Heat and Light from Renewable Energy for Village Houses in England

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Abstract

This paper reports on an investigation into supplying from renewable sources the entire domestic energy needs, both heating and electricity, for three remote communities in the English Pennines. The study took a whole system approach converging the pattern of energy demand, appropriate technologies, the possible sources of energy and opportunities for energy efficiency. The results indicate that the energy needs could be readily met through the use of solar power for some electricity and heat by using photovoltaic roofs and solar collectors; wind for electricity; and biomass for heat and electricity. There was strong local support for the proposals and the future challenge is to develop renewable energy communities to demonstrate the possibilities.

Introduction

This paper examines the lessons of recent research into the potential and practicalities of introducing renewable energy to meet the housing energy needs in a group of remote communities in the North East of England. It shows that despite a reduction in CO_2 emissions due to the decline in industry - transport in particular has contributed to a more recent trend in increased emissions. Remote communities, such as those studied, do not have mains gas and rely on coal as the main source of domestic heating. This has an adverse effect on the local environment, and on the health of the residents. Electricity is supplied by overhead cables, which are especially prone to failure in winter. Infrastructure renewal costs are prohibitively expensive and thus any large scale source whether it be nuclear or renewable would still face the difficulties of a fragile distribution network. This project therefore examined in detail the energy needs, both heat and electricity demand, and how these could be met by locally produced renewable energy.

Renwable Energy

There are growing reasons for Britain to shift to renewable energies. The present high dependence on fossil fuels both for direct use and to produce electricity contributes to human induced climate change. Between 1990 and 2000 releases of CO_2 declined by over 7% (DEFRA, 2005), this was mainly due to one off factors such as the decline in industry and the shift from coal to gas to produce electricity. However since 2000, releases of CO_2 have risen again as use of energy continues its steady increase (Tables 1 & 2) (DEFRA, 2005), putting in doubt the government's targets. So far there seems little evidence of a serious reversal in the trend of increased energy use. To tackle the releases of CO_2 there needs to be both a shift from fossil fuels and a reduction in energy use through energy efficiency.

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The nature of the supply of fossil fuels is a further reason to consider a shift away from them. The UK supply of oil and gas has peaked as fields have reached maturity and gone into decline. This means Britain is increasingly dependent on international supplies of oil and gas. As Peak Oil begins to bite, these supplies will be at risk of interruption and price instability (Oil Depletion Conference, 2005). Renewable energy, which is available within Britain, would increase the security of energy with greater stability of price and supply.

The British government, in response to the issues of climate change and international energy dependency, has launched a debate on increasing the country's reliance on nuclear fission for electricity generation. It appears that, regardless of the debate, there is already strong commitment to such a policy within the senior levels of government (Adam, 2005; Wintour & Milner, 2005). However, none of the problems of the treatment of highly dangerous radioactive waste have been resolved. In addition Britain has no supplies of uranium, so it too is vulnerable to international developments. If the world makes a significant shift to nuclear power the supplies of uranium will only last a few decades.

Table 1: Carbon Dioxide emissions in the UK (DEFRA, 2005).

	1990	2000	2004
Carbon Dioxide (Million tonnes of carbon)	165	153	158
% Change		-7.3%	3.3%

A successful renewable energy policy requires using a basket of energy sources to meet different needs and to deal with the interrupted nature of at least some sources, such as wind and solar. In addition the supplying of renewable energy, for all or most needs, would require a different supply system from those presently used for electricity, oil and gas.

The present networks are based on large-scale sources of energy from substantial generating stations or oil and gas fields, long supply lines, with a one-way flow of energy from the producer to the individual users. Control of the system is remote from the users, sometimes even in other countries. The energy flows one way and the money flows back the other way.

Table 2: Final Energy Consumption in the UK (DEFRA, 2005).

	1980	1990	2000	2004	% Increase (1980 to 2004)
	(Million tonnes of oil equivalent)				
Transport	35.5	48.6	55.3	57.4	61.7%
Domestic	39.8	40.8	46.9	48.7	22.4%
Industry	48.3	38.7	34.6	34.1	-29.4%
Services	18.7	19.2	21.5	20.8	11.2%
Total	142.4	147.3	158.3	161	13.1%

Currently, these networks have the ability, in most circumstances, to respond to increased demand by increasing supply either by drawing on storage tanks, as in gas, or increasing generation of electricity either by increasing the output of operating plant or bringing on stream generators that can respond rapidly, such as hydro or burning gas. While the present energy networks generally can respond to day-to-day changes in demand, there are serious questions about their resilience. Disruption can happen, and has happened internationally, through war, political tensions, shortage of supply or even just a breakdown in part of the network. The entire network is also vulnerable to price rises beyond the control of the consumer or the government, which can have serious impacts for individuals and the economy generally.

