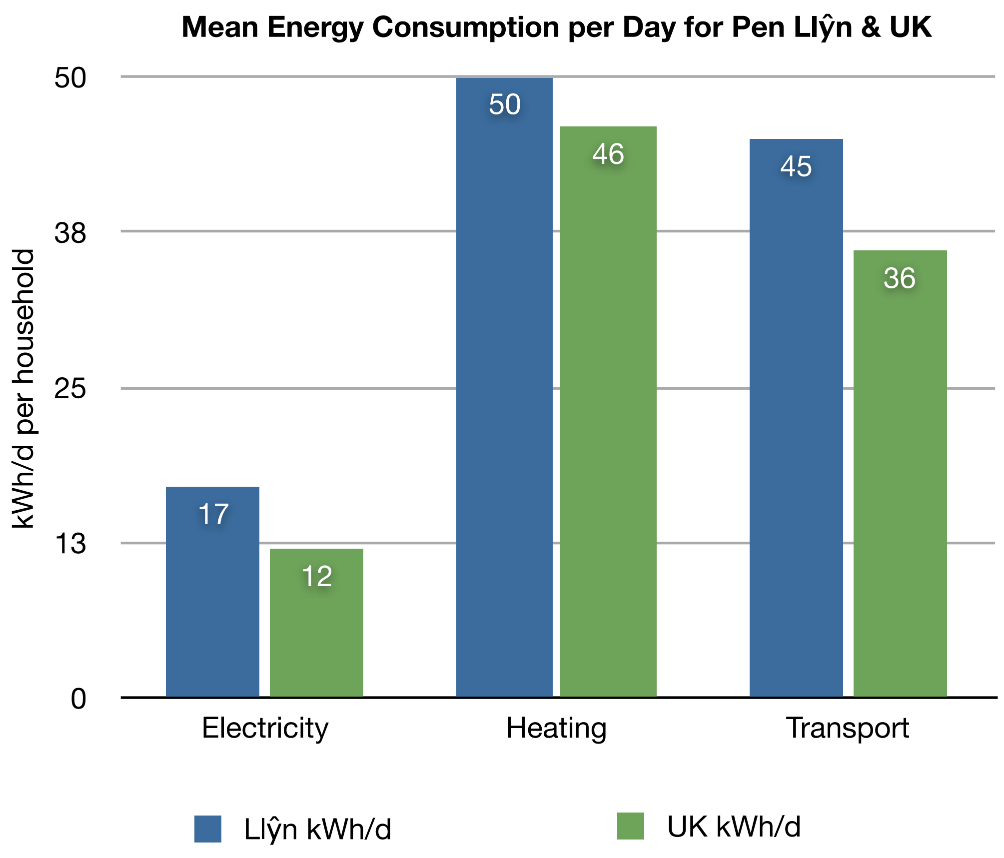

Fig (vi). Average energy consumption for Pen Llŷn and the whole of the UK.[9]

---

[8]From this point forward mean energy consumption figures are presented in kWh per day. This was calculated by dividing the yearly consumption by 365 in order to produce lower figures which are easier to grasp.

[9]Heating and Electricity energy use figure from DECC's energy flowchart (2010). Transport energy is from DfT (2011b) and includes energy consumption for cars, taxis, vans, buses/coaches and rail.

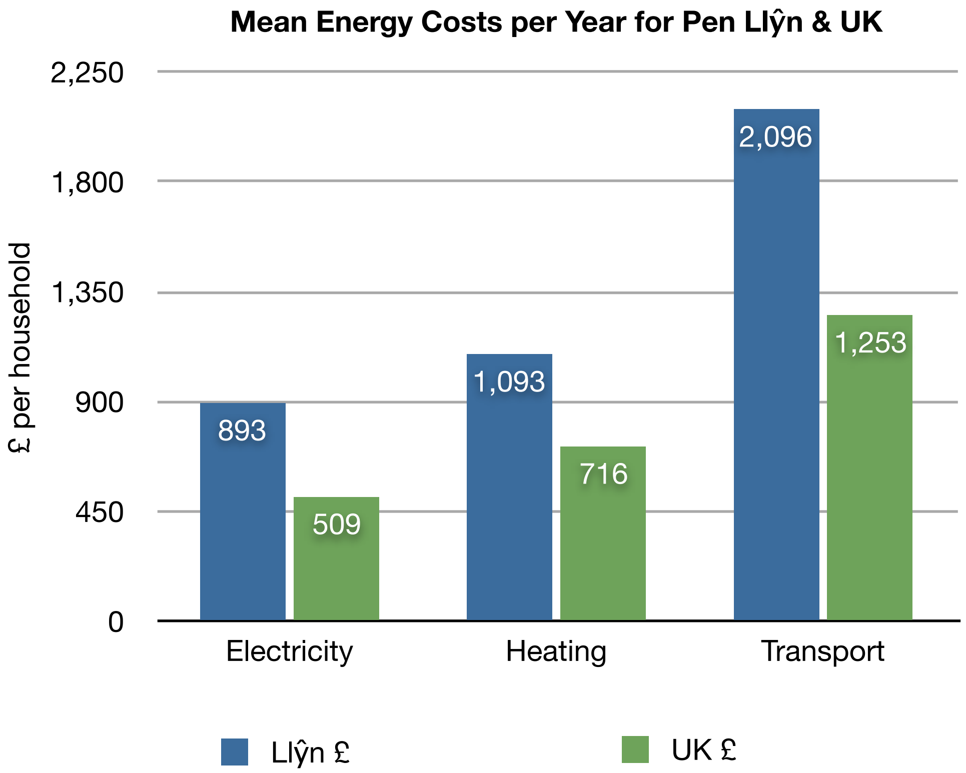

Fig (vii). Average energy costs for Pen Llŷn and UK[10].

The domestic sample's total energy use indicated that the demand for electricity, heating and transport in Pen Llŷn (averaging 112 kWh/d) was greater than for the UK overall (averaging 94 kWh/d). However, it appeared that the higher consumption was outstripped by greater costs (the Pen Llŷn annual average was £4082 compared to the national average of £2478). These effects will be explored in further detail for each category.

3.2.1.5 Ynys Enlli

The energy profile of Ynys Enlli (Bardsey Island) differs from the mainland in that there is no mains electricity supply. One of the three full-time residential properties has solar panels and the remaining electricity demand is met by diesel generators. The 12 holiday lets are without electricity. Diesel, gas for cooking and fridges, and wood and coal for heating are transported to the island by boat. Farming vehicles and bikes are the only transport on the island. The Bardsey Island Trust (who provided data for the holiday lets) and one of the full time households participated in the study. The Island's suggested annual energy consumption (excluding boat fuel) was 172,280kWh costing £7,709.[11]

---

[10] Electricity and heating costs are from UK Consumer Trends Survey 2010 (reported in DECC, 2011b). Transport cost is an average score from Department for Transport (2011c) and includes expenditure on domestic fuel, rail and bus fares.

[11] The one full time household's data was scaled up to represent the three full time households.

3.2.2 Electricity

3.2.2.1 Average Consumption & Costs

Annual electricity consumption varied hugely, ranging between 2kWh/d and 117kWh/d, with bills of between £135 and £6000 per year. For full time residents (data from seven second homes removed) the average consumption was 17.26kWh/d (*SE* = 1.28) and the average cost was £918.38 (*SE* = 72.50) per year. However, these figures could be considered misrepresentative of the majority of the sample as around 70% of consumption and cost scores fell below the means. A relatively small number of extreme cases therefore skewed the means for both consumption and costs.

The median averages are probably a better representation of the figures and the national average electricity usage figures provided by Ofgem (2011) are also based on the median[12]. Figure (viii) compares the Pen Llŷn and national figures.

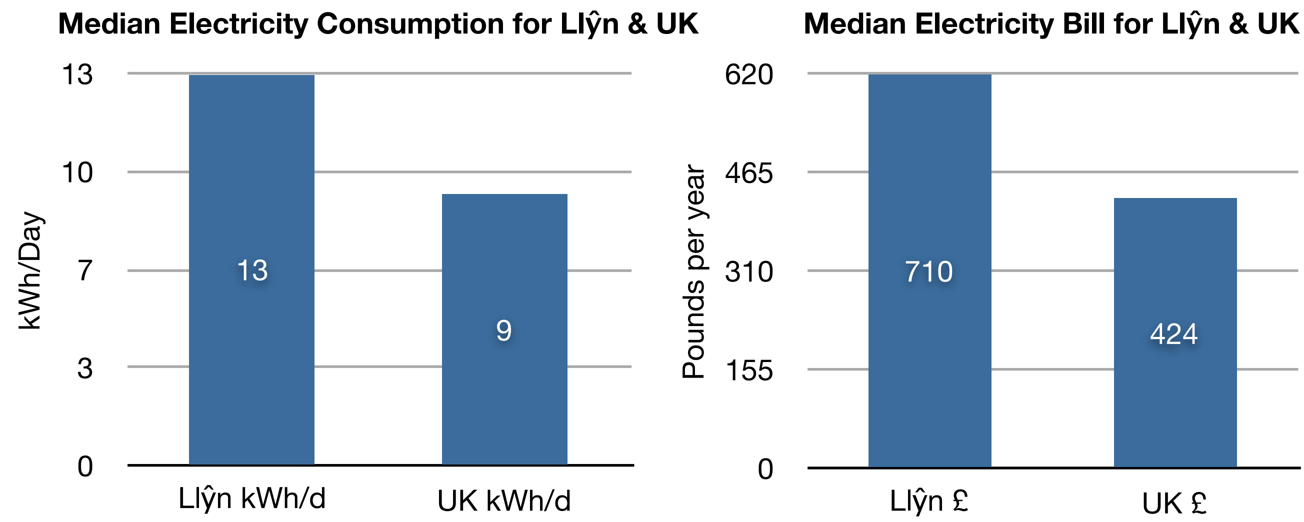

Fig (viii). Median annual electricity consumption and costs for Pen Llŷn and UK.

Pen Llŷn appeared to have greater electricity demand and costs than the UK average. However, this is to be expected in non mains-gas households (of which all households in the project area are) due to a higher reliance on electricity for heating (White et al, 2010). To explore the effect further the data was adjusted so that electricity use and costs were designated to the heating

[12] Ofgem quotes 9kWh/d as median consumption, though DECC (2010) indicates that enough electricity for 12kWh/d per households is delivered to the domestic sector. It is likely, therefore that about a quarter of electricity is being used by a small group of very high users.

category for households using electric heating[13]. Figure (ix) presents the medians for the adjusted figures.

