Renewable and Low Carbon Energy Study

Final Report

September 2010

Pendle Borough Council
Burnley Borough Council
Rossendale Borough Council
Calderdale Metropolitan Borough Council
Kirklees Metropolitan Council

Maslen Environmental

Salts Mill
Saltaire
Shipley
BD18 3LF

Maslen Environmental Project Manager

Susan Wagstaff

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Initial draft interim Report, February 2010		Neil Watson, Pendle BC.
Draft Final Report, April 2010		Neil Watson, Pendle BC.
Draft Report May 2010	Addressed feedback comments	Neil Watson, Pendle BC
Final Report September 2010	Addressed feedback comments	Neil Watson, Pendle BC

Contract

This report describes work commissioned by Pendle Borough council, Planning and Building Control, Town Hall, Market Street, Nelson, BB9 7LG, on behalf of the Partnership of: Pendle Borough Council, Rossendale Borough Council, Burnley Borough Council, Calderdale Metropolitan Borough Council and Kirklees Metropolitan Council, by an email dated 14-12-2009.

Pendle Borough Council's representatives for the contract were Christine Galvin and Neil Watson.
Rossendale Borough Council's representative for the contract was Adrian Smith. **Burnley Borough Council**'s representative for the contract was David Hortin. **Calderdale Metropolitan Borough Council**'s representative for the contract was John Houston.
Kirklees Metropolitan Council's representative for the contract was John Buddle.

Alex Jones, Tom Hudson, David Gooch, Andy Wood, Jessica Kennedy, Stephanie Hughes and Susan Wagstaff of Maslen Environmental carried out this work. Technical review was provided by Jo Adlard of CO_2 Sense.

Prepared by .... Alexander Jones BSc MSc

Analyst

Prepared by .... David Gooch MA CMLI

Senior Analyst

Prepared by .... Susan Wagstaff MA MSc C.Geol EurGeol FGS

Technical Director

Reviewed by .... Steve Maslen BSc MPhil MLI

Technical Director

Purpose

This document has been prepared as a final draft report for Pendle Borough Council on behalf of the Partnership. Maslen Environmental accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

Maslen Environmental has no liability regarding the use of this report except to the Partnership Councils.

Acknowledgments

Maslen Environmental would like to thank the representatives of the councils for assistance in obtaining data.

Carbon Footprint

working with
the Carbon Trust
627g
CO2

A printed copy of the main text in this document will result in a carbon footprint of 627g if 100% post-consumer recycled paper is used and 798g if primary-source paper is used. These figures assume the report is printed in black and white on A4 paper and in duplex.

JBA is a carbon neutral company and the carbon emissions from our activities are offset.

Executive Summary

Maslen Environmental were commissioned to undertake a study on the capacity for renewable and low carbon energy in the Partnership councils: Burnley Borough Council, Pendle Borough Council, Rossendale Borough Council, Calderdale Metropolitan Borough Council and Kirklees Metropolitan Council, situated in the South Pennines. In particular it was to identify the opportunities for delivering energy from renewable and low carbon (RLC) sources, including micro and district scale technologies, in order to meet both local and site specific targets.

The UK has signed up to the EU Renewable Energy Directive, which includes a UK target of 15% of energy from renewable sources by 2020. This is equivalent to a seven-fold increase in the UK renewable energy consumption from 2008 levels.

Indicative percentages as to how the government envisages that the 15% target could be fulfilled are: 30% of electricity; 12% heat and 10% transport energy from renewables. This study considers the production of electricity and heat. Since the recent revocation of Regional Spatial Strategies, **there are currently no standing regional and sub-regional renewable energy targets**. This study has therefore developed local notional targets based on national targets. The notional electricity target is based on 30% of local electricity demand; however contributions from off-shore wind generation could reduce, on-shore local authority electricity generation targets and may lead to future South Pennine Local Authority RLC generation targets being lower than suggested by the notional targets developed in this study.

The potential technologies and sources of renewable energy which are assessed through a capacity assessment are summarised in the following table.

Types of Renewable and Low Carbon Energy

Category	Sub - category Level 1	Sub -category level 2	Comment
Electricity and CHP	Large scale (>50 MW)	Wind	
		Biomass combustion	Municipal solid waste, virgin and recycled timber, energy crops, solid recovered fuel, all biomass co-firing with coal and other wastes.
	Medium scale (50 kW to 50 MW	Wind	
		Biomass combustion	Municipal solid waste, virgin and recycled timber, solid recovered fuel.
		Biomass anaerobic digestion	Agricultural waste, food waste, energy crops.
		Hydro	
		PV	
		Natural Gas CHP	Heat use from CHP.
	Micro scale (<50 kW)	Wind	
		Hydro	
		PV	
Heat only	Medium scale (50 kW to 50 MW)	Biomass combustion	Municipal solid waste, virgin and recycled timber, solid recovered fuel.
		Biomass anaerobic digestion	Injection to gas grid or local use.
		Solar thermal	Water or space heating.
		Heat pumps (heating and cooling)	Ground source, air source, water source.
	Micro scale (<50 kW)	Biomass combustion	Virgin and recycled timber.
		Solar thermal	Water or space heating
		Heat pumps	Ground source, air source, water source.

Notes.
Combined heat and power is a more efficient use (in certain contexts) of energy generation, which can be used with either fossil fuels (gas or solid fuels) or renewable (biomass) fuels.
Waste to energy is generally an incineration process for dry matter and includes biomass combustion.

Overall the study indicates that:

Electricity

- By far the most significant potential for renewable electricity in all the council areas is commercial scale wind.
- There is significant potential also for small scale wind energy.
- There is the potential for large amounts of solar electricity generation, but the current efficiencies of solar technology mean that installations have a relatively low load factor (a measure of effectiveness) and so installations may only deliver limited electricity. Improvements in technology may change this in the future.

Heat

- The largest available low carbon heat source is ground source heating. This is a mature technology which has been used extensively in Europe, particularly Scandinavia, but has been used less in the UK. There is a growing level of experience particularly in the south of England and London. The setup costs are likely to be more than the solar heat costs. Air source heating can also be used instead of ground source heating, although this may be slightly less efficient.

- There is also considerable potential for solar energy. This is a relatively mature technology and has some uptake in the area already. There is the potential for a high level of uptake of this technology.
- Additionally there is some potential for energy from wood (various forms), digestion and energy crops in most of the council areas (Rossendale has little energy crop potential). However, these are mainly small scale potential sources of renewable heat. It should be noted that if heat is obtained from biomass this may be at the expense of generating electricity from biomass.

The most suitable types of RLC for each district and the Partnership Area overall are identified based upon the capacity for developing each type of renewable energy technology.

Scenarios are presented which consider the potential for uptake of renewable and low carbon energy within the Partnership Area. The renewable energy uptake is considered in the context of the wider energy provision in the area.

The scenarios highlight both the uncertainties with regard to renewable energy uptake and also the importance of the scale of installations. Large scale installations can generate large amounts of energy, whereas small scale installations only provide a small contribution.

The theoretical capacity available for many technologies is much greater than a more 'pragmatic capacity' which is limited by physical, technical, economic, environmental and legislative constraints. For example the technical resource for solar PV is large; however, it is very expensive and current technology is not very efficient. Similarly there is a very significant wind resource, but its full exploitation would have visual impacts. The 'pragmatic' accessible resource therefore represents the resource that could be utilised if all projects received planning consent and the political, infrastructural and institutional barriers facing development were all overcome. The scenario development provides an opportunity to consider in more detail the extent to which the planning, political, institutional and infrastructural issues may influence uptake.

The following scenarios for renewable energy development within the Partnership Area are considered:

- **High Renewable Energy Uptake Scenario -** this equates to a level of uptake which is within the pragmatic capacity available and feasible. However, the level of uptake required to generate this level of renewable energy would be high and would entail a level of commitment to renewable energy that has not currently been seen.
- **Medium Renewable Energy Uptake Scenario-** the medium uptake scenario equates to a considerable but feasible uptake of renewable energy resources.
- **Low Renewable Energy Uptake Scenario-** this is a baseline scenario - it assumes that the current situation largely persists – i.e. onshore wind, and waste technologies remain as the main source of renewable generation, and biomass (electricity generation) and solar technologies don't prove to be technically and commercially viable at a large scale, though there will be some small capacity increase from demonstration projects.

Uptake Scenarios - Electricity

Scenario	Total Generation (MW) (approx.)	Additional Generation Requirement to meet the notional 2020 Target (MW)[1]	Technologies required	Comment
Burnley				
High Uptake	25.4	9.2	High level of commercial wind and other technologies.	Potential to exceed the notional target by a significant margin.
Medium Uptake	15.6		Some commercial wind, moderate uptake of other technologies.	Potential to meet and exceed the target.
Low Uptake	11.8		Some commercial wind, some biomass, some domestic installations.	Target met by a small margin.
Calderdale				
High Uptake	47.0	28.34	High level of commercial wind and other technologies.	Potential to exceed the notional target by a significant margin.
Medium Uptake	29.0		Some commercial wind, moderate uptake of other technologies.	Potential to meet the target by a small margin.
Low Uptake	21.4		Some commercial wind, some biomass, some domestic installations.	Target not met by a significant margin.
Kirklees				
High Uptake	28.4	44.6	High level of commercial wind and other technologies.	Target not met by a significant margin.
Medium Uptake	16.7		Some commercial wind, moderate uptake of other technologies.	Target not met by a significant margin.
Low Uptake	10.6		Some commercial wind, some biomass, some domestic installations.	Target not met by a significant margin.
Pendle				
High Uptake	33.2	15.3	High level of commercial wind and other technologies.	Potential to exceed the notional target by a significant margin.
Medium Uptake	20.5		Some commercial wind, moderate	Potential to exceed the

Scenario	Total Generation (MW) (approx.)	Additional Generation Requirement to meet the notional 2020 Target (MW)[1]	Technologies required	Comment
			uptake of other technologies.	target.
Low Uptake	15.7		Some commercial wind, some biomass, some domestic installations.	Target met by a small margin.
Rossendale				
High Uptake	42.6	4.03	High level of commercial wind and other technologies.	Potential to significantly exceed target due to high wind resource.
Medium Uptake	26.4		Some commercial wind, moderate uptake of other technologies.	Potential to significantly exceed target due to high wind resource.
Low Uptake	20.6		Some commercial wind, some biomass, some domestic installations.	Potential to significantly exceed target due to high wind resource.
Notes 1. Additional Requirement to meet target consists of the notional 2020 30% target minus the existing renewable generation.				

Similar scenarios were developed for renewable heat generation; these showed that a medium level uptake of the potential resource available is required in order to meet the 12% local notional heat targets developed by this study.

Development of Potential Future Baskets of Technology

In this study, three potential electricity baskets of technology were developed to show possible ways that the notional local electricity targets could be achieved.

'High Wind' uptake basket

The high wind basket considers 100% utilisation of the pragmatically available potential wind energy with some further uptake in non-wind technologies.

When you consider this approach and the notional targets for generation as a measure of performance then, with the exception of Kirklees, all the individual councils significantly out perform the target and collectively as a Partnership Area they exceed the combined targets.

Generation Shortfall under the High Wind Uptake Basket

Councils	Generation Shortfall from Notional Target (MW)
Burnley	+20.7
Calderdale	+26.7
Kirklees	-16.5
Pendle	+24.5
Rossendale	+47.5
N.B. –ve equals shortfall and +ve equal exceedance	

Enough Wind

This basket considers the previously used medium level uptake rates for non-wind technology; it then considers that the notional target for each council is met with topping up from wind technologies.

The following summary table expresses as a percentage the proportion of additional wind resource required to reach the notional targets.

Proportion of Wind Resource Utilised under the Enough Wind Basket

Councils	Total Available Commercial and Small Scale Wind Resource (MW)	Proportion of wind resource that would be utilised under this basket (%)
Burnley	29.4	29
Calderdale	53.7	48
Kirklees	26.0	100+
Pendle	39.2	36
Rossendale	51.1	6
N.B. Under is scenario Kirklees can not achieve its notional target		

Maximising Non-Wind

This basket considers that the potential generation from non-wind technologies is fully utilised, and compares the total generation to the notional targets. As in all these technology baskets existing generation has been accounted for.

The following table summarises this and additionally expresses the shortfall in the number of 2.5MW capacity turbines that would be required to make up this shortfall in generation.

Generation Shortfall and Required Turbines under the Maximising Non Wind Scenario

Councils	Generation Shortfall from Notional Target (MW)	Number of additional turbines required to meet the target
Burnley	-6.1	9
Calderdale	-21.1	31
Kirklees	-31.5	47
Pendle	-12.1	18
Rossendale	-0.88	1
N.B. –ve equals shortfall and +ve equal exceedance The number of additional turbine was calculated on the basis of a 2.5 MW capacity turbine, generating 0.675 MW of electricity (assuming a 27% capacity factor).		

These baskets show that the development of the local wind energy potential would be needed to meet the local notional targets; however the degree to which it is needed could be reduced to a small degree by the effective utilisation of other resources.

Similar baskets of technology are presented to achieve the local notional heat targets. They show that a high uptake solar heating and/or the ground source heating potential of the study area would have to be utilised.

Conclusions

The potential for commercial wind energy development is significantly larger than any other local resource and will have to be further utilised to varying degrees if the local notional targets are to be met.

The two important actions arising from the study are the need to promote greater acceptance, public and political, of the need for locally generated renewable energy and the continued expansion of long term government financial support for RLC development at all scales. Large scale RLC installation are likely to be more significant in meeting targets than small scale developments and a suitable planning regime is likely to be key in promoting these technologies in suitable locations and appropriate ways.

Contents

Executive Summary .... **iv**

1. Introduction **1**

1.1 Background 1
1.2 Scope of Study 1
1.3 Methodology 1
1.4 Report Structure 2

2. Policy Review and Existing RLC Energy **3**

2.1 Review of Existing Policy and Studies 3
2.2 Existing and Programmed RLC Energy 12

3. RLC Framework - Methodology **17**

3.1 Development of the Framework 17

4. RLC Framework - Potential and Constraints **19**

4.1 Introduction 19
4.2 RLC Potential - Wind Power 30
4.3 RLC Potential - Energy derived from Biomass 42
4.4 RLC Potential - Combined Heat and Power 59
4.5 RLC Potential - Solar Energy 62
4.6 RLC Potential - Ground Source Heating - Technology 70
4.7 RLC Potential - Hydro Power 82
4.8 RLC Potential - Micro-Generation - Overview 87
4.9 Grid Capacity and Constraints 89
4.10 Decentralised Generation 97

5. Site Specific Case Study Assessments and Visualisations **100**

5.1 Selection of Case Study Sites 100
5.2 Impacts for Financial Viability of sites 100
5.3 Visualisations 102

6. Code for Sustainable Homes **104**

6.1 Code for Sustainable Homes - Cost Analysis 105
6.2 Driving change 108

7. Scenarios and RLC Potential **110**

7.1 Introduction 110
7.2 Baseline Energy Assessment - Electricity 110
7.3 National Targets and Scenarios 112
7.4 Regional Targets 112
7.5 Notional Local Targets for Renewable Electricity Generation 112
7.6 Notional Local Targets – Renewable Heat 114
7.7 Capacity, Generation and Potential 115
7.8 Summary of Technology Choices 116

8. Technology mixes - baskets of technology **128**

8.1 Baskets of Technology 128

9. Conclusions **134**

Appendices .... **I**

A. Figures .... **I**

B. ROC Accredited Stations .... **IX**

Contents

C. Case Studies and Visualisations XII

References XIV

List of Figures

Figure 3-1 Stages for Developing a Comprehensive Evidence Base for Renewable Energy Potential 18

Figure 4-1: Proposed Lancashire Waste Disposal Network (www.lancashire.gov.uk) 47

Figure 6-1 1.1% Growth in Regional Electricity Consumption forecast to 2020 (from Arup, 2008) 111

Figure 6-2: Council Electricity Consumption Projections until 2020 113

Table 7-2: Projected Electricity Consumption and derived Notional 2020 Target (MW) 113

Figure 6-3: Installed Capacity in 2008 and Under a Possible UK Technology Basket in 2020 (DECC, 2009) 114

Figure 7-1 Possible UK Technology Basket in 2020 (source UK Renewable Energy Strategy, 2009) 128

Figure 7-2 Illustrative Sector Contributions to Renewable Heat in 2020 (in the lead scenario, FES, 2009) 132

Figure A 1 - Environmental Designations I

Figure A 2 - Biodiversity Action Plan Priority Habitats I

Figure A 3 - Air Quality Management Areas I

Figure A 4 - Wind Resources Map (10m above ground level) I

Figure A 5 - Wind Resources Map (45m above ground level) I

Figure A 6 - Commercial Scale Wind Energy Opportunities I

Figure A 7 - Commercial Scale Wind Energy Constraints I

Figure A 8 - Small Scale Wind Energy Opportunities I

Figure A 9 - Small Scale Wind Energy Constraints I

Figure A 10 - Agricultural Land Classifications in the Study Area I

Figure A 11 - Forestry Commission Woodland Classifications I

Figure A 12: Character Areas I

Figure A 13 - Aquifers within the Study Area I

Figure A 14 - Yearly Sum of Global Irradiation on Optimally Inclined Surfaces I

Figure A 15 - NFCDD and LYRES Identified Weirs for Hydropower I

Figure A 16 - Electricity Distribution Network in the Study Area I

Figure A 17 - Gas Network I

Figure A 18 - Large Renewable and Low Carbon Schemes in the Study Area I

Figure A 19 - ROC Accredited Stations in the Study Area I

Figure A 20 Conservation Areas I

List of Tables

Types of Renewable and Low Carbon Energy v

Uptake Scenarios - Electricity vii

Generation Shortfall under the High Wind Uptake Basket viii

Proportion of Wind Resource Utilised under the Enough Wind Basket ix

Generation Shortfall and Required Turbines under the Maximising Non Wind Scenario ix

Table 2-1 Indicative Targets for the Lancashire Sub Region for Additional Capacity (Targets including existing schemes are in brackets) (MW) (Government Office for the North West 2008) 7

Table 2-2 Indicative local targets for installed grid-connected renewable energy in 2010 and 2021 (MW) (Government Office for Yorkshire and the Humber 2008) 10

Table 2-3 Types of Renewable and Low Carbon Energy 12

Table 2-4 Installed Electricity Capacity Factor 16

Table 4-1 Summary of Potential RLC Sources 20

Table 4-2 Proportion of Council Areas Covered by Conservation Areas 24

Table 4-3 Proposed generation tariff levels (1 April 2010 – 31 March 2013) 26

Table 4-4 Proposed Renewable Heat Tariffs - Small installations 27

Table 4-5 Proposed Renewable Heat Tariffs - Medium installations 28

Table 4-6 Proposed Renewable Heat Tariffs - Large installations 28

Table 4-7 Wind Turbine Installed Capacities 30

Table 4-8 Wind Energy Development Sizes 30

Table 4-9 Operational Commercial Scale Wind Energy within the Partnership Area 31

Table 4-10 Consented Commercial Scale Wind Energy within the Partnership Area 31

Table 4-11 Consented and Operational Small Scale Wind Energy within the Partnership Area 31

Table 4-12 Commercial Scale Wind Energy Theoretical Maximum Installed Capacity 34

Table 4-13 Commercial Scale Wind Energy Potential Installed Capacity 36

Table 4-14 Commercial Scale Wind Energy Pragmatic Installed Capacities 37

Table 4-15 Theoretical Maximum Land Resource available for Small Scale Wind Energy Development 38

Table 4-16 Area of unconstrained land available for small scale wind energy development 39

Table 4-17 Potential small scale wind energy installed capacity (MW) 39

Table 4-18 Combined Pragmatic Maximum Installed Capacity 40

Table 4-19 Potential Area Available for Energy Crops and Potential Annual Energy Generation 43

Table 4-20 Landscape Sensitivity to Energy Crops (from Defra website) 44

Table 4-21 Potential Energy Source available from Municipal Waste 46

Table 4-22 Waste Wood Volumes Across the UK (Wrap 2005) and the estimated proportions arising from each council 49

Table 4-23 Energy from Sewage Waste Facilities in the Study Area 50

Table 4-24 Current landfill Gas sites 50
Table 4-25 Potential Woodfuel Harvest and Energy Generation in the Study Area 52
Table 4-26 SWOT Analysis of the North West England's Woodfuel Sector (from North West England Biomass Woodfuel Strategy) 53
Table 4-27 Summary of the Pragmatic Biomass Potential in the study area 54
Figure 4-2: Anaerobic Digester System (from www.biogas-info.co.uk) 57
Table 4-28 Summary of the main types of CHP systems currently available (from Carbon Trust Website) 59
Table 4-29 Number of Air Quality Management Zones per Council 61
Table 4-30 Energy efficiency of typical PV installations 64
Table 4-31 Potential for Solar Energy PV 66
Table 4-32 Potential for Solar Energy Water Heating 69
Table 4-33 Aquifers within the Council Areas 71
Table 4-34 Environment Agency CAMS areas and Water Availability 74
Table 4-35 Potential for Domestic Ground Source Heating 78
Table 4-36 The proportion of 'off gas' properties by Council 79
Table 4-37 Estimation of Theoretical and Pragmatic Uptake of Ground Source Heating for Commercial Properties 80
Table 4-38 Ground Source Heating Capacity Potential Summary 81
Table 4-39 Potential for Hydro Power 84
Table 4-40 Potential Small Scale Hydro Schemes Identified by the LYREPS Report (1998) 85
Table 4-41 Indicative costs for Connection Works 93
Table 4-42 On and off-grid gas connected households 95
Table 6-1- Baseline build costs for the dwelling types 106
Table 6-2 Summary of extra-over costs of building to each level of the Code in each of the dwelling types and for a range of development scenarios. 107
Table 7-1 Existing Electricity Consumption and Renewable Generation 110
Table 7-3 Current Shortfall from Notional 2020 Study Targets (MW) 114
Table 7-4 Total Domestic and Commercial Renewable Heat Requirements 115
Table 7-5 Installed Electricity Capacity Factor 116
Table 7-6 Commercial Scale Wind Farm Generation Potential in the Study Area 117
Table 7-7 Total Pragmatic RLC Electricity Generation 119
Table 7-8 Uptake Scenarios - Electricity Generation 122
Table 7-9 Total Pragmatic RLC Heat Generation 124
Table 7-10: Renewable Heat Generation Uptake Scenario Summary 125
Table 7-11 On-site requirements for Renewable Energy Generation 127
Table 8-1 Technologies particularly suitable for different contexts 129
Table 8-2 Generation Shortfall under the High Wind Uptake Basket 130

Table 8-3 Proportion of Wind Resource Utilised under the Enough Wind Basket 131

Table 8-4 Generation Shortfall and Required Turbines under the Maximising Non Wind Scenario 131

Table 8-5 Potential for Non-Wind Technologies 132

Table 8-6 Renewable Heat Technology Baskets 133

Table A 1 Potential Livestock Organic Waste and the Energy it could Generation Across the Study Area through AD II

Table A 2 Existing RLC Capacity in the Study Area II

Table A 3 Total Theoretical RLC Electricity Capacity II

Table A 4 Total Theoretical RLC Heating Capacity II

Table A 5 Total Pragmatic RLC Electricity Capacity II

Table A 6 Total Pragmatic RLC Heating Capacity II

Table A 7 Total Theoretical RLC Electricity Generation II

Table A 8 Total Theoretical RLC Heating Generation II

Table A 9 Total Pragmatic RLC Electricity Generation II

Table A 10 Total Pragmatic RLC Heating Generation II

Table A 11 Electricity Capacity Factors II

Table A 12 Heating Capacity Factors II

Table A 13 High Level Electricity Uptake Scenario II

Table A 14 Medium Level Electricity Uptake Scenario II

Table A 15 Low Level Electricity Uptake Scenario II

Table A 16 High Wind Uptake Scenario Basket II

Table A 17 Maximising Non-Wind Scenario Basket II

Table A 18 No Additional Wind Scenario Basket II

Table A 19 Existing and Planned Wind Energy and Landscape Capacity II

Table A 20 All Wind in Planning Scenario Basket II

Table A 21 Projected Electricity Consumption, Targets and Current RLC Installed Capacity II

Table A 22 Burnley Electricity Scenario Baskets II

Table A 23 Calderdale Electricity Scenario Baskets II

Table A 24 Kirklees Electricity Scenario Baskets II

Table A 25 Pendle Electricity Scenario Baskets II

Table A 26 Rossendale Electricity Scenario Baskets II

Table A 27 High Level Heating Uptake Scenario II

Table A 28 Medium Level Heating Uptake Scenario II

Table A 29 Low Level Heating Uptake Scenario II

Table A 30 Estimated Domestic and Commercial Heat Demand for 2010 and 2020 II

Table A 31 Additional Housing Required by 2020 III

Table A 32 Heat Scenario - Moderate Solar Heat Uptake - High GSH III

Table A 33 Heat Scenario - Moderate Solar Heat Uptake - Low GSH III

Table A 34 Existing Small Scale Wind Turbines in Burnley..................................... III

Table A 35 Sites with Planning Permission for Small Scale Wind Turbines in Calderdale III

Table A 36 Existing Small Scale Wind Turbines in Kirklees III

Table A 37 Existing Small Scale Wind Turbines in Pendle III

Table A 38 Existing Small Scale Wind Turbines in Rossendale............................... III

Table A 39: ROC Accredited Stations within the Study Area.................................. IX

Additional large tables are provided in the tables Appendix A2 at the end of the report.