The day-to-day supply of renewable energy from some technologies is not open to easy control as it depends on natural factors, such as sunshine or wind speed. One of the challenges for renewable supply is to ensure the network is able to respond to changes in supply and demand through storage methods and having overcapacity from a range of sources so that different sources can compensate for each other.

Renewable energy supply would use a number of energy sources with a significant proportion located near to the place of use. Consumers, whether households or organisations, could at times also be suppliers of energy; and more of the money would stay in the locality. Local production of renewable energy would also have potentially wider benefits such as community involvement in decisions about energy production, local employment, and increased awareness about energy, which might help encourage energy efficiency.

In terms of protecting the environment and increasing security of supply and price, Britain would benefit from a shift to renewable energy.

Remote Communities

Remote communities provide opportunities to begin the exploration of a significant shift to renewable energy. Remote communities are at risk of disruption in supply, have the potential to clearly define energy use within the area and are likely to have a greater potential to utilise a range of renewable energy technologies within the locale than might occur in urban areas.

Although the remoteness of communities is a relative concept and will vary from country to country, there are some common features (Hanley & Nevin, 1999) including:

- Low population densities
- Limited conventional energy sources (may not be connected to all the national networks)
- Lack of infrastructure
- Low levels of local economic activity (depend on commuting)
- Physical access constraints (terrain, distance and weather may cause problems)
- Long distances to external markets

These features describe significant parts of upland England (Pennines, Lake District and moors of the Southwest) and Wales as well as much of Scotland. Almost all the commercial energy needs of these areas are presently met by importing through supply lines involving pipelines, trucks, or wires. They are at risk of disruption such as through bad weather blocking roads or bringing down power lines. In a number of countries there is already recognition that the energy needs of remote communities can be met through renewables with environmental and economic benefits (Clark & Isherwood 2004).

In Britain so far the main emphasis on developing renewables has been on larger scale developments, such as on and off shore wind farms; with little attention being paid to the introduction of small-scale local schemes in remote communities. Although the rural North East has many potential renewable energy sources, including wind, hydro and plantations for biomass, there are constraints in some parts from other pressures such as tourism and social acceptability. Clearly developing significant renewable energy is important for Britain to tackle climate change, however this should combine large-scale developments with a host of smaller schemes; one size does not fit all.

Table 3: Socio-Economic Profiles of the Villages.

	Cockfield	**Romaldkirk**	**Bowes**
Population	1500	900	700
Village Services	High	Low	Low
Good Health	Low	Medium	High
Permanent Illness	High	Low	Medium
Employed	Low	High	High
Retired	High	Medium	Low
Pensioners	High	Medium	Low
Children	Low	Medium	Low
Qualifications	Low	Medium	Medium
Council Rented	High	Low	Low
Without Car	Medium	Low	Low
2 Cars or more	Medium	High	High
Public transport	Medium	Low	Medium

To successfully shift to a renewable energy economy, which surely must be the long term aim given the global pressures of climate change and peak oil, will require a diverse range of actions.

Development of local renewable energy, as well as helping to respond to climate change and peak oil, would have local benefits including increased sustainability. Among the features of a sustainable community are that it meets:

"*the diverse needs of all existing and future residents … [and] also limit the adverse external effects on the environment, society and economy.*" (Kearns and Turok, 2004)

Some of the features of a local renewable energy system for a remote community would be that it is Carbon Neutral; uses reliable and available technology; meets, at least, the heating, light and power needs of households; ensures secure and autonomous supply; is able to be locally controlled and is appropriate to the community and location.

In order to ensure a match of supply and demand for energy it is necessary to capture the details of these patterns. To develop a robust model, hopefully leading to implementation of a renewable energy supply, a whole system approach is necessary.