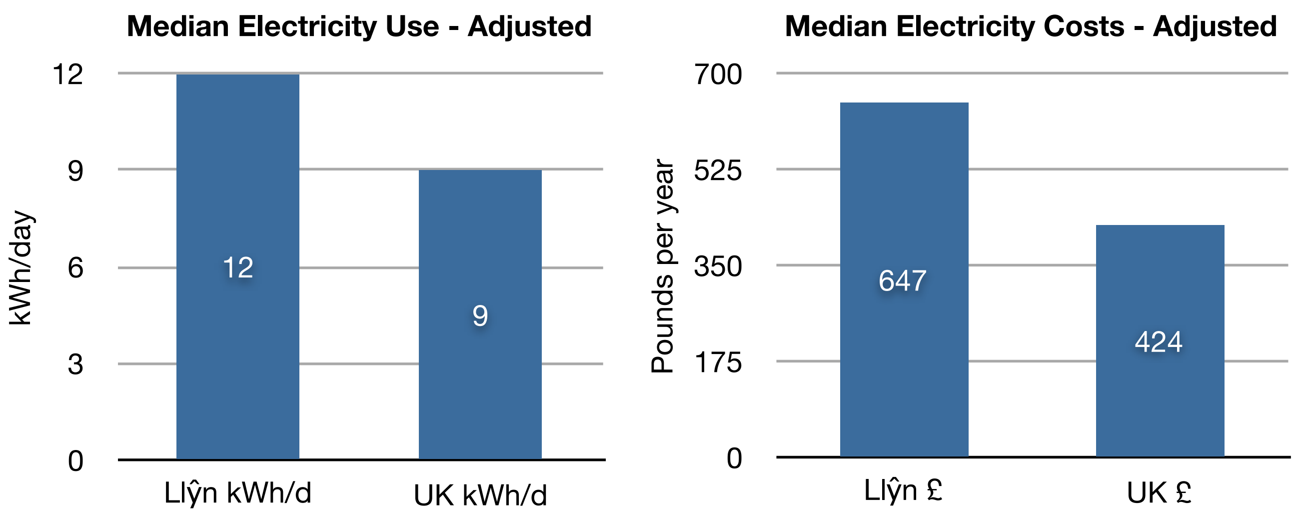

Fig (ix). Median Pen Llŷn and UK electricity consumption and costs - with sample adjusted to reduce the impact of electric heating.

Despite the allocation of a significant proportion of electricity consumption and costs to the heating category, the area still appeared to be using more electricity than the UK median household. Furthermore, the Pen Llŷn bills were higher than could be attributed to increased use alone. The median unit price suggested by the UK median is 12.9p whereas for the Llŷn sample it was 14.8p[14].

3.2.2.2 Electricity Provision

This increased median tariff could be explained by a significant preference for one electricity provider - Scottish Power (part of the Scottish & Southern Electricity group[15] who own the local network following take over from Manweb, the pre competition provider). Figure (x) shows the breakdown of electricity providers across the entire sample (including organisations).

---

[13] Households heating completely or almost completely with electricity (n = 13) had 77.5% of their electricity use and costs designated to the heating category.
Households whose main heating was split between electricity and another system (n = 5) had 50% of their use and costs designated to the heating category.

[14] This was extrapolated from the median rather than based on unit price responses in the questionnaire due to poor data quality.

[15] Now owned by Spanish energy giant Iberdrola.

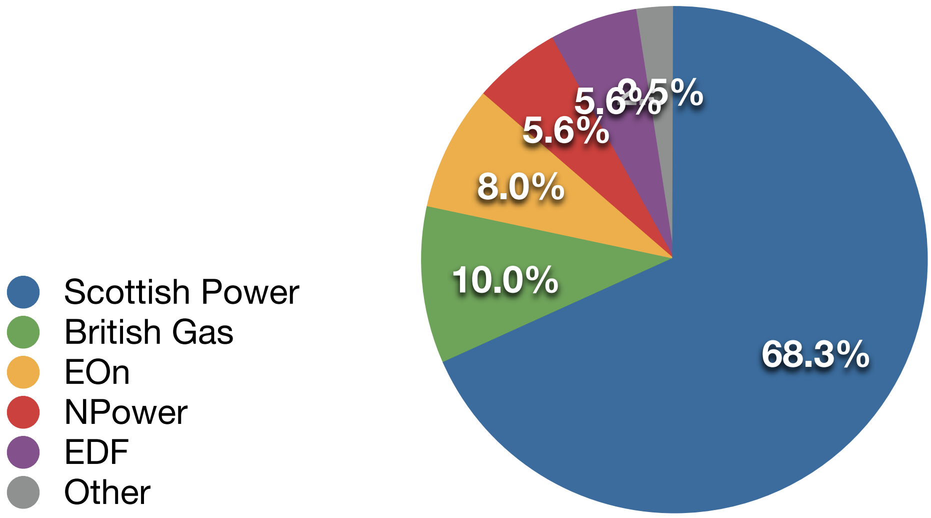

Fig (x). Breakdown of electricity providers across households and organisations in Pen Llŷn.[16]

Scottish Power's domination of the Pen Llŷn market could be slightly overestimated by the sample's over-representation of older people who may be less likely to change their consumption habits to suit the introduction of competition into the market place. However, the over-representation is not large enough to account for much of the variance and it is highly likely that most households in the area are Scottish Power customers.

The appropriateness of competition in electricity supply is contested. Thomas (2002), for example, argued that as 80% of the household bill derives from generation and network charges (which do not vary significantly between providers once a degree of efficiency is achieved in the system), this leaves companies genuinely competing on only relatively minor administrative costs. To achieve any degree of power as consumers, households would need to switch provider regularly (Thomas, 2002). Before 1997, when choice was introduced for small consumers, data was published suggesting that those still bound to the local supplier were paying around 30% more for the generation element of their bill (Thomas, 2002). Despite choice being available now, the majority of Pen Llŷn households have remained with Scottish Power and appear to be paying over-the-odds. Discussions with participants suggested that one rationale for this was the experience that Scottish Power, who own the network, did not see their household as a priority for repair following power-cuts when they switched loyalties.

Over half the sample (30% very likely, 22% possibly) were alerted to potentially significant electricity savings through switching suppliers on their personal feedback reports.

---

[16] Four participants reported using a supplier which is a member of the SSE group (SWALEC/Atlantic/Southern Electric) and one reported using Manweb, SP's predecessor - these were designated as Scottish Power customers. The 'Other' category contained two OVO Energy customers and one Ecotricity, one Good Energy and one Co-Operative energy customer.

3.2.3 Heating

3.2.3.1 Average Consumption & Costs

For the adjusted figures (reflecting electrical heating), heating energy input ranged from 6.5 kWh to 160 kWh per day, costing between £180 and £4474 per year. For the full time residents (data from seven second homes removed) the mean consumption was 52.01kWh/d (*SE* = 2.27), with a mean annual cost of £1178.04 (*SE* = 52.28). This was higher than the 46kWh/d mean heat input provided by DECC (2010)[17] and much more costly than the £715.50 per year heating cost suggested by the Consumer Trends Survey (DECC, 2011b).

The mean was skewed for the heating figures (though to a lesser extent than for electricity), with around 60% of scores falling below the mean for both consumption and costs. The median heating energy use was 48kWh/d, with a median cost of £1029 per year. The median heating statistics provided by Ofgem (2011) are based on gas bills and are 45.2kWh/d and £608 per year.

3.2.3.2 Heating Fuels

One factor contributing to the higher costs experienced by the Llŷn sample was probably the reliance on more expensive heating fuels due to the area being off mains gas[18]. DEFRA (2012) suggested that households relying on oil pay almost twice as much per week as those using gas. This was born out by the average price per unit of heat in the sample which was 6p/kWh - compared to the average price of 3.67p/kWh for mains gas quoted by the EST (2010a).

Figure (xi) compares the use of different heating fuels in the sample to the national distribution (DBERR, 2007).

---

[17] Excludes electrical heat input.

[18] Heating fuel prices fluctuate widely between providers, over time and depending on the quantities in which they are sold. Where cost information was not provided, the following unit prices were used:

Oil = 5.8p/kWh (based on £0.60/litre)	Wood = 4.6p/kWh (based on £63.50/m³)
Bottled gas = 12.9p/kWh (based on £1.80/kg)	LPG = 4.5p/kWh (based on £0.5/litre)
Coal = 7.3 p/kWh (based on £0.49/kg)	

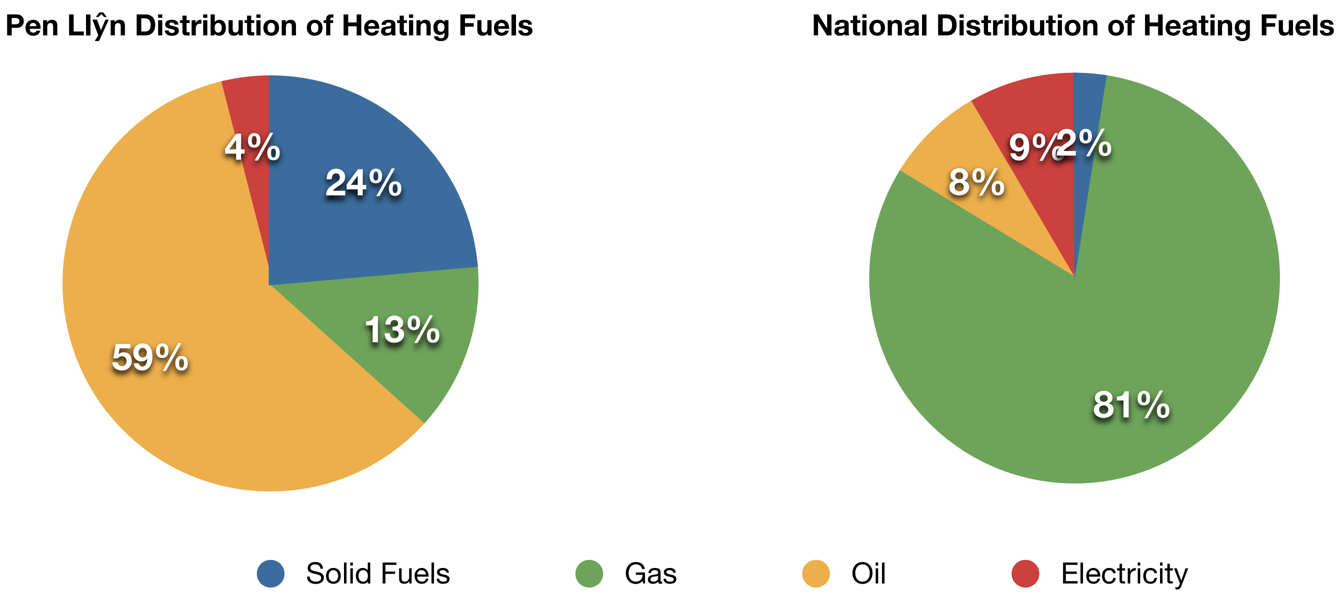

Fig (xi). Proportion of heating achieved with solid fuels, gas, oil and electricity for Pen Llŷn and the UK.

The sample had a far greater reliance on heating oil and solid fuels (wood and coal) than the national average, a smaller number of households using electrical heating and a far reduced reliance on gas. The Pen Llŷn pattern is more consistent with that found in other rural off-grid areas, though with more solid fuel and less electrical heating (OFT, 2011). The heavy reliance on oil is a cause for concern given the 'high and volatile' prices of liquid heating fuels (OFT, 2011).

Annual energy use and costs for the various heating fuels used by the sample were as follows:

i. Oil = 4,440 kWh/d / £95,445 (area estimate: 37,000 kWh/d costing £800k)
ii. Wood = 1,136 kWh/d / £19,129 (area estimate: 9,466 kWh/d costing £160k)
iii. LPG = 737 kWh/d / £12,301 (area estimate: 6,142 kWh/d costing £100k)
iv. Coal = 628kWh/d / £15,831 (area estimate: 5,233 kWh/d costing £132k)
v. Bottled Gas = 234kWh/d / £11,058 (area estimate: 1,950kWh/d costing £92k)

Figure (xii) shows the proportion of heat input and costs for the range of heating fuels used by the domestic sample.