Abbreviations

AGMA Association of Greater Manchester Authorities

AONB Area of Outstanding Nature Beauty

BAP Biodiversity Action Plan

CA Capacity Area

CCGT Combined Cycle Gas Turbine

CCL Climate Change Levy

CHP Combined Heat and Power

COP Coefficient of Performance

DECC Department of Energy and Climate Change

DTI Department of Trade and Industry

EAS Environment Advisory Service

FIT Feed in Tariff

HAP Habitat Action Plan

IPC Infrastructure Planning Commission

kWp Kilowatt Peak

kWth Kilowatt Thermal

LCT Landscape Character Type

LDD Local Development Document

LDF Local Development Framework

LNR Local Nature Reserve

LWT Lancashire Wildlife Trust

MBC Metropolitan Borough Council

MC Metropolitan Council

MWe Megawatt Electrical

MWt Megawatt Thermal

NCA National Character Area

NFCDD National Flood and Coastal Defence Database
NNR National Nature Reserve
ORED Office of Renewable Energy Development
PD Permitted Development
PPA Planning Performance Agreement
PPS Planning Policy Statement
PV Photovoltaic
RES Renewable Energy Strategy
RHI Renewable Heat Incentive
RLC Renewable and Low Carbon
ROC Renewable Obligation Certificates
RSPB Royal Society for the Protection of Birds
RSS Regional Spatial Strategy
RTFO Road Transport Fuel Obligation
SAC Special Area of Conservation
SCOSPA Standing Conference of Southern Pennine Authorities
SINC Sites Important for Nature Conservation
SPA Special Protection Area
SSSI Site of Special Scientific Interest
UDP Unitary Development Plan
ZEN Zero Emissions Neighbourhood

Glossary

For a good glossary of renewable energy terms the following website is recommended;

http://www.r-e-a.net/info/glossary

1. Introduction

1.1 Background

Associated with the growing likelihood that climate change is a consequence of increases in greenhouse gases there has been a growing interest in low carbon and sustainable sources of energy.

Maslen Environmental was commissioned by the Partnership Councils: Burnley Borough Council, Pendle Borough Council, Rossendale Borough Council, Calderdale Metropolitan Borough Council and Kirklees Metropolitan Council, situated in the South Pennines, to undertake a study on renewable and low carbon (RLC) energy in their respective areas.

1.2 Scope of Study

1.2.1 Outline of the Project Activities

Overall the purpose of the study is to:

- Identify the opportunities for delivering energy from RLC sources, including micro and district scale technologies, in order to meet both local and site specific targets.

It should be noted that at the outset of this study the Regional Spatial Strategies (RSSs) provided the context for establishing targets at a Local Authority scale. The RSS was revoked when the study was nearing completion. The lack of regional targets necessitated a new approach to Local Authority targets having to be developed for the purposes of the study.

Within this overall purpose this study includes the following aspects:

- A review of the relevant policy context;
- A review of existing (baseline) and programmed RLC for electricity generation and for the provision of heating;
- An assessment of the potential for each RLC energy technology type;
- The identification of the key constraints and barriers for each technology;
- An assessment of the potential for local RLC energy generation for specific sites and localities;
- The development of scenarios for each District to meet a 'notional' RLC energy target;
- The development of an RLC Energy Framework.

The study provides baseline information and assessments, but does not address policy development. The study is policy neutral but provides an evidence base which can be used in the development of local development framework (LDF) policies. The 'notional' targets developed in the study are NOT recommendations for an appropriate Local Authority based target. Their purpose was to consider how different mixes of RLC technologies might meet a 'target'.

1.3 Methodology

The methodology is described in more detail in chapter 3 and is based upon an assessment of the technologies available, the landscape setting, feedstock requirements, end user connectivity and financial aspects.

1.4 Report Structure

The report is structured as follows:

1. Chapter 1 - Introduction
2. Chapter 2 - Policy Review and Existing RLC Energy
3. Chapter 3 - RLC Framework - outlining the assessment methodology
4. Chapter 4 - RLC Framework - Potential and Constraints - giving details of the potential of the different renewable and low carbon energy sources within the Partnership Area.
5. Chapter 5 - Site Specific Case Study Assessments and Visualisations
6. Chapter 6 - Scenarios and RLC Potential
7. Chapter 7 - Technology mixes - baskets of technology
8. Chapter 8 - Conclusions

Figures are given in Appendix A.1

Additional information and tables are given in Appendix A.2 and B

2. Policy Review and Existing RLC Energy

2.1 Review of Existing Policy and Studies

The Partnership Area is subject to many relevant European, National, Regional and Local policy drivers and initiatives. These include spatial planning documents and planning guidance, energy efficiency and RLC energy targets and climate change initiatives.

Since the Partnership Area includes councils within the North West Region and Yorkshire and the Humber Region, regional policies for both these areas are relevant.

The policy context is described from the top down - starting with national and European policy drivers and progressing through regional to the local level relevant policies.

2.1.1 National Policy and European Context

THE UK has signed up to the EU Renewable Energy Directive, which includes a UK target of 15% of energy needs being derived from renewable sources by 2020. This is equivalent to a seven-fold increase in the UK renewable energy consumption from 2008 levels[1].

The following documents provide a summary of the context for renewable energy development within The Partnership Area. The framework for national policy is set by the following:

- Planning and Energy Act 2008;
- Energy White Paper 2007 (HM Government);
- Energy Review 2006 (DTI);
- Planning Policy Statement 1 - Delivering Sustainable Development;
- Climate Change Supplement to Planning Policy Statement 1;
- Planning Policy Statement 22: Renewable Energy;
- UK Biomass Strategy 2007 (HM Government);
- Microgeneration Strategy 2006 (HM Government);
- England Woodfuel Strategy 2007 (Forestry Commission/HM Government);
- Waste Strategy for England 2007 (Defra);
- UK Renewable Energy Strategy - RES (July 2009).

For nationally significant energy infrastructure, a series of new National Policy Statements have been drafted and consulted upon and are currently being finalised. These will form the basis for planning decisions taken by the new Infrastructure Planning Commission (IPC), which is now responsible for considering and making decisions on significant infrastructure planning applications (>50MW for onshore generation). The draft NPSs relevant to this study include:

- Draft Overarching National Policy Statement for Energy (EN-1);
- Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), which covers energy from biomass and/or waste (>50 megawatts (MW), offshore wind (>100MW), onshore wind (>50MW).

The key documents for steering regional and local renewable energy policy are summarised below.

UK Renewable Energy Strategy

In July 2009, the government launched the Renewable Energy Strategy (RES) which sets out the measures that the Government will pursue to achieve the target to source 15% of the

[1] **http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx**

UK's energy needs from renewables by 2020. The RES forms an important part of the wider Low Carbon Transition Plan also published in July 2009, which details how the Government intends to reduce UK CO_2 emissions to 34% below 1990 levels by 2020, and keep within prescribed carbon budgets in the intervening period. Ultimately, the Government is committed to reducing emissions to 80% below 1990 levels by 2050.

The UK target for 2020, in line with European requirements set out in the Renewable Energy Directive, requires 15% of the UK's energy demand (output, rather than capacity) to come from renewable sources. Indicative percentages are given of how the government envisages that the 15% target could be fulfilled: 30% of electricity; 12% heat and 10% transport energy from renewables.

In addition to the renewable energy target for 2020, milestones or interim, non-binding renewable energy targets have been set by the European Commission, as follows: 4% in 2011/12, 5.4% in 2013/14, 7.5% in 2015/16 and 10.2% in 2017/18 (SQW Energy, 2009).

The strategy sets out of a number of measures by which the planning process could be facilitated for renewable energy. These include:

- Giving priority to appeals for renewable energy proposals (currently 65% of appeals were allowed in 2008-2009).
- Recovering planning appeals for decision by Secretary of State.
- Encouraging the wider use of Planning Performance Agreements (PPAs).
- Reducing the number of small scale developments that require full planning permission, including extension of permitted development rights to business and public services and widening the types of renewable development within permitted development rights.
- Revising the Cost Award procedure: so that if a developer appeals against non-determination, costs may be awarded against the local authority if there was no substantive reason for the delay and greater communication with the applicant could have avoided the appeal.

PPS1 - Delivering Sustainable Development

PPS1 'Delivering Sustainable Development' states that local planning authorities should ensure that development plans contribute to global sustainability by addressing the causes and potential impacts of climate change – through policies which:

- Reduce energy use;
- Reduce emissions;
- Promote the development of renewable resources; and
- Take climate change impacts into account in the location and design of development.

PPS1 Supplement - Planning and Climate Change

This supplement provides additional guidance and differs from other policies and guidance nationally regarding climate change, and where this is the case this PPS takes precedence.

PPS1 supplement states that: the ambition and policies in PPS1 should be fully reflected by regional planning bodies in the preparation of Regional Spatial Strategies, and by planning authorities in the preparation of Local Development Documents. Planning authorities should bear in mind that the policies in this PPS are capable of being material to decisions on planning applications.

The supplement states that there is a need to use and expand existing decentralised energy supply systems, and ensure a significant proportion of energy supply is gained from on-site renewable energy and/or from a decentralised energy supply.

In developing their core strategy and supporting local development documents, planning authorities should provide a framework that promotes and encourages renewable and low carbon energy generation. Policies should be designed to promote and not restrict renewable and low-carbon energy and supporting infrastructure.

In particular, planning authorities should:

- Not require applicants for energy development to demonstrate either the overall need for renewable energy and its distribution, nor question the energy justification for why a proposal for such development must be sited in a particular location;
- Ensure any local approach to protecting landscape and townscape is consistent with PPS22 and does not preclude the supply of any type of renewable energy other than in the most exceptional circumstances;
- Alongside any criteria-based policy developed in line with PPS22, consider identifying suitable areas for renewable and low-carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources, but in doing so take care to avoid stifling innovation including by rejecting proposals solely because they are outside areas identified for energy generation; and
- Expect a proportion of the energy supply of new development to be secured from decentralised and renewable or low-carbon energy sources.

In considering areas suitable for planning, authorities should take account of known physical and environmental constraints on the development of land such as flood risk and stability, and take a precautionary approach to increases in risk that could arise as a result of likely changes to the climate.

Regional planning authorities should recognise the potential of, and encourage, those land uses and land management practices that help secure carbon sinks. This aspect is relevant for management of the upland blanket bog areas within the Partnership Area.

Guidance on implementing PPS1 Supplement - Planning and Climate Change is available from: **http://www.hcaacademy.co.uk/planning-and-climate-change**.

PPS22 - Renewable Energy

Planning Policy Statement 22: 'Renewable Energy' states that planning authorities may include policies that require a percentage of the energy to be used in new residential, commercial or industrial developments to come from on-site renewable energy developments. Such policies should ensure that the requirement is only applied where viable given the type of development proposed, location, and design, and should not place undue burden on developers, i.e. by specifying that all energy to be used in a development should come from on-site renewable generation.

Regional spatial strategies and local development documents should contain policies designed to promote and encourage, rather than restrict, the development of renewable energy resources. Regional planning bodies and local planning authorities should recognise the full range of renewable energy sources, their differing characteristics, location requirements and the potential for exploiting them subject to appropriate environmental safeguards.

At the local level, planning authorities should set out the criteria that will be applied in assessing applications for planning permission for renewable energy projects. Planning policies that rule out or place constraints on the development of all, or specific types of, renewable energy technologies should not be included in regional spatial strategies or local development documents without sufficient reasoned justification. PPS 22 states that the Government may intervene in the plan making process where it considers that the constraints being proposed by local authorities are too great or have been poorly justified.

Regional planning bodies and local planning authorities should not make assumptions about the technical and commercial feasibility of renewable energy projects. Technological change can mean that sites currently excluded as locations for particular types of renewable energy development may in future be suitable.

It should be noted that PPS Draft: 'Planning for a Low Carbon Future in a Changing Climate' has been published for consultation. Once the consultation process has been completed, this document will supersede the Planning and Climate Change supplement to PPS 1 and PPS 22 to become a consolidated supplement to PPS1.

2.1.2 Regional Policy

On the 6th July 2010, the government revoked Regional Spatial Strategies. The following section is included as an open letter from the Chief Planner at the Department for Communities and Local Government[2] states that:

Through their local plans, authorities should contribute to the move to a low carbon economy, cut greenhouse gas emissions, help secure more renewable and low carbon energy to meet national targets, and to adapt to the impacts arising from climate change. In doing so, planning authorities may find it useful to draw on data that was collected by the Regional Local Authority Leaders' Boards (which will be made available) and more recent work, including assessments of the potential for renewable and low carbon energy.

Therefore the following review of regional policy and spatial strategies still contains useful information which could inform local planning authority decisions.

2.1.2.1 Regional Policy Overview

There are regional policies in place in both the North West Region and the Yorkshire and the Humber Region. These have broadly the same emphasis. However, the details vary between the two regions. Some of the regional policies and strategies are now several years old and may not reflect current national targets and ambitions. However, they are included here as a background to the study.

Across both Yorkshire and the Humber and North West Regions it is proposed that 10% of the energy requirements for new developments and major refurbishments should be from renewable sources with an emphasis on on-site generation.

Local Government Yorkshire and Humber (LGYH) are currently commissioning a renewable and low carbon energy capacity study for Yorkshire and Humber. This study will scope a wide array of renewable and low carbon options for electricity as well as heat and site based targets at a sub-regional level. The report is due to be published in the latter half of this year (2010).

2.1.2.2 Regional Policy Context - North West Region

The North West Sustainable Energy Strategy (NWRDA July 2006) has aspirations for the North West Region to provide:

- 10% of final energy demand from renewable sources by 2010.
- 15% of final energy demand from renewable sources by 2015.
- 20% of final energy demand from renewable sources by 2020.

The following documents outline the regional context for renewable energy.

- North West Sustainable Energy Strategy 2006 (North West Regional Assembly). The Welsh Assembly, Technical Advice Note 8 on renewable energy is quoted in the strategy as being an approach which could be followed in the North West.
- Sustainable Appraisal Statement for the North West Regional Spatial Strategy 2008 (Government Office for the North West);
- Towards Broad Areas for Renewable Energy Development; Sustainability Appraisal Report 2006 (4NW);

The North West of England Plan Regional Spatial Strategy to 2021 sets out renewable energy uptake targets for the region as indicated in the following table.

[2] http://www.communities.gov.uk/documents/planningandbuilding/pdf/1631904.pdf

Table 2-1 Indicative Targets for the Lancashire Sub Region for Additional Capacity (Targets including existing schemes are in brackets) (MW) (Government Office for the North West 2008)

Renewable/ Energy Type	2005 - 2010	2010 - 2015	2015 -2020
On-shore wind farms	11-16 (195)		13-20 (232.5)
Single large wind turbines	7 (10.5)		11 (16.5)
Small stand-alone wind turbines	10 (0.3)		15 (0.45)
Building mounted micro turbines	205 (0.205)	2,050 (205)	4,100 (4.1)
Biomass-fuelled CHP / Electricity schemes	1 (9)	2 (14)	3 (19)
Biomass co-firing	-	-	-
Anaerobic digestion of farm biogas	1 (2)	3 (6)	5 (10)
Hydro Power			2 (0.1)
Solar Photovoltaics*	205 (0.41)	5,125 (10.25)	10,250 (20.5)
Landfill gas	14 (20.2)	7 (14.3)	0
Sewage gas	4 (1.2)	4 (1.2)	4 (1.2)
Thermal treatment of municipal / industrial waste	0	0	1 (40)
Total**	**50 - 55 (239)**	**57-64 (297.4)**	**54-61 (344.4)**

*This category is assumed to consist of a variety of different scales of domestic, commercial and "motorway" scheme.
**All totals are exclusive of micro wind and photovoltaics installations
Values in Brackets are cumulative and include existing capacity in 2005; values outside the bracket are targets for additional generation in that period
Merged cells indicate that the targets are the same across the whole period, and could be achieved early or by 2020

The North West Regional Authority set out the following target in their Sustainable Energy Strategy (2006):

- *These (targets) should be a requirement in residential and non-residential developments and major refurbishment schemes where 10% of the predicted energy requirements should be met by renewable energy production.*

This was adopted in the North West of England Plan Regional Spatial Strategy to 2021 under Policy EM 17 which is set out below:

- In line with the North West Sustainable Energy Strategy, by 2010 at least 10% (rising to at least 15% by 2015 and at least 20% by 2020) of the electricity which is supplied within the Region should be provided from renewable *energy sources. To achieve this new renewable energy capacity should be developed which will contribute towards the delivery of the indicative capacity targets set out in Tables 9.6 and 9.7a-c. In accordance with PPS22, meeting these targets is not a reason to refuse otherwise acceptable development proposals.*

- *Local authorities should work with stakeholders in the preparation of sub regional studies of renewable energy resources so as to gain a thorough understanding of the supplies available and network improvements, and how they can best be used to meet national, regional and local targets. These studies should form the basis for:*

- informing a future review of RSS to identify broad locations where development of particular types of renewable energy may be considered appropriate (119); and
- establishing local strategies for dealing with renewable resources, setting targets for their use which can replace existing sub regional targets for the relevant authorities.

* *Plans and strategies should seek to promote and encourage, rather than restrict, the use of renewable energy resources. Local planning authorities should give significant weight to the wider environmental, community and economic benefits of proposals for renewable energy schemes to:*

  - *contribute towards the capacities set out in tables 9.6 and 9.7 a-c; and*
  - *mitigate the causes of climate change and minimise the need to consume finite natural resources.*

* *Opportunities should be sought to identify proposals and schemes for renewable energy. The following criteria should be taken into account but should not be used to rule out or place constraints on the development of all, or specific types of, renewable energy technologies:*

  - *anticipated effects on local amenity resulting from development, construction and operation of schemes (e.g. air quality, atmospheric emissions, noise, odour, water pollution and disposal of waste). Measures to mitigate these impacts should be employed where possible and necessary to make them acceptable;*
  - *acceptability of the location/scale of the proposal and its visual impact in relation to the character and sensitivity of the surrounding landscape, including cumulative impact. Stringent requirements for minimising impact on landscape and townscape would not be appropriate if these effectively preclude the supply of certain types of renewable energy, other than in the most exceptional circumstances such as within nationally recognised designations as set out in PPS22 paragraph 11;*
  - *effect on the region's World Heritage Sites and other national and internationally designated sites or areas, and their settings but avoiding the creation of buffer zones and noting that small scale developments may be permitted in such areas provided there is no significant environmental detriment;*
  - *effect of development on nature conservation features, biodiversity and geodiversity, including sites, habitats and species, and which avoid significant adverse effects on sites of international nature conservation importance by assessment under the Habitats Regulations;*
  - *maintenance of the openness of the Region's Green Belt;*
  - *potential benefits of development to the local economy and the local community;*
  - *accessibility (where necessary) by the local transport network;*
  - *effect on agriculture and other land based industries;*
  - *ability to make connections to the electricity distribution network which takes account of visual impact (as qualified above);*
  - *integration of the proposal with existing or new development where appropriate;*
  - *proximity to the renewable fuel source where relevant – e.g. wood-fuel biomass processing plants within or in close proximity to the region's major woodlands and forests;*

- o *encourage the integration of combined heat and power (CHP), including micro CHP into development.*

- *Developers must engage with local communities at an early stage of the development process prior to submission of any proposals and schemes for approval under the appropriate legislation.*

It is assessed (Arup, July 2008) that to achieve the regional 20% renewable energy target by 2020 in the North West will be very challenging.

2.1.2.3 Regional Policy Context - Yorkshire and the Humber Region

Yorkshire and the Humber Region has set a target of delivering 708MW of renewable energy in the region by 2010 and 1862MW of renewable energy by 2021.

The Yorkshire and Humber Plan; Regional Spatial Strategy to 2026 (May 2008) states in policy YH2 (Climate change and resource use) that plans, strategies, investment decisions and programmes should:

- 'Help to meet the target set out in the RES to reduce greenhouse gas emissions in the region in 2016 by 20-25% (compared to 1990 levels) with further reductions thereafter' by various means, including 'increasing renewable energy capacity and carbon capture'.

Their strategy for delivering the core approach suggests that in the early years increasing renewable energy generation is likely to come mainly from wind turbines, whereas in mid and later years of the plan delivery, greater contributions will come from combined heat and power systems, via biomass and photovoltaic technologies.

Policy ENV 5 states that 'the Region will maximise improvements to energy efficiency and increases in renewable energy capacity. Plans, strategies, investment decisions and programmes should:

A. Reduce greenhouse gas emissions, improve energy efficiency and maximise the efficient use of power sources by:

1. Requiring the orientation and layout of development to maximise passive solar heating;
2. Ensuring that publicly funded housing, and Yorkshire Forward supported development, meet high energy efficiency standards;
3. Maximising the use of combined heat and power, particularly for developments with energy demands over 2MW, and incorporating renewable sources of energy where possible;
4. Ensuring that development takes advantage of community heating opportunities wherever they arise in the region, including at Immingham and near Selby;
5. Providing for new efficient energy generation and transmission infrastructure in keeping with local amenity and areas of demand;
6. Supporting the use of clean coal technologies and abatement measures.

B. Maximise renewable energy capacity by:

1. Delivering Regional and Sub-Regional targets for installed grid-connected renewable energy capacity;
2. Monitoring annually planning permissions and developments against the indicative local authority targets for 2010 and 2021 set out in Table 10.2 and taking action accordingly in order to ensure the regional and sub-regional targets are exceeded;
3. Promoting and securing greater use of decentralised and renewable or low-carbon energy in new development, including through Development Plan Documents setting ambitious but viable proportions of the energy supply for new development to be required to come from such sources. In advance of local targets being set in DPDs,

new developments of more than 10 dwellings or 1000m^2 of non-residential floorspace should secure at least 10% of their energy from decentralised and renewable or low-carbon sources, unless, having regard to the type of development involved and its design, this is not feasible or viable.

The following documents provide details of existing targets for renewable energy in the Yorkshire and the Humber region.

- Planning for Renewable Energy Targets in Yorkshire and the Humber 2004 (Government Office for Yorkshire and the Humber);
- Development of a Renewable Energy Assessment and Targets for Yorkshire and the Humber 2002 (Government Office for Yorkshire and the Humber).

The Yorkshire and the Humber Regional Spatial Strategy to 2026 (2008) has under the requirements of Planning Policy Statement 22 derived renewable energy targets for the region as indicated in the following table.

Table 2-2 Indicative local targets for installed grid-connected renewable energy in 2010 and 2021 (MW) (Government Office for Yorkshire and the Humber 2008)

Council	2010	2021
Calderdale	19	53
Kirklees	11	48

On-site Renewable Energy - The Merton Rule

The development of planning targets for renewable energy was pioneered by the London Borough of Merton (the Merton Rule) leading to an increased uptake of on-site renewable energy options. These options may provide some power for the site in question, and in certain cases export power back to the grid. The inclusion of ENV 5 Policy within the Yorkshire and the Humber Plan – Regional Spatial Strategy provides a driver for increased on-site renewable energy generation within the Yorkshire and the Humber region - see section B.3 of ENV 5 above.

2.1.3 Local Policy Context

It is anticipated that the findings of this study will be used as part of the evidence base for development of policies within the Partnership Areas. However, in order to provide background to the study the current policies and approaches to renewable energy within the Partnership councils are outlined below.

- **Calderdale UDP** (2006, amended 2009) has a number of policies in the UDP relating to renewable energy, although specific targets are not stated except for Policy EP 27 Renewable Energy in New Developments where major employment, retail and residential developments (either new build, conversion or renovation) will be required to incorporate on-site renewable energy generation to provide at least 10% of predicted energy requirements up until 2010, 15% up until 2015 and 20% up until 2020.
- **Calderdale UDP** (2006, amended 2009) recognises the contribution of some forms of RLC energy, but indicates the limited availability of some such as landfill gas due to the lack of landfill sites[3].
- **Kirklees UDP** (1999, revised in 2007) **-** policies relating to renewable energy are contained within Chapter 5 of the UDP. It states that currently wind energy is the most likely source of renewable energy in the area, though both solar and energy from waste may be developed further in the future. Wind farms are likely to be viewed more favourably than a proliferation of individual turbines provided that no serious harm is caused to any landscape of special character or importance. In planning applications, plans to maximise solar heat and reduce exposure to wind chill will be taken into account.