Methodology

In contrast to most past studies on the potential for renewable energy which have taken a broad brush approach, this study considered in detail the energy demand and possible renewable supply for a small group of remote communities. This is necessary in order to map the fluctuations, both during the day and throughout the year, in both supply and demand for energy. The present energy networks have the capacity to increase supply if demand increases. In contrast the supply of some renewable energy sources fluctuate, which necessitates a detailed exploration of the mix and level of supplies to meet people's needs.

The study went into more detail and built upon the previous research of the Teesdale Renewable Energy Challenge (TREC) which was funded by the European Commission’s ALTENER programme. This found that it would be fairly straightforward for the entire Teesdale Council area to source 40% of its electricity and some heat from renewables in a few years using a mix of photovoltaics, solar hot water, wood fuel, developing wind and hydro and increased energy efficiency. The benefits would include developing new businesses and employment, improving the local environment, making a contribution to tackling climate change and increasing energy security (TNEI, 2003).

The area chosen for this pilot study included three small villages, Cockfield (54^{0}37’N 1^{0}48’W), Romaldkirk (54^{0}36’N 2^{0}01’W) and Bowes (54^{0}31’N 2^{0}01’W), in Teesdale set among the Pennines of the North of England. They have many of the features of remote communities and have a total population of only 3100. The residents have a varied socio-economic profile with a spread of levels of employment, health, families with children, retired households, car ownership and services within the village (Table 3). This variety helps to ensure that the findings from these villages are relevant to a wider range of communities.

The strategy for the research was to adopt a whole system approach, converging the pattern of energy demand, appropriate technologies, possible sources of energy and opportunities for energy efficiency.

The Pattern of Energy Demand

The demand for household heat and power was modelled in detail, using specially developed software. Among the factors considered were:

- The housing types (large detached, average detached, small single storey detached, 2 storey semidetached, 2 storey terrace and 3 storey terrace)
- Age of house
- Level of insulation
- Level of occupancy of house (empty, household out during weekdays for work and school, or continuous occupation)
- Orientation of main living space
- Having an open fire or conservatory

Use was made of modelling methods contained within the framework of the Building Research Establishment Domestic Energy Model (Bredem-12) (Anderson *et al*., 2002). Refinements were devised to enable more detailed predictions for numbers of houses rather than an individual house, and this grouped system was termed the Macro Scale Domestic Energy Model (MacroDEM). This model enabled the calculation of energy demand values, for both heat and electricity, for groups of houses of similar types and these were combined to give demand values for entire villages. The weather data - external temperature and solar flux - was based on daily values rather than monthly readings and combined with a daily activity schedule produced an hourly pattern of demand. This level of weather data is only available as typical UK data from the International Weather for Energy Calculations File (ASHRAE 2001). However it could be adjusted for local conditions from the average annual statistics (Met Office, 2006; DTI, 2006).

The energy demand for each village was calculated gathering housing data from direct visits, Teesdale Council, the 2001 Census and Ordnance survey maps, as well as weather data. On this basis, it was possible to draw up a profile of housing, covering features such as age, types (terrace, detached, etc), level of insulation and the profile of occupancy.

The results are a set of tables and graphs of net demand for heat and electricity for each village for each month in hourly steps (see Figure 1 and Table 5 for examples). Electricity demand does not vary greatly throughout the year. The daily weekday pattern is a night-time trough, a morning peak, lower mid-day demand and then a second longer peak in the evening. Demand over the weekend is more consistent throughout the day, at a level higher than the weekday trough but lower than the morning peak. Heat demand varies much more during the year, with a secondary daily cycle of morning and evening peaks, a moderate mid-day trough and a night-time trough.

Table 4: Average Annual Weather Statistics for Teesdale.