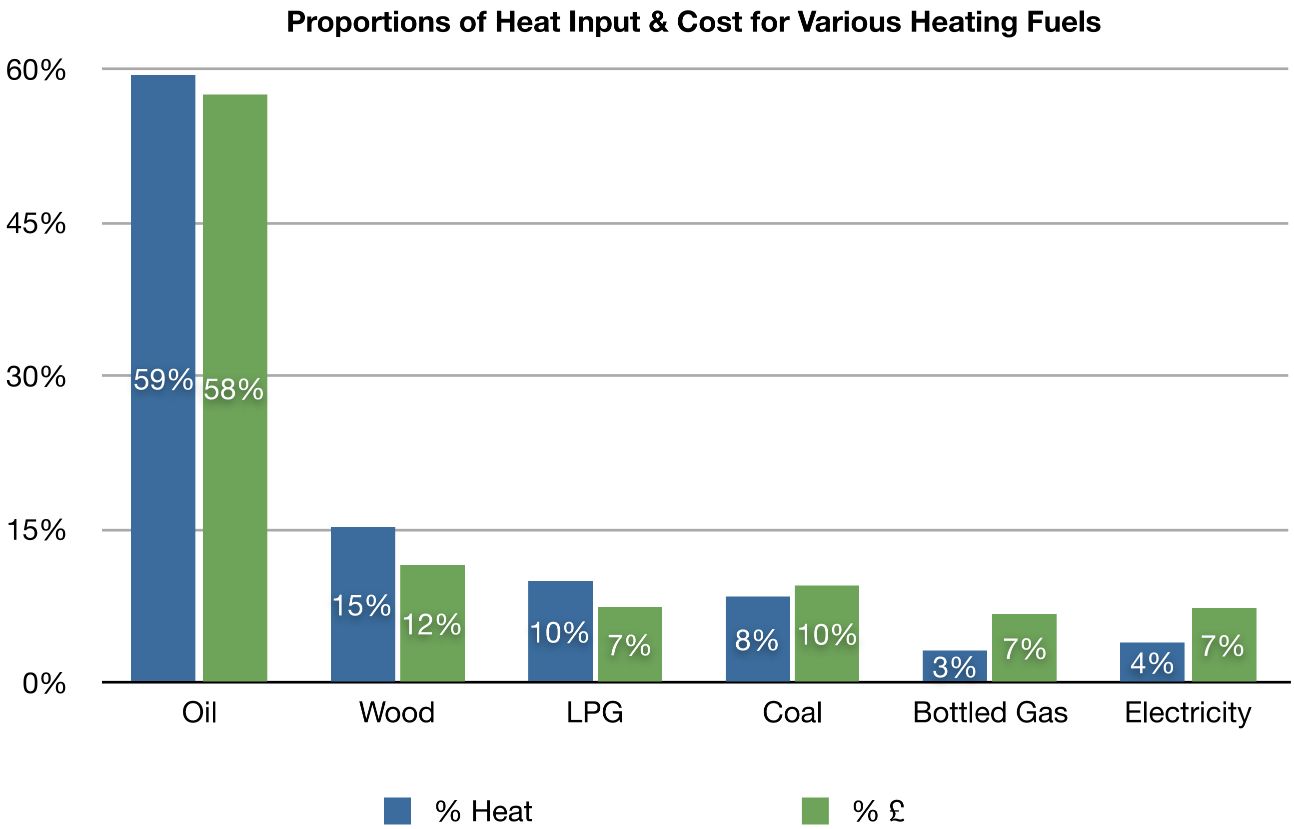

Fig (xii). The distribution of energy input and costs for the heating fuels used by the domestic sample.

The cheapest heating method appeared to be wood, given that it was the second most popular fuel (15.2% of energy) but accounted for a smaller portion of the total cost (11.5%). Furthermore, these cost figures were probably higher than in reality given that participants who provided cost information for wood frequently reported sourcing it themselves for little/no cost, but those who did not mention costs were attributed an average unit cost. Properly managed and burned efficiently, wood could be a sustainable heating source for sparsely populated rural areas such as this (Crawford, 2008). LPG was also a cheaper option, whilst costs outstripped consumption for coal, bottled gas and electric heating.

3.2.3.3 Heating Systems

Another source of variance in heating costs is the efficiency of the system in which the fuel is burned. Figure (xiii) shows the variety of heating systems used by the residential sample[19].

---

[19] Percentages calculated for 148 participants who answered the question

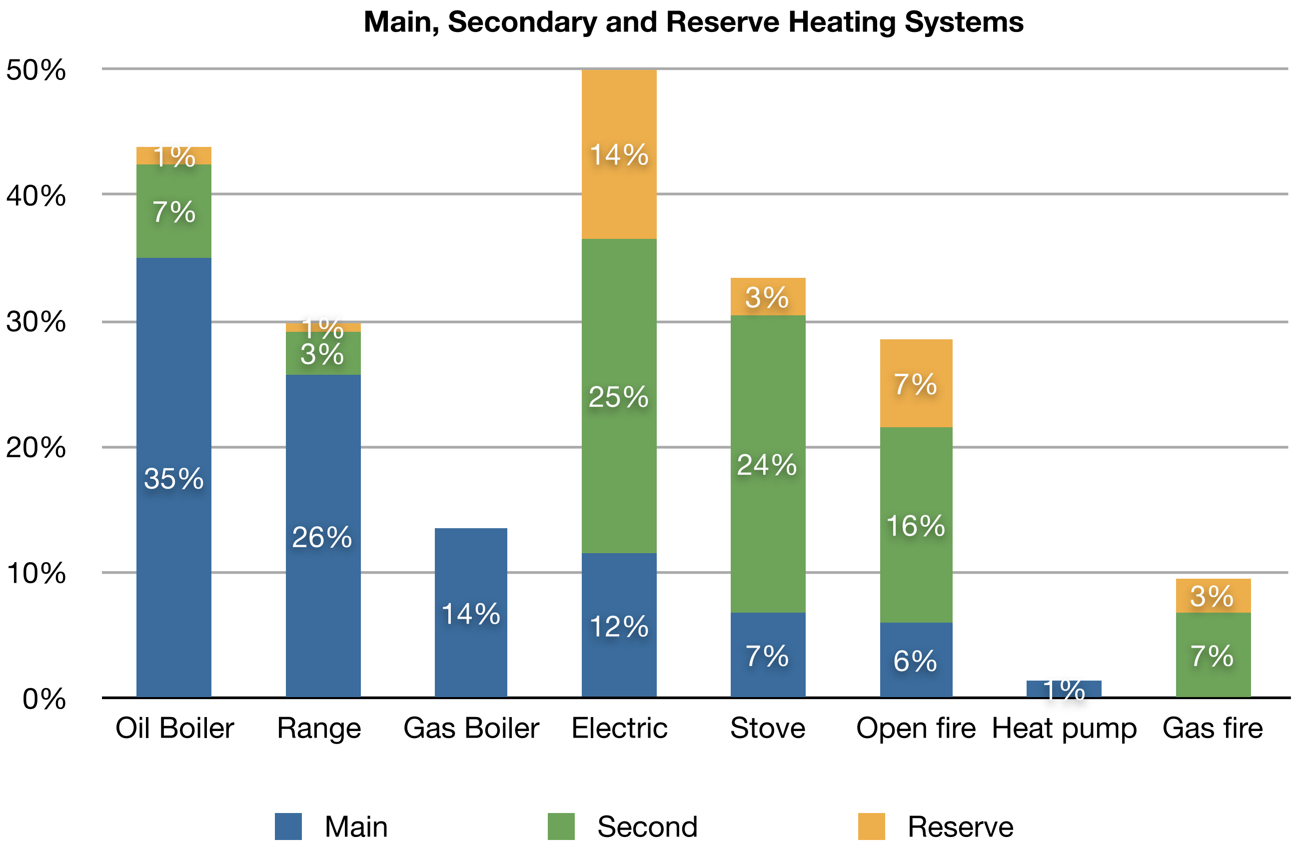

Fig (xiii). Heating methods used by participants as their main, second and reserve heating system.

There was a fairly large range in the methods used, with under 50% using a conventional gas or oil boiler as their main system. The second most widespread primary heating systems were oil-fuelled range cookers (mainly Aga, Rayburn and Stanley stoves) which have been criticised for high energy consumption due to their continuous use and lack of fuel efficiency (which can be as low as 49%[20] (BRE, 2009). This is a particular cause for concern where continuous use of a range is justified by its use for cooking, as gas or electric cookers demand a tiny fraction of the energy. Electricity was the most popular method for both secondary and reserve heating. Three people noted methods that did not require heating fuel as their reserve heating system ('going to bed', 'putting more clothes on' and 'going abroad').

The variations in efficiency of different systems meant that the heating potential of the various fuels was not realised. Figure (xiv) displays the heat and loss from different fuels used by the sample[21].

---

[20] Meaning that over 51% of the heating potential of the fuel is wasted.

[21] There are many variables affecting the efficiency of different heating systems. These figures are based on the following estimated averages (based on BRE, 2009):

Boiler:	80%	Old/inefficient boiler:	60%	Multifuel stove:	70%
Range:	60%	Gas fire:	50%	Open fire:	30%

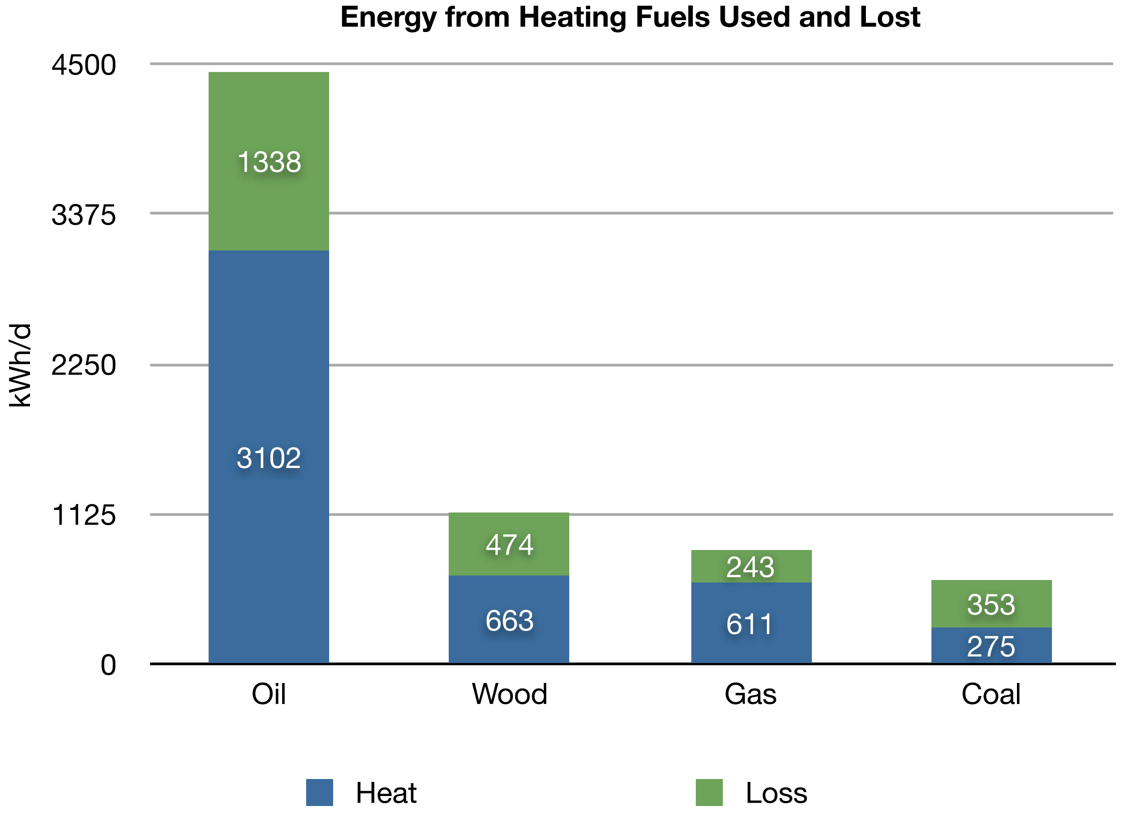

Fig (xiv). The amount of heat energy from each heating fuel used and lost.