[3] Calderdale Council Unitary Development Plan. Amended 2009. Chapter 12 - Development of Renewable Energy, paragraph 12.78

- Similarly in the North West there is an aspiration that this type of policy will be widely adopted, with policies already in place in some areas.
- **The Pendle Local Plan Policy 5** regarding renewable energy sources states that the Council are committed to providing a renewable energy supply for Pendle. The local plan indicates areas and types of renewable energy generation which will be encouraged and where they will be resisted. Large wind farms will be resisted, but individual wind turbines will be permitted with some constraints (situated outside of the AONB, SSSI etc).
- **Rossendale (Draft) Core Strategy Policy 19**: Climate Change and Renewable Energy (except wind), requires new developments to maximise decentralised, renewable and low-carbon energy generation opportunities.
- **Burnley Local Plan (2006)** states, under Policy GP8, that all new buildings, conversions and change of use of buildings should reduce energy consumption and include energy efficiency measures, in line with the local plans key aim to encourage sustainable development. Policy E31 states that, though the potential wind resource in Burnley is large, wind farms will only be allowed if they have no unacceptable impacts on landscape, the setting of building, nature conservation and local amenities and that cumulative impacts in relation to other wind farms will be taken into account. Other forms of renewable energy will be encouraged where they do not have a detrimental effect on the landscape and environment.

2.1.4 Existing Studies

The following existing studies are relevant to the Partnership Area or neighbouring areas:

- Towards Broad Areas for Renewable Energy Development, (Arup, July 2008) is a study in the northwest region. This provides an overall assessment of broad areas for regional and sub regional renewable energy developments for the Regional Spatial Strategy (RSS) and for Local Authorities' Local Development Frameworks (LDFs). This includes theoretical and pragmatic scenarios. The theoretical maximum scenario has been estimated as approximately 3,090 MW installed capacity (equivalent to 8,539 GWh electrical output). This represents an absolute upper limit to potential generation. The pragmatic scenario reflects a level of renewable energy generation that may be more likely to come forward in the period to 2020: this has been estimated at approximately 1,990 MW (equivalent to 5,455 GWh). The key findings of the study are that the North West faces a considerable challenge to meet the current renewable energy targets in the draft RSS.
- Landscape Sensitivity to Wind Energy Developments in Lancashire, (Lovejoy 2005). The study provides strategic guidance on the sensitivity of the Lancashire landscape to wind energy development.
- Landscape Capacity for Wind Energy Development in the South Pennines, (Julie Martin Associates January 2010). This study assesses the capacity of the landscape of the local authority areas of Burnley Borough Council, Bury Metropolitan Borough Council, Calderdale Metropolitan Borough Council, Kirklees Metropolitan Council, Rochdale Metropolitan Borough Council and Rossendale Borough Council to accommodate wind energy development.
- A Renewable Energy Study for Housing in Burnley 2005 (RenewEL for Burnley Borough Council). This assesses the technical, non-technical and cost implications of incorporating sustainable energy technologies into refurbished terraced housing stock and new builds and concludes that high uptake of energy efficiency, solar water heating systems, biomass community heating and solar photovoltaics are feasible.
- RSPB in partnership with the Wildlife Trust for Lancashire, Manchester & North Merseyside (LWT), Lancashire County Council, Natural England and the Merseyside Environmental Advisory Service (EAS), developed a Spatial Planning Guide for Biomass Energy Crop planting in North West England (July 2008).
- AGMA (Association of Greater Manchester Authorities) - Energy Study and Bury Energy Opportunity Framework (November 2009) and associated case studies.

Town centre development of RLC technology was considered with the possibility of decentralised generation in conjunction with new development. The study focused upon sewage gas, landfill gas, single turbine wind, geothermal mine water, hydropower and CHP, e.g. from anaerobic digestion.

- Yorkshire and Humber Vision for Biomass, AEA Energy and Environment, Report to Yorkshire and Humber Regional Energy Forum, 2007. The action plan outlined in this report includes:
    - Developing the local market for biomass heat and power;
    - Developing a local fuel supply from wood fuel and energy crops;
    - Including biomass energy in regeneration schemes.

2.2 Existing and Programmed RLC Energy

2.2.1 RLC Energy Types

The following types of renewable and low carbon energy are considered within this study.

Table 2-3 Types of Renewable and Low Carbon Energy

Category	Sub - category Level 1	Sub -category level 2	Comment
Electricity and CHP	Large scale (>50 MW)	Wind	
		Biomass combustion	Municipal solid waste, virgin and recycled timber, energy crops, solid recovered fuel, all biomass co-firing with coal and other wastes.
	Medium scale (50 kW to 50 MW	Wind	
		Biomass combustion	Municipal solid waste, virgin and recycled timber, solid recovered fuel,
		Biomass anaerobic digestion	Agricultural waste, food waste, energy crops.
		Hydro	
		PV	
		Natural Gas CHP	Heat use from CHP.
	Micro scale (<50 kW)	Wind	
		Hydro	
		PV	
Heat only	Medium scale (50 kW to 50 MW)	Biomass combustion	Municipal solid waste, virgin and recycled timber, solid recovered fuel,
		Biomass anaerobic digestion	Injection to gas grid or local use.
		Solar thermal	Water or space heating
		Heat pumps (heating and cooling)	Ground source, air source, water source.
	Micro scale (<50 kW)	Biomass combustion	Virgin and recycled timber
		Solar thermal	Water or space heating
		Heat pumps	Ground source, air source, water source.

Notes.
Combined heat and power is a more efficient use (in certain contexts) of energy generation, which can be used with either fossil fuels (gas or solid fuels) or renewable (biomass) fuels.
Biomass - energy generation - anaerobic digestion - from sources of biomass with higher moisture content. Gas generated can be used for heat or to power CHP - combined heat and power.
Waste to energy is generally an incineration process for dry matter and includes biomass combustion.

2.2.2 Existing RLC

The following renewable installations are present in the study area. This summary is based upon a review of readily available information. It is not exhaustive and include only a few on-site generation schemes; however it does capture all the significant generating installation claiming ROCs. Further information on installations claiming ROC (renewable obligation certificates) is given in Appendix B.

Wind Farms

Commercial wind farms currently operational within the Partnership Area are located at:

- Ovenden Moor 23 turbines total installed capacity 9.2MW (Calderdale MBC);
- Coal Clough 24 turbines total installed capacity 9.6MW (Burnley Borough Council);
- Hameldon Hill 3 turbines total installed capacity 4.5MW (Burnley Borough Council);
- Scout Moor 26 turbines total installed capacity 65MW (11 turbines in Rossendale Borough Council).

Recently planning permission has been granted following a public inquiry for Crook Hill Wind Farm (within Calderdale Metropolitan Borough Council and Rochdale Metropolitan Council areas) and Reaps Moss wind farms (Rossendale Borough Council and Calderdale Metropolitan Borough Council areas). The appeal did not grant permission for Todmorden Moor wind farm - which was considered as part of the same inquiry - on a technicality (and this is likely to be resubmitted as the same size 5 turbines, each 3MW). The inspector noted the importance of renewable energy technologies for tackling climate change and the current gap between existing provision and targets for both the North West Region and Yorkshire and the Humber for 2010. In light of this it was considered that the need to meet national and regional targets was great. Permission for the two wind farms was granted, despite some green belt, landscape, ecological (peat) and hydrological (private water supplies) concerns. These sites are in areas of ecological interest, but not designated sites. This decision clearly affects how the potential for additional wind energy (and possibly other forms of RLC) are to be considered in the planning process, with the requirement to meet RLC targets viewed as very important.

Small Wind Turbines

There are almost 100 consented and installed small wind turbines across the Partnership Area, for example:

- Burnley - The Kestrels, Manchester Road, Burnley - one 11KW turbine
- Calderdale - B & Q Shroggs Road, Halifax - three 6KW turbines
- Kirklees - Civic Centre III - two 6KW wind turbines
- Pendle - Herders Inn, Lancashire Moor Road - one 6KW turbine
- Rossendale - Higher Bridge Clough Farm, Coal Pit Lane - one 6KW turbine

Combined Heat and Power

- Todmorden Sports Centre;
- Burnley Sewage Power Plant;
- Syngenta CHP plant provides 16MWe capacity at a natural gas plant operated by Dalkia in Huddersfield (Kirklees MC).
- Thornhill CCGT (Combined Cycle Gas Turbine) Power Station (burning natural gas) generates 42MWe nominally via gas turbines, through reuse of exhaust gases to generate steam to drive steam turbines 50MW electricity is produced in total, Dewsbury, Kirklees MC.

Waste to Energy

Combustion

- Huddersfield Incinerator provides 10MWe electricity power from combustion of municipal waste and is operated by Sita (Kirklees MC).

Landfill

- Landfill gas provides 1 MWe electricity at Honley Wood, Huddersfield (Kirklees MC)
- Rossendale Power, 1.63MW Landfill gas power generation in Rossendale.

Digestion

- Emley AD – anaerobic digestion 0.3MWe capacity in Kirklees MC.

Solar Power

- Kirklees Suncities Project: a European Commission funded project which began in 2000 and was completed in February 2006. A Total of 351kWp solar electricity systems and 63 solar thermal systems were installed across the borough and around 518 households were involved in total.

Solar Power PV

- Moldgreen Primary School has 0.0156 MWe PV electricity installed as a UK Government Major Demonstration Project (Kirklees MC).
- The Alternative Technology Centre (ATC) has Solar PV with a 0.001MWe capacity at Hebble End Mill in Hebden Bridge (Calderdale MBC).
- Pennine Housing 2000 has used solar PV technology to fuel community lighting 0.011MWe at Mytholm Court/Meadows extra care scheme in Hebden Bridge (Calderdale MBC).
- Gibson Mill owned by the National Trust has solar PV electricity 0.005MWe at Hardcastle Craggs, Hebden Bridge (Calderdale MBC).
- Sowerby Bridge market has an array of photovoltaic panels on the roofs of stalls in the market.

Solar Thermal

- Burnley Solar Savings Scheme offered £1000 grants to household to install solar heating.
- Burnley Youth Theatre has a solar thermal hot water system installed.
- Blackshawhead Community Energy Project in Hebden Bridge has solar thermal (heat only) installations for 10 domestic dwellings with 0.002MWt capacity (Calderdale MBC).
- Calder High School has 0.003MWt capacity solar thermal heating in Mytholmroyd (Calderdale MBC).
- Height Gate Farm has solar thermal of 0.003 MWt capacity at Todmorden (Calderdale MBC).
- Solar thermal panels have been installed at Bradshaw Junior and Infants School

There are likely to be many more solar thermal schemes in the study area but no central register exists, however DTI (2005) statistics estimated there were over 100,000 installations in the UK.

Biomass

There are large numbers of small scale biomass heating schemes across the study area including a demonstation scheme at Gibson Mill (National Trust), Hebden Bridge and a number of schemes run by Talbotts in Halifax and Burnley.

Biofuels

There is limited information regarding biofuels in the Partnership Area. The following provides context from a wider area.

Biofuel production and distribution in the UK can be broken down into three main groups: crop based fuel derivatives; waste cooking oil derivates and Biogas derivates. Although it is clear that crop based production facilities are already producing significant volumes of fuel in the UK, the potential for waste oils and biogas is more complex due to a combination of high input prices and an adverse regulatory regime.

Hydropower

Gibson Mill – National Trust property has 0.009 MWt micro-hydro capacity at Hardcastle Craggs, Hebden Bridge (Calderdale MBC).

Ground Source Heat Pump

Shibden Hall Mereside Café has a ground source heat pump.

Sites Operating with multiple renewable energy Technology

Within the Study Area, there are examples of recent developments which have incorporated multiple renewable energy generating technologies. A particularly good examples of this is Titanic Mills, Huddersfield. The Mill, was originally designed as a textile mill. Begun in 2004, the Lowry Renaissance Ltd refurbishment project features a roof-mounted, 50kWp PV system as well as a biomass-fuelled CHP, producing 100kW of electricity and 140kW of heat. This hybrid PV and CHP system is expected to reduce annual CO_2 emissions by approximately 400 tonnes in the residential areas and 200 tonnes in the commercial areas. The PV system is estimated to produce approximately 40,000kWh per year of electricity, approximately 2 per cent of the total demand. The biomass CHP system will generate approximately 700,000kWh per year, around 70 per cent of the total site demand (Energy Savings Trust, 2006).

2.2.3 Renewable Energy - Capacity Factors and Efficiencies

An important consideration in the strategic planning and target setting for renewable energy generation is that the installed capacity is not the same as actual generation. The installed capacity of a generation plant represents the maximum output; however, plants do not run at 100% capacity all the time. There can be various reasons for this: for wind turbines, the wind does not always blow; solar PV installations cannot work at night and some days may be cloudy resulting in some generation but less than full capacity. All generating plant is subject to maintenance, or down time to repair faults. This means that actual generation is always lower than the installed capacity.

To account for the difference between installed capacity and actual generation, capacity factors are used, which represent the proportion of the installed capacity that will actually be generated. Capacity factors vary between types of installations due to the different factors affecting the amount of energy actually generated. This means that small scale wind has a smaller capacity factor than hydro power as hydro power is often more able to operate closer to its full capacity, more of the time (see following table).

Table 2-4 Installed Electricity Capacity Factor

Technology	Capacity Factor
Biomass	0.85
Co-firing of biomass with fossil fuel @ 5%	0.9
Biomass and waste using ACT (advanced conversion techniques)	0.85
Hydro (all types)	0.45
Sewage gas	0.4
Landfill gas	0.64
Onshore wind	0.27
Wind ≤ 50kW	0.1
Solar PV ≤ 50kW	0.08

Notes.
1. Source Arup, July 2008.
2. The amount of electricity generated is the installed capacity times the capacity factor.
3. Figures for biomass represent the amount of time typically required for maintenance of large scale plant which operates all the time. Domestic biomass burning, which is not planned to operate all of the time, will generate on average much less energy.
4. Some newer PV installations may have higher efficiencies of up to 20%; however, the local Burnley (IT Power, 2005) study assumes a capacity factor of around 4%. Similarly some newer wind farms located in particularly good locations may have a capacity factor greater than 0.27.

It must be noted that capacity factors are not the same as efficiency, as efficiency relates resource input to energy output. Energy is lost in the conversion of potential energy within the fuel to available electricity or heat energy. For example when light energy falls onto a solar PV panel some of the energy is converted into heat or lost within the installation through other means. This means that the energy output is at best only 20% of the light energy to fall on the panel. Efficiency therefore relates to the ability to convert the feedstock into usable energy; as opposed to the capacity factor, which is the proportion of the maximum output generation that a plant actually produces over a year. For wind farms, the actual power generated is monitored and the capacity factor for that installation is defined following a year's worth of generation. For example for Coal Clough Wind Farm the installed capacity is 9.6MW, and in 2008 23,123MWh electricity was generated, giving a capacity factor of 27.5%[4].

The difference between capacity factors and efficiencies becomes more complicated in the case of biomass. For example when a wood stove is not working, it is not using its feedstock but unlike wind or flowing rivers, this does not mean that the energy is lost as it is stored within the wood until it is required. This study calculates the energy contained within the potential biomass feedstocks (rather the installed capacity of plants that use biomass feedstocks). Then, this study shows that the total potential energy within the feedstocks can be used in a variety of ways, i.e. to generate electricity or heat. A further complication affecting heat pumps is that heat pumps have an efficiency of over 100%; this means that there is a greater output of energy than input. This calculation of the efficiency results from only taking into account of the input of energy put in by the plant (e.g. electricity) rather than the total energy input which includes the energy drawn from the ground (or air in the case of air pumps).

[4] http://www.renewable-energyfoundation.org.uk/images/PDFs/REDs09/ref%20reds%20wind%201109.pdf).

3. RLC Framework - Methodology

3.1 Development of the Framework

In order for a coherent approach to be taken to RLC energy development, a framework is required which identifies which technologies are most suitable within each of the five districts within the Partnership Area and at what scale.

There is a significant difference in scale of energy output across the RLC technologies. This is related both to the size of typical installations and also the capacity factor for each technology.

In pursuing renewable energy targets at the regional, subregional and local authority scale capacity factors for the respective technologies are significant. It is also important at a regional scale that technologies with the capacity to generate significant levels of power output are pursued to meet renewable generation targets. In contrast at a development site or community level, a different set of technologies are most likely to be appropriate, with lower levels of energy output, but with a suitability for use within, or adjacent to, buildings and communities.

The methodology is described in more detail in the following sections. It is based upon the development of a 'RLC Technology Typology Framework' which establishes the key requirements for each technology and also the key limitations. This Technology Framework, allied to key local data sets, informs the assessment of the potential for each technology across the Partnership Area. Additionally reference has been made to the DECC report (SQW energy 2009) methodology for assessing the capacity for renewable and low-carbon energy.

The Framework considers each Renewable and Low Carbon technology across five headline themes. The requirements of each technology and the feasibility of implementing the technologies within each council are assessed. The Framework also outlines the likely limiting factors affecting each in the environment of the South Pennines.

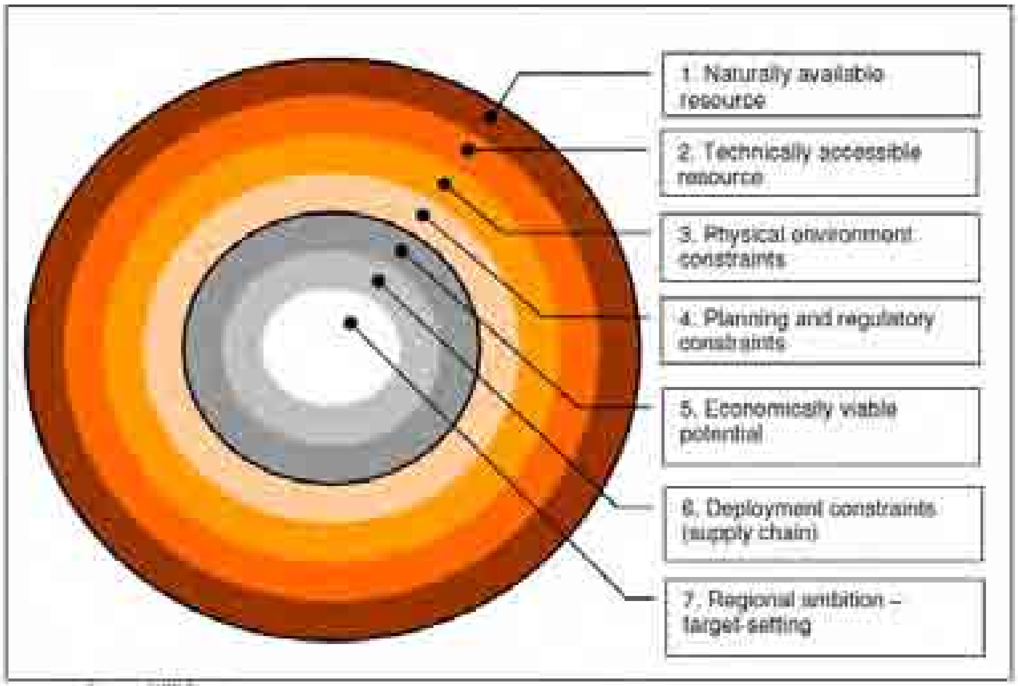
These themes form the basis for assessment criteria for each type of RLC technology. The five themes in our framework are:

- **Technology**: technological requirements, availability, technology support;
- **Landscape**: physical, spatial and cultural requirements and constraints;
- **Feedstock**: sustainability of primary energy source;
- **End User Connectivity**: access to market;
- **Financial**: investment return - 'bang for your buck' and payback times, investment incentives (e.g. grants, 'feed in tariffs' (FITs)).

The assessment across these themes informs the overall assessment of each technology.

This assessment is consistent with that proposed by SQW energy (2009 and 2010) for use in capacity assessment regionally (Figure 3-1).

Figure 3-1 Stages for Developing a Comprehensive Evidence Base for Renewable Energy Potential



4. RLC Framework - Potential and Constraints

4.1 Introduction

The framework considers renewable and low carbon (RLC) energy sources which are applicable at a regional and development site scale. It considers both renewable electricity generation, and low carbon heating. The following list indicates the most likely applications of the technologies across a range of spatial scales.

- Regional Schemes:
  - Wind farms.
- Local to regional schemes:
  - Biomass heating and Combined Heat and Power;
  - Energy From Waste:
    - Advanced Thermal Treatment;
    - Anaerobic Digesters.
- Site specific RLC (generally fairly small scale) such as:
  - Ground source heat pumping;
  - Hydro: consideration of local river and also potentially other schemes (e.g. using reservoirs, and decommissioned reservoirs);
  - Most heating schemes (such as ground source heating, wood stoves and solar thermal).
- Small scale and micro-generation including site specific RLC such as:
  - small scale wind turbines;
  - household solar technologies

The available technologies are summarised in the following table.

Table 4-1 Summary of Potential RLC Sources

Type of Energy	Renewable Energy	Low Carbon Heating	Site based	Regional	Comments
Technologies using natural resources within the Partnership Area					
Wind Farms	√		√	√	A number of turbines supplying electricity to the National Grid – can have fairly large output.
Wind Turbines	√		√		Site specific, lower output and generated electricity may be entirely used on site.
Solar (Photo voltaics)	√		√		Expensive and small scale but widely applicable to un-shaded roofs and facades.
Solar (heating)	√		√		Useful heating source. Some non-domestic buildings may have too low a hot water demand for this to be applicable. It can also be used for space heating.
Hydro-power	√		√		Schemes usually fairly small, can be either low (river weirs) or higher head (e.g. reservoirs above valleys).
Ground Source Heating		√	√		For heating space and water – domestic or non-domestic. Water based (lakes, canals) and air based heat pumps can also be used but are less efficient.
Ground Source Cooling		√	√		Can be combined with ground source heating.
Processes involving combustion or digestion of bio-fuels or other materials. These need a fuel source: ideally sourced within the Partnership Area					
Anaerobic Digesters	√		√		Uses sources of biomass with higher moisture content than suited to combustion. Gas produced can be burned for heat or used to power CHP.
Biomass – energy generation	√		√		Domestic and/or non-domestic: fuels include wood, woodchip, energy crops, agricultural residues, food waste, pellets and some industrial waste and co-products. Fuel may be converted through gasification, pyrolysis and steam turbines.
Biomass - heat	√		√		
Biomass Combined Heat and Power	√	√	√	√	
Waste Thermal Treatment	√		√	√	
Fossil Fuelled Combined Heat and Power		√	√		Combined Heat & Power (CHP) systems are capable of achieving 70-90% fuel efficiency, compared to 30-50% for conventional sources. They are particularly suitable for buildings which have a simultaneous demand for hot water and electricity - including swimming pools, hospitals, leisure centres, offices and old housing. It is less viable in new buildings developments because of improved insulation.

Notes.
1. CHP using fossil fuels can be counted as a low carbon technology as it is a particularly efficient source of heat.

4.1.1 Capacity Assessments

Estimates of the potential energy available for each technology type, assessed in Chapter 4, is calculated in terms of capacity, in line with national guidance (DECC, 2010). The notional renewable energy targets, based upon national targets as developed in Chapter 6, are given in generation. Therefore, within Chapter 7 and 8, the assessed capacity of each technology is converted into potential generation through the relevant capacity factor (see 2.2.3).

4.1.2 General Constraints

Within the scope of this study it is important to identify the high level 'key' constraints on each technology. The scope of this study, both its breadth of geographic area and its strategic nature, requires the limiting factors to be listed and the most significant identified. These will be the limitations which will determine the feasibility of the individual technologies for widespread use.

The development of RLC energy is subject to the same types of constraints as other forms of development. All but the smallest micro installations require planning permission, although extension of permitted development rights (PD) to cover more small scale renewables is being considered. RLC energy installations may require a formal environmental impact assessment (EIA), with those over 50MW being considered by the IPC guided by the National Policy Statements (see Section 2.1.1).