Weather parameter	Value
January mean temperature	2^0C - 3.5^0 C
July mean temperature	14^0C - 15^0C
Average sunshine duration	1250 - 1350 hours
Rainfall	1050 - 1300 mm
Average number of days snow lying	36 - 105
Average wind speed	5.6 ms^{-1}

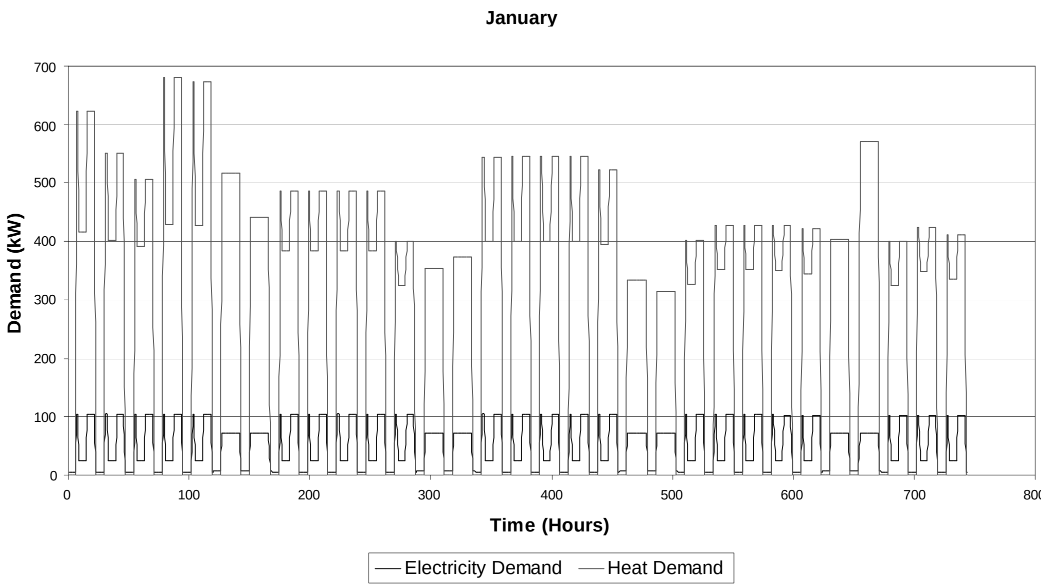
Appropriate Renewable Energy Technologies

A wide range of potential technologies to supply renewable energy were analysed through a series of filters to test which were appropriate for a renewable energy strategy in the area. The filters considered whether the technologies were commercially available, reliable, their likely life span and the necessary level of operating and maintenance support. Initially the candidate technologies were considered and examined in a two stage filtering process (Figure 2). The first filter, of fitness for application, considered whether the technology was commercially available, reliable in use and suitable for small-scale production of heat or power or both. The second filter considered the robustness and autonomy of the technology, passing those that required low levels, both of skill and frequency, to operate and maintain.

Table 5: Pattern of Energy Demand in Cockfield.

Energy Type	Season	Time of Day	Demand (kW)
Electricity	All Year	Peak (morning & evening)	500
		Mid-day Trough	150
		Night-time Trough	30
		Weekend Peak	350
Heating	Winter	Peak	2000-4000
		Mid-day Trough	1500-2500
		Night-time Trough	Near 0
	Summer	Peak	700
		Mid-day Trough	250

Figure 1: January Energy Demand for Village of Bowes.



At the first filter stage a wide range of renewable energy technologies were considered including 3 types of solar hot water, 4 types of Photovoltaics, 3 types of wind turbines, 3 types of wave power, 2 types of tidal power, 5 means of using biomass (including municipal solid waste), 6 types of fuel cells, 5 types of engines and 3 types of ground source heat pumps. Many of these were rejected as unsuitable for remote communities either because the technology is still in development, reliability is uncertain or they are not suitable for small-scale applications. Those technologies that passed the first filter were then tested by the second filter (Table 7) for:

- the level of skill and frequency to maintain,
- the level of skill needed to operate, and
- the likely life span of the equipment.

The levels of maintenance skills were defined as:

- Low level: simple work such as ash removal,
- Medium level: repair or replacing components, e.g. changing filters, lubricating, oil etc., and
- High level: major overhauls such as changing fuel cell stocks.

The frequency of maintenance requirement was classified into 3 groups:

- Low Frequency: Yearly/Bi-yearly,
- Medium Frequency: Monthly/Quarterly, and
- High Frequency: Daily/Weekly.

Figure 2: Filters for Selection of Candidate Technologies.