Each bar represents the total fuel input[22], with the blue section showing the heat transferred to the house and the green representing heat lost through inefficiencies. The most efficiently burned fuel was gas (28% energy loss) - most gas was burned in boilers and the majority were not reported as being 'old or inefficient'. Oil was slightly less efficient (30% loss) due to the use of range cookers. Wood (42% loss) and coal (56%) were the least efficiently burned fuels due to the widespread use of open fires. These figures suggested that around £17,000 worth of wood and coal, £28,000 worth of oil and £5,000 worth of gas was being lost each year. Extrapolating to the rest of the area suggested loss figures of roughly £140,000 for wood and coal, £230,000 worth of oil and £40,000 worth of gas[23].

All heating systems incur some thermal loss, however, modern systems can achieve 80-90% efficiencies, representing significant scope for improvement. Rough estimates suggested that, without experiencing any reduction in temperature[24]:

---

[22] Gas does not include gas used for cooking

[23] Based on actual costs reported by sample

[24] Based on estimated costs noted on p.24, savings do not include capital costs

i. 657 kWh/d of oil (worth around £14,000 per year) could be saved by replacing old/inefficient oil boilers and oil fuelled range cookers with 90% efficient boilers (area estimates: 5,475 kWh/d worth around £115,000 per year)
ii. 316 kWh/d of wood (worth around £5,300 per year) and 174 kWh/d of coal (worth around £12,000 per year) could be saved by replacing all open fires with 85% efficient multifuel stoves (area estimates: 4,000kWh/d worth around £145,000 per year)

Another highly important factor contributing to the sample's consumption of heating fuel was the nature of the local housing stock. This is discussed further in section 3.4.

3.2.4 Transport

3.2.4.1 Average Consumption & Costs

For the domestic sample, annual energy use across all modes of transport ranged between 0 and 159 kWh/d, costing up to £7,200 per year. The mean energy use was 45.17 kWh/d (*SE* = 2.55) and the mean cost was £2096.42 per year (*SE* = 114.99). This compared to a national average of 35kWh/d costing £1,253 per year. Transport scores were nearing normal distribution with around 57% of scores falling below the mean for both consumption and costs. The median figures were 42kWh/d and £1920 per year.

3.2.4.2 Mode of Transport

Pen Llŷn's higher energy use for transport could have resulted from an increased reliance on cars due to the rurality of the area. People in rural areas travel on average 53% further than those in urban areas and do so by more expensive means (DEFRA, 2012). Car ownership averages 91% in rural areas of the UK compared to 57-78% in urban areas (DfT, 2011a). Figure (xv) shows the pattern of car ownership for the sample, Wales and other rural parts of the UK.

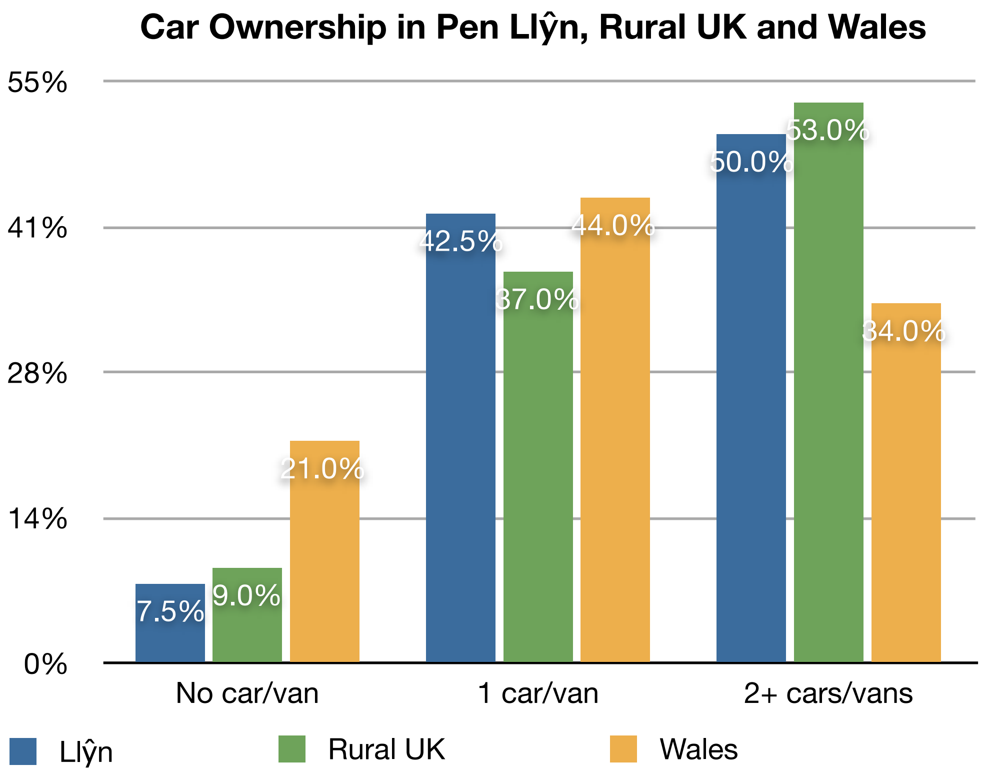

Fig (xv). The pattern of car ownership in the YnNi Llŷn sample, Wales and other rural areas in the UK[25].

[25] Data from Department of Transport (2011a).

The use of public transport in the sample was very low - with only 28 households reporting using either buses or trains at all. For the domestic sample, 98.8% of transport energy was consumed by cars/vans, 0.5% by motorbikes, 0.3% by bus and 0.2% by rail. This compares to national figures of 84% for cars/vans, 1% by motorbike, 6% by bus, 8% by rail and 1% by bicycle (Department for Transport, 2011d).

3.2.4.3 Mileage & Fuel

The average annual mileage was 8,059 miles per car (*n* = 221), or 13,807 miles per year for car owning households. 63.8% of the sample's cars ran on diesel, 35.7% petrol and 0.5% on other fuels (petrol/electric hybrid).

Whilst cars and vans are a high energy, inefficient, form of transport (most cars use only around 15% of the fuel's energy for motion, with the remainder lost), they are also much more expensive than other forms of transport. The average vehicle's fuel efficiency was 34.8 miles per gallon. Participants appeared to be responding to economies to be gained through fuel efficiency, with the most efficient cars experiencing heaviest usage. The average was 38.9 mpg for first cars (*n* = 134), 35.3 for second cars (*n* = 74) and 30.4 for third cars (*n* = 12). Accordingly, most first (70%) and second (57%) cars ran on diesel - the more efficient fuel - whilst most third cars (58%) used petrol.

Petrol prices have risen by 43.9% and diesel prices 38.3% since 2009. Taking into account the sample's vehicles' average mpg, the estimated annual fuel bills based on UK average fuel prices were as follows[26]:

i. Petrol = £103,300 (area estimate = £860,800)
ii. Diesel = £197,550 (area estimate = £1,646,250)

Beyond the necessity of travelling long distances for income and services, relying on more expensive forms of transport, owning vehicles with fairly low fuel efficiency and sharply increasing fuel prices, a further reason why Pen Llŷn appears to be experiencing such high transport costs could be a discrepancy in fuel prices based on rurality (DEFRA, 2012). In 2010 the cost of unleaded fuel averaged 2.1p more than the national average in sparsely populated rural areas[27]. Moreover, these figures fluctuated significantly depending on the area, so the effect may well be

---

[26] Based on 2011 prices (DfT, 2011f). Other overall transport costs within the report did not take into account vehicles' mpg and were slightly lower.

[27] This issue is currently being investigated by the Office of Fair Trading (DEFRA, 2012).

more pronounced in Pen Llŷn. Given that driving further inland to buy fuel at cheaper rates incurs its own costs, this leaves local people with very little room to manoeuvre.

3.3 Renewable Energy

3.3.1 Renewable Electricity

In 2010 6.8% of UK electricity was produced renewably (DECC, 2011a). The majority of participants (80%) did not know how much of their electricity came from renewable sources. 18% of households reported it as being under 25% and 2% (3 households) had subscribed to 100% green electricity tariffs. These households accounted for 1.7% of the sample's electricity demand.

18 households (12%) and five organisations reported having solar panels. 10 of these systems had been installed for under a year - probably due to a combination between quickly rising popularity and the dash to install before the lower feed-in-tariff was introduced in March 2012. Of those who knew (7 households) the average annual generation was 2220 kWh (6kWh/d)[28]. If this average were applied to the 18 households generating electricity, the total generation would amount to 108kWh/d - 4.7% of the sample's total domestic electricity demand[29]. The average output was almost half the 13kWh/d median consumption figure, suggesting potential to meet a significant portion of the area's electricity demand through small-scale domestic solar power.

One household owned a newly installed wind turbine and there were no hydro electric schemes.

3.3.2 Renewable Heat

11 households (7.3%) and one organisation reported having a solar thermal panel. If each panel generated an average of 5kWh/d of heat per year[30] this would account for 10.4% of the median household heating energy demand for households owning a panel, or 0.76% of the sample's total heat energy demand.

1136.4kWh/d of the sample's heating demand (15%) was met through wood - a renewable, though not necessarily a sustainable, resource. 15 households (10% of those who gave heating data) reported wood as their primary heating fuel.

---

[28] This figure is based on a small number of cases and should be interpreted with care - the data appear to reflect generation from larger domestic arrays.

[29] This may be inflated due to the increased likelihood of a household with solar panels taking part in an environmental project. In December 2011 the uptake of solar installations across Gwynedd was 0.53% (DECC, 2012) though this is likely to be significantly higher now.

[30] Actual output is highly variable, depending on size/type/location/weather.

3.3.3 Renewable Transport

Four households (2.7% of those who gave transport data) reported cycling as a form of transport[31].

3.3.4 Overall Contribution of Renewables

Figure (xvi) shows estimates for the levels of domestic electricity, heating and transport energy provided renewably in Pen Llŷn.