There are a number of types of constraints which can influence the location of development including:

- Environmental sensitivities such as:
    - Local designations e.g. SINCs (sites important for nature conservation), LNRs (local nature reserves);
    - National designations e.g. SSSIs, NNR (there are none in the area), AONBs (Figure A 1);
    - International designations, e.g. SACs, SPAs, Ramsar (Figure A 1 and Figure A 2); Priority Biodiversity Action Plan (BAP) habitats for which there is a Habitat Action Plan (HAP), these may include: blanket bog; ancient woodlands; heathland network; upland heathland; and purple moorgrass and rush pasture .
    - Air Quality Management Areas - which are particularly relevant for any form of combustion including waste to energy and biomass sources of energy (Figure A 3).
    - PPS22 and its companion guide provide guidance as to how the potential impact of environmental sensitivities should be considered in relation to where renewable energy development is located.
- Cultural sensitivities such as:
    - Scheduled Ancient Monuments (held on the national English Heritage register) of national importance;
    - UNESCO World Heritage sites (including non-built landscapes and geological features) of international significance;
    - Listed buildings (I, II*, II) held on a national register;
    - Conservation areas - more strict planning requirements are present in these areas compared to other areas;
    - Green belt.
- Environmental Risks such as:
    - Flooding - flood risk areas have been defined by the Environment Agency and for all types of RLC generation consideration of flood risk is important. PPS 25 indicates that currently, energy generation (classified as essential infrastructure) is permitted within flood zones 1 (very low risk) and 2 (between 0.1 and 1% annual risk). Where there is highest flood risk (i.e. flood

zones 3a and b), an exception test is required for before development is allowed, to show that no viable alternatives exist in areas of lower flood risk. With the exception of hydropower, which should be designed to be flood resilient, and not to increase flooding elsewhere, current planning requirements would tend to direct RLC infrastructure to areas outside zones prone to flooding. Data such as the Environment Agency's Flood Zones and council specific Strategic Flood Risk Assessments can be used to scope this. Within the Partnership Area much of the lower lying, flat land adjacent to rivers is at risk of flooding. There is also the potential that flood risk may increase as a result of climate change.

4.1.3 Considering Suitable Locations

International Designated Sites

Planning permission for renewable energy developments likely to have an adverse effect on a site of international importance for nature and heritage conservation (Special Protection Areas, Special Areas of Conservation, Ramsar Sites and World Heritage Sites) should only be granted once an assessment has shown that the integrity of the site would not be adversely affected (PPS 22).

If the renewable energy development would have an adverse effect on the integrity of an internationally designated nature conservation site, planning permission should only be granted where there is no alternative solution and there are imperative reasons of overriding public interest, including those of a social or economic nature (PPS 22).

The Conservation (Natural Habitats &c) Regulations 1994 set out the legal requirements to be met in respect of European nature conservation sites and protected species where it is intended to grant planning permission for a project. Further guidance is currently provided in PPG9. The Government will also be publishing a draft Circular "Biodiversity and Geological Conservation – Statutory obligations and their impact within the planning system" which will provide administrative guidance on the legislative framework at both international and national level for the protection of sites and species.

SPAs (Special Protection Areas) and SACs (Special Areas of Conservation) are of European nature conservation importance and were created under the EC Birds Directive and Habitats Directive. Within the Partnership Area, SACs and SPAs can be found in Burnley, Pendle, Calderdale and Kirklees and are mainly found on the upland blanket bog areas (Figure A 1).

National Designated Sites

In sites with nationally recognised designations (Sites of Special Scientific Interest, National Nature Reserves, National Parks, Areas of Outstanding Natural Beauty, Heritage Coasts, Scheduled Monuments, Conservation Areas, Listed Buildings, Registered Historic Battlefields and Registered Parks and Gardens) planning permission for renewable energy projects should only be granted where it can be demonstrated that the objectives of designation of the area will not be compromised by the development, and any significant adverse effects on the qualities for which the area has been designated are clearly outweighed by the environmental, social and economic benefits (PPS 22).

Regional planning bodies and local planning authorities should set out in regional spatial strategies and local development documents criteria based policies which set out the circumstances in which particular types and sizes of renewable energy developments will be acceptable in nationally designated areas. Care should be taken to identify the scale of renewable energy developments that may be acceptable in particular areas. Small-scale developments may be permitted within areas such as National Parks, Areas of Outstanding Natural Beauty and Heritage Coasts provided that there is no significant environmental detriment to the area concerned (PPS 22).

SSSIs are found in every council in the Partnership Areas. The boundaries of SSSIs within the Partnership Areas tend to be very similar to the SACs and SPAs boundaries and are also focused on the blanket bog upland areas; however there are a few sites which do not follow this general pattern (Figure A 1).

Green Belts

Policy on development in the green belt is set out in PPG2. When located in the green belt, elements of many renewable energy projects will comprise inappropriate development, which by definition will impact on the openness of the green belt. Careful consideration will therefore need to be given to the visual impact of projects, and developers will need to demonstrate very special circumstances that clearly outweigh any harm by reason of inappropriateness and any other harm if projects are to proceed. Such very special circumstances may include the wider environmental benefits associated with increased production of energy from renewable sources (PPS 22).

Buffer Zones

Regional planning bodies and local planning authorities should not create "buffer zones" around international or nationally designated areas and apply policies to these zones that prevent the development of renewable energy projects. However, the potential impact on designated areas of renewable energy projects close to their boundaries will be a material consideration to be taken into account in determining planning applications (PPS 22).

Local Designations

Local landscape and local nature conservation designations should not be used in themselves to refuse planning permission for renewable energy developments. Planning applications for renewable energy developments in such areas should be assessed against criteria based policies set out in local development documents, including any criteria that are specific to the type of area concerned (PPS 22).

The distribution of environmental and cultural designations and other potential constraints are presented in a series of maps (See Appendix A.1).

While the location of proposed development within or close to an area of environmental sensitivity, or a designation, does not mean that the development cannot proceed, it does mean that the potential to impact on the environment needs to be assessed and mitigated. One such local sensitivity, effecting renewable uptake at a local scale, could be designated Conservation Areas, where the introduction of solar heating, PV or wind turbine installations could adversely impact upon the local amenities and alter the historic fabric and setting. Table 4-2 shows the proportion of the council's areas that are covered by conservation areas and the proportion of urban areas which are covered by conservation areas. The table shows that Pendle has a very high proportion of its area covered by conservation areas (though this mainly covers non-urban areas) whilst Burnley and Rossendale have relatively little.

Table 4-2 Proportion of Council Areas Covered by Conservation Areas

Authority	Total Council Area (km²)	Total Conservation Area (km²)	Proportion of Council Area covered by Conservation Areas (%)	Total Urban Area (km²)	Conservation Areas in Urban Area (km²)	Percentage of urban area in conservation (%)
Burnley	110	1.27	1.15	19.10	1.21	6.3
Calderdale	362	7.67	2.12	46.70	5.04	10.8
Kirklees	409	11.94	2.92	91.72	8.24	9
Pendle	169	24.94	14.76	20.61	3.42	16.6
Rossendale	138	0.96	0.69	19.12	0.55	2.9

4.1.4 General Financial Consideration

The Government has introduced three financial mechanisms to incentivise renewable energy development in order that the UK can meet its renewable energy targets and reduce its greenhouse gas emissions. These are:

- Climate Change Levy (CCL) - the CCL was introduced on 1st April 2001 and is a tax on energy use by business and public sectors. Its aim is to encourage non-domestic energy users to become more energy efficient thereby reducing carbon emissions.
- Renewable Obligations Order - the Renewable Obligations Order was introduced in April 2002 and is the main support mechanism for renewable electricity projects in the UK. It places an obligation on suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated and supplied to customers within the United Kingdom. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated. Suppliers meet their obligations by presenting sufficient ROCs. Where suppliers do not have sufficient ROCs to meet their obligations, they must pay an equivalent amount into a fund, the proceeds of which are paid back on a pro-rated basis to those suppliers that have presented ROCs. The scheme is open to commercial and small scale wind energy developments which must pass through an accreditation process before ROCs can be issued. For owners of wind energy schemes who are not licensed electricity suppliers they are able to auction the ROCs they have earned in a quarterly auction. The scheme is banded in order to incentivise emerging technology and was amended in April 2010 to reflect the introduction of the Government's Feed in Tariff Scheme and extended the lifetime of the scheme until 31st March 2037.
- Feed in Tariffs (FITs) - On the 1st April 2010 the Government introduced a system of FITs to incentivise small scale, low carbon, electricity generation. The scheme is intended to support the established technologies of wind, solar photovoltaics (PV), hydro, anaerobic digestion, and domestic scale micro-CHP (with a capacity of 2kW or less). Schemes will have to be accredited either through the Microgeneration Certification Scheme (projects <50kw) or by a scheme based on the current accreditation scheme under the Renewable Obligations Order. Further information on FITs is given below.

The current DECC Low Carbon Buildings Programme Phase 2 has now closed to new applications for electricity generation in preparation for the launch of the new Feed-in-Tariff scheme. Other forms of capital investment may be available through local or other funding sources.

Feed In Tariffs - Electricity

This study must take into consideration the recent consultation paper on 'Renewable Electricity Financial Incentives 2009' put forward by DECC in July 2009. Results of this consultation were published in February 2010, and show few changes to what has been proposed.

The consultation focussed on Renewables Obligation (RO), Feed In Tariffs (FITs) and the Renewable Heat Incentive (RHI). In summary, DECC proposed to extend its incentives framework as follows:

- The existing Renewables Obligation (RO) will remain in place with a focus on supporting large-scale renewable electricity projects;
- Implement new Feed-In Tariffs (FITs) from April 2010 to provide a better focus of support for small-scale low-carbon electricity;
- New Renewable Heat Incentive (RHI) in place by April 2011 for renewable heat installations of all sizes;
- To date RO has mostly succeeded in encouraging investment from energy companies in large-scale renewables projects whilst largely ignoring the smaller generators. For the purpose of this study the FITs are relevant, as they benefit the smaller scale RLC generators.
- A proposed new system of Feed-in Tariffs (FITs) will provide support for small RLCs. The aim is to use FITs to open-up the low-carbon electricity generation market, beyond the boundaries of the traditional larger companies. It also aims to make it more cost effective for communities and householders to take part.

The key aspects to FITs are:

- A fixed payment from the electricity supplier for every kilowatt hour (kWh) generated (the “generation tariff”);
- A guaranteed minimum payment for every kWh exported to the wider electricity market (the “export tariff”);
- On-site usage benefits: electricity generated on-site will be able to be offset against electricity they would otherwise have had to buy;
- A focus on the following technologies from 2010 and beyond, this includes wind; solar PV; hydro; anaerobic digestion; and biomass. Biomass combined heat and power (CHP) and non-renewable micro CHP are still under the Renewable Obligation at all scales.
- It also promised to be a simpler and user-friendly system in order to maximise take-up.

Table 4-3 Proposed generation tariff levels (1 April 2010 – 31 March 2013)

Technology	Scale	Tariff level for new installations in period (p/kWh) (NB tariffs will be inflated annually) Year 1: 1/4/10 – 31/3/11	Year 2: 1/4/11 – 31/3/12	Year 3: 1/4/12 – 31/3/13	Tariff Lifetime (years)
Anaerobic digestion	≤500kW	11.5	11.5	11.5	20
Anaerobic digestion	>500kW	9.0	9.0	9.0	20
Hydro	≤15kW	19.9	19.9	19.9	20
Hydro	>15-100 kW	17.8	17.8	17.8	20
Hydro	>100 kW-2MW	11.0	11.0	11.0	20
Hydro	>2mw – 5mw	4.5	4.5	4.5	20
MicroCHP pilot*	≤2 kW*	10*	10*	10*	10
PV	≤4 kW(new build**)	36.1	36.1	33.0	25
PV	≤4 kW(retrofit**)	41.3	41.3	37.8	25
PV	>4-10kW	36.1	36.1	33.0	25
PV	>10-100kW	31.4	31.4	28.7	25
PV	>100kW-5MW	29.3	29.3	26.8	25
PV	Stand alone system**	29.3	29.3	26.8	25
Wind	≤1.5kW	34.5	34.5	32.6	20
Wind	>1.5-15kW	26.7	26.7	25.5	20
Wind	>15-100kW	24.1	24.1	23.0	20
Wind	>100-500kW	18.8	18.8	18.8	20
Wind	>500kW-1.5MW	9.4	9.4	9.4	20
Wind	>1.5MW-5MW	4.5	4.5	4.5	20
Existing microgenerators transferred from the Renewable Obligation Order		9.0	9.0	9.0	To 2027

Notes
* The MicroCHP pilot will support up to 30,000 installations with a review to start when the 12,000th installation has occurred
** These terms are defined as follows:
“Retrofit” means installed on a building which is already occupied
“New Build” means where installed on a new building before first occupation
“Stand-alone” means not attached to a building and not wired to provide electricity to an occupied building

There is no proposal to offer FITs for sewage gas derived or landfill gas.

Benefits to Study Area

Consistent with the aims to benefit small scale RLC energy technologies the eligibility criteria for FITs is limited to installations up to 5MW scale. This limit is proposed to provide certainty to investors believing that the greater simplicity and financial certainty of FITs will be attractive.

FITs for small-scale low-carbon electricity is intended to support the growth of proven technologies identified up to 2020.

It is proposed that these tariffs will be paid through long-term agreements of 20 years (25 years for PV), with a percentage of regression depending on the RLC; although it is recognised that some technologies may have shorter lifetimes and therefore may require shorter-life tariffs.

Remote communities and dwellings are potentially areas where small-scale generation can deliver major benefits. These communities currently often have high energy costs and depend on carbon-intensive generation. Off-grid electricity supply will be eligible for FITs[5].

[5] http://www.energysavingtrust.org.uk/Generate-your-own-energy/Sell-your-own-energy/Feed-in-Tariff-scheme

Proposed Feed in Tariffs - Heat

The government is proposing a Renewable Heat Incentive RHI to provide financial support for those who install renewable heating[6]. The proposals have the following key aspects:

- The scheme should support a range of technologies, including:
    - air and ground-source heat pumps (and other geothermal energy);
    - solar thermal panels (but not passive solar heating);
    - biomass boilers - solid biomass but excluding use in stoves, open fires and similar circumstances;
    - renewable combined heat and power;
    - use of biogas - heat produced from on-site combustion of biogas (including from landfill and sewage plants and syngas);
    - bioliquids and the injection of biomethane into the natural gas grid.
- Support heating at all scales, including households, businesses, offices, public sector buildings and industrial processes in large factories.
- Tariff levels have been calculated to bridge the financial gap between the cost of conventional and renewable heat systems at all scales, with additional compensation for certain technologies for an element of the non-financial cost and a rate of return of 12% on the additional cost of renewables, with 6% for solar thermal.
- The Energy Act 2008 provides the statutory powers for a renewable heat incentive scheme to be introduced across England, Wales and Scotland. The detailed legal framework will be set out in secondary legislation.

The government is working towards having a RHI in place for April 2011. The incentive will not be applicable to cooling. The tariff has been calculated to provide a rate of return of 12% across the tariff bands with a 6% return applying to solar thermal heat.

Table 4-4 Proposed Renewable Heat Tariffs - Small installations

Technology	Scale	Proposed tariff (pence/ kWh) (2)	Deemed or metered (3)	Tariff lifetime (years)
Solid biomass	Up to 45 kW	9	Deemed	15
Bioliquids (7)	Up to 45 kW	6.5	Deemed	15
Biogas on-site combustion (5)	Up to 45 kW	5.5	Deemed	10
Ground source heat pumps (8) (9)	Up to 45 kW	7	Deemed	23
Air source heat pumps (9)	Up to 45 kW	7.5	Deemed	18
Solar thermal	Up to 20 kW	18	Deemed	20

[6] http://www.decc.gov.uk/en/content/cms/consultations/rhi/rhi.aspx

Table 4-5 Proposed Renewable Heat Tariffs - Medium installations

Technology	Scale	Proposed tariff (pence/kWh) (2)	Deemed or metered (3)	Tariff lifetime (years)
Solid biomass	45-500kW	6.5	Deemed	15
		2 (fuel tariff)	Optional: for metered kWh above deemed number of kWh	15
Biogas on-site combustion (5)	45-200 kW	5.5	Deemed	10
Ground source heat pumps (8) (9)	45-350 kW	5.5	Deemed	20
Air source heat pumps (6) (9)	45-350 kW	2	Deemed	20
Solar thermal (6)	20-100 kW	17	Deemed	20

Table 4-6 Proposed Renewable Heat Tariffs - Large installations

Technology	Scale	Proposed tariff (pence/kWh) (2)	Deemed or metered (3)	Tariff lifetime (years)
Solid biomass (4)	500 kW and above	1.6 - 2.5	Metered	15
Ground source heat pumps (8) (9)	350 kW and above	1.5	Metered	20

Notes
1. HM Treasury/HM Revenue will clarify the treatment of RHI payments for income tax purposes in due course.
2. Proposed tariff levels have been rounded to the nearest half pence and are in 2009 prices and would be recalculated to 2011 prices for the start of the RHI in 2011, taking into account inflation. We also intend to adjust tariff levels for inflation going forward for both new and existing projects.
3. The information in this table on where we propose to meter and where to deem is simplified. In particular process heating and district heating are proposed to be metered regardless of technology and size.
4. Large biomass. We propose to provide the same tariffs for biomass CHP and biomass used for heat-only. RHI compensation for large-scale CHP under the large scale biomass tariff would compare to support currently available under the Renewables Obligation for the heat part of CHP in the form of a half-ROC uplift.
3. Analysis undertaken on the cost of large-scale heat-dedicated biomass boilers suggests that their required support level may be lower than the equivalent of the half-ROC uplift for biomass CHP under the RO. Our current proposal for the large scale biomass tariff as set out in the tariffs table reflects this variation by indicating a range of tariff levels.
5. Biogas combustion. The biogas tariffs are proposed to apply to all forms of biogas including syngas. Injection of biomethane into the gas grid is subject to a separate tariff. We will need to consider the approach on RHI tariff(s) for biogas combustion above the ones proposed up to 200 kW. We have calculated the proposed tariffs up to 200 kW on the basis of the costs of dedicated heat installations. Above 200 kW, biogas combustion installations may more likely come forward in the form of CHP, in which case it could be more appropriate to calculate the RHI tariff for biogas combustion at such sizes on the basis of the additional cost for CHP to be compensated in addition to the compensation available through the Feed-in Tariffs.
6. Air source heat pumps and solar thermal. We currently have do not have sufficient data on air source heat pumps above approximately 350 kW, and solar thermal heat above approximately 100 kW to inform decisions on tariffs above these scales (in addition to the data gap on biogas combustion above 200 kW as mentioned in note 5 above). We would welcome any available evidence which indicates whether tariffs above these sizes are needed, and at what level they should be set.
7. Bioliquids. All tariffs are given for 100% renewable use. The bioliquids tariff will only be available for the renewable fraction of the blend used. See the section on mixed fuels further below in this chapter for the proposed treatment of installations with part-renewable operation, or part-renewable input fuels.
8. Heat from the ground. The tariffs for ground source heat pumps are also intended to cover other eligible heat from ground energy such as geothermal.
9. Water source heat pumps. We intend to include water source heat pumps as eligible either for the tariffs of ground or air source heat pumps.

Heat accounts for 47% of the UK's carbon dioxide emissions and 60% of average domestic energy bills (DECC, February 2010). In order to meet the 15% 2020 renewable energy target, the renewable heat sector is likely to have to grow from 1% to 12%. If implemented as proposed, these renewable heat incentives are likely to significantly change the financial viability of renewable and low carbon heat installations. There is also the suggestion to provide uplift to the tariffs for district heating, as this is likely to have additional infrastructure costs. Overall it is proposed that once applied to particular installations, RHI tariffs would be fixed for the duration of payment, and that the overall scheme would remain open until 2020. It should be noted that under Action 13 of DECC's Annual Energy Statement (2010), the Government 'will set out detailed proposals for taking forward the Government's commitment to renewable heat through the Spending Review'. This means that the future of RHIs is currently likely to be reliant on the outcomes of the spending review in October 2010.

4.2 RLC Potential - Wind Power

4.2.1 Introduction

Wind power is the conversion of the energy contained in the wind into electricity using a wind turbine. It is a tried and tested form of renewable energy generation that has existed for centuries. The UK's first wind farm was constructed in 1991 at Delabole in Cornwall and since then the wind sector has seen unprecedented growth in the UK which is now the world's eighth largest generator of electricity from wind power[7].

The Government's Renewable Energy Strategy highlights that the UK is the windiest country in Europe and that wind power (on and offshore) could provide a contribution of up to 30% towards the Government's 15% target for energy generated from renewables by 2020.

The upland landscape of much of the Partnership Area coupled with the current 'push for wind' means that the Partnership can expect continued interest from developers seeking suitable locations to build wind farms for the foreseeable future.

4.2.2 Technology - Wind Energy

For the purposes of this study wind turbines have been grouped as follows:

Table 4-7 Wind Turbine Installed Capacities

Installed Power Output	Scale
≤1.5kW	Small
>1.5-15kW	Small
>15-100kW	Small
>100-500kW	Commercial
>500kW-1.5MW	Commercial
>1.5MW-5MW	Commercial

The above sizes of wind turbines reflect the Government's Feed in Tariffs scheme and the recently published Renewable and Low-carbon Energy Capacity Methodology for the English Regions[8]. Wind turbine size has been defined by reference to the power output of the turbine not blade tip height or rotor diameter.

Table 4-8 Wind Energy Development Sizes

Number of turbines	
1	Single
2-3	Small group
3-5	Small wind farm
6-10	Medium wind farm
11-20	Large wind farm
21+	Very large wind farm
Note Taken from Landscape Capacity Study for Wind Energy Developments in the South Pennines. Julie Martin Associates. January 2010.	

Commercial scale onshore turbines range in physical size from circa 50m for earlier turbines currently installed within the study area (e.g. Ovenden Moor and Coal Clough) through to 120m at the proposed schemes at Crook Hill and Reaps Moss.

Small scale turbines are typically installed individually or in pairs within the curtilage of domestic, business, agricultural land or in some instances they are mounted on the roof of a building, or incorporated into its structure. They vary in height from about 10m to 50m.

[7] http://www.gwec.net/index.php?id=13 - Total installed capacity 2008
[8] Renewable and Low-carbon Energy Capacity Methodology. Methodology for the English Regions, January 2010. SQW Energy and Land Use Consultants for the Department of Energy and Climate Change (DECC)

Table 4-9 Operational Commercial Scale Wind Energy within the Partnership Area

Wind Farm Name	Authority Area	Number of turbines	Blade tip height	OS Grid Ref
Ovenden Moor	Calderdale	23	49m	404399, 430871
Coal Clough	Burnley	24	49m	389051, 428039
Hameldon Hill	Burnley	3	90m	389501, 432489
Scout Moor	Rossendale	11 within study area (26 total)	100m	382000, 418975
Holmfirth	Kirklees	1	Est. 40m	

Table 4-10 Consented Commercial Scale Wind Energy within the Partnership Area

Wind Farm Name	Authority Area	Number of turbines	OS Grid Ref
Crook Hill	Calderdale	5 (within authority area)	391437, 420802
Reaps Moss	Rossendale	3	389497, 422506
Note Both Crook Hill and Reaps Moss are subject to approval under the Commons Act			

From the tables above the height of existing wind turbines within the Partnership Area varies significantly which is largely attributable to the age of the wind farm. Planning applications have been submitted for the repowering of wind farms constructed within the Partnership Area in the early 1990s at Ovenden Moor and Coal Clough. Both applications see a reduction in the number turbines (from 23 and 24 to 10 and 8 respectively), doubling of blade tip height and a five-fold increase in the maximum power output of the turbines. This represents a natural technology progression.

Information about the number of operational small scale wind turbines within the Partnership Area has been collated with the help of the Project Partners.

Table 4-11 Consented and Operational Small Scale Wind Energy within the Partnership Area

Authority Area	Number of installed turbines
Burnley	7
Calderdale	68
Kirklees	31
Pendle	4
Rossendale	9

(N.B. A detailed list of operational and consented small scale wind turbines can be found in Appendix A.2 to this report.)

4.2.3 Landscape - Wind Energy

Wind energy generation potential is intimately linked to the landscape and its development can potentially impact upon the landscape in many ways. The method by which these impacts are assessed is through landscape and visual impact assessment. It is the method by which the impact of a new development on the existing landscape character and visual resource is objectively assessed. Landscape Character Assessment can be defined as:-

"Landscape Character Assessment provides a framework for describing an area in a systematic way. It lets different interest groups make better judgments by knowing what's present and what is distinct, so any change can respect local character, or add to it, and even change it if that is what's desired."[9]

[9] Scottish Natural Heritage and The Countryside Agency "Making Sense of Place. Landscape Character Assessment. Summary Guidance for England and Scotland. 2002

The Character of England Landscape, Wildlife and Cultural Features Map (2005) produced by Natural England with support from English Heritage subdivides England into 159 National Character Areas (NCAs) and provides an overview of the differences in landscape character at the national scale. Each NCA is accompanied by a character description explaining the influences and features which determine the character of the area.