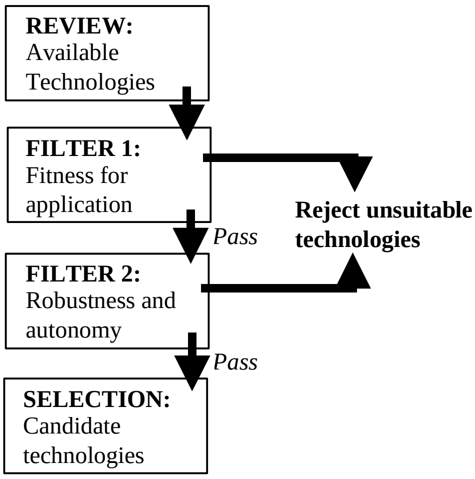


Table 6: Annual Energy Demands for the 3 Villages.

Village	Heating Demand (GWh)	Electricity Demand (GWh)
Bowes	3.79	0.441
Romaldkirk	2.12	0.399
Cockfield	11.378	2.063
Total	17.288	2.903

Outcomes

The summary outcomes are:

- Solar Hot Water Collectors: require minimum maintenance, no regular trained operator involvement and have a long life span,
- PV Systems: have very low maintenance, no regular trained operator involvement and have a long life span,
- Wind Energy: require some maintenance, no regular trained operator involvement and have a long life span,
- Micro Hydro: very low maintenance, no regular trained operator involvement and have a long life span,
- Biomass Direct Combustion: requires regular maintenance, some operator involvement but low skill, have a life span up to 20 years ,
- Gasifier and Pyrolysis: require periodic routine maintenance, some operator involvement but low skill and have a life span up to 20 years,
- Digester: requires several hours each week for regular maintenance as well as twice yearly maintenance closed down, needs a trained person for operation and a life expectancy of 10 - 20 years,
- Internal combustion engines: require regular maintenance some from skilled staff and a life expectancy of 10 - 12 years,
- Micro Turbine: require regular maintenance, little trained operator involvement and have a life span of 7 - 10 years,

- Stirling Engine: require little maintenance, little trained operator involvement and have a life span of 6 - 10 years,
- Fuel Cells: require annual maintenance, little trained operator involvement and have a life span of 5 - 8 years, and
- Heat Pumps: require little maintenance, little trained operator involvement and have a long life span.

Table 7: Filter 2: Operating and Maintenance Needs.

Technology	**Maintenance**									**Trained Operating Staff**	**Life Span (years)**
	Low Skill			***Medium Skill***			***High Skill***				
Frequency	***L***	***M***	***H***	***L***	***M***	***H***	***L***	***M***	***H***		
Solar Collectors (Evacuated Tube)	□			□			□				20 - 30
Photovoltaics (Slates)	□			□			□				30 - 40
Wind Systems (Chimney vertical axis)	□			□			□				20 - 25
Micro Hydro	□			□			□				20 - 30
Biomass (Direct Combustion)			□			□	□				15 - 20
Gasification/Pyrolysis			□			□	□				15 - 20
Digester			□			□	□			Yes	10 - 20
Internal Combustion Engine			□			□	□				10 - 12
Micro Turbine	□			□			□				7 - 10
Stirling Engine	□			□			□				6 - 10
Fuel Cell	□			□			□				5 - 8
Heat Pump		□		□			□				40

Possible Sources of Energy

On the basis of the energy needs study for heat and electricity in the 3 villages and a range of suitable technologies for meeting these needs, it was possible to draw up an integrated renewable energy strategy for the area as part of the whole systems approach. In order to meet these needs it is important to ensure that there is a good supply of specific energy sources (Table 8). Clearly there is no wave or tidal power locally. It was considered that the potential for small-scale hydro was low, and geothermal was uncertain. Therefore the main sources of energy are solar, wind and biomass.

Solar power is considered to have moderate availability. This is due to the variable conditions throughout the year and especially the small number of daylight hours in winter. Nevertheless, it is still a valuable source of energy. According to a recent study on wind turbines *Britain has the best wind resource in Europe* (Eco-Schools, 2006). With an average of 5.6ms^{-1} in sheltered terrain (table 4), the villages are well placed to take advantage of this natural phenomenon.

The final stages of the modelling were to combine the needs of the area, practical sources of energy and suitable technologies. Solar power could provide a portion of domestic hot water using solar collectors and photovoltaics. Wind could be used to drive small chimney mounted turbines for electricity. However, because of the intermittent nature of these sources there remains a shortfall of around 45% of total energy needs. After all on winter nights there is no sun for heat and possibly no wind.

Table 8: Availability of Energy Sources at Cockfield.