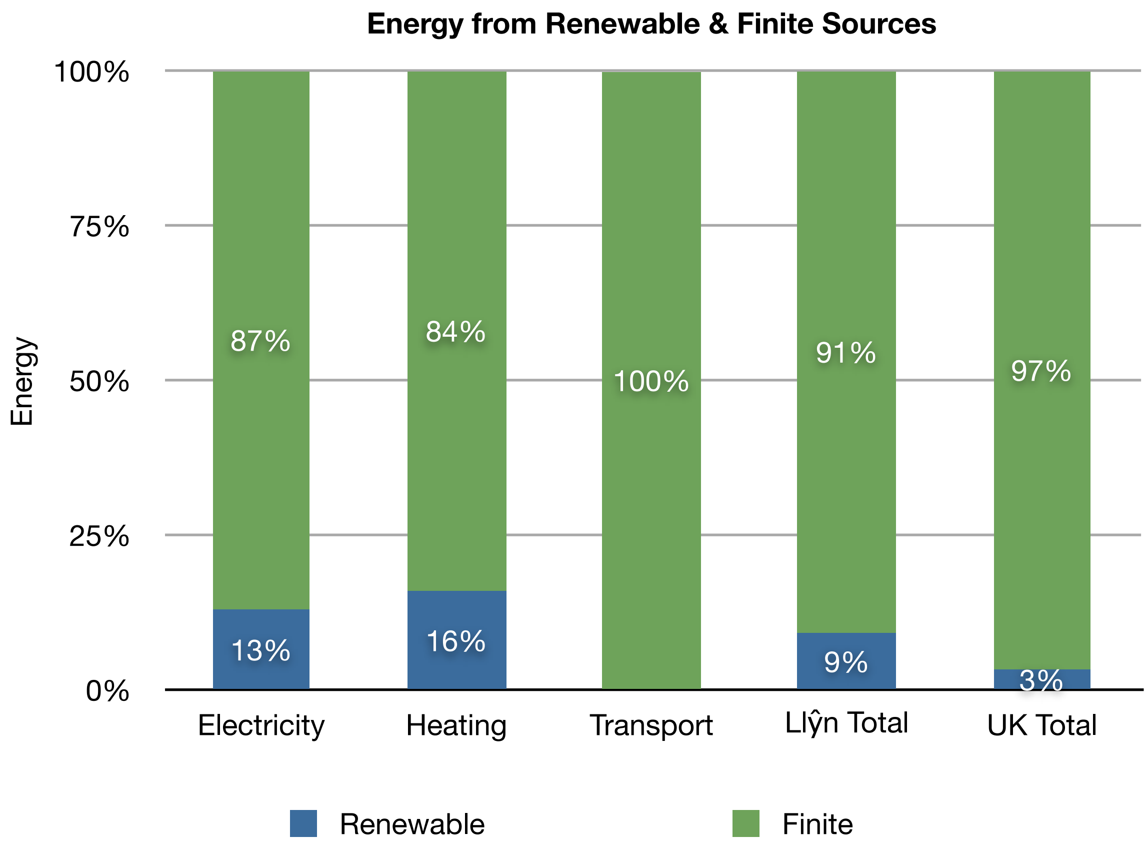

Fig (xvi). Estimated percentage of energy currently derived from renewable and finite resources.

Overall a higher percentage of Pen Llŷn's domestic energy demands appear to be met renewably compared to the UK at large. This can probably be attributed largely to the use of wood fuel falling at a slower rate than in other areas of the UK. Whilst the absence of a gas mains in the area may have had a negative effect on expenses, therefore, it has been a protective factor in terms of sustainability.

[31] The questionnaire did not ask directly about cycling so this may not be a fair representation

3.4 Energy Efficiency

3.4.1 Construction & Type

The vast majority of the sample's dwellings were detached houses (63%). 20.5% were bungalows, 9% were semi-detached houses, 4% were mid-terrace, 2% were end-terrace and 0.5% was a caravan. The dominant construction type was solid stone (65%), followed by cavity walls (31%), timber frames (3%) and other types (1%)[32]. Most of the houses had been built before 1923 (64%), followed by those built between 1924 - 1983 (26.5%), with a smaller portion of newer houses built after 1984 (9.5%).

Detached houses are more difficult to heat - requiring around three times the energy needed to maintain the same temperature in a mid-terrace house and twice that needed in a semi (Energy Saving Trust, 2010b). Furthermore, solid stone walls lose heat more rapidly than even uninsulated cavities. The most widespread building type, age and construction type in the area, therefore, is also the most difficult to heat.

3.4.2 Insulation & Draughts[33]

Most participants reported that their homes felt fairly draughty. Draught scores were measured on a slider with a score of 0 meaning draught-free and a score of 100 meaning very draughty. Scores ranged along the whole distribution with an average score of 40.1 (SE = 2.36) which suggested that there is significant scope for energy saving through draught-proofing. Around 40% of households gave low subjective draught measures (scores of 25 or under). Assuming that 60% of homes could benefit from draught-proofing, therefore, a very basic estimate was savings of around £7,250 per year through applying the measure across the sample[34] (or around £60,500 if applied throughout Pen Llŷn).

Floor insulation was the least widespread measure, present in only 13% of households. Assuming that 87% of the households have uninsulated floors, estimated savings from applying the measure throughout the sample were almost £14,000 per year (or around £115,000 if applied throughout Pen Llŷn).

---

[32] Including two single brick homes and one with clay walls.

[33] All estimates assume 63% of homes are detached and 37% are semi-detached and are scaled up from Energy Saving Trust's (2010a/b/c) estimates to reflect the sample's actual average heating price of 6p/kWh.

[34] Based on an average saving of £70p/a for a semi-detached house and £87p/a for a detached house. Measures include draught-proofing windows and doors and blocking gaps in floors and skirting boards.

Wall insulation was more widespread and was present in 29% of properties. 13 properties (8.8%) had uninsulated cavity walls. Of the households with wall insulation, the average depth was 81mm. The EST's (2010b) estimated savings for wall insulation are very high. Assuming that, of the homes without wall insulation, 13 households were detached houses with uninsulated cavity walls, 66 were detached houses with solid walls and 27 were semi-detached houses with solid walls, the estimated annual saving was £83,600[35] (or almost £700,000 p/y for the whole area).

Roof insulation was the most widely taken-up measure and was present in 96% of properties. Whilst only 12.5% of homes met or exceeded the industry standard of 270mm, the average insulation depth was a fairly high 171mm (*SE* = 9.36). 37.5% of homes had under 100mm of roof insulation. Based on the EST's (2010c) estimates, fully insulating all roofs with under 50mm of insulation could save the sample around £1,740 per year (or around £14,500 if applied throughout the area).

6% of households reported having an uninsulated hot water cylinder. The EST (2010a) estimates suggest savings of around £515 per year if these tanks were given new jackets (the area saving would be almost £4,300).

In their personal feedback reports 22% of participants were notified that they were highly likely to be eligible for subsidised loft/cavity wall insulation and a further 24% were notified of possible eligibility[36].

3.4.3 Glazing

76% of households had double glazing, 0.5% had triple glazing and 0.5% were secondary glazed. 23% had all or mostly single glazed windows. Whilst double glazing is one of the most widely taken up efficiency measures, it saves relatively little energy in comparison to measures such as draught-proofing and insulation.

---

35 Savings are £285p/a for cavity walls, £604p/a for semi-detached with solid walls and £964p/a for detached homes with solid walls.

36 Homes with uninsulated cavity walls are eligible for free/subsidised cavity wall insulation and homes with under 100mm of loft insulation are eligible for a free/subsidised upgrade to 270mm. This system is to be replaced by the Green Deal.

3.4.4 Low energy bulbs

Most participants reported having low energy bulbs, with only four households reporting having none. On average, households reported that 65.3% (*SE* = 2.4) of their bulbs were low energy. Based on the EST (2010d) average of 26 bulbs per household, if all remaining traditional bulbs were replaced with low energy versions the sample could achieve electricity cost savings of around £4000 per year on electricity [37] (Pen Llŷn saving: £33,000 per year).

3.4.5 Combined Efficiency Savings

Figure (xvii) presents the estimated total potential efficiency savings from taking all measures discussed above.

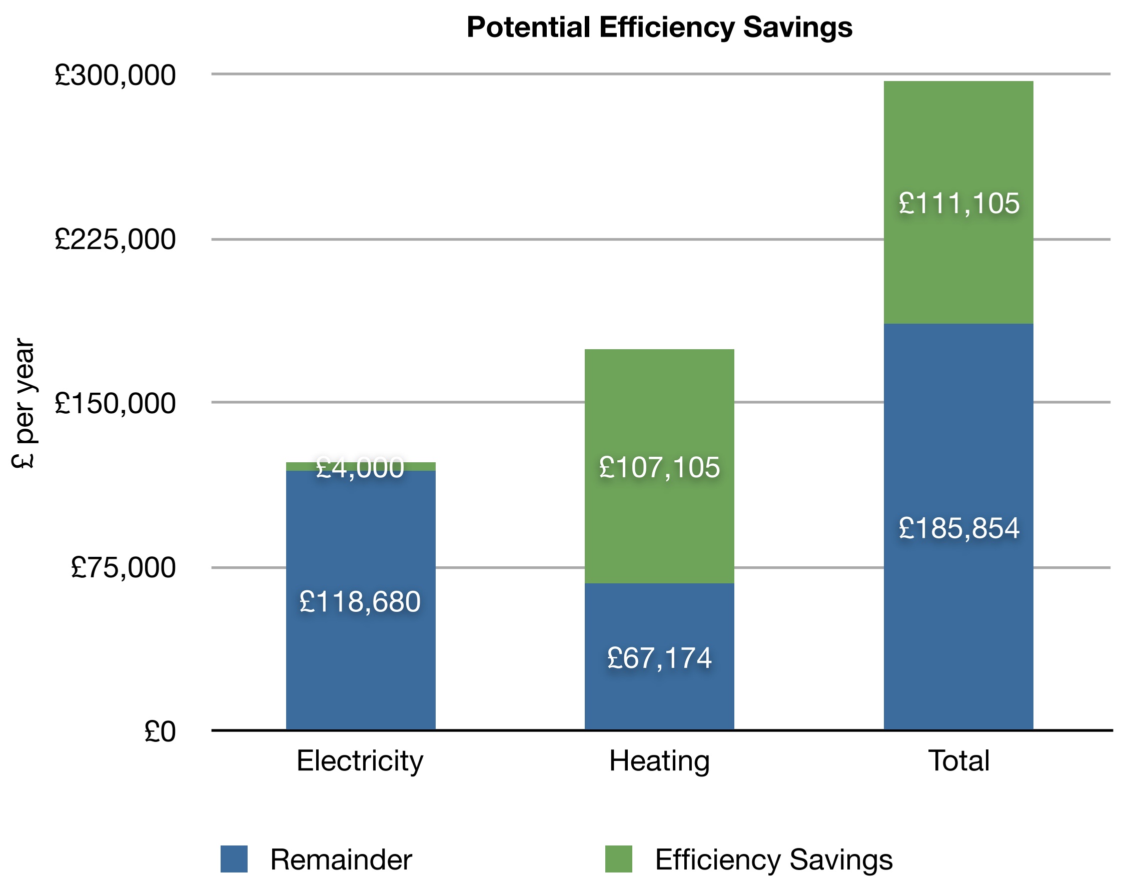

Fig (xvii). Potential estimated efficiency from draught-proofing, insulation and low-energy bulbs[38].