Within the Partnership Area there are the following NCAs:

- NCA33 - Bowland Fringe and Pendle Hill
- NCA35 - Lancashire Valleys
- NCA36 - Southern Pennines
- NCA37 - Yorkshire Southern Pennine Fringe
- NCA38 - Nottinghamshire, Derbyshire and Yorkshire Coalfield
- NCA51 - Dark Peak

Descriptions of the key characteristics of each of these character areas can be found on Natural England's website[10]. To further develop the NCAs extensive regional studies have been carried out to promote greater understanding of the Partnership Area's special qualities.

In 1999 the Standing Conference of South Pennine Authorities (consisting of the partner local authorities of Bradford, Burnley, Calderdale, Kirklees, Lancashire, Oldham, Pendle, Rochdale and Rossendale) commissioned the South Pennines Landscape Assessment. The assessment defines 11 main landscape types which represent the variation in landscape character across the South Pennine landscape.

The objectives of this study were to:

- Understand how and why the landscape of the South Pennines has evolved;
- Classify and describe the landscape of the South Pennines;
- Identify factors that have influenced landscape change during the 20th century and to indicate forces for, and the direction of, change in the future;
- Provide the starting point for fuller assessment of the environmental qualities of the South Pennines;
- Promote an appreciation of landscape issues within the South Pennines; and guide and influence those responsible for developing policies for the South Pennines.

Environmental Resources Management (ERM)[11] was commissioned by Lancashire County Council to undertake a landscape character assessment of the Lancashire area and to produce a landscape strategy for the area informed by the character assessment. This assessment defined 21 principal landscape character types (LCTs) and subdivided these into 102 landscape character areas (LCAs) found in the county.

These studies have provided the basis for further detailed landscape character and capacity studies in the Partnership Area over subsequent years.

The Government Office for Yorkshire and Humber and the Yorkshire and Humber Assembly commissioned the study "Planning for Renewable Energy Targets in Yorkshire and Humber" (2004) in order to inform the setting of renewable energy targets included within the Yorkshire and Humber Regional Spatial Strategy. The study carried out technical assessments for all the possible renewable energy sources and "strategic capacity assessments".

In 2005 Lovejoy's Landscape Sensitivity to Wind Energy Development in Lancashire was published. The study sought to provide strategic guidance on the sensitivity of Lancashire's landscapes to wind energy development by assessing each of the 102 landscape character areas defined in Lancashire County Council's Landscape Character Assessment and assessing each area's sensitivity to wind energy development.

---

[10] **http://www.naturalengland.org.uk/ourwork/landscape/englands/character/areas/default.aspx**
[11] A Landscape Strategy for Lancashire. Landscape Character Assessment. Environmental Resources Management. 1999

The North West Regional Assembly (now 4NW) commissioned Arup in 2008 to identify broad areas for renewable energy development. The study looked at the existing capacity, the broad potential and constraints for renewable energy development in the region and produced two estimates: a theoretical maximum and a pragmatic scenario.

In response to continued pressure in the South Pennines for wind energy development the "Landscape Capacity Study for Wind Energy Developments in the South Pennines" (Julie Martin Associates, 2010) was carried out to assess the South Pennines landscape's capacity for wind energy development. The report highlights the value of the South Pennines landscape in terms of: its scenic qualities; value as an extensive recreational resource, its importance in habitat and historical and cultural terms. The study covers the Partner authority areas with the exception of Pendle.

This 2010 study provides a detailed assessment of the existing landscape character baseline, existing and planned wind energy development and existing and cumulative impacts within each National Character Area (NCA). Using the subdivisions of the SCOSPA South Pennines Landscape Character Assessment as a spatial framework, the sensitivity of each Landscape Character Types (LCTs) has been assessed.

Following the assessment of sensitivity, Capacity Areas (CAs) have been defined to compliment the LCTs. The CAs have been defined so as to be areas recognisable to planners and local people. The boundaries are generalised but "represent the main areas of landscape and visual association, informed by the strategic analysis of topography (including ridgelines, watersheds and valleys) and the way in which it influences visibility."[12] The sizes and scales of wind farms that each CA can accommodate in landscape and visual terms have been suggested.

In many ways wind energy development has the greatest potential negative impact on the receiving landscape of all the RLC technologies considered within this study. This is because wind farms introduce dynamic structures into landscapes which are often remote, wild and tranquil. They have the potential to alter the perception of a landscape's character and impact the visual resource over considerable distances.

Wind farms introduce new elements into the landscape such as:-

- Turbines - Towers (and foundations), hubs, blades. Blade rotation introduces movement into views.
- Access tracks - Wind farms can introduce significant lengths of new access tracks into the landscape where none existed. Track gradients required for access and delivery of turbine components may result in sections of tracks being recessed into new cuttings which could potentially have a visual impact.
- Buildings - Ancillary buildings are often required to house electrical and other necessary equipment for the operation of the wind farm.
- Wind anemometers - Permanent wind monitoring masts may be required throughout the lifespan of the wind farm.
- Fencing - New fencing may be required during construction and operation of the wind farm.
- Electricity transmission lines - Electrical cables required to connect the wind farm to the electricity grid are often located underground but in some instances may require new above ground transmission lines over long distances.

As well as these direct impacts wind farms have the potential to result in a number of indirect impacts that are often overlooked or not envisaged at the planning stages e.g. changes in land management practices such as grazing regimes and the vegetative changes caused by the drying or wetting of areas of land[13].

[12] Landscape Capacity Study for Wind Energy Developments in the South Pennines. Final Report January 2010. Julie Martin Associates Chapter 5.1.2.
[13] Natural England "Investigating the impacts of windfarm development on peatlands in England". Maslen Environmental. January 2010

4.2.4 Feedstocks - Wind Energy

An assessment of the wind resource potential has been carried out using the DECC wind speed database[14]. This database gives an estimate of the annual mean wind speed across the UK at 1 kilometre grid square resolution, at 10 metre, 25 metre or 45 metre heights above ground level (agl).

The database gives a broad indication of the potential wind resource available. It does not account for small topography changes or the effects of different land cover on wind speed and is intended as a guide which should be followed by on-site wind speed monitoring.

A wind resource opportunity map has been produced (see Figure A 6 Appendix A) of all areas with wind speeds ≥6m/s at 1m/s wind speed classes and clearly illustrates that there is significant wind resource potential across the Partnership Area. The DECC RLC Methodology suggests that all areas with wind speeds greater than 5m/s are included however a site with an average wind speed of 5m/s is unlikely to be favourable to commercial wind farm developers for the time being. The South Pennines Landscape Capacity study also suggests that areas "most likely to be subject to commercial wind energy development, in the short to medium term at least, are those with wind speeds exceeding 6m/s. The 4NW capacity study suggests wind speeds of 6.5m/s (Arup, 2008).

Existing wind farms have been filtered out from the potential land resource area. From this the theoretical absolute maximum Partnership installed capacity has been calculated using a wind farm density of 9MW/km² to allow for adequate spacing between turbines.

This density has been suggested by the RLC Methodology guidance for the English Regions[15]. This has been checked against the Scout Moor wind farm which has a density of 11MW/km². Using a density of 9MW/km² will therefore result in a cautious approach and give some allowance for localised differences in landform, topography and land cover across the Partnership Area.

Table 4-12 Commercial Scale Wind Energy Theoretical Maximum Installed Capacity

Authority	Land Area (km²) with wind speed ≥6m/s	Theoretical maximum installed capacity MW (9MW/km²)
Burnley	63.87	574.83
Calderdale	243.76	2,193.84
Kirklees	267.95	2,411.55
Pendle	106.51	958.59
Rossendale	113.75	1,023.75
TOTAL:	**795.84km²**	**7,162.56 MW**

(NB Theoretical maximum installed capacity = Land area (km²) X Installed density (9MW/km))

These figures are based upon the maximum land resource that could be potentially exploited and the theoretical maximum installed capacity for the Partnership Area.

These figures should be viewed with caution as they are the theoretical absolute maximum land resource and installed capacity. They do not account for any environmental, landscape, spatial or technical constraints other than wind speed and existing and consented wind farm development within the Partnership Area.

Following this opportunity assessment, a constraints analysis has been carried out to map 'broad areas' which have the greatest potential for commercial scale wind development after constrained areas have been removed from the theoretical maximum land resource.

---

[14] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/wind/windsp_databas/windsp_databas.aspx (Also referred to as the NOABL database).

[15] Renewable and Low-carbon Energy Capacity Methodology. Methodology for the English Regions, January 2010. SQW Energy and Land Use Consultants for the Department of Energy and Climate Change (DECC)

A typical turbine with dimensions of 135m to blade tip, an 85m hub height and rotor diameter of 100m has been used in the constraints analysis.

The constraints which have been considered are:

- **Existing wind farms** - Sites have been removed from the available land resource.
- **Roads & Railways** - A buffer of 150m has been applied around roads and railways (Height to blade tip + 10%) as recommended in the DECC RLC Methodology. Highways Agency guidance[16] suggests height plus 50m but notes that this may be relaxed in some instances.
- **Settlements** - The RLC Capacity Methodology suggests a minimum buffer of 600m to account for safety and noise. PPS22 Companion Guide states that "shadow flicker effects have been proven to occur only within ten rotor diameters of a turbine[17]. Therefore a buffer of 10 times rotor diameter (1km) has been applied to provide adequate protection against shadow flicker effects and noise impacts.
- **Rivers, reservoirs, lakes and inland waterways** - A buffer of 150m has been applied around all rivers, reservoirs and inland waterways (Height to blade tip + 10%).
- **National Designated Landscapes** - National Parks, Areas of Outstanding Natural Beauty have been excluded. No buffer zone has been applied as recommended by PPS22 paragraph 14. It should be noted that the Forest of Bowland Management Plan Objective 19 - Responding to Climate Change supports the development of renewable energy so long as the purpose of the AONB is upheld. The Peak District National Park Authority suggests that large scale wind energy development is not acceptable as it is likely to conflict with the special character of the area[18].
- **International and national nature conservation sites** - SPAs, SACs, Ramsars, SSSIs, NNRs. The RLC Capacity Methodology suggests that these sites may be able to accommodate some form of renewable energy. In practice it is unlikely that SPAs, SACs and Ramsar sites will be able to accommodate wind energy development without comprising the integrity of the site. Some SSSIs and NNRs may be able to accommodate wind farm development if the integrity of the site and the reasons for its designation are not compromised. However, in order to adopt a cautious approach these sites have been excluded.
- **Sites of historic interest** - World Heritage sites, Registered Parks and Gardens, Listed Buildings, Ancient Woodland have been removed from the land resource as these areas are unlikely to be suitable for commercial scale wind energy development. No buffer has been applied as recommended by the DECC RLC Methodology[8].
- **Woodlands** - Due to problems of wind shadowing and air turbulence which can affect performance of turbines woodlands have also been excluded. However, some woodland areas may be suitable for wind energy and could be considered by developers if the wind resource was adequate.
- **Airfields and aerodromes** - A buffer of 17km radii has been applied around Leeds Bradford International Airport, with a buffer of 30km radii around Manchester Airport.
- **Military constraints** - Ministry of Defence air safe guarding maps have been consulted. These highlight that there are a number of potential constraints within the study area. However given the number of operational wind farms in constrained areas each site must be assessed individually. It is not possible to provide accurate guidance at this broad scale therefore no constraints have been applied.
- **Met Office Radar** - A buffer of 1km around Met Office Station at Hameldon Hill.

[16] Network Services Spatial Planning Advice Note: SP12/09. Planning Applications for Wind Turbines Near to Trunk Roads.
[17] PPS22 Companion Guide, paragraph 73.
[18] Peak District National Park Authority. Supplementary Planning Guidance. Energy: Renewables and Conservation. Chapter 3 para 3.1

The area of remaining 'unconstrained' land in each authority area and the Partnership Area as a whole has been used to calculate the potential maximum installed capacity.

Table 4-13 Commercial Scale Wind Energy Potential Installed Capacity

Authority	Unconstrained land area (km²)	Potential Maximum Installed Capacity (9MW/km²)
Burnley	16.44	147.96
Calderdale	29.33	263.97
Kirklees	13.29	119.61
Pendle	21.91	197.19
Rossendale	28.81	259.29
TOTAL	**109.78km²**	**988.02MW**

(N.B. Potential maximum installed capacity = Unconstrained land area (km²) X Installed density (9MW/km))

It should be noted that the above constraints are a guide to where potentially unconstrained areas of land suitable for commercial scale wind are located in their broadest sense. Developers should still carry out their own detailed site specific feasibility assessments which account for other potential constraints such as impacts on television reception and telecommunication links which cannot accurately be considered as part of a regional scale assessment.

The buffering around settlements does not include isolated rural properties and so in practice the total available area for wind farms may be less than the figures indicated.

Factors such as the location of blanket peat bogs may also be a constraint to development; however, in areas of degraded blanket peat the impact of a wind farm can probably be mitigated. In some locations careful siting and construction of tracks could lead to improvement in degraded peatland if carefully managed[19].

Other matters such as landscape character, visual and cumulative impacts have not been considered within these figures as they are not considered within the DECC RLC Methodology[15] and have been considered separately in detail in the Landscape Capacity Study for Wind Energy Developments in the South Pennines[19].

If landscape character, visual and cumulative impacts are introduced into a constraints analysis the installed density (MW/km²) is likely to reduce.

[19] Natural England "Investigating the impacts of windfarm development on peatlands in England". Maslen Environmental. January 2010

Table 4-14 Commercial Scale Wind Energy Pragmatic Installed Capacities

Authority	Unconstrained land area (km²)	DECC RLC density (9MW/km²)	4NW density (6.5MW/km²)	Landscape Capacity derived density (2.59/km²)
Burnley	16.44	147.96	106.86	42.58
Calderdale	29.33	263.97	190.65	75.96
Kirklees	13.29	119.61	86.39	34.42
Pendle	21.91	197.19	142.42	56.75
Rossendale	28.81	259.29	187.27	74.62
TOTAL	**109.78km²**	**988.02MW**	**713.57MW**	**284.33MW**

(N.B. In Kirklees the National Park has been scoped out)

The DECC suggested installed density figure of 9MW/km² is a generalised figure for the English Regions which considers constraints at the broadest of scales. It does not take account of the landscape qualities of the South Pennines.

In their study for 4NW[20] Arup have suggested an installed density of 6.5MW/km² for areas of land identified as 'less constrained' in the North West Region.

The Landscape Capacity Study for Wind Energy Developments in the South Pennines[21] (the JMA report) recommends numbers and groupings of turbines that each identified Capacity Area could accommodate without unduly impacting upon the landscape and visual resource.

An installed density (2.59 MW/km²) has derived using the recommendations of the number of turbines the capacity areas identified in the JMA report could accommodate without changing the character of the landscape and applied to the unconstrained land area of this study's partner authorities.

It should be noted that the JMA report does not explicitly suggest or recommend an acceptable installed density. This has been derived solely for the purposes of this report to illustrate potential landscape and visual constraints.

Therefore an appropriate installed density figure for the Partnership Area could be anywhere between the 4NW and the installed density derived from the recommendations in the JMA report in order that a balance is achieved between the need for renewable energy development and the conservation of the area's special landscape qualities and visual aesthetics.

Considering these latter two studies the installed density figure for the Partnership Area could be as high as 6.5 MW/km^2 discounting landscape and visual impact limitations or as low as 2.59MW/km^2 taking due allowance of the landscape's capacity to accommodate commercial scale wind energy.

4.2.5 Small Scale Wind Energy

Using the DECC Wind Speed Database described above wind speed contours have been produced from the 10m height wind speed data and these have been adjusted into 1 metre per second wind speed bands (m/s) (see Figure A 4 in Appendix A).

A small scale wind turbine with a hub height of 9m and a rotor diameter of 5.5m with an installed capacity of 6kW[22] has been used as a typical turbine in order to inform the assessment. A wind speed resource map (see Figure A 4 in Appendix A) has been produced using the 10m height wind speed data. This shows annual mean wind speeds at 1m contour intervals. In accordance with the DECC RLC Methodology[22] areas with wind speeds of ≥4.5m/s have been considered in the opportunity assessment for small scale wind

[20] Toward Broad Areas for Renewable Energy Development. Arup 2008. pg30
[21] Landscape Capacity Study for Wind Energy Developments in the South Pennines. Final Report January 2010. Julie Martin Associates
[22] Renewable and Low-carbon Energy Capacity Methodology. Methodology for the English Regions. DECC January 2010

energy. Areas with wind speeds of less than 4.5m/s have been removed along with operational and consented wind farms and areas identified as having potential for commercial scale wind energy development within the Partnership Area.

Table 4-15 Theoretical Maximum Land Resource available for Small Scale Wind Energy Development

Authority	Available Land Resource (km^2)
Burnley	51.16
Calderdale	225.51
Kirklees	273.90
Pendle	89.92
Rossendale	84.95
TOTAL	**725.44km^2**

The figures above represent the theoretical maximum land area that could potentially be exploited by small scale wind development. As explained above, areas identified as having potential for commercial scale wind energy development within the Partnership Area have been excluded from this opportunity assessment. This is not to say that these areas are unsuitable for small scale wind development, however due to their upland location and distance and high mean wind speeds they are more favourable for commercial wind energy development.

Following this opportunity assessment a constraints analysis has been carried out to map areas which have the greatest potential for small scale wind development after constrained areas have been removed from the theoretical maximum land resource.

As stated above a typical small wind turbine with a hub height of 9m and a rotor diameter of 5.5m with an installed capacity of 6kw has been used in the constraints analysis.

The constraints which have been considered for small scale wind are:

- **Roads & Railways** - A buffer of 13m has been applied around roads and railways (Height to blade tip + 10%).
- **Rivers, reservoirs, lakes and inland waterways** - A buffer of 13m has been applied around all rivers, reservoirs and inland waterways (Height to blade tip + 10%).
- **International and national nature conservation sites** - SPAs, SACs, Ramsars, SSSIs, NNRs. In practice it is unlikely that these sites would be able accommodate small scale wind development without compromising the integrity of the site. Therefore these sites have been excluded.
- **Other designations** - World Heritage Sites, Registered Battlefields, Ancient Woodland, Listed Buildings, Registered Parks and Gardens, Scheduled Monuments.
- **Woodland** - Due to problems of wind shadowing and air turbulence which can affect performance of turbines.
- **Existing wind farms** and areas within the study area identified in this report as having potential for commercial scale wind farm development. The reason these areas are a constraint to small scale wind turbines is because small wind turbines are typically installed in close proximity to a residential property, an agricultural building or a commercial property and where these buildings are most likely to be found have removed as part of the constraints analysis for commercial scale wind energy.

Airfields and aerodromes have not been not considered as a constraint to small scale wind energy development. Developers must however consult with the relevant authorities on an individual site basis.

National Parks and Areas of Outstanding Natural Beauty have not been considered as a constraint to small scale wind energy development as highlighted by policies covering the Peak District National Park and the Forest of Bowland mentioned earlier.

It may be possible to site small wind turbines in some of the designated sites excluded if it can be demonstrated that the wind turbine will not adversely affect the reasons for designation. Proposals for small scale wind energy within designated areas will need to be considered on their individual merits to assess whether the development is compatible with the site's reasons for designation.

The area of remaining 'least constrained' land in each authority area and the Partnership Area as a whole is as follows:-

Table 4-16 Area of unconstrained land available for small scale wind energy development

Authority	Land Area (km^2)
Burnley	34.80
Calderdale	118.43
Kirklees	202.67
Pendle	70.12
Rossendale	79.64
TOTAL	**505.66km^2**

The above constraints are a guide to where potentially unconstrained areas suitable for small scale wind are located in the broadest sense. Developers should still carry out their own detailed site feasibility assessments.

In accordance with the DECC RLC Methodology the available small wind resource potential has not been calculated using an installed density because small scale wind turbines are normally located in proximity with a building.

Therefore the potential installed capacity has been calculated using data of the number of residential and commercial properties in each of the partner authority areas and the installed capacity of the typical small scale turbine mentioned above . Details of the assumptions used are provided in the footnotes in the following table.

Table 4-17 Potential small scale wind energy installed capacity (MW)

Authority	Urban Areas	Large Market Towns	Rural Towns	Villages	Dispersed Properties	Commercial Properties	Total
Burnley	2.2	0.0	0.2	0.6	0.4	1.56	5.0
Calderdale	3.6	1.5	2.7	2.5	7.9	3.78	22.0
Kirklees	8.7	0.0	3.8	2.2	5.7	6.39	26.7
Pendle	2.0	0.0	0.9	0.5	2.3	1.51	7.1
Rossendale	1.4	0.0	0.3	0.9	1.9	1.14	5.7
TOTAL							**66.6**

Notes
1. Methodology adapted from DECC RLC Methodology January 2010 to reflect the scale of the study.
2. Estimated number of properties in Urban/Rural areas has been calculated by dividing the total population in each Defra district class by the average number of occupants per household (based on 2001 Census data)
3. Defra district classes taken from the Defra Classification of Local Authority Districts and Unitary Authorities in England. Post April 2009
4. A typical small scale wind turbine with a hub height of 9m and a rotor diameter of 5.5m with an installed capacity of 6kW has been used in the calculation of potential installed capacity
5. Uptake assumptions - Urban areas 1%, Rural Towns 5%, Villages 7.5%, Dispersed properties 25%, Commercial properties 30% based on professional judgement of a pragmatic uptake scenario for each area.
6. In Kirklees, the National Park has been included in this assessment.

These figures are judged to represent a reasonable and pragmatic level of uptake of small scale wind energy. For example, in urban areas it is neither reasonable nor technically practical due to space requirements, shadow flicker effects etc to assume that small turbines will be installed in all properties. Therefore it has been judged that 1% or 1 in 100 properties may represent a pragmatic installation however in more rural locations it is reasonable to assume that a higher uptake maybe achievable.

However, it could be envisaged that higher uptake could occur if the correct incentives are provided and other sources of energy are relatively expensive. A maximum small scale wind scenario might represent three times this amount - but this would require nearly 100% uptake of suitable locations, or use of locations which might also be suitable for large scale wind development.

4.2.6 End user connectivity - Wind Energy

Grid connection and capacity have been considered in detail within Section 4.9 of this report.

4.2.7 Financial - Wind Energy

The largest constraint to any form of wind development is wind speed. Siting wind energy developments in areas of poor wind speed will have a huge impact on the financial viability of commercial and small scale wind development. The impact will be twofold: it financially harms developers and it will negatively affect the public perception of renewable wind energy. Therefore planning authorities have a positive role to play in guiding development to the most suitable locations within their authorities.

The second largest potential financial constraint to commercial scale wind farm development is the distance from the wind farm to a point where a suitable grid connection can be made. Although parts of the Partnership Area are remote they are situated in relative close proximity to settled areas therefore grid connection is unlikely to be a significant financial constraint within the study area. Grid capacity and proximity to grid are factors considered on an individual site basis.

Grid connection is a significant factor for commercial wind farms, but less so for small scale wind energy.

Financial methods to incentivise wind energy are described in Section 4.1.4

4.2.8 Wind Energy Summary

The available resource potential for both commercial and small scale wind energy is indicated in the following table.

Table 4-18 Combined Pragmatic Maximum Installed Capacity

Authority	Combined Maximum Installed Capacity (MW)
Burnley	111.9
Calderdale	212.7
Kirklees	113.1
Pendle	149.5
Rossendale	192.9
Partnership Area Total	**780.2MW**

Notes
1. The commercial scale wind farm installed capacities calculated using the 4NW report density of 6.5MW/km² have been used as an upper figure in the calculation of combined wind energy capacity total.

The total figure represents a significant resource potential that could be exploited within the Partnership Area.

Commercial scale wind energy is likely to make the most significant contribution towards achieving local targets for RLC energy in the short to medium term. However small scale wind energy development makes an important contribution to the overall combined resource potential.

The introduction of the Government's Feed in Tariffs in April 2010 may encourage increased development in the small scale wind sector as more people are encouraged to invest in renewable technology with the introduction of these financial incentives. Future changes to permitted development rights concerning small wind turbines may also increase the number being built, if introduced.

The development of wind projects across the Partnership Area will require a balance between the need for renewable energy and the constraints and landscape qualities of the Partnership Area in order that the overall capacity highlighted in this study can be harnessed to a degree without sacrificing the intrinsic landscape character of the area.

4.3 RLC Potential - Energy derived from Biomass

Biomass is biological material derived from living or recently living organisms (**http://www.biomassenergycentre.org.uk**). Plants take in carbon dioxide from the atmosphere and use it with the energy provided by sunlight to produce biomass (e.g. wood, leaves, etc.). Naturally much of this carbon is returned to the atmosphere when plants are eaten, decompose or are burnt. Burning biomass and releasing energy is therefore deemed to be a low carbon source of energy because much of the carbon burned would have been released naturally back to the atmosphere anyway, as part of the carbon cycle.