Resource	Availability at Cockfield
Solar	Moderate
Wind	High
Biomass	High
Hydro	Low
Wave & Tidal	None
Geothermal	Uncertain

This shortfall could be met through the use of biomass. The technology filter passed a number of technologies to harness biomass. Ideally Combined Heat and Power (CHP) would be used to produce both heat and electricity. It can either be provided through a central CHP plant with district heating and power distribution or a biogas distribution network with local Stirling engines. The latter would have the advantage of simpler distribution, greater flexibility, lower losses and slightly easier maintenance overall. One other option would be to develop a domestic pulverised biomass Stirling engine as current Stirling engine technology does not run on solid fuel without a separate combustor that increases technical and maintenance issues. This development would cut out the need for centralised gasification of the biomass, with a local gas distribution network. However there would be a need for a solid fuel distribution system. Heat pumps were not included as they would only be an option if there were to be a consistent electricity supply to power them is from renewable sources, which might be in short supply especially during winter evenings at the very times when heat is needed. In addition, with the use of CHP there is likely to be spare heat so there would be no need for heat pumps in this particular strategy.

As one of the aims of the research was to develop a local supply system, allowing autonomy and local control, it was proposed that a major source of electricity, and some heat, would be from locally grown biomass. This could be from local coppiced willow or from the timer maintenance programmes in the existing nearby forests. It is estimated that just less than 250 tonnes a year of biomass (with a moisture content of 30%) would be needed to meet the energy needs. This would be readily within the capacity of either the forest management programme or local coppiced willow. Thus the resulting package of energy sources recommended for these villages would be solar for electricity and water heating, micro wind for electricity and biomass for electricity and heat.

Figure 3: Sunpaths in Britain (University of Bath, 2006).

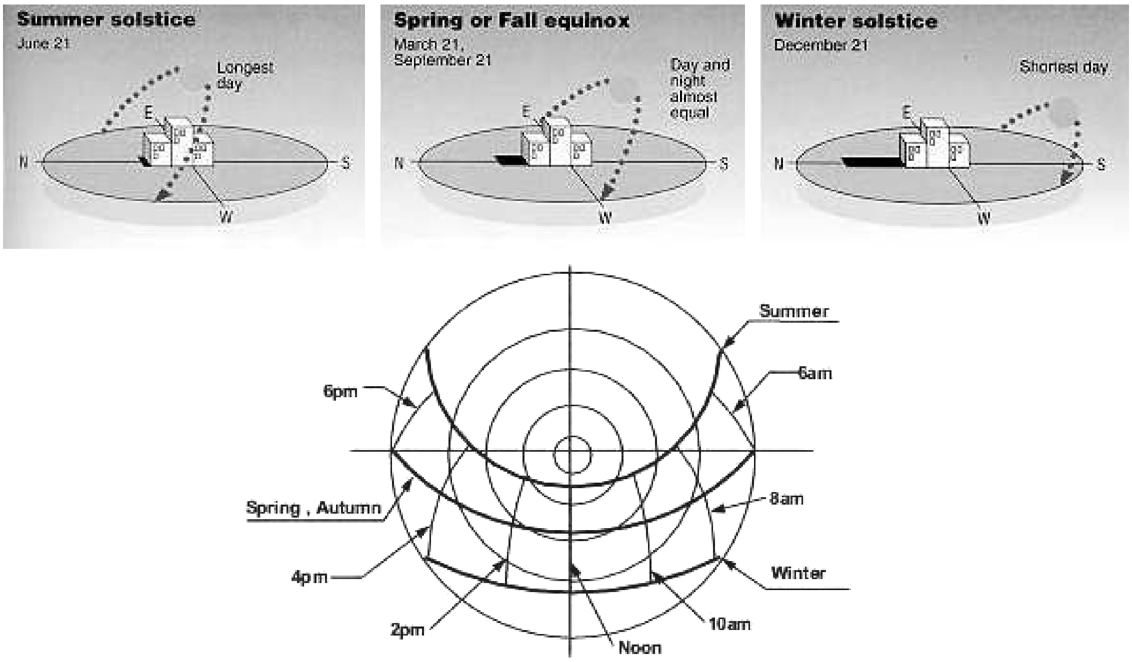
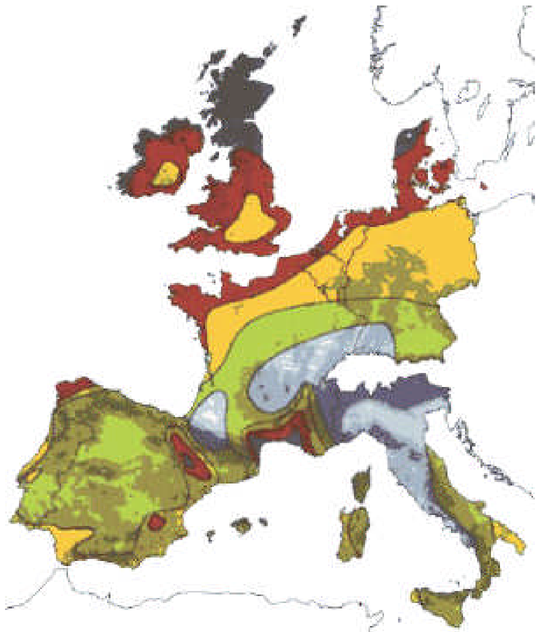