---

[37] Assumes average saving of £2.90 per bulb (scaled up from the Energy Saving Trust (2010d) estimate which is based on a 12.5p/kWh unit price to the sample's average unit price of 14.5p/kWh.

[38] Costs are based on the sample's average costs scaled up to 150 households (as this was how the efficiency savings were calculated). Costs are adjusted so that electrical heating is represented in the heating column.

Considering that it is generally quoted that around a third of heat energy can be lost through uninsulated walls (EST, 2012), the contribution of wall insulation to these savings may be over-ambitious and further investigation is necessary. Furthermore, these figures do not take into account the costs of applying the various efficiency measures. External wall insulation is particularly expensive and is currently unsubsidised. A final qualification is that in reality, projected financial savings are unlikely to be realised because many households will enjoy the increase in temperature rather than maintaining the previous temperature through burning less fuel (EST, 2010b). This is likely to be especially true for colder homes and on a scale of 0 (cold) - 100 (very warm), the mean score for perceived indoor temperature was 53.09 (SE = 1.14).

3.4.6 Correlates of Energy Efficiency measures[39]

The following relationships among energy efficiency measures were significant:

i. A negative correlation between overall energy use and the subjective measure of indoor temperature ($r = -.21$, $p > .05$). This indicated a significant role for poor energy efficiency as colder feeling homes were consuming more energy than warm ones.
ii. A positive correlation between overall energy use and house size ($r = .25$, $p < .01$) - to be expected given that larger spaces require more energy to heat.
iii. A positive correlation between the number of low energy bulbs and the subjective measure of heat ($r = .25$, $p < .001$), possibly due to both measures being underlying predictors of a household's overall energy efficiency.
iv. A negative correlation between draughtiness and perceived indoor temperature ($r = -.33$, $p < .001$) and a correlation between draughtiness and wall type[40] ($r = .34$, $p < .001$), with more draughts present in solid stone properties. Wall type was also correlated with temperature ($r = -.19$, $p < .05$), with stone homes feeling colder.
v. A correlation between building type and overall energy use ($r = .17$, $p < .05$) and between building type and perceived temperature ($r = -.22$, $p <. 01$) showing that detached buildings used more energy and felt colder.
vi. Strong correlations between building age[41], type and construction reflecting the high percentage of old, stone built, detached homes (*r(type/age)* = .45, *r(type/construction)* = .40, *r(age/construction)* = .87, all *ps* < .001).

[39] Only variables which met the assumptions of parametric tests were included in bivariate analyses - the results do not reflect causality and interpretations are for guidance only.

[40] This measure categorised walls as solid or not-solid.

[41] A categorical measure of whether houses were built before or after 1923.

vii. Correlations between building age and overall energy use (r = .18, $p < .05$), age and draughtiness (r = .24, $p < .001$) and age and temperature (r = -.19, $p < .05$) showing that older houses were more draughty and cold and consumed more energy.

3.4.7 Public Buildings

Energy costs accounted for almost the entire annual income of the three community buildings which took part. Community buildings are not eligible for subsidised insulation and struggle to raise the capital necessary to realise any efficiency savings. Given rising fuel prices, if no strategic changes are made, their position is likely to become quickly unsustainable.

3.5 Fuel Poverty

3.5.1 Heating & Electricity Poverty

The UK government defines households as in 'fuel poverty' if there is a need to spend more than 10% of household income to maintain a satisfactory temperature (DECC, 2011c). The indicator takes into account *required* energy input[42], energy prices and income. The measures presented here take into account income and *actual* spending on energy and so are likely to give conservative estimates as many homes may be colder than DECC standards. Many households in this study chose not to give income data (*n* = 61, 44.5%), therefore the sample size was significantly lower for these analyses[43].

43% of those who provided income data were in fuel poverty. A further 33% of households were spending 5 - 10% of their annual income on electricity and heating, meeting the Government's criteria for being 'at risk' of entering fuel poverty if energy costs continue to rise (WAG, 2008). 27% of households defined as fuel poor were spending over 20% of their annual income on heating and electricity. Figure (xviii) compares these results to those collected by the WAG in 2008.

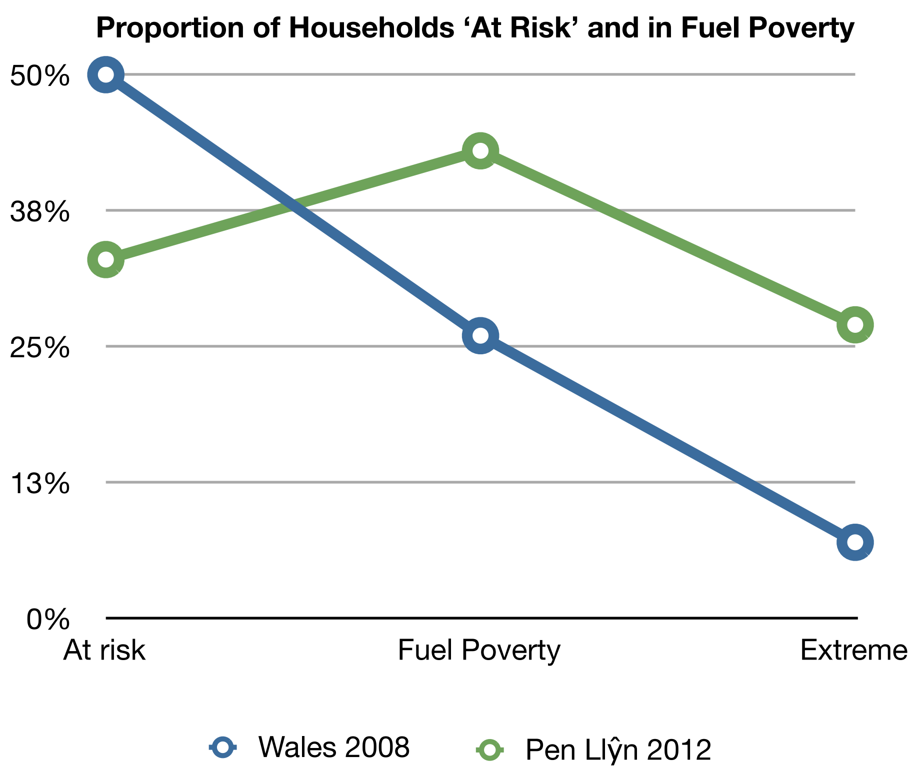

Fig (xviii). The proportion of households at risk of fuel poverty, in fuel poverty and in extreme fuel poverty.

[42] To provide a temperature of 21°C in the main living area and 18°C in other used rooms

[43] The analysis, therefore, comes with the health warnings that:
i.The sample may be over-representative of those on lower incomes
ii.It is harder to identify significant relationships in smaller samples - some effects may be overlooked

Whilst only of 26% of Welsh households were in fuel poverty as measured in 2008, that figure represented an increase of 15% since 2004 (WAG, 2008). This result, therefore, is only slightly over what would be expected if the trend had continued at the same rate since 2008. Also of note is that, within both Pen Llŷn and WAG samples, exactly 76% of households were classified as either in or 'at risk of' fuel poverty, possibly implying that a significant proportion of those 'at risk' entered fuel poverty between 2008 and 2010 and a group of 24% of people have remained immune.

There are sources of financial support for people in fuel poverty - the WAG's Nest scheme offers an unlimited investment in eligible households to lift them to a C energy rating (see BRE, 2009) and the Warm Homes Discount is a £120 per year payment towards electricity through providers. The proportions of households who were alerted to eligibility for these schemes in their personal feedback reports is shown in figure (xix).

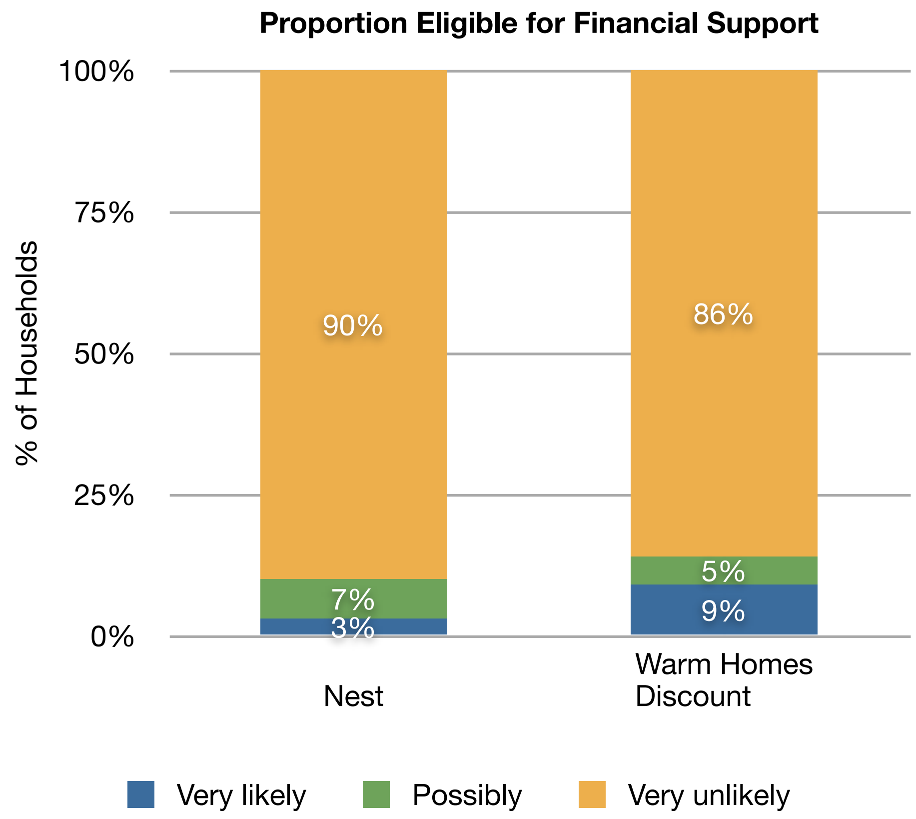

Fig (xix). The proportion of households eligible for Nest and the Warm Homes Discount.

3.5.2 Transport Poverty

Whilst transport poverty is not currently officially recorded, charities are campaigning for its recognition. Sustrans (2012) argues that the Government's assumption that people own cars has forced many into choosing between possessions they cannot afford or isolation and exclusion.

Sustrans reported that 50-60% of people in Gwynedd are having to spend over 10% of their income to run a car.

In order to produce a comparable measure, a flat rate of £1000 was added to participants' fuel costs to represent the cost of maintaining a car[44]. By this measure 69% of the households who provided the relevant data were classified as in transport poverty, with 24% of those spending over 20% of their annual income on transport. These figures do not identify households who do not own cars due to even more critical financial circumstances.

This represents a significant vulnerability requiring a strategic, area-based, solution.