Burning biomass therefore differs from burning fossil fuels in terms of contributing greenhouse gases to the atmosphere. Fossil fuels, like coal or gas, are a store of carbon which has been locked away from the atmosphere and removed from the carbon cycle for millions of years. By burning fossil fuels, the carbon is released back into the atmosphere and increases the concentration of greenhouse gases in the atmosphere.

An alternative way to access the stored energy in Biomass is to process it into chemical forms which are readily convertible into usable energy, these include for example Anaerobic Digestion (AD).

There are a number of potential sources for biomass (feed stocks) and also there are a range of potential systems to unlock this source of energy (end users). It is possible for end users such as combined heat and power (CHP) or anaerobic digesters to use biomass from a number of sources. This section aims to review the potential and constraints for each biomass source and then assess the potential and constraints affecting the range of potential end users.

Generally it is considered to be more efficient to transport biomass fuels to generating plants than to transport the resultant electricity and heat to users. Studies have suggested the limit of feasibility for accessing biomass is within 40km of the energy plant where it is to be used (Oxera Environmental, 2002), although importing biomass to the UK is also being undertaken which involves transportation over much larger distances. Transporting heat is particularly difficult; therefore biomass plant needs to be located near a heat load that matches the heat generated. For electricity, there are also energy losses in transmission which mean that using electricity near to the generating location is more efficient than transporting it.

The energy contained within biomass can often be converted in electricity or heat energy. Many of the assessments, in the following section, calculate the energy that can be released from the biomass feedstock if used for electricity or heat.

4.3.1 Biomass Source - Energy Crops

Energy crops are grown specifically for fuel. There are two main types: crops grown for direct combustion or anaerobic digestion (AD); and crops grown to derive biofuels, such as biodiesel. The latter is not a source which is often used for heating or electricity production and is therefore not included in this assessment.

There are two main types of crops grown in the UK for direct combustion: Miscanthus, also known as Elephant Grass; and Short Rotation Coppice (SRC): willow and poplar are the primary species in the UK.

4.3.1.1 Potential for Energy Crops

For the UK to meet its bioenergy targets, between 0.7 and 5.4% of agricultural land may be required to be used for biomass cultivation (Aylott et al. 2008). This means, that across the UK, the government is involved in actively encouraging the planting of energy crops. The Natural England Energy Crop scheme offers grants to farmers in England for the establishment of Miscanthus and short-rotation coppice (**www.naturalengland.org.uk/ourwork/farming/funding/default.aspx**). It appears that in the last round of grants provided by Natural England no energy scheme grants were provided within the study area (**www.gis.naturalengland.org.uk**).

An assessment of the potential for future schemes within the area has been undertaken for this study. Defra 'Energy Crop Yield' maps and agricultural land classifications have been reviewed to assess where agricultural conditions may be favourable for energy crop schemes. Guidance produced by Defra regarding the landscape impacts of energy crops was reviewed to assess the areas most suitable for energy crop production.

4.3.1.2 Agricultural Land Classifications

Energy crops, like most crops, grow best on high grade agricultural land. However with grant schemes the economics of growing energy crops, as apposed to other traditional crops, become practical on lower grade land (Natural England – A Growing Opportunity[23]). In Lincolnshire and Somerset, Grade 3 land is most actively targeted for energy crops (Richter et al. 2007). Lower grade 4 and 5 land has been excluded from energy crop development due to climatic and soil parameter constraints.

Defra's potential energy crop yield maps[24] have been produced for the whole of the UK. These are based upon a model which inputs climate data and soil type to assess whether areas are likely to be suitable for energy crops. They show a similar pattern to the agricultural land use map suggesting that the higher ground which is of a low agricultural grade within the study area has a low potential for energy crops and the Grade 3 land has a high potential. Figure A 10 shows that there are some areas within Kirklees, Burnley and Pendle and Calderdale where the agricultural land grade indicates that farmers could find energy crops an economic alternative to traditional crops. However, within Rossendale, it is unlikely that there will be a large potential for Miscanthus or Short Rotation Coppice due to the absence of grade 3 agricultural land. Table 4-19 outlines a calculation of the potential energy resource for the study area from energy crops based on a method laid out in Richter et al. 2007.

Table 4-19 Potential Area Available for Energy Crops and Potential Annual Energy Generation

Council	Area of Grade 3 Land (km^2)	100 % Land Conversion			5 % land Conversion		
		Yield t/ha*	Electricity Capacity (MW)**	Heat Capacity (MW)***	Yield t/ha*	Energy Produced (MW)**	Heat Capacity (MW)***
Kirklees	76.71	95,888	13.70	43.84	4,794	0.68	2.176
Calderdale	21.32	26,650	3.81	12.192	1,333	0.19	0.608
Burnley	10.53	13,163	1.88	6.016	658	0.09	0.288
Pendle	8.97	11,213	1.60	5.12	561	0.08	0.256
Total	117.53	146914	20.99	67.168	7346	1.04	3.328

*Assuming 12.5 t/ha and 18MJ/kg
**Assuming 25% efficiency
***Assuming 80% efficiency (SQW 2010)
Note: In Kirklees, the National Park was included in the assessment but no ALC grade 3 land lies within the National Park
There is no Grade 1 or 2 land within the study area.

A 5% conversion of Grade 3 agricultural land to energy crops would be consistent with the upper end of agricultural land conversion envisaged to meet the Government's targets (Aylott et al. 2008). 5% Grade 3 land therefore has been chosen in this assessment to represent a reasonable likely maximum uptake for energy crops.

23 http://www.naturalengland.org.uk/Images/EnergyCropsFlyer_tcm6-12979.pdf
24 (http://www.defra.gov.uk/foodfarm/growing/crops/industrial/energy/opportunities/final-designations.htm

4.3.1.3 Landscape Sensitivity

Defra have produce guidelines on the landscape sensitivity of National Character Areas to energy crop plantations. Figure A 12 shows the National Character Areas within the study area and Table 4-20 summaries the Defra guidelines for the National Character Areas which are present within Grade 3 agricultural land in the study area. It is these areas which are likely to be suitable for energy crops and may be targeted by farmers.

Table 4-20 Landscape Sensitivity to Energy Crops (from Defra website)

National Character Area	Overview of Defra Guidance
Yorkshire Southern Pennine Fringe	Conditions are unfavourable for biomass crops on the higher land, opportunities will exist for biomass crops to be planted within urban fringe areas. Biomass crops may also be accommodated within some of the remaining pastoral areas, if care is taken to plant in sympathy with local patterns of fields and woodland cover.
Nottinghamshire, Derbyshire and Yorkshire Coal Fields	A gently rolling landscape significantly influenced by extensive urbanisation, this area could easily accommodate biomass crops. This would undoubtedly result in a change in the landscape, but the increase in enclosure and the enhancement of its woodland character would be acceptable in many locations.
Lancashire Valleys	There are some opportunities to accommodate biomass crops in lower-lying and more westerly, flatter and less built-up parts of this urbanised and complex character area, particularly where it grades into the Lancashire and Amounderness Plain

The landscape character guidance from Defra suggests that the Nottinghamshire, Derbyshire and Yorkshire Coal Fields National Character Areas would be well suited to accommodating energy crops within the landscape. This means achieving a 5% agricultural land conversion target may be possible without detrimentally affecting the landscape. Within the Yorkshire South Pennine Fringes and the Lancashire Valleys, character features such as field patterns and dry stone walls could make finding suitable sites with limited landscape impact more difficult.

4.3.1.4 Other Constraints

The Defra guidance on opportunities for energy crop siting also list a number of other landscape constraints[25]; these include:

- World Heritage Sites,
- Battlefields,
- Ancient Woodland,
- Community Forests,
- National Nature Reserves,
- Registered Parks and Gardens,
- Scheduled Monuments,
- SACs,
- SSSI,
- National Parks,
- AONB,
- Existing important habitats.

[25] (http://www.defra.gov.uk/foodfarm/growing/crops/industrial/energy/opportunities/index.htm).

These constraints will further limit the areas which might be suitable. Where these constraints are present an individual site assessment may be required to identify mitigation measures which might make the crops acceptable. These constraints are similar to the general environmental constraints (Section 4) shown in Figure A 1 and Figure A 2.

4.3.1.5 Uptake Constraints

Generally uptake of energy crop schemes has been fairly low. The successful increase in energy crop production within the study area will rely on several factors. Natural England provide grants for energy crop production through their Energy Crop Scheme and the assessment in this section has attempted to identity areas where this grant scheme is likely to make energy crops an attractive alternative for farmers. However, Natural England data (**www.gis.naturalengland.org**) shows that under their last scheme (2000-2006) that there were no recorded schemes within the study area (though there were two schemes on the borders of Kirklees and Burnley). Though a scheme may appear economic, the lifespan of miscanthus or short rotation coppice scheme can be up to 25-30 years, which means that farms have to be confident in the long term strength of the market to take the risk of planting biomass crops. Until the long term market is proven uptake of the schemes could be limited. However confidence could be improved if there were investment in local end users, such as CHP plants, which would provide more guarantee that there is an end user market.

The ARBRE power plant at Eggborough near Selby went into liquidation in 2002 before the plant was fully commissioned with farmers who had signed long term contracts to grow willow left out of pocket (**http://news.bbc.co.uk/1/hi/england/north_yorkshire/3025755.stm**). This was to have been the main flagship of the UK biomass industry[26], and its demise has not generated confidence in large scale biomass; particularly in the Yorkshire farming community (NFU meeting per comms). Large scale plants are more efficient than numerous small scale plants (Arup, July 2008).

4.3.2 Biomass Source - Organic Waste and Residues

Biomass material is produced as a by-product of many industrial or commercial processes and is also a component within municipal waste. Currently across the UK much of this waste is sent to landfill. By sorting out the biomass content of these waste streams, and sending them to energy recovery or anaerobic digester facilities, the volume of biodegradable waste going to landfill can be reduced (so aiding in achieving Landfill Directive targets) and it also provides a feedstock for the electricity and heat generating technologies.

4.3.2.1 Potential Biodegradable Municipal Waste Streams

Data on the municipal waste streams for the five councils was derived from Waste Data Flow website (**http://www.wastedataflow.org/**). From this information the potential energy resource of the biomass element of this waste was assessed. This assessment is laid out in Table 4-21. It makes several assumptions, which are indicated in the following table.

[26] http://www.berr.gov.uk/files/file16448.pdf

Table 4-21 Potential Energy Source available from Municipal Waste

Authority	Household Waste Collected (tonnes)*	Proportion of Municipal Waste Available for AD (tonnes)**	Potential Energy Source (MWe)***
Burnley Borough Council	30920	9276	0.27
Calderdale MBC	82346	24704	0.71
Kirklees MBC****	178583	53575	1.53
Pendle Borough Council	32679	9804	0.28
Rossendale Borough Council	24318	7295	0.21
Total	348845	104654	2.99

*Data from the Waste Data Flow Website volumes from April 08-09 and does not include waste already sent for recycling, composting or reuse.
**Assuming 30% of household waste is suitable for Anaerobic Digestion (AD) (Faber Maunsell 2009)
*** Assuming 1MW can be generated from 35,000 tonnes based on an average of two AD plants (Faber Maunsell 2009 and Arup 2008).
****For Kirklees - includes waste streams from the National Park.

It is planned in future that, through the Lancashire Waste Partnership, the amount of material going to landfill will be reduced and suitable material diverted to composting and recycling facilities. Planning permission is being sought for a recycling, compost and Mechanical Biological Treatment facility (involving anaerobic digestion) at the East Lancashire Waste Technology Park, Huncoat, Hyndburn[27]. Under the plan, waste from Pendle, Rossendale and Burnley would be treated there to complement two other facilities in Lancashire, in Thornton and Leyland which are coming online this year[28] Figure 4-1). The Leyland site is expected to generate 1.27 MW of electricity.

[27] http://www.lancashire.gov.uk/environment/lmwlp/waste/pdf/huncoat.pdf

[28] http://www.globalrenewables.co.uk/content/contentPage.asp?contentID=14&countyID=1&pgID=1

Figure 4-1: Proposed Lancashire Waste Disposal Network (www.lancashire.gov.uk)

Incineration is a possible alternative to AD (Anaerobic Digestion) and in fact more energy could be released from municipal waste through incineration than through AD. In Kirklees approximately half of the municipal waste stream is currently processed at Huddersfield Energy from Waste Plant[29], with a 10MW electricity capacity. However, the plans for the Lancashire waste disposal network show that Pendle, Rossendale and Burnley Councils will be moving towards MBT (Mechanical Biological Treatment (involving AD)). As Kirklees already incinerates much of its municipal waste, this leaves only Calderdale with the possible potential to increase significantly the proportion of municipal waste going to some form of energy recovery and this is like to occur under Calderdale's new waste collection service[30].

By 2014 the Bradford/ Calderdale Waste PFI partnership should be operational. These councils are looking to a partner to provide solutions which bring the benefits of robust technologies to the district and add value through innovation by such means as combined heat and power, closed-loop use of materials and energy or perhaps the development of industry links for recyclate and residue utilisation[30]. Under such a partnership the utilisation of Calderdale's waste for energy generation is likely to rise.

[29] Kirklees Municipal Waste Management Strategy 2006
[30] http://www.bradford.gov.uk/NR/rdonlyres/ADC25DBA-51A3-4DCF-A6C3-B16FEBAC88F1/0/WastePartnershipBrochure.pdf

4.3.2.2 Large Food Processers and other Commercial Waste Producers

Manufacturers of food and drinks can produce large quantities of organic waste material. There are two main forms of food and drink waste of interest:

- Wet food related waste – which can be treated similar to municipal food waste through technologies like anaerobic digesters.
- Waste oils – vegetable oils and animal fats which can be processed into biodiesels.

The first type can be used as an additional feedstock for Anaerobic Digesters. The volumes potentially available for the study area are currently unknown but there are a number of potential supplies within the study area and include bakeries, breweries, and other types of food processors (see Appendix B.1).

In addition to these, commercial outlets such as restaurants could be a potentially large feedstock source of biomass material. Within this study, this source has not been quantified.

4.3.3 Biomass Source - Waste Wood

Waste Wood can arise from many sectors, notably the sawmill or timber processing industries. Volumes of waste wood potentially available as an energy source in the study area have not been directly assessed due to difficulties in obtaining area specific data. However Table 4-22 shows that waste wood is a large untapped resource across the UK as a whole and that if this resource is evenly spread across the country it could provide additional generating capacity. This source could be used as an additional feedstock supplementing supplies from other sources such as managed woodlands and energy crops. It has been suggested that up to 50% of waste wood could be made available for energy generation (DECC 2009). The way that results in Table 4-22 have been produced does not take into account that there is likely to be spatial variation in the amount of waste wood produced across the country. For example within Rossendale a large furniture manufacturing plant is present (J and J Ormerod, Stackstead), which is likely to raise Rossendale's waste wood production from the furniture industry above the national average. However, due to the constraints of the information available, accounting for this local variation was not possible within the scope of this study.

Table 4-22 Waste Wood Volumes Across the UK (Wrap 2005) and the estimated proportions arising from each council

Waste Type	Tonnage	Area Covered	Estimated Volumes based on Population Size*				
			Burnley	Calderdale	Kirklees	Pendle	Rossendale
Furniture Manufacture	530,511	UK	808	1736	3506	805	592
Manufacture of Panel boards	1,107,074	UK	1686	3623	7317	1681	1236
Manufacture of Wood Products for the Construction Industry	201,298	England and Wales	346	744	1503	345	254
Manufacture of Wooden Packaging	40,000	UK	61	131	264	61	45
Total Wood Wastes from Industry and Commerce other than Furniture Manufacture, Waste from Sawmills or the Wood Products Industry	2,552,312	England and Wales	3887	8353	16869	3875	2850
Railway Sleepers Arising	26,000	UK	40	85	172	39	29
Utility Poles	23,500	UK	36	77	155	36	26
Total	4,481,000		6864	14750	29788	6842	5033
Theoretical Maximum Electricity Capacity (MW)**			1.2	2.5	5.0	1.1	1.8
Pragmatic Electricity capacity (MW)***			0.6	1.2	2.5	0.6	0.4
Theoretical Maximum Heat Capacity (MW)****			2.0	4.4	8.8	2.0	1.5
Pragmatic Heat capacity (MW)***			1.02	2.19	4.42	1.02	0.75

*Estimate proportion of national waste wood volumes arising from each council was calculated on the basis of relative population size from 2001 Census Data
**SQW 1MW 6,000 odt/year = 1MW(e)
***Based on a 50% uptake (DECC 2009)
**** Based on 12.5 GJ/odt and a 80% efficiency rate
For Kirklees - includes waste rising from the National Park

4.3.4 Biomass Source - Sewage Sludge for incineration and AD (Sewage Derived Gas)

Sewage sludge can be dried and then co-fired to generate renewable electricity. It can also be used in on-site CHP Plants installed at the sewage treatment plant, where the heat can be fed back into the sewage treatment process. Sewage can also be used to generate gas which can then be used to generate electricity and heat.

4.3.4.1 Feedstock

The quantity of sewage produced is dependant upon population. It is likely to be a fairly continuous source into the future. There is the potential for additional uptake of this technology at existing sewage treatment works where additional housing and local population increase is envisaged in the future.

Currently there are a number of Sewage Gas Plants within the area (Table 4-23), which means that there may be limited capacity to expand electricity generation in this sector.

Table 4-23 Energy from Sewage Waste Facilities in the Study Area

Name	Location	Capacity (MW)	Source
Mitchell Laithes STW	Earlsheaton, Dewsbury (Kirklees)	0.66 Electricity 1.19 Heat	CO2 Sense Website
Burnley CHP	Burnley	0.25	ROCs Register

There is the potential in some cases for the co-digestion of sewage sludge with farm or food wastes.

The recovery of this waste stream is economically advantageous at present. This means that it is likely that resources which are feasible to develop have already been utilised. DECC (2010) states that it is unlikely that nationally, additional capacity will be developed in the future.

4.3.5 Biomass Source - Waste derived Land fill Gas

Landfill gas arises from landfill sites where putrescible waste has been deposited. The technology for utilising landfill gas is fairly well developed and has been used for some time. The infrastructure required is generally sited at the landfill site in question. The use of landfill gas at landfill sites is generally not constrained by site or environmental limitations. The constraints on siting landfill sites are much greater than those regarding using derived landfill gas.

Landfill sites typically release landfill gas for around 30 years (SQW Energy, 2009), and so for existing landfill sites which are fairly full and near the end of their life, the landfill gas resource is likely to decrease. As waste volumes decrease, and the biodegradable component in particular decreases, this resource is likely to be fairly minor and is likely to contribute decreasingly to the generation of RLC energy in the study area (see Section 4.3.2). For this study, it is assumed that landfill gas electricity capacity will not increase in the future as the biodegradable waste it relies on will be diverted to other end users such as anaerobic digestion plants which would produce greater yields of energy from the waste.

Table 4-24 Current landfill Gas sites

Name	Location	Capacity MWe	Status
Soothill Landfill	Kirklees	1	Planning
Honley Wood	Kirklees	1	Built
Queens Park Energy	Burnley	1.85	Built
Atlas Power	Calderdale	1.136	Built
Horncliff Quarry Landfill	Rossendale	1.44	Built

Landfill sites generate gas if they have a source of biodegradable waste (e.g. municipal waste). Operators need to make provision for managing this gas. Hence some of the infrastructure required to collect and manage the gas for energy production is required as essential landfill infrastructure as part of the permit requirements for the site.

Recent changes to the ROC banding for landfill gas has reduced the incentives for these projects. This might reduce the incentive for development of new schemes.

4.3.6 Biomass Source - Agricultural Waste (Animal Slurries and Manures)

Manure and Slurry can be most easily collected when animals are housed indoors: either during the winter months for cattle; or all year round in the cases of some pig and chicken farming practices. The water content of this material is often very high and so the proportion of biomass is small (though chicken pellets can be an exception to this). This makes both transporting the material large distances and thermal treatments unsuitable. However there are anaerobic digester technologies which are available to take manure and slurry. These can be classified as:

- Small Scale On-site AD for residues produced on a farm;
- Co-operative enterprise between several farmers;
- Centralized Anaerobic Digesters – AD which take slurry and manure as one of a range of feedstocks.

An assessment of the potential for agricultural anaerobic digesters was conducted for this study. Figures on the potential yields were adopted from the Good Practice Guide – Anaerobic Digestion of farm and food processing residues (British Biogen), and information on livestock numbers was derived from Defra's Agricultural and Horticultural Censuses (Defra 2005, 2006a, 2006b and 2009). The potential electricity output was calculated on the basis of 100% collection rate of organic waste and a potentially feasible 15% collection rate (LUC and IT Power 2001). This analysis shows that there is the pragmatic potential for 0.59 MW of electricity generation or 0.87 MW of heat generation from manure and animal slurry across the study area (see Table A 1).

4.3.7 Biomass Source - Woodfuels (other than Energy Crops)

The Forestry Commission Woodfuel Strategy (2007) states that the Government are looking to achieve a target of 2 Mt wood fuel increase by focusing on undermanaged woodland. The woodfuel strategy states that a 50% target of harvesting wood from currently under-managed woodland is achievable. A GIS layer of woodlands in the area with information on their type, management status and likely potential woodfuel yields was obtained from the Forestry Commission (Figure A 11). Table 4-25 outlines an assessment of the potential energy available in the woodland in the study area. It shows that up to 5.5 MW of heat could be generated by woodfuel with over half of that coming from the Kirklees Council area.

Table 4-25 Potential Woodfuel Harvest and Energy Generation in the Study Area

	Council (Woodland type)	50 % of Yield m3/yr	50 % of Oven Dry Yield (tonnes/yr)*	Heating MW**	Electricity (MW)***
Rossendale	Mixed	239	120	0.07	
	Conifer	434	190	0.11	
	Broadleaf	589	336	0.19	
	Total	1262	646	0.36	0.11
Pendle	Mixed	279	139	0.08	
	Conifer	916	400	0.22	
	Broadleaf	453	259	0.14	
	Total	1648	799	0.44	0.13
Kirklees	Mixed	1540	770	0.43	
	Conifer	797	348	0.19	
	Broadleaf	7991	4563	2.53	
	Total	10329	5682	3.15	0.95
Burnley	Mixed	116	58	0.03	
	Conifer	255	111	0.06	
	Broadleaf	**484**	**276**	**0.15**	
	Total	855	446	0.25	0.07
Calderdale	Mixed	12	6	0.00	
	Conifer	92	40	0.02	
	Broadleaf	3997	2282	1.27	
	Total	4102	2329	1.29	0.39

***Based on m3 of Mixed Wood = 0.5 tonnes, m3 of conifer wood = 0.436 tonnes, m3 of broadleaf wood = 0.57 tonnes (RenewEL 2006)**
****I tonne = 0.000555MW of Heat (RenewEL 2006)**
*****1 tonne = 0.000166 MW (SQW 2009)**
For Kirklees - includes wood resources within the National Park but the location of the installations that could utilises this resources do not have to be with the National Park.

4.3.7.1 Constraints

The Northwest England Biomass Woodfuel Strategy states that the major barriers to larger scale uptake of woodfuels are:

- Problems with fuel quality and feed problems;
- Imbalance between supply and demand;
- Wood fuels are out-priced by other cheaper fuels, notably mains gas.

The economic situation for woodfuels is set to improve with feed in tariffs (see section on Feed in Tariffs) and the rising price of gas. Table 4-26 sets out the SWOT analysis from the North West Regional Authority on the strengths, weakness, opportunities and threats (SWOT) to the North West's woodfuel sector.

Table 4-26 SWOT Analysis of the North West England's Woodfuel Sector (from North West England Biomass Woodfuel Strategy)

Strengths	Weaknesses
Established wood reprocessing sector, Well established forestry sector, Existing raw material supply chains in place, Proven technology available, Existing regional examples of technology.	Lack of co-ordination between potential supply and demand side of fuel chain, The major forest resource is concentrated in certain parts of the North West (not necessarily the study area), Projects fail when public funding not forthcoming, History of failure, Existing supply chain is set up for bulk deliveries, Competitions with other fuel sources
Opportunities	**Threats**
Biomass Task Force Report and Government response, Large potential land area, Large number of public buildings, Emerging Rural Development Programme for England priorities, CAP reform Single Payment Scheme, Rising fossil fuel prices, Higher waste wood disposal costs,	Imported material is more price competitive than locally produced fuels, Capital cost of equipment more expensive than gas/oil equivalents, Specific supply chains not well developed for small and medium scale users, Demand for fuel outstrips supply, Limited or no financial support available for the increased costs of installing woodfuel equipment contributes to lack of adoption.

Both the Yorkshire and the Humber (2007) and the North West Regional Governments have produced woodfuel strategies. They are both looking to increase investment and education in woodfuels to increase their uptake and over come weaknesses and difficulties in the supply changes.