Figure 4: Wind Resources in Europe (Eco-Schools, 2006).



	Sheltered terrain	Open plain	At sea coast	Open sea	Hills and ridges
(dark blue)	> 6.0	> 7.5	> 6.5	> 9.0	>11.5
(red)	5.0 - 6.0	6.5 - 7.5	7.5 - 8.5	8.0 - 9.0	10.0 - 11.5
(yellow)	4.5 - 5.0	5.5 - 6.5	6.0 - 7.0	7.0 - 8.0	8.5 - 10.0
(green)	3.5 - 4.5	4.5 - 5.5	5.0 - 6.0	5.5 - 7.0	7.0 - 8.5
(light blue)	< 3.5	< 4.5	< 5.0	< 5.5	< 7.0

Opportunities for Energy Efficiency

Key to tackling the issues linked to the use of energy is not only a shift from fossil fuels to renewables but also a reversal in the upward demand for energy through a significant increase in energy efficiency. In addition household energy efficiency would have a significant benefit in tackling fuel poverty. Across England, it is estimated that at least 2 million households suffer fuel poverty and with the recent sharp rise in fuel prices this is increasing (DTI, 2005; & NEA, 2005a). Durham County Council estimates that 11% of households in the County suffer from fuel poverty. Research for National Energy Action indicates that perhaps surprisingly fuel poverty is higher in rural than urban areas (NEA, 2005b). It is therefore assured that fuel poverty is a significant issue in the communities studied. As part of the study a more detailed analysis of a sample of houses was carried out to investigate the potential benefits of energy efficiency through a range of measures including installing high levels of loft insulation, cavity wall insulation (where appropriate to building construction), high level insulation of hot water cylinder, double glazing and energy efficient lights. These resulted in significant gains, which if applied across the three villages would, over a year, save 5.462 GWh of heat (over 30%) and 0.159 GWh of electricity (over 5%). (Table 9).

Table 9: Potential Energy Savings with High Insulation and Energy Efficiency Lighting.

Village	Heating Demand (GWh)		Electricity Demand (GWh)	
Insulation Level	***Existing***	***High***	***Existing***	***High***
Bowes	3.79	1.71	0.441	0.417
Romaldkirk	2.12	1.57	0.399	0.349
Cockfield	11.378	8.546	2.063	1.978
Total	17.288	11.826	2.903	2.744
Saving		**5.462**		**0.159**

Thus the whole systems approach was enacted by determining the specific energy demands for these communities and assessing appropriate technologies. A key concern for a local renewable energy system is reliability of supply. The present conventional grids are perceived by the public as reliable a they are largely unaware of the risks inherent in these networks for remote communities. To successfully introduce a new technology it needs to operate effectively without inconvenience to the users. An autonomous local system, in order to be self sufficient would need to be reliable and have some spare capacity to cope with extreme peaks in demand and interruptions to supply. These were significant criteria in assessing candidate technologies. The possible sources of energy in the villages were mapped against candidate technologies and those meeting both sets of criteria selected. It also became apparent that the selected technologies could not meet the calculated energy demand unless the specified opportunities for energy efficiency were realised. Therefore the circle of supply and demand was balanced by incorporating all four issues of the whole systems approach.