3.5.3 Correlates of Energy Poverty

The following relationships were significant:

i. A positive correlation between overall energy use and income[45] ($r = .33$, $p < .001$) with households who earned more consuming more energy.
ii. Strong negative correlations between income and fuel poverty ($r = -.60$, $p < .001$), extreme fuel poverty ($r = -.50$, $p < .001$) and transport poverty ($r = -.35$, $p < .001$), suggesting that earning less, rather than consuming more was the more important determinant of fuel poverty.
iii. Overall energy use was negatively correlated with the being 'at risk' of fuel poverty ($r = -.24$, $p < .05$) perhaps as those who were 'feeling the pinch' of rising energy bills were consuming less.
iv. A negative correlation between extreme fuel poverty and having low energy bulbs ($r = -.22$, $p < .05$) which suggested a possible knowledge and behaviour component to the issue of fuel poverty.
v. Fuel poverty and transport poverty were highly correlated ($r = .53$, $p < .001$) suggesting that many households were struggling with both heating/electricity and travel costs.

[44] This was a conservative estimate based on AA (2012) and did not increase for households owning more than one car. It did not include the capital cost of buying a car.

[45] A categorical measure of whether or not a household earned above the sample's median income.

3.6 Attitudes[46]

3.6.1 Attitudes towards the Environment

On the scale of 0 - 100 most participants expressed being 'concerned about the environment'. Actual scores ranged from 5 to 100 and the mean score was 72.13 (SE = 1.82), though around 60% of scores were above this value, indicating a strong concern[47]. In conversation some people mentioned that whilst they felt a concern for the environment they were aware that their behaviour did not reflect this.

Some participants (16%) made comments specifically about their views on sustainability/ environmentalism. 1% were strongly against such initiatives, 10% were supportive and 5% were highly supportive. 7% of participants wrote about something they did/had done towards achieving sustainability (e.g. planting trees, cycling, raising awareness).

3.6.2 Attitudes towards a Local Energy Company

Views towards a local energy company were overwhelmingly supportive. Scores ranged all the way from 0 - 100 and the mean score was 80.6 (SE = 1.79). 25% of the sample had scores over 98.

Whilst both means were high, support for a local energy company was significantly higher than concern for the environment ($Z = -4.09$, $p < .001$, $r = -.32$) suggesting that participants' reasons for supporting the initiative went beyond environmental concerns. Other reasons expressed in conversation included:

i. The need for local jobs
ii. Concerns with unfairness in prices which could be rectified by a not-for-profit company
iii. A local company would be more accountable
iv. Cheaper electricity

One participant thought that YnNi Llŷn was a profit-making venture and was less keen to support it if this were the case.

[46] Both households and organisations were included in these analyses.

[47] Participants may have felt a social expectation to give high scores on this measure.

3.6.3 Attitudes towards Renewable Power

Some participants wrote qualifying statements stating that their support for a renewable energy company depended on the type of generators it used. Others wrote in support of particular methods. Figure (xx) represents the results of coding each questionnaire according to the tone of their comments[48].

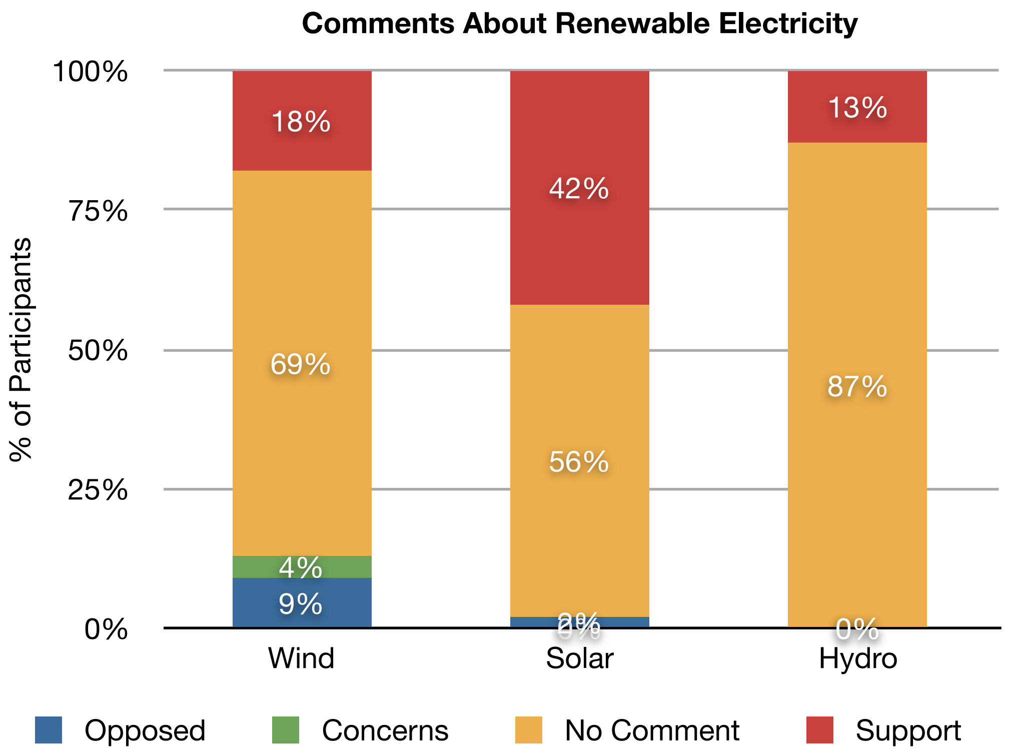

Fig (xx). Proportions of participants who made particular comments about renewable technology.

Solar power appeared to be the technology that most participants were familiar with - it received the most comments overall and also the most positive comments. Many participants expressed a wish to have solar panels on their homes and some were keen for financial assistance and/or advice. Some spoke about the possibility of generating more power through solar arrays on community and agricultural buildings.

The next most discussed method was wind power and results were more split between those in favour and those against. Wind was the least preferred option of the three, although more participants wrote comments in support than against. Those who expressed concerns were not opposed in theory but felt the number, size and location of turbines was important. Comments against wind were frequently lengthy and/or quasi-scientific. The primary concern was that wind

[48] The comments question was open-ended and did not ask specifically about renewable generators.

turbines would detract from the beauty of the area. The least commented-on technology was hydro/marine, with 13% of participants suggesting it would be a good idea.

Some participants expressed an interest in sustainable heating technologies, with 15% referring directly to heat pumps and 19% to solar thermal panels.

3.6.4 Correlates of Attitude Measures

The following relationships with attitude measures were significant:

i. A negative correlation between supporting a local energy company[49] and being anti wind power[50] (r = -.21, p < .01), suggesting that it was fears about this type of generation which resulted in lower support for the idea in general for some people.
ii. A negative correlation between concern for the environment and extreme fuel poverty (r = -.25, p < .05), possibly due to households in this situation contending with more immediate stressors.
iii. A positive correlation between concern for the environment and being pro solar power[51] (r = .17, p < .05) suggesting that solar power is something which people see as an appropriate option for increasing sustainability. It could also mean that solar power might lead people to be open to further care for the environment. Having low energy bulbs was also positively correlated with being pro solar power (r = .21, p < .01).
iv. Being anti wind power was correlated with being pro solar power (r = .16, p < .05), suggesting that for some households one form of technology was acceptable where the other was not. However, being pro solar power was also correlated with being pro wind power (r = .29, p < .001) suggesting the underlying predictor of support for renewable electricity in general.

---

[49] Participants were categorised as above/below the mean score for 'local company support' and 'concern for the environment' measures due to the raw data being non-normally distributed.

[50] A categorical measure of whether participants had made anti wind power statements or not.

[51] A categorical measure of whether participants had made favourable comments about solar power or not.

4.0 Conclusions

4.0.1 A Local Energy Picture

These results paint a delicate economic and environmental picture for Pen Llŷn. For all three categories investigated, both energy consumption and costs outstripped the national average. This was due to a combination of living in older houses, using inefficient heating systems, reliance on expensive heating fuels and reliance on expensive forms of transport. There were also concerns with the fairness of fuel and energy providers. The majority of households appeared to be either in, or at risk of, heating/electricity poverty and transport poverty.

Whilst founding a community electricity company was the original vision for this work, electricity provision has, arguably, not emerged as the most pressing issue: what is more fundamental is that people are tied to travelling outside the area for work using a method of transport that is quickly becoming unaffordable. As fuel costs rise, this may mean that living in this area full-time could become impossible for most families.

There are, however, three positive aspects to the situation. First, the study showed that people here care a great deal for the environment and are willing to support initiatives which support their community. Second, the study represents a significant step towards strategic resolution of the issues brought to light - by helping define them and identifying a starting point against which progress can be measured. Third, the combination of these factors represents a genuine leadership opportunity for this community to carve out and pioneer sustainable solutions for rural Wales.

4.0.2 In a Global Context

These results must be appreciated within the context of why public funding would be supplied to undertake such a study; a context defined by the combined challenges of climate change and peak oil.

The increase in atmospheric carbon concentration of 106ppm since the industrial revolution has led to a 0.8°C rise in global temperatures from pre-industrial levels and commits a further rise of 0.6°C due to the delayed warming effect of gasses already emitted (Hansen et al, 2005). Meinshausen *et al* (2009) concluded that there is an 84% chance of avoiding runaway climate change (the point after which changes in emissions will have no effect) if global emissions peak by

2020 and reduce by 72% by 2050. *This implies a reduction in personal emissions of 86 - 92% from 1990 levels.*

In the vast majority of oil producing nations, production peaks 30 - 40 years after discoveries peak. The global peak in oil discoveries happened in 1965 (Strahan, 2007). Despite high demand and prices tripling, conventional oil production has levelled at about 72 - 74 million barrels per day since 2004 (APSO, 2012). In a report to the US government, Hirsch (2005) concluded that without mitigating action before the peak, the world would experience a liquid fuel deficit of at least 20 years[52]. The implications of this are yet to be fully appreciated, but it does mean that cutting fuel prices is not a long term solution to sustaining communities in remote areas such as Pen Llŷn (Sustrans, 2012). Exactly how high oil prices would have to rise to undermine the economic case for most people to continue living here full-time was not modelled in this study. However, what is clear is that oil is what currently sustains the community and the ability to continue with 'business as usual' will unremittingly decline if action is not taken to adapt to this issue.

4.0.3 Action Planning

Whilst being situated on a rural peninsula presents certain challenges, Pen Llŷn has a particular protective characteristic which many places have lost: a visible sense of community. People here have a sincere wish to support their people and their place. The issues raised by this study are serious, pervasive and require a co-ordinated and in-depth strategic response. However, they are not without solutions and if the energy of Llŷn's communities can be focused, then a positive, practical response is still possible.

Whilst this research revealed that most people are concerned about the environment, this does not necessarily imply a general understanding of *how* to achieve sustainability, suggesting a need for information and leadership. Focusing too strongly on any one solution too soon, however, could lead to losing momentum later on arguing over disagreements. Strategic change is likely to require raising widespread recognition of the actual issues and allowing the community to voice its own priorities in response [53].

---

[52] The issues of climate change and peak oil should be considered alongside or solutions to one problem could compound the other (Hopkins, 2008). Attempts to transition to other fossil fuels, for example, would sustain carbon emissions and miss the opportunity to achieve sustainability.

[53] The finding that people in extreme fuel poverty were less likely to have concerns about the environment may be interpreted as an indication that time is of the essence. As energy prices rise and more households enter a critical financial situation, the chances of engaging the community may decrease.

