Achieving Carbon Neutral Communities:
A Feasibility Study at Malhamdale

UNIVERSITY OF LEEDS
CRAVEN DISTRICT
JBA trust

Research carried out by Emma Brook as part of an MSc in Sustainability and Consultancy

Background & context

This research has arisen because the small community of Malhamdale are working towards becoming carbon neutral.

Malhamdale is a small and sparsely populated community with approximately 300 houses. Houses tend to be older in nature and many are poorly insulated.

Malhamdale is not connected to the gas grid, meaning there is high dependence on oil and electricity for heating purposes.

Malhamdale lies within the Yorkshire Dales National Park, meaning there is an abundance of natural resources and space, but planning conditions are stringent.

Malhamdale has an aging population as many young people choose to move away to seek employment opportunities.

Carbon neutrality is most commonly defined as 'no net release of carbon dioxide into the atmosphere' (Murray, 2007). In terms of energy use, this can be achieved by balancing renewable energy generation with total energy consumption, and then offsetting any remaining emissions, as shown in Figure 1.

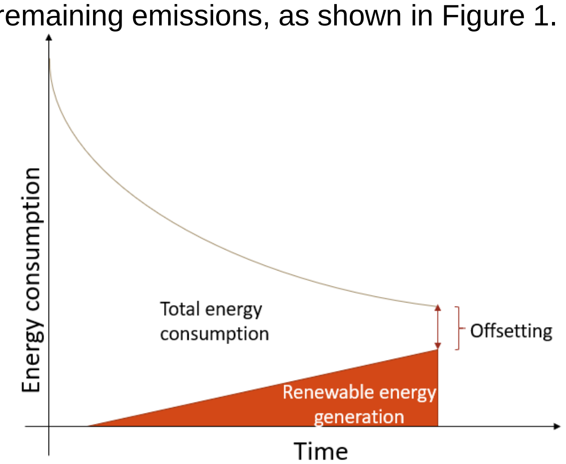

Figure 1. Adapted from Dracou et al. (2017).

Aims & objectives

Aim:

To determine **feasible** renewable energy options for reducing the fossil fuel reliance of Malhamdale community.

Objectives:

1. Identify and analyse literature on household- and community-scale renewable energy
2. Create a sustainability assessment framework (SAF) for renewable energy opportunities in Malhamdale through analysing feasibility factors.
3. Carry out a sustainability assessment for renewable energy generation opportunities in Malhamdale.
4. Identify how the process piloted at Malhamdale could be applied to other rural settlements.

Methodology

The overarching strategy for the development of the SAF follows a 7-step methodology:

1) Selection of potential renewable energy technologies for Malhamdale and scoping out of unsuitable options.
2) Definition of assumed characteristics of each technology using desk-based research.
3) Selection of feasibility indicators from literature to create a skeleton SAF for the assessment of renewable energy options.
4) Modification of SAF to suit Malhamdale community using analysis of primary data to identify area-specific indicators and relative weightings.
5) Completion of technical, financial, social and environmental assessments for each of the selected technologies.
6) Integration of assessments by weighted sum
7) Formulation of recommendations based on SAF outputs.