Micro Grid

As renewable energy systems use ‘distributed generation’ networks with a two way flow of energy, at times households can be consumers while at other times producers of energy. This approach is very different to the conventional one-way system. In a remote community a micro grid could be used to distribute electricity, and perhaps heat in a district heating scheme (for houses and premises grouped together), to clusters of loads drawing on a mix of small-scale local sources. In addition a successful renewable grid would require capacity that can respond to peaks in demand at times when some sources of energy are not available such as solar and wind on a calm night. Options would include the use of storage systems, hydropower or biomass. In addition to the modelled biomass, solar and household wind sources of energy it would also be possible to have other renewable sources such as larger scale wind or hydro schemes. The TREC study (TNEI, 2003) pointed out that in the Teesdale area there are several water reservoirs, which could produce hydropower although they presently do not. One of these, Selset, is near to the villages in this study and could produce 1MW of electricity. There are also several possible sites for wind generators nearby. Such a system would allow for the development of imaginative and flexible schemes, building up modules of renewable energy production feeding into the grid. In the development stages new schemes could draw on conventional sources of electricity, but over time move entirely to using renewable electricity.

Community Engagement

Vital to the success of introducing renewable energy is the support of the local community. Renewable energy would require the construction of local infrastructures, some of them visible. Without community support the proposals could be stopped by local opposition. One of the aims of local scale renewable energy is encouraging the community to control the system, which requires community participation. Furthermore one of the expected benefits is increased awareness about energy so encouraging energy savings is also best achieved with community engagement.

Although the project only went as far as the research stage it did include working with the community. It was developed in consultation with Teesdale District Council, Teesdale Community network, The Northern Energy Initiative (TNEI) and Renewable Energy at the Local Level (REALL).

As part of the project, a public meeting was held to discuss the ideas. It was very well attended and there was a high level of interest and understanding about the issues. In fact the general response of the villagers was - *when are you going to implement all these exciting plans?* Unfortunately as this research is only the feasibility stage it was necessary to be realistic as there was no guarantee it would be implemented despite proclamations from Government in support of such initiatives.

Discussions

The research demonstrated that it is practical to establish fully renewable energy communities, using wind, solar and biomass. The big challenge for Britain, in general, and in many communities is to move from the theory to the practice.

At this stage the Government's policy has concentrated on increasing the proportion of electricity generated from renewables to 10% of the total by 2010. The funding policy has supported this aim with most efforts going into support for larger scale generation in particular wind farms on and off shore. However, even if this target were realised, as electricity is only around 25% of total energy use, the renewables would only supply a relatively small proportion of total energy use. To make the case for renewables more powerfully, Britain needs demonstrations of communities mainly supplied from renewable sources. To this end, funding resources need to be made available to support the introduction of a cluster of several small-scale technologies to develop local schemes that produce renewable energy for communities.

It is often claimed that renewable energy will provide jobs. In a study of possibilities for renewable energy in northern Scotland, Hanley & Nevin (1999) suggest that generation capacity of 2050 kilowatts, mainly from a wind farm with a small contribution from hydro and biomass, would produce only 2 jobs. It is also the case that a number of the technologies suggested in this paper also imply low staff levels for maintenance and operation. Yet, the relatively high proportion of biomass will provide greater employment opportunities. More significantly though, if several hundred photovoltaic roofs and wind turbines were installed and the area became a showcase of renewable energy, it would be possible to develop local skills to service the installation and maintenance of the renewable energy system in the area. The development of a renewable energy community would also attract visitors and stimulate interest to the benefit of the local economy. As presently there is a shortage of skilled workers to install and maintain renewable energy technologies, the skills developed in support of the proposed local system would be in demand elsewhere as the impact of a successful example spreads.

Conclusion

The study took a whole system approach to energy use, investigating in detail the energy needs of three relatively remote villages. It looked at the patterns of demand, the availability of supply, appropriate technologies and opportunities for energy efficiency. The study demonstrated that it would be practical to meet the housing energy needs, for heat and electricity, from local renewable energy sources such as solar, wind and biomass. There are sufficient options in the supply to ensure sufficient capacity to meet the fluctuations in supply and demand. The test for the long-term and widespread development of a renewable energy society in Britain is whether such research projects, which demonstrate the potential, are translated into practice.

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