These priorities could form the basis of a Pen Llŷn Energy Descent Action Plan (Hopkins, 2008), possibly containing some of the following elements:

<table>
<tr><th>Small Steps</th><th>Medium Steps</th><th>Bigger Steps</th></tr>
<tr><td rowspan="2">Switch to green energy tariffs

Car-sharing clubs and/lift-sharing schemes

Awareness raising/education about energy use and efficiency</td><td rowspan="2">Widespread energy efficiency programme, particularly insulation and draught-proofing

Green heating schemes (possibly making use of the Renewable Heat Incentive)

Further uptake of domestic renewables

Projects to assist those in energy poverty

Campaign/collaborate to achieve better public transport

Community food projects</td><td>Community energy company

Alternatives to car ownership

Plant crops for wood fuel

Sustainable food strategy</td></tr>
<tr><td>Resources:

The Transition Handbook (Hopkins, 2008): From oil dependency to local resilience

Zero Carbon Britain (CAT, 2010). Zero Carbon Britain: A new energy strategy</td></tr>
</table>

4.0.4 Opportunities

Specific opportunities identified as a result of this research include:

i. A community energy company - whilst some raised concerns over the method of generation, the community’s response to this idea was highly favourable.
ii. Oil Vulnerability Auditing (OVA) - an opportunity to collaborate with the University of Liverpool to run OVAs with the businesses who took part in order to assess how high oil prices would need to rise to undermine their profit margin and develop protective strategies.
iii. Modelling habitability - researching length of travel to the work place, energy costs and income in order to assess the effects of incremental rises in oil prices (e.g. with each 5p increase in the cost of fuel, what percentage of the community are likely to enter fuel poverty/ extreme fuel poverty/transport poverty).
iv. Solar PV - many people stated an interest in this technology suggesting possible scope for a community ‘rent-a-roof’ scheme.
v. Ensuring available support is taken-up - there are a still many homes eligible for measures such as Nest, Warm Homes Discount, subsidised insulation.
vi. Monitoring - a follow up study to measure the impact of participation on the households which took part (e.g. how many people accessed grants).
vii. Further engagement - the vast majority of participants wanted to hear more from YnNi Llŷn.

6.0 Evaluation

The primary limitations to the study were that it was highly time-constrained and cross-sectional - providing a simple snapshot of energy use in Pen Llŷn. A follow up study could have enabled changes over time/trends to be modelled. Moreover, whilst measurement was a primary aim of the research, this was not a simple observational study but was also aimed at engaging the community in energy issues - more time could have allowed monitoring to assess the effects taking part. One positive observation was that participating organisations appeared to get a much better understanding of their energy use simply by putting together all the information necessary to complete the study.

Taking into account the length and complexity of the questionnaire, the response rate and data quality were high, suggesting potential for the measure to be reused/redeveloped for further studies. The analysis would have benefited from the following:

i. Data on water heating method
ii. Data on the capacity of solar arrays
iii. Data on the general location of participants' workplaces
iv. A better response rate for the income measure

Acknowledgements

With heartfelt thanks to all who took part.

Thanks also for the support of:

The YnNi Llŷn steering group

Cywaith & particularly Wil Parry

Pen Llŷn Communities First & particularly Meinir Jones

Dafydd Jones (SWEA)

Tai Eryri

Megan Llŷn

Crispin Jones (Energy Saving Trust)

Megni energy monitoring

Droplet graphic design

Gwerfyl Price (Dadlen Cyf)

References

Association for the Study of Peak Oil & Gas - USA. (2012). http://www.aspousa.org/index.php/peak-oil-reference/peak-oil-data/

Automobile Association. (2012). *Car running costs 2011/12.* http://www.theaa.com/motoring_advice/running_costs/index.html

Building Research Establishment. (2009). *The government's standard assessment procedure for energy rating of dwellings.* http://www.bre.co.uk/filelibrary/SAP/2009/SAP-2009_9-90.pdf

CACI Paycheck. (2011). http://www.caci.co.uk/paycheck.aspx

Crawford, M. (2008). *Is Burning Wood Really A Long-Term Energy Descent Strategy?* www.transitionculture.org.

Department for Business, Enterprise and Regulatory Reform. (2007). *Estimates of Heat Use in the UK.* http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file43843.pdf

Department for Energy & Climate Change. (2008). *Energy Consumption in the United Kingdom.* http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

Department for Energy & Climate Change. (2010). *Energy Flow Chart.* http://www.decc.gov.uk/assets/decc/11/stats/publications/flow-chart/2276-energy-flow-chart-2010.pdf

Department of Energy & Climate Change. (2011a). *Digest of United Kingdom Energy Statistics (DUKES).* http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

Department of Energy & Climate Change. (2011b). *Energy Price Statistics.* http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/prices/prices.aspx

Department of Energy & Climate Change. (2011c). *Annual report on fuel poverty statistics*. http://www.decc.gov.uk/assets/decc/Statistics/fuelpoverty/2181-annual-report-fuel-poverty-stats-2011.pdf

Department of Energy & Climate Change. (2012). *Feed-in Tariff Statistics.* http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/fits/fits.aspx

Department for Environment, Food & Rural Affairs. (2012). *The Cost of Fuel in Rural Areas*. http://www.defra.gov.uk/publications/2012/03/30/pb13741-rural-fuel-costs/

Department for Transport. (2011a). *Household car ownership by region and area type: Great Britain.* http://www.dft.gov.uk/statistics/tables/nts9902/

Department for Transport. (2011b). *Petroleum consumption by transport mode and fuel type: United Kingdom, annual from 1999.* http://www.dft.gov.uk/statistics/tables/env0101/

Department for Transport. (2011c). *Household expenditure on transport.* http://www.dft.gov.uk/statistics/tables/tsgb0121

Department for Transport. (2011d). *Passenger Transport by Mode.* http://www.dft.gov.uk/statistics/tables/tsgb0101

[Department for Transport. (2011e). *National Travel Survey.* http://assets.dft.gov.uk/statistics/releases/national-travel-survey-2010/nts2010-01.pdf]

Department for Transport. (2011f). *Petrol and diesel prices and duties in April: United Kingdom, annually from 2000.* http://www.dft.gov.uk/statistics/tables/env0105/

Energy Saving Trust (2012). *Wall insulation guide.* http://www.energysavingtrust.org.uk/In-your-home/Roofs-floors-walls-and-windows/Wall-insulation

Energy Saving Trust (2010a). *Advisor Factsheet: Insulation around the home.*

Energy Saving Trust (2010b). *Advisor Factsheet: Wall insulation.*

Energy Saving Trust (2010c). *Advisor Factsheet: Roof & loft insulation.*

Energy Saving Trust. (2010d). *Advisor Factsheet: Energy efficient lighting.*

Hancock, R., Askham, J., Nelson, H., & Tinker, A. (1999). *Home-Ownership in Old Age: Financial Benefit or Burden?*. Joseph Rowntree Foundation.

Hansen, J., Nazarenko, L., Ruedy, R., Sato, M., Willis, J., Del Genio, A., Koch, D., Lacis, A., Lo, K., Menon, S., Novakov, T., Perlwitz, J., Russell, G., Schmidt, G. A., & Tausnev, N. (2005). Earth's energy imbalance: Confirmation and implications. *Science,* 308, 1431-1435.

Hirsch, R. (2005). *Peaking of World Oil Production: Impacts, Mitigation, and Risk Management.* http://www.netl.doe.gov/publications/others/pdf/oil_peaking_netl.pdf

Hopkins, R. (2008). *The transition handbook: from oil dependency to local resilience.* Dartington: Green Books.

Hopkins, R. (2011). *The transition companion: Making your community more resilient in uncertain times.* Dartington: Green Books.

Meinshausen, M., Meinshasen, N., Hare, W., Raper, S. C. B., Frieler, K. Knutti, R., Frame, D. J., & Allen, M. R. (2009). Greenhouse gas emission targets for limiting global warming to 2 degrees C. *Nature,* 458, 1158-62.

Milbourne, P. & JRF Commission on Rural Housing in Wales. (2008). *Rural Housing in Wales.* Jospeh Rowntree Foundation. http://www.jrf.org.uk/publications/rural-housing-wales

Office of Fair Trading. (2011). *Off-Grid Energy: An OFT market study.* http://www.oft.gov.uk/OFTwork/markets-work/off-grid/

Office of National Statistics. (2010). *ONS Mid-year population estimates.*

Office of National Statistics. (2001). *Census.*

Ofgem. (2011). *Typical domestic energy consumption figures.* Factsheet 96: www.ofgem.gov.uk

Palmer, G. (2012). *Without Central Heating.* The Poverty Site. http://www.poverty.org.uk/77/index.shtml

Strahan, D. (2007). *The last oil shock: The imminent extinction of petroleum man.* John Murray Publishing.

Sustrans. (2012). *Access Denied: Transport poverty in Wales.* http://www.sustrans.org.uk/assets/files/Wales%20Policy%20Docs/Transport%20Poverty%20Briefing%20English.pdf

Thomas, S. (2002). *Why retail electricity competition is bad for small consumers: British experience.* London: University of Greenwich.

Welsh Assembly Government. (2008). *Living in Wales 2008: Fuel poverty.* http://cymru.gov.uk/topics/statistics/headlines/housing2010/1011261/;jsessionid=W3HrM2GVVS1wMnWjkmskL2BWnpTb1vXPr4xQZxzdpmsYXnkGZy7Y!-1406392113?lang=en

White, V., Roberts, S., & Preston, I. (2010). *Understanding 'high use low income' energy consumers - Report to Ofgem.* Bristol: Centre for Sustainable Energy.

Appendix (i) YnNi Llŷn Leaflet (front page)

YnNi Llŷn

Hysbysu, Arbed, Cynhyrchu
Inform, Conserve, Produce

Sut fyddech chi'n teimlo am...

Brynu trydan yn rhatach gan gwmni lleol?

Na fydd yn niweidio'r amgylchedd wrth ei gynhyrchu?

Gyda'r elw'n aros yn y gymuned?

Mae Ynni Llŷn eisiau eich barn!

How would you feel about...

Buying discounted electricity from a local company?

Whose generation did not harm the environment?

Whose profits stayed in the community?

Ynni Llŷn wants your views!

Cywaith

Appendix (ii) Missing data treatment for heating

128 participants (77%) gave accurate figures for their heating energy based on fuel type and costs or quantities. In a further 34 cases (20.5%) it was possible to infer heating energy input from descriptive information about fuel type and frequency of use. The mean use of the participants who reported using the same fuel in the same way and provided quantity data was used to calculate these figures. The following figures were used:

a. Wood/coal stove (evenings in winter): 10 kWh/d
b. Oil fuelled AGA/other range cooker (constant): 47kWh/d
c. Oil/gas fuelled boiler controlled by a thermostat and on all year: 49kWh/d

This research was made possible by the Energy Saving Trust's Local Energy Assessment Fund and was prepared as part of Cywaith Cyf's YnNi Llŷn project - laying the foundations for community based sustainability in Pen Llŷn.

Author: Bethan Gritten
Gritten mgmt: Traian, Llanfrothen,
Penrhyndeudraeth, Gwynedd LL48 6SW
beth.gritten@gmail.com