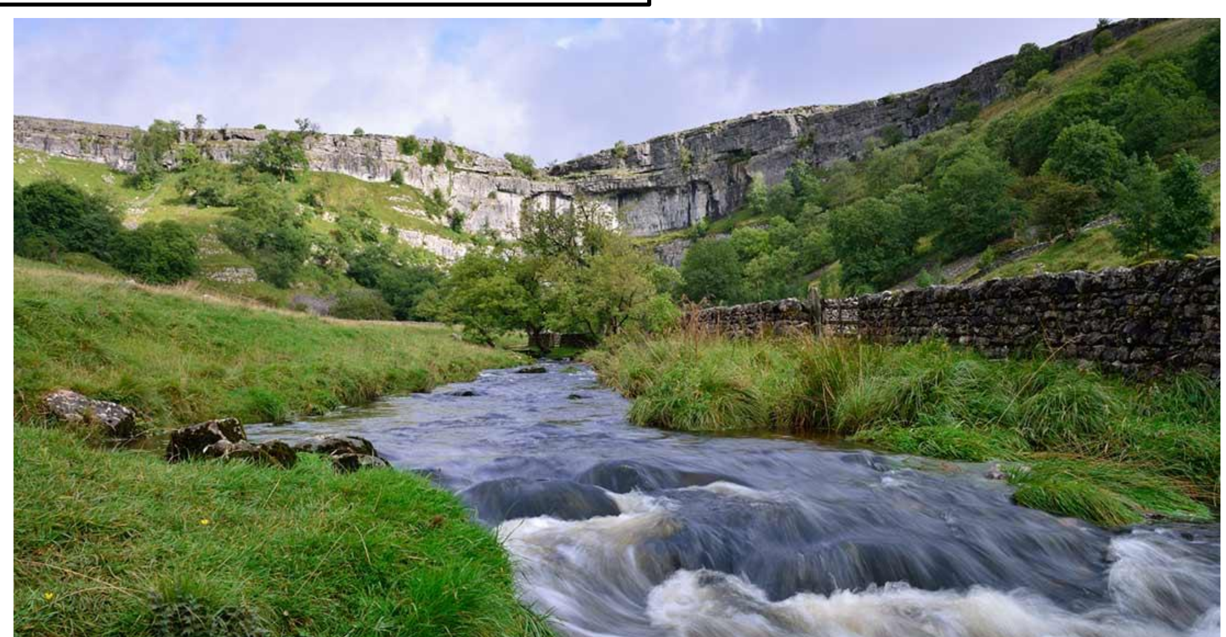

Figure 2. Malham Cove and the River Aire.

Literature review

The UK currently relies on a centralised power network to generate large quantities of energy and provide a constant supply to meet high energy demands (Allen et al., 2012). Complementing this system with decentralised generation networks, made up of small community or household generation devices close to the area of energy consumption, has the potential to utilise a mix of renewables and improve the efficiency of the energy network, whilst bringing wider benefits to rural communities (Raybould et al., 2020).

Table 1. Potential renewable technologies for Malhamdale

Energy Output	Scale: Household	Scale: Community
Electricity	• Wind • Solar PV • Combined Heat and Power (CHP)	• Wind • Solar PV • Hydro • Anaerobic Digestion (AD)
Heat	• Biomass boilers • Ground source heat pumps (GSHP) • Solar thermal • CHP	• Biomass district heating • AD

To ensure the most sustainable alternatives are selected, rural areas require holistic methods for screening the feasibility of renewable options (Allen et al., 2012). Economic, technical, social and environmental criteria, such as the indicators listed in Table 2, need to be considered in order to determine appropriate rural developments within the energy sector (Fitriyana et al., 2019).

Table 2. Feasibility indicators

Feasibility Indicators	
Technical	Presence of local resources, spatial fit
Economic	Upfront cost, subsidies, operational costs
Social	Community acceptance, job creation
Environmental	Biodiversity impacts, landscape impacts, CO_2 emissions

ALLEN, J., SHEATE, W. R. & DIAZ-CHAVEZ, R. 2012. Community-based renewable energy in the Lake District National Park - local drivers, enablers, barriers and solutions. *Local Environment,* 17, 261-280
DRACOU, M. K., SANTAMOURIS, M. & PAPANICOLAS, C. N. 2017. Achieving nearly zero energy buildings in Cyprus, through building performance simulations, based on the use of innovative energy technologies. *Energy Procedia,* 134, 636-644.
FITRIYANA, D., PRABAWATI, M., TANUWIJAYA, F. & NAIMAH, D. 2019. Multi-criteria analysis for renewable energy generation: A case of Tokyo. *IOP Conference Series: Earth and Environmental Science,* 291, 012027.
MURRAY, J. & DEY, C. 2009. The carbon neutral free for all. *International journal of greenhouse gas control,* 3, 237-248.
RAYBOULD, B., CHEUNG, W. M., CONNOR, C. & BUTCHER, R. 2020. An investigation into UK government policy and legislation to renewable energy and greenhouse gas reduction commitments. *Clean Technologies and Environmental Policy,* 22, 371-387.

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Data collection and analysis

Surveys were distributed to Malhamdale residents and used to collect data on area-specific feasibility criteria, community opinions and barriers for renewable energy uptake in Malhamdale.

Telephone interviews were conducted with local owners of household renewables to gain a detailed insight into the practicalities of microgeneration within Malhamdale.

Quantitative and thematic data analysis was undertaken and the results used to tailor the SAF for use in Malhamdale, ultimately facilitating the formulation of recommendations.