4.3.8 Imported Biomass

4.3.8.1 Potential

Imported palm, olive and sunflower residue tend to be cheaper sources of fuel than imported wood chips or pellets; though currently even five sixths of woodfuels are imported. In many cases in the UK, competition for local resources means that it is expected that a growth in imported biomass is inevitable (E4tech 2010).

Palm, olive and sunflower residue used for electricity generation (mainly through co-firing) is likely to be still economically attractive in 2020 but projections for these fuel sources become less confident further into the future (E4tech 2010). There are, however, believed to be few opportunities for co-firing in study area.

Importing biomass has the potential to increase the RLC capacity of the study area. Theoretically, the potential generation could be huge if large volume of biomass were imported, however economic constraints and environmental concerns will cap the amount that will actually be generated. The limits to importing are difficult to quantify so this study has not assessed the pragmatic capacity of imported biomass for the study area.

4.3.8.2 Constraints

Imported woodfuel for heating tends to have a higher cost than domestically produced woodfuel (E4tech 2010) due to the distances involved in transportation, though these costs can vary with exchange rates. In 2020, UK pellet prices are projected to be on average lower than those from imported wood. This means that if local supply chains were developed to meet heating demand, importing biomass for heating might be less economically attractive.

4.3.9 Summary of Biomass Feedstock Potential

Table 4-27 summaries the potential energy from each of the biomass feedstocks assessed. It shows that if a supply chain system could be put in place to tap into the wood fuel potential it could generate up to 5.49 MW. The energy generated from municipal waste could be easier to realise as the collection infrastructure is already in place and this could generate almost 3 MW of electricity.

Table 4-27 Summary of the Pragmatic Biomass Potential in the study area

	Energy Crop Potential (MW)		Municipal Waste Potential (MW)	Farm scale Anaerobic Digestion Potential (MW)		Wood Fuel Potential (MW)		Waste Wood Estimated Potential	
	Electricity	Heat		Heat	Electricity	Heat	Electricity	Electricity	Heat
Kirklees	0.68	2.176	1.53	0.28	0.19	3.15	0.95	2.5	4.4
Calderdale	0.19	0.608	0.71	0.21	0.14	1.29	0.39	1.2	2.2
Burnley	0.09	0.288	0.27	0.09	0.06	0.25	0.07	0.6	1.0
Pendle	0.08	0.256	0.28	0.20	0.14	0.44	0.13	0.6	1.0
Rossendale	0	0	0.21	0.10	0.07	0.36	0.11	0.4	0.7
Total	1.04	3.328	2.99	0.87	0.59	5.49	1.65	5.3	9.4

Notes:
A high proportion of Kirklees waste is already used in an incinerator so not all this feedstock will be available for AD.
The electricity and heat columns calculate the amount of energy that would be produced if used for electricity or heat - not the power generated if the feedstocks were used within a Combined Heat and Power Plant to produce both heat and electricity.

4.3.10 Energy Producing Systems that require Biomass

This section so far has considered the potential supply of biomass from various sources. There are three main types of energy technologies which use biomass as a feedstock:

- Combustion - Stoves, Boilers and Co-firing of traditional power stations;
- Thermal Conversion;
- Anaerobic Digesters.

A single project, depending on its scale and type, could take feedstocks from a number of sources. These technologies are discussed in more detail below.

4.3.10.1 Technology - Combustion

There are a number of forms of biomass which are suitable for direct combustion, these include:

- Wood,
- Wood Waste,
- Energy Crops,
- Chicken Pellets,
- Municipal Waste.

There are a range of sizes of plant available for these feedstocks, and these can be used: solely for heating, combined heat and electricity production, or solely for electricity production. Plant types include:

- Log Stoves and Boilers.
- Pellet Stoves and Boilers.
- Chip Boilers - appropriate for medium and large scale installations.
- District Heating - appropriate where heating networks are viable.
- Combined Heat and Power - appropriate where heating networks are viable.
- Waste to Energy Incineration
- Co-firing - wood and energy crops can be burnt within traditional fossil fuel coal fired power stations to reduce the amount of coal burnt. Further details on co-firing are provided later in the report (it is believed there are no co-firing facilities within the study area).

There are several constraints on these types of systems depending on their size including:

- Air Quality Management Zones;
- Heat distribution through district heating networks and such like (combined heat and power will only be appropriate in certain built environments);
- A suitable secure local supply of feedstock needs to be available.

Household-scale log stoves and boilers should have limited constraints on their installation except those particular to the dwelling e.g. they may not be appropriate within a flat. Local smokeless zones as part of air quality control areas may also constrain certain types of fuel; however there are stoves which meet requirements to burn wood in these zones. The potential for co-firing stations is likely to be limited to existing facilities due to the constraints on building new ones (e.g. a new coal fired station).

4.3.11 Technology - Co-Firing Biomass

Technology Capacity

One means of increasing the use of biomass whilst decreasing the use of fossil fuels is co-firing of conventional electricity generation plants. Typically a coal fired power station can handle up to around 10 - 15% biomass - such as woody material [NB other types of waste e.g. tyres can also sometimes be used.]

Feedstock - Co-Firing with Biomass

As conventional power plants can have very high capacities even the use of 10-15% biomass can result in the requirement for considerable volumes of biomass on a fairly continuous basis. This may result in the net import and transport of biomass into the area if local sources of biomass are not available.

Co-firing replaces some fossil fuel with renewable fuels but the overall capacity of the plant remains the same. Hence approximately the same amount of electricity will be generated but the proportion of fossil carbon burned will be reduced. A figure of around 10% co-firing (SQW Energy 2009) can be used.

It is likely that co-firing biomass will be financially viable until at least 2027 as the financial incentives through the Renewables Obligation will continue until then (SQW Energy 2009).

Within the study area there are no large power stations which currently take in biomass material (AEATS 2004 and Arup 2008). Within Yorkshire and Humberside the main end users of biomass are: Eggborough, Drax and Ferrybridge power stations and in the northwest Fiddler's Ferry is the main biomass user.

It is unlikely that there will be new coal fired power stations built within the study area which will take biomass material, therefore the pragmatic capacity of this technology is zero.

4.3.11.1 Technology - Thermal Conversion

Some modern Energy Recovery Facilities (also known as Energy from Waste facilities) also use advanced thermal treatment technologies (e.g. gasification or pyrolysis). These are a modern and cleaner version of old fashioned gasworks, where the fuel is burnt in limited oxygen to produce gas, which is then burnt to produce heat and/or electricity. This technology can use a range of feedstocks including municipal waste, wood and energy crops.

The constraints on the location of thermal conversion systems will include spatial planning constraints such as Air Quality Management Zones (Figure A 3). In addition to this, energy recovery facilities are often unpopular with local residents and this may reduce the uptake of this technology.

Due to the difficulties arising from the public perception of managing and treating waste close to residential areas this technology, in common with incineration of waste, has limited public acceptance. It is not generally well suited to integration in urban environments; though there are exceptions to this such as urban industrial parks or in locations with an historic association with waste management such as, the new Sheffield Incinerator in the heart of the city. Many energy from waste schemes also require flare stacks or chimneys to dispose of by-products, and may involve equipment of an industrial scale (PPS22 companion). However, in locations with good road connections they may be appropriate.

4.3.11.2 Technology - Anaerobic Digestion

Anaerobic Digesters can be used for almost all biomass feedstocks (except woody biomass as the bacteria cannot easily break down the lignins within wood). In Anaerobic Digestion biomass is converted into methane and carbon dioxide by microbial digestion in the absence of air. There are two other by-products:

- A solid residue which can be used as a soil conditioner;
- A liquid liquor that can be used as a fertilizer.

Figure 4-2 outlines the main parts of an AD system. Based on this basic concept there are a range of system types including, wet or dry, batch or continuously fed. Each have their own advantages and disadvantages (see **http://www.biogas-info.co.uk/index.php/types-of-ad** for further information).

Figure 4-2: Anaerobic Digester System (from www.biogas-info.co.uk)

Though there are a range of systems available, suitable to different situations, there are constraints to AD technology:

- Collection of animal waste - health and safety regulations and animal by-product regulations have to be adhered to and often animals are kept in conditions where collection may prove difficult.
- Transportation distances have to be limited to maintain economic benefit.
- Supplies have to be secure to encourage investment.
- Competition with alternative users/ disposal methods.
- Especially for Farm AD - a sustainable outlet for the liquor: the potential for the land application of the liquor is likely to be the main constraint on the size of the plant, in order to meet local standards (especially in a Nitrate Vulnerable Zone or similarly controlled areas).
- Suitable outlets, or uses, for the fibre e.g. as soil conditioner.

.

Siting and Location Constraints

Small ADs are likely to be sited near, or within, existing farm building so there are generally likely to be limited visual impacts from such schemes. There are a range of other factors involved in siting farm scale AD processors, including:

- Sufficient land available;
- Landscape Designations (AONB, National Parks etc.);
- Ecological Impacts (e.g. proximity to SSSI wetlands);
- Water courses;
- Flooding risk (e.g. as indicated by the Environment Agency Flood Zones).

These factors in combination with the scale of the AD should be taken into consideration whilst siting an AD project. They are similar constraints to those applicable to other renewable energy development and have been considered elsewhere in the report.

Financial

A small 10 kW capacity AD (requiring a feedstock from 100 cattle or 1000 pigs) will cost around £60,000 and a complex 1MWe plant (with a 10,000m^3 digester) will cost £3m to £4 million (NNFCC 2008). In addition to this there are planning development costs (legal fees, licences, gaining planning permission etc.) and running cost; around £7,000 - £10,000 per year for an on-farm project (British Biogen). The National Non-Food Crops Centre (**www.nnfcc.co.uk**) has developed a spreadsheet calculator tool to assess the costs and profits involved in setting up farm-scale AD schemes.

An economically viable municipal and commercial anaerobic digester currently requires an installation capacity of approximately 0.8MW (Arup 2008).

4.4 RLC Potential - Combined Heat and Power

Combined heat and power is a means of generating both electrical power and using the heat generated as well. This has the potential to be more efficient than traditional power generation where heat generated is not used but released to the environment e.g. via cooling towers or waste water streams. Studies have shown that CHP can save up to 20% on total carbon emissions for heating and electricity when installed in small commercial settings (www.carbontrust.org.uk). However, for CHP to be effective a nearby heat load (i.e. demand for heating) is required close to the plant.

One potential use of the heat generated as part of CHP is through district heating.

Though this section lies within the biomass assessment, CHP is often fuelled by non-biomass feedstocks such as gas, oil and coal. These non-biomass fuelled CHP plants, such as the Syngenta in Kirklees, can be defined as low carbon technologies (Jo Adlard pers comm.) because of their relatively high efficiency.

4.4.1 Technology

There are several types of CHP systems and scales that they can be built at (**www.carbontrust.org.uk**). Systems include:

- **Gas turbines** - which drive a turbine generator and have a typical output of 1 - 200MWe, although there are small-scale 'mini turbines' of between 80kWe and 100kWe.
- **Reciprocating engines** - which use gas fuels. Spark–ignition engines are available up to 4MWe, although they typically range from 70kWe-1,500kWe in size. High–grade heat (at about 400ºC) is available from the exhaust gases from reciprocating engines and low–grade heat (at about 80ºC) is available from jacket cooling and lubricating/cooling systems.
- **Steam turbines** - they can use any fuel to generate power and medium–grade heat. Units can be from 0.5MWe upwards. They are often used in conjunction with waste heat boilers and produce medium grade heat. Steam turbines can incorporate several pressure stages and may be fully condensing or pass out intermediate pressure or low–pressure steam for process use. These are the type of plant that biomass is mainly used in.
- **Combined–cycle systems** - they use exhaust gas from a gas turbine in a steam–raising boiler, with the steam generated being used in a steam turbine. Such systems are available from 10MWe upwards and produce medium–grade heat.

Table 4-28 Summary of the main types of CHP systems currently available (from Carbon Trust Website)

Type of engine	Typical output	Typical fuels	Heat grade
Gas turbine	1MWe - 200MWe	Natural gas, gas oil, landfill gas, biogas, mine gas/process gas	High
Steam turbine	0.5MWe upwards	Any but converted to steam	Medium
Combined-cycle	10MWe upwards	Natural gas, gas oil, landfill gas, biogas, mine gas/process gas	Medium
Spark-ignition engine	Up to 4MWe upwards	Natural gas, landfill gas, biogas, mine gas/process gas	Low and high
Compression-ignition engine	Up to 15MWe upwards	Natural gas +5% gas oil, heavy fuel oil	Low and high

CHP systems can come in a number of scales from micro-CHP systems, which could be an alternative to traditional heating systems for small commercial or domestic settings (**www.carbontrust.org.uk**), to district heating systems.

The landscape and environmental impacts for combined heat and power are similar to those for other types of energy generation (Section 4.1.1).

The key difference between CHP and traditional generation is the requirement for a nearby heat load to make use of the heat supplied. This means that these CHP installations are generally sited near to either industrial or housing development which utilises the heat. Transportation of heat is not practicable over significant distances.

One of the most effective ways to provide energy efficiently is through decentralised heating and cooling networks, using Combined Heat and Power (CHP) or in some cases Combined Cooling, Heat and Power (CCHP). These networks are energy efficient because:

- They are 'decentralised' so they lose less electricity through transmission than centralised power supplies from the national grid.
- It is a networked system with a mix of uses drawing heat and electricity. It can therefore balance demand from domestic and commercial users which have different peak periods to make the use of energy more efficient.
- CHP usually consists of an engine which powers a generator producing electricity. Heat is recovered and distributed (in the form of hot water) as a side-effect of this electrical generation, and can also be stored for use when demand is high.
- CHP can use gas or low carbon fuels
- As it is a networked system, it can 'free up' plant space within buildings for other uses.

Decentralised heating and cooling networks can be a very effective in city areas, due to the dense character of the built environment and the complex mix of uses, which produces a high and relatively even density of heat demand. Heating and cooling networks can also be a relatively unobtrusive form of energy use within the historic built environment, in comparison to other forms of energy provision.

4.4.2 Financial

For CHP to be viable it is important to have a high and consistent heat load for most of the year. This means that long operating hours are required for the system to be cost-effective – ideally a minimum of 4,500 hours/year (www.carbontrust.org.uk). In general, the longer the annual period of demand, the greater the cost savings.

Typical capital costs are around £500,000 for a large–scale 1,000KWe generator but these will be often offset by cheaper electricity costs within the lifespan of the plant. However, this is not always guaranteed as fuel prices can fluctuate.

The capital cost for biomass community heating per house is approximately £6,000 per house, with a slightly lower figure for new builds (IT Power, 2005). The fuel for biomass typically costs around £0.013 per kWh, and operational costs are around £0.004 per kWh heat produced. This results in costs which are overall similar to gas heating (at 2005 prices, not including the proposed heat incentives). The new renewable heat feed in tariff will pay between 1.6 and 9 p/kwh depending upon the technology and the size of the installation (see Section 4.1.4)

Biomass CHP can provide up to 100% of heating and hot water demand for domestic properties. This equates to a CO_2 saving of around 5,280 Kg in an existing house and 900 Kg in a new house (IT Power, 2005).

4.4.3 Air Quality Management Area Constraints

Potential air quality constraints have been referred to regularly in this section. The following explains further why these might affect the siting of some technologies.

Local Authorities must declare an area an Air Quality Management Area if it is unlikely to be able to meet national air quality objectives set out in DEFRA's Air Quality Strategy 2007. The

Environment Act 1995 specifies eight pollutants all councils must consider as part of a National Air Quality Strategy. These are:

- Carbon monoxide,
- Benzene,
- 1-3 Butadiene,
- Lead,
- Nitrogen dioxide,
- Fine particulates (PM_{10}),
- Sulfur dioxide,
- Ozone.

An air quality management zone can be declared if any one of the thresholds for these species is exceeded.

Air Quality Management Zones should be taken into account in the planning process. If projected emissions from a planned biomass plant would increase the concentration levels in the atmosphere of a pollutant that is already elevated (and does not meet targets), then the plant may be deemed not to be suitable for the area. However, to complicate the issue, predicted emissions for a biomass plant may not include pollutants that are elevated in the area. In this situation, though in general the biomass plant could lead to a general lowering of the air quality, it might not lead to an exacerbation of the reasons why the area was declared an Air Quality Management Area. Specific proposals should be treated on a case by case basis by planning authorities who should refer to what has been suggested in the specific Air Quality Management Area Action Plans.

The Air Quality Management Zones in the study area are shown in Table 4-29 and in Figure A 3. Burnley, Calderdale and Kirklees councils have declared Air Quality Management Areas; a number of which are for Nitrogen Dioxide levels. These cover relatively small areas.

Table 4-29 Number of Air Quality Management Zones per Council

Council	Number of Air Quality Management Areas
Burnley	1
Calderdale	6
Kirklees	3
Pendle	None
Rossendale	None

Defra (2009) guidance lists NO_2 and PM_{10} as relevant pollutants for biomass combustors. The significance of domestic biomass combustion is currently thought to be relatively small. However, it may become more significant in the future. There are concerns, that a significant increase in biomass combustion generally, and in particular the use of wood fuel, could detrimentally affect local air quality. Recent modelling work in Scotland (The Scottish Government 2010) on future projections of biomass uptake in Dundee and Edinburgh shows that biomass boilers would likely have minimal impact on urban PM_{10} level except in the immediate vicinity of the installation.

4.5 RLC Potential - Solar Energy

Solar energy is freely available everywhere in the UK. It can be used passively or actively. Passive solar energy is utilised through the design and orientation of buildings. Technologies which actively use solar energy include Photo Voltaics (PV) and Solar Water Heating.

Solar energy is available in all parts of the country. However, solar radiation is greatest in the south of England, particularly the southwest and east. However, there is a moderate level of solar radiation within the Partnership Area which is adequate for domestic systems. Careful installation of the systems to maximise sunlight and avoidance of shading is important for optimum efficiency of the systems.

4.5.1 Passive Solar Gain though Design

Passive Solar Design offers a significant one-off opportunity to reduce lifetime energy requirements at little or no cost. It can only be considered at the design stage, but can reduce the requirement for energy for heating and lighting by up to 20-25%, although lower savings may typically be obtained.

Typical energy savings from passive solar design are around 8-10% (Source GIRO27 - Passive Solar Layout - look up from IT Power, 2005):

- Estate layout (houses orientated north-south): 1-3%
- Estate layout minimising shading: 2-4%
- House design - glazing towards the south: 3-4%
- House design - main rooms to south: 1-2%

There is the potential for including passive solar design in all new buildings. However, this must be undertaken early in the masterplanning process for major developments. Passive solar design should be regarded as the most basic starting point from which other energy efficiency measures or additional renewable energy features should be added.

Passive solar design need not add any additional cost to the development, but can offer considerable savings for occupiers by keeping fuel bills to a minimum, as well as the environmental benefits of reduced demand for conventional energy in the form of lighting, heating or cooling. In addition, it can maximise the potential for other forms of renewable energy such as solar power generation, by promoting layouts that maximise the extent of south-facing roof areas.

Provision should be made for passive solar design in masterplanning for new development and designing individual schemes. Passive solar design can be incorporated in buildings of many architectural styles, and it should not be assumed that because a building is designed to maximise solar gain, it will sit uncomfortably with the local architectural style. Subtle ways to incorporate passive solar design can include minimising the area of north-facing windows, and placing garages on the north side of homes to act as additional thermal buffers. However, to maximise solar gain it may be necessary to have less dense housing to avoid shading. For instance in Burnley for a two storey house to have 3 hours of solar gain a day throughout the year requires a spacing of 26m between houses (IT Power, 2005).

The orientation of developments, and the degree of shading, is also important to allow uptake of solar PV and solar thermal technologies.

4.5.2 RLC Potential - Solar PV

The Burnley RenewEL study (IT Power 2005) reviewed a number of photovoltaic studies and made the following points:

- Most people involved in solar PV trials were positive.

- Solar PV had the potential to add value to a property.
- However, the initial capital costs could make uptake unattractive.
- It is important that the system's benefits are visible to the householder (e.g. via clear metering). Initial problems with metering are likely to be overcome with the new feed-in tariffs which will require effective metering.

4.5.2.1 Technology - Solar PV

Solar PV units can be either incorporated within the fabric of the building (as a cladding) or an additional structure. PV can either be roof mounted, free standing or integrated into roof or building facades.

For best performance, PV modules need to be inclined at an angle of 20-40 degrees (depending if they are orientated for maximum gain - i.e. during the summer or maximum output during the winter when solar energy is lowest), and orientated facing due south. In practical terms, this is not always possible on existing buildings, and some degree of flexibility in inclination and orientation is acceptable although this will be at the expense of best performance. To function well PV installations need to be inclined at between 10 and 60 degrees, and orientated facing from east to west (i.e. within 90 degrees of due south).

Although roof mounted PV is the most common, modules can also be mounted on the sides of buildings, or on free standing support structures on the ground. In some cases, particularly on institutional or commercial buildings, PV cladding on the side of the building can be an architectural feature as well as a supply of electricity. Other examples of building integrated PV include external sun shading of office windows (bris-solaires) and glass atrium roofs.

Shadows from buildings, trees or other structures can significantly reduce performance of the PV system and planners and designers should take reasonable steps to minimise permanent overshading of the PV (PPS22 Companion).

There are three main types of solar cells readily available in the UK:

- Monocrystalline – very thin wafers of silicon cut from a small seed crystal. More efficient than polycrystalline, but more expensive due to the manufacturing process.
- Polycrystalline – instead of one crystal, several different crystals are used for producing the slices. The result is cheaper PV cells than monocrystalline but lower efficiencies.
- Amorphous silicon – silicon is made into a continuous strip of film. Cells can be produced more quickly and hence cheaply than mono or polycrystalline, but with substantially lower efficiencies.

A variety of solar cells based on materials other than silicon, such as cadmium telluride (CdTe) and copper indium diselenide (CIS) are also starting to appear in the UK market as they are easier and cheaper to manufacture.

Hybrid solar cells are also available which usually incorporate a combination of monocrystalline and thin-film technologies. This approach can help to balance the costs and qualities of the cell types. The table below shows typical conversion efficiencies of silicon based PV modules; cells with lower efficiencies would require a greater surface area of PV modules in order to produce the same electricity output.

Table 4-30 Energy efficiency of typical PV installations

Efficiency (per cent)	Module type	Durability (years)
12 – 15	Polycrystalline	20 – 25
13 – 17	Monocrystalline	25 – 30
5 – 8	Thin Film Amorphous Silicon	15 – 20
Source: http://www.greenspec.co.uk/html/durability/photovoltaic.html, although other sources may give slightly lower efficiency figures.		

A full domestic system may well have several modules, together with other system components such as an AC/DC inverter, batteries (for storing the energy until it is needed), a central control unit, mounting structure or materials for fixing the array, wiring, fuses and isolator.

Solar PV is well suited to urban environments as it is clean and silent in operation. A typical installation of around 1.5-2kWp (kilowatts peak) can produce around 40% of the electricity a household uses in a year (Source: **http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-electricity**). This array would typically cover 10-15m^2 of roof area - this gives around 7.5m^2 per kWp. A minimum area of around 8m^2 might be considered (IT Power, 2005).

While it is far more common to have a fixed mounting, tracking mechanisms can improve energy generation by up to 30% (DCLG, April 2007). This may be most applicable to households where a suitable south facing sloping roof is not available.

A PV system is particularly advantageous where peak loads are required in the day when solar generation is at its highest level. However, the new feed in tariffs mean that PV is more financially viable as discussed in Section 4.1.4.

PV is widely used to provide power for communications systems, domestic dwellings and monitoring systems either in remote areas or locations where connection to the grid is expensive or otherwise problematic.

4.5.2.2 Constraints - PV

Generally the installation of PV on roofs is permitted development. However, if the property is in a conservation area or is listed planning permission may be required.

The Partnership Area has fewer sunshine hours than more southerly parts of the UK. As it is relatively far north within England it has less incident solar radiation than more southerly locations. However, solar installations are still viable as they can work (although significantly less efficiently as it is dependant upon the intensity of the sunlight) without direct sun and have been successfully installed on a number of sites in the partnership area.

In 2000, Kirklees was involved in a EU funded project to install 3.05MW of solar electricity on 2,000 homes in Germany, the Netherlands and Kirklees. In Kirklees, solar voltaic systems were installed on 518 houses/rooms and 63 solar thermal systems. In total it is estimated that 260 MWh per annum (0.0286 MW) will be generated by the scheme; equating to 4.9% of the UK total solar electricity domestic installations (www.kirklees.gov.uk).

Hence there is clearly the potential for a high level of solar PV uptake, subject to technical and financial limitations as indicated above.