Findings

Refining the Sustainability Assessment Framework (SAF)

Findings from surveys and interviews identified two area specific indicators:

- **Planning policy** as a technical indicator
- **Visual acceptance** as a social indicator

Analysis of primary data also found that not all indicators carried an equal weight in decision-making. Taking this into account, weightings were developed relative to influence, with two indicators allocated a weighting of 2:

- **Upfront cost** from the financial indicators
- **Community acceptance** from the social indicators

All other indicators were weighted at 1.

Table 3. Sustainability Assessment Framework with refined indicators, weightings and scores for Malhamdale. Indicator scoring: 1- low feasibility, 2- medium feasibility, 3- high feasibility

Renewable Energy Scheme		Energy output	Technical			Economic			Social			Environmental			Total
			Presence of local resources	Planning policy	Spatial fit	Upfront cost	Subsidies	Operational costs	Community acceptance	Visual acceptance	Job creation	Biodiversity impacts	Landscape impacts	CO2 emissions	
		Weighting	1	1	1	2	1	1	2	1	1	1	1	1	
Household Scale	Solar PV	Electricity	2	3	3	3	1	3	3	2	1	3	3	3	36
	Wind	Electricity	3	1	2	1	1	2	1	1	1	2	2	3	22
	Biomass	Heat	1	2	2	2	2	1	2	2	1	2	2	2	25
	GSHP	Heat	2	3	3	2	3	1	3	3	1	2	3	2	33
	CHP	Heat	1	3	3	3	1	1	2	3	1	3	3	1	30
	Solar Thermal	Heat	2	3	3	3	3	3	3	2	1	3	3	3	38
Community Scale	Solar PV	Electricity	2	1	2	3	1	3	3	2	1	2	2	3	31
	Wind	Electricity	3	1	2	2	1	2	2	1	1	1	2	3	25
	Hydro	Electricity	3	1	3	1	1	2	1	3	1	1	2	3	24
	AD	Both	1	1	1	1	2	1	3	1	3	2	1	1	22
	Biomass	Heat	1	1	1	2	3	1	1	1	3	2	1	2	22

Completing the Sustainability Assessment for Malhamdale

Once the SAF was refined to best reflect the needs of the local community, feasibility assessments were carried out for each of the indicators against each technology. Through synthesis of findings from both desk-based research and primary data analysis, each pairing was allocated a score between 1 and 3 based on expected feasibility, as shown in Table 3 above. Application of a standardised scoring system across all indicators allowed comparisons to be drawn between different technologies in a transparent and user-friendly manner.

To facilitate assessments, a scoring criteria guide was drawn up which detailed the characteristics of a score of 1,2 or 3 for each indicator at both the domestic and community levels. Scoring criteria were quantified where possible to reduce subjectivity.

To achieve integration of technical, economic, social and environmental assessments, weighted sum totals for each technology were calculated. Indicator weightings were assigned based on survey and interview findings to ensure the most important considerations for Malhamdale carried more weight in decision-making. The outputs of the SAF indicate that solar power is the most feasible option for Malhamdale at both the community and household scale.

Recommendations...

For Malhamdale...

Household-scale Solar:

Maximising household uptake of solar PV and thermal devices could help Malhamdale transition towards becoming carbon neutral. Recommendations include:

- Careful design and placement of solar schemes to ensure solar power remains acceptable to the local community
- Following advice given in the Yorkshire Dales Design Guide.
- Investigating potential incentives to increase individual uptake.

Community-scale Solar:

A number of options could be suitable for Malhamdale, including:

- Formation of a solar cooperative which would run and finance solar projects and then invest the profits in a community fund
- Installation of community solar panels on the local school, church or village hall which would offer free energy to these establishments whilst providing renewable energy for the community.
- Creation of a community solar buying scheme offering discounted installations by recommended and trustworthy supplier.

As community solar schemes can take different forms and vary according to community size and local conditions, it is recommended further research is carried out to find the optimum scheme for Malhamdale.

For use of the framework...

The adaptable nature of this framework makes it suitable for applied use in other communities. Recommendations for future use include:

- Modification of feasibility indicator set and weightings to suit application.
- Adjustment of sensitivity where needed, for example where a number of total scores are the same or similar. This could be achieved by increasing the scoring range, eg from 3 to 5.
- Quantification of all feasibility assessments to reduce subjectivity.