There are a number of factors which influence the uptake of PV technology including:

- Whether a particular system requires planning permission or listed building consent;

- The importance of siting and orientating systems so that they can collect most energy from the sun. This may be an important consideration where existing housing stock has roofs orientated east-west rather than north-south; or in steep valleys with a high degree of over-shadowing.
- The area of PV cells is directly related to the amount of energy output.
- The aesthetics of systems are also likely to influence their uptake.
    - Particular issues exist with regard to listed buildings and designated areas:
    - The installation of a PV array on a building listed for its special architectural merit or historic interest – or on another building or structure within its curtilage – is likely to require an application for listed building consent. This will be so, even if specific planning permission is unnecessary.
- Permitted development rights to clad the walls or alter the existing roofline of a dwelling do not necessarily apply in Areas of Outstanding Natural Beauty, Conservation Areas, Sites of Special Scientific Interest, National Parks or the Norfolk Broads. When considering applications in these areas the potential impact on the character or appearance of the area should be considered.
- If an application for a PV module is submitted for a building close to a conservation area, or close to a listed building, its proximity to such an area or buildings may be a material consideration for the local planning authority in deciding the application.

4.5.2.3 Connectivity - PV

Given the relatively small size of most PV systems, grid connection is local and normally not a very significant problem. However, if there is a very high level of uptake of PV systems in a particular area this might cause local grid constraints.

The Electricity Association regulations to which the grid connection of a PV system of less than 11 kWp must adhere is Engineering Recommendation G83/1 2003 "Recommendations for the connection of small-scale embedded generators (up to 16 A per phase) in parallel with public low voltage distribution networks". Systems of rated size greater than 11 kWp (which may apply if a larger system is installed on a multi occupancy building) must comply with Engineering Recommendation G59/1 1991 "Recommendations for the connection of private generating plant to the electricity boards' distribution systems". An agreement with the local Distribution Network Operator (DNO) is required by law before connection of the PV system to the grid can be made. This would normally be done by the PV installer.

Further consideration of grid connection is given in Section 4.9.1.

4.5.2.4 Financial - PV

Prices for the average domestic system can be around £4,000-£9,000 per kwp (Energy Savings Trust, 2005). Average costs in recent years have been fairly constant (source Energy Savings Trust 2008):

- 2002-2003 - £7,435 per kWp
- 2003-2004 - £6,797
- 2004-2005 - £6,218
- 2005-2006 - £6,241
- 2006-2007 - £7,358

Costs for a solar PV system can vary depending on the technology specified. Approximate costs of PV/m^2 are (Source: Solar PV and Your Business, Energy Saving Trust, 2006):

- PV rainscreen cladding: £600/m^2
- PV integrated curtain walling: £780/m^2
- PV roof systems: £350-400/m^2

A 1 kWp system, which will produce 750 kWh per year costs around £6,000 (IT Power, 2005). kWp is the output of a PV system at Standard Test Conditions (STC) of 1000 Wm^2 solar radiation, 25^oC, Air Mass 1.5. Generally a PV system has a lifespan of around 25-30 years.

Some housing developers (3 private, one housing association) indicated (IT Power, 2005) that they had charged more for the houses due to the PV installations. Two actually gave concrete figures offering following explanations, "more than £3,000 but less than £6,000" and "less than £3,000". Due to the high demand of properties in general across all developments, there seemed to be no indication that the properties were sold or occupied more readily because of PV.

The proposed new energy tariffs have a significant potential impact on the financial viability of solar PV as indicated in Section 4.1.4. However, some studies have indicated that in rented accommodation, particularly where the landlord may benefit, tenants may have limited interest in PV installations (IT Power 2005).

4.5.3 Opportunities - PV

PV technology is expected to decrease in cost over the next decade and PV systems could provide a useful contribution to renewable energy generation. Planning authorities can consider the encouragement of PV systems by placing strict energy targets on new build houses and other buildings, and encouraging the incorporation of PV systems where appropriate. This will be made easier with the introduction of new materials, such as PV roof tiles, in a similar way that roofing materials (e.g. slate) are stipulated on new dwellings in some areas. As PV and solar thermal installations are generally going to be competing for the same roof space for installation on buildings, an estimation of the total potential for solar thermal energy is given in Section 4.5.5.4. Given that both technologies are expensive, it can generally be assumed that either solar thermal or PV technology might be installed, rather than both.

The following table sets out the potential for solar PV based upon the number of properties in each council area.

Table 4-31 Potential for Solar Energy PV

Council	No of Domestic Households	Total Capacity (domestic) MW (25% appropriate)1	Capacity assuming 44% domestic properties suitable MW	No Commercial Properties (40% appropriate)2 PV only.	Commercial Capacity (MW)	Total Capacity (commercial and domestic) MW
Pendle	38358	19	40	3353	7	26
Burnley	39604	20	42	3458	7	27
Rossendale	35530	14	36	2524	5	23
Kirklees	177476	83	185	14210	28	117
Calderdale	87838	42	94	8396[3]	17	61
Total	**378805**	**178**	**397**	**31941**	**64**	**253**

Notes.
1. Assuming that on average generation is 2kW for domestic properties and only 25% of properties are appropriate for solar energy (either PV or thermal) due to factors such as orientation, shadowing, property types e.g. flats, roof construction etc. Source of household numbers - census data or council updated studies where provided. However, in Burnley around 55% of houses are south facing with around 80% of these with sufficient space - giving a total of 44% properties suitable for solar energy (IT Power, 2005).
2. Assuming that on average generation is 5kW electric for commercial properties (hot water demand in commercial properties is low).
3. There are 8396 business rate assessments for Calderdale, but 1616 are empty. However, the assessment is made upon the total number of properties.
4. Total capacity is a sum of the 25% domestic uptake and the commercial uptake
5. For Kirklees - excludes housing within the National Park

The above table indicates that the capacity estimation for solar PV is very dependant upon the percentage of houses which are assessed as suitable for solar installations. The national figures given by SQW (2010) are more conservative than the figures obtained from the more local Burnley study. However, the main constraint for solar uptake is the capital expense of installing the equipment. It is likely with the current feed-in tariffs that solar PV will become much more popular than before. However, it is likely that uptake will only be a relatively small percentage of the total capacity.

4.5.4 RLC Potential - Solar Thermal

The vast majority of micro installations in the UK are currently solar thermal. The Burnley RenewEL study (IT Power, 2005) made the following points about solar water heating:

- Users of solar water heating are generally enthusiastic;
- Generally users noted a significant reduction in fuel bills;
- Provision of information and a demonstration of the system were important for users to understand how it worked.
- It was useful where the temperature of the water could be monitored. Some early systems had very high water temperatures in summer, and provision of a mixer valve to avoid this problem was useful.
- Availability of trained plumbers and electricians was important, and these were not always available.

4.5.5 Technology - Solar Thermal

Solar water heating is a mature technology which has been applied widely across Europe and there is now a reasonable level of experience in the UK. They have been shown to be effective in the north of England (IT Power, 2005).

A suitably sized solar water heating system will typically provide 50% of a household's hot water needs over the year. The systems can usually provide nearly all the hot water needs over the summer months (90%) and requires back up from conventional heating methods at other times. Approximately 50% of hot water is provided in spring and autumn and 20% in winter[31]. Factors such as the level of occupancy, and when the water is actually used will mean that this range can vary widely. Solar water heating systems don't require direct sunlight, and can still heat water on cloudy days.

The types of solar hot water system range in complexity from simple plastic tubing on a roof for heating swimming pools to advanced evacuated tube collectors which can offer improved performance in cloudy conditions. For a typical installation, the surface of the hot water panel is around 100mm above the roof line (or proud of the wall).

Typical Solar Water Devices include:

- Flat Plate Collector 0.8 to 9.0 m^2
- Evacuated Tube 1.2 to 3.0 m^2

The solar system should be orientated south (or in the range southwest to southeast), at an inclination of 20 - 60^o to obtain best use of solar radiation (IT Power, 2005). There should be no overshadowing. Ideally the installation should be on a south facing roof, but east-west orientation roofs can also be used[31]. Flat roofs may be suitable, but require a mounting frame.

A solar hot water (SHW) system for a typical three bedroom semi-detached house would require around 4m^2 of roof area for the collector and provide the majority of the domestic hot water requirement during the summer months. Allowance can be made for 1m^2 collector per person with a minimum of 2.5m^2 (IT Power 2005). Typical installations for a range of housing sizes will be 2-5m^2. A 1m^2 collector will give around 300kWh per year.

Either a conventional boiler with a hot water tank or a combination boiler capable of taking warm water feed are required. There needs to be space for a large twin coil hot water tank to

---

[31] Burnley Solar Savings Scheme Frequently Asked Questions, Burnley.gov.uk.

store hot water. Typically around 50 litres of water storage is required per m^2 of collector (IT Power, 2005). This can be a significant space requirement within a modern house.

4.5.5.1 Landscape - Solar Thermal

Generally the impacts of solar thermal systems are the same as for PV systems installed on roofs (see section 4.5.2.2).

4.5.5.2 Connectivity - Solar Thermal

Connectivity to a grid is not a problem for solar thermal systems which are generally just developed to supply local hot water to domestic properties and properties which require a relatively high hot water demand (not offices).

4.5.5.3 Financial - Solar Thermal

Generally users of solar thermal hot water systems are enthusiastic about the system and find that they have a significant reduction in their fuel bills.

Typical systems for domestic houses could be expected to cost between £2,000 and £5,000 to install. The total system cost for a $2.7m^2$ system is given as £2,590 + scaffolding + VAT[31], with costs of £500 to £1000 per m^2 of collector given by IT Power (2005). Current cost estimates from the Energy Savings Trust are around £3,000 - £5,000 (source - http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-water-heating).

The cost per tonne of CO2 saved for a typical $4m^2$ system would be between £130-£600 (Energy Saving Trust, March 2006).

The amount saved depends upon how much hot water is usually used at the property, the efficiency of the boiler, and what type of fuel is used (mains gas is currently cheaper than oil, LPG, electricity). If mains gas is used then typical savings may be £70 a year, or £200 for an electrically heated property. However, IT Power (2005) gave lower savings values of around £26 per year on gas bills.

It would be expected that these savings would increase significantly when the renewable heat incentive commences, with payments of 18p/kWh.

The life expectancy of a system is around 20 years, although it is recommended that they are checked every 3 years.

4.5.5.4 Solar Thermal Opportunities

Overall the opportunities for installation of solar thermal hot water heating are similar to those for solar PV. However, solar thermal is mainly suitable for locations where there is a high level of hot water demand, such as domestic houses. It is not suitable for low hot water demand properties such as offices.

Given the size of typical roofs on domestic properties, and the fact that both types of solar energy have similar constraints, it has been assumed that either solar water or PV are installed. If both types of installation can be placed on one roof then the total capacity would be the sum of the two installations. However, it appears at present that this would represent an unrealistically high level of uptake.

The levels of potential uptake for different types of property are taken from SQW energy (2010). It can be assumed that around 50% of all new domestic properties will be suitable for solar energy installations (SQW 2010).

Table 4-32 Potential for Solar Energy Water Heating

Council	No of Domestic Households	Total generation (domestic) MW (25% appropriate)[1]	Generation assuming 44% domestic properties suitable MW
Pendle	38,358	19	34
Burnley	39,604	20	35
Rossendale	35,530	18	31
Kirklees	177,476	89	55
Calderdale	87,838	44	77
Total	**378,805**	**189**	**333**

Notes.
1. Assuming that on average generation is 2kW for domestic properties and only 25% of properties are appropriate for solar energy (either PV or thermal) due to factors such as orientation, shadowing, property types e.g. flats, roof construction etc. Source of household- census data or council updated studies where provided . However, in Burnley around 55% of houses are south facing with around 80% of these with sufficient space - giving a total of 44% properties suitable for solar energy (IT Power, 2005).
For Kirklees - excludes housing within the National Park

The above table indicates that the capacity estimation for solar thermal heating is very dependant upon the percentage of houses which are assessed as suitable for solar installations. The national figures given by SQW (2010) are more conservative than the figures obtained from the more local Burnley study. However, the main constraint for solar uptake is the capital expense of installing the equipment and the space requirement for a large hot water tank. Solar thermal installations are more efficient than PV solar installations per unit area - so where suitable roof space is limited solar thermal may be a preferable option. However, new houses and houses with modern boilers are not likely to have a hot water tank (as they generate hot water on demand), people may be unwilling to reinstall a large hot water tank when they have used the space for something else. In these circumstances they are possibly more likely to consider installing PV if their property is suitable as this takes up less space. It is likely with the proposed heat incentives will mean that solar thermal installations become much more popular than previously. However, it is likely that uptake will only be a relatively small percentage of the total capacity. It is likely that one domestic property would only have either solar PV or solar heating, not both. Another potential outlet for solar thermal technologies is for swimming pools. Indoor swimming pools have large roof spaces and a large cost for heating the pool. In this situation, solar thermal installations could help reduce energy costs.

4.6 RLC Potential - Ground Source Heating - Technology

4.6.1 Introduction

Ground source heating and cooling are energy-efficient methods of regulating the temperature of buildings. They utilise the heat storage properties of the ground and have been used for many years in countries such as Sweden, the USA and Canada. Increasingly, they are being used in the UK, and are actively encouraged through building regulations and subsidies.

Active ground source heating and cooling employ a heat pump coupled to the ground. Cooling can also be carried out passively by circulating cool water (e.g. groundwater) through buildings. Usually heat pumps are powered by electricity, which may be generated from renewable or non-renewable sources. If the electricity used to power a heat pump is derived from the National Grid then the carbon emissions will be approximately equivalent to those of a mains gas heating system. In this situation, the heat pump cannot be considered to be a low carbon option. The use of electricity to power heat pumps can reduce carbon efficiency by around one third compared to other renewable options[32].

Ground source heat pumps can be used as part of open loop, or closed loop, systems. In an open loop system, groundwater is abstracted from the ground, passed through a heat exchanger, and then disposed of. Often the water is re-injected into the ground some distance away. In a closed loop system, refrigerant or antifreeze solution is circulated within a closed loop of pipe buried in the ground.

Ground source heating and cooling can be carried out in most areas, but local conditions will generally dictate which type of system is most suitable. Open loop systems require an aquifer, and will often need an abstraction licence and discharge consent from the Environment Agency. Geological maps can be used to identify areas that contain aquifers and that might therefore be suitable for open loop systems.

Closed loop systems can be employed in low permeability formations, and do not require a groundwater abstraction. However, the Environment Agency may require steps to be taken to protect groundwater from pollution by heat or by the fluid circulated in the loop.

Closed loop systems may be vertical (within a borehole) or horizontal (within a trench). The choice between the two is often influenced by the amount of land available: if there is plenty of space then a horizontal loop may be the cheapest option; if space is at a premium then a borehole may be more suitable.

Other factors that may limit the use or design of ground source heating/cooling schemes include the proximity of existing ground loop installations and also the proximity of existing groundwater abstractions and sensitive water environments (e.g. groundwater-dependent wetlands).

4.6.2 Potential for Open Loop Groundwater-Based Systems

Groundwater-based open loop systems require an aquifer that can yield enough water to support the required heating or cooling load. Typical domestic heating loads are 10-30kW. Banks (2008) presents calculations showing that a modest flow rate of 1 l/sec would be sufficient to support a heat pump with a heating effect of 28 kW, an electrical input of 7 kW and a (typical) change in groundwater temperature of 5°C.

Table 4-33 lists the aquifers present within the study area, and Figure A 13 shows their spatial distribution. The most extensive are the Carboniferous Millstone Grit and Coal Measures. These are Secondary (formerly known as Minor) bedrock aquifers that have the potential to supply water at rates of up to 50 l/sec (Table 4-33). However, borehole yields depend on the intersection of fractures and are therefore highly variable. Initial yields are not always sustainable, sometimes declining with pumping as storage is depleted (Aitkenhead *et*

[32]http://www3.westminster.gov.uk/newcsu/Planning_Sub-Committee_Briefs_LDF/2009/14%20July%2009/Item%205%20-%20Appendix%201%20-%20Briefing%20Note%20on%20Energy%20etc.doc.

al., 2002). Older Carboniferous strata (Bowland High / Craven Group) occur in northern Pendle, and these may be able to provide water locally, although they are dominated by non-aquifer material (mudstone). Superficial sand and gravel deposits are another potential source of groundwater, although they have a restricted distribution and are not significant on a regional scale.

Geologically, the area has the potential to support open loop ground source heating/cooling systems, but highly variable aquifer properties and borehole yields mean that there is no guarantee that any given location will be suitable.

Table 4-33 Aquifers within the Council Areas

Age	Aquifer	Description	Distribution	Comments
Quaternary	Alluvial sand and gravel	Superficial sand and gravel deposits	Alluvial deposits are concentrated along the major rivers, but may or may not contain significant deposits of sand and gravel. Small areas of glacial sand/gravel occur in Rossendale and, to a lesser extent, in Burnley.	Very restricted distribution and extent. Not significant on a regional scale.
	Glacial sand and gravel			
Carboniferous	Coal Measures	Mudstone, siltstone, sandstone, coal, ironstone and ferricrete.	All Council areas.	Most groundwater flow occurs in fractured sandstones. Borehole yields are highly variable. They commonly range up to 10 l/s, and locally exceed 20 l/sec. Initial yields are not always sustainable.
	Millstone Grit	Mudstone, siltstone and sandstone.	All Council areas.	Most groundwater flow occurs in fractured sandstones. Borehole yields are highly variable, even over short distances. Yields are often between 5 and 10 l/sec, but may be as great as 50 l/sec. Initial yields are not always sustainable.
	Bowland High Group and Craven Group	Mudstone, siltstone, sandstone and limestone (mainly mudstone).	Restricted to northern Pendle.	Most groundwater flow occurs in fractured limestones and sandstones. Borehole yields are likely to be highly variable. Boreholes may be dry if they do not intersect fractures.
Sources: BGS (digital mapping at 1:625,000), Jones *et al*. (2000), Aitkenhead et al. (2002).				

4.6.3 Potential for Closed Loop Groundwater-Based Systems

Closed loop systems do not require abstraction or discharge of water and can therefore be placed almost anywhere (Banks, 2008). The whole area can therefore be regarded as having the potential to support closed loop systems (obviously there are practical considerations, such as the amount of space available - see Section 4.6.8).

4.6.4 Potential for Systems Based on Surface Water

Ground source heating/cooling systems can be installed in ponds, lakes, canals and other surface water bodies. They may be of open loop or closed loop type (Banks, 2008). The study area contains many surface water bodies - including lakes and canals - that could potentially be used for ground source heating and/or cooling.

Pond-, lake- and canal-based systems have the advantage that they do not require the drilling of boreholes or excavation of trenches. They can therefore be relatively cheap. However, they have the disadvantage that they cannot be used everywhere, either because there is no surface water body at the location where heating or cooling is required, or because the body (or bodies) present are in some way unsuitable.

If the building to be heated/cooled does not lie on the edge of the water body then the system will be less efficient because the carrier fluid will gain or lose heat during its journey to and from the building. Not all surface water bodies are suitable for ground source heating and cooling. It is important to consider the thermal and water budgets of the water body, and also any environmental sensitivities. Small, shallow and isolated water bodies may be unsuitable because of their susceptibility to large temperature changes. Kavanaugh and Rafferty (1997) suggest that a lake-sourced ground source heating/cooling scheme is likely to be feasible if (1) the lake has a substantial through-flow of water (replenishing/removing heat), or (2) if the lake is deep (more than 3 or 4 m) and the peak heating load is less than 8.7 W/m^2 and the peak cooling load less than 17.4 W/m^2.

Many ponds and lakes are ecologically sensitive, and some are used as sources of drinking water. In such cases it may be unacceptable to change the temperature of the water, or to introduce a closed loop containing antifreeze, which could potentially leak and cause pollution.

Canals traverse Pendle (Leeds and Liverpool Canal), Calderdale (Rochdale Canal, and the Calder and Hebble Navigation Canal), Kirklees (Huddersfield Narrow Canal, Huddersfield Broad Canal, and the Calder and Hebble Navigation Canal) and Burnley (Leeds and Liverpool Canal). Any installation of ground source heating/cooling systems in canals would need to be instigated by British Waterways, or undertaken with their permission. Open loop systems would probably be the best option for canals because they would not require the placement of significant lengths of piping. Piping could cause an obstruction, or could be damaged by passing boats. An open loop system would only require a pump intake and a discharge point.

4.6.5 Landscape - Ground Source Heating

There are a number of constraints with regard to the development of ground source heating (or cooling). The most significant are as follows:

- Obtaining an abstraction licence (and discharge consent if required) for open loop systems (see Section 4.6.7);
- Access for installing boreholes or land for installing horizontal systems (see Section 4.6.8)
- Practicalities - the temperature of water supplied from a ground source system working at its optimum efficiency is more suitable for space heating, or underfloor heating than for pumping through radiators. Hence it may be more effective to install ground source heating in new builds or in major refurbishments of properties.

4.6.6 Environment Agency Guidance

The Environment Agency is in the process of developing good practice guidance for open loop ground source heat pumps; this is due for publication in 2010 (Environment Agency website).

4.6.7 Licensing and Consents (Open Loop Systems)

Water abstraction is regulated by a licensing system administered by the Environment Agency: abstractions exceeding 20 m^3/day (0.23 l/sec) require a licence. Licensing decisions are based both on local conditions (such as the proximity of other users or ecologically-sensitive sites) and on Catchment Abstraction Management Strategies, or CAMS. As part of the CAMS process the surface water and groundwater resources of an area are assessed in order to determine the availability of water for abstraction, given environmental considerations such as the need to maintain minimum river flows. Table 4-34 summarises the availability of water within the five Council areas as assessed as part of the CAMS process.

In 2007/08 most of the area was assessed as having water available for surface water abstraction; however, it was predicted that by 2011 or 2013 there mostly would be no surface water available (Table 4-34). Although the underlying aquifers have water available, restrictions on groundwater abstraction may be imposed in order to protect surface water flows. Schemes that involve returning abstracted water locally are likely to be favoured by the Environment Agency as the net abstraction of groundwater is zero. However such systems would require discharge consent[33] and there maybe heat (and other) pollution impacts if schemes are too densely installed which have to be taken into consideration (Fry, 2009). This is likely to be the case with many groundwater-based open-loop schemes.

Disposal of abstracted water may require a discharge consent from the Environment Agency. In general the chemical quality of groundwater in the Millstone Grit and Coal Measures aquifers is poor (Environment Agency website) so, in some cases, there may be a requirement for the water to be treated prior to discharge. Water quality is likely to be worst (i) beneath major urban areas and (ii) in former mining areas.

Subsurface investigation work for open loop systems may require a Licence to Investigate Groundwater (Environment Agency website). Closed loop systems do not usually require a permit or licence from the Environment Agency (Environment Agency website).

[33] http://www.environment-agency.gov.uk/netregs/118839.aspx

Table 4-34 Environment Agency CAMS areas and Water Availability

Council	Water Availability
Calderdale	**Aire and Calder CAMS (2007, 2008):** **Upper Mid Calder WRMU** - Water available at low flows, but 2011 target status is no water available. Groundwater licences may then be tied to hands-off level conditions in order to protect surface water flows. Applications that involve returning most of the water locally are most likely to be acceptable. **Lower Aire and Lower Calder WRMU** - Water available at low flows, but 2011 target status is no water available. Hands-off flow conditions may apply to new or varied abstractions from the main river.
Kirklees	**Aire and Calder CAMS (2007, 2008):** **River Colne WRMU** - No water available. The underlying aquifers have water available, but this status has been over-ridden in order to protect the River Colne, which is over-licensed. Groundwater licences may be tied to hands-off level conditions to protect surface water flows. **Lower Aire and Lower Calder WRMU** - See above.
	Don and Rother CAMS (2003, 2008): **Upper Dearne WRMU** - Water available, but hands-off flow conditions may be applied to new or varied licences.
Pendle	**Aire and Calder CAMS (2007, 2008):** **Upper Aire WRMU** - Water available at low flows, but 2011 target status is no water available. Groundwater licences may be tied to hands-off level conditions to protect surface water flows. Applications that involve returning most of the water locally are most likely to be acceptable.
	Ribble ICMP (2007): **Calder Policy Area** - The Upper Calder is over-licensed. There is no extensive groundwater resource. **Upper Ribble Policy Area** - Water available.
Burnley	**Ribble ICMP (2007):** **Calder Policy Area** - See above.
	Aire and Calder CAMS (2007, 2008): **Upper Mid Calder WLMU** - Water available at low flows, but 2011 target status is no water available. Groundwater licences may be tied to hands-off level conditions when the unit reaches no water available status.
	Northern Manchester CAMS (2007): **River Irwell (WLMU 1)** - Water available at low flows, but 2013 target status is no water available. When this status is reached, a hands-off flow condition may be imposed.
Rossendale	**Ribble ICMP (2007):** **Calder Policy Area** - The Middle and Lower Calder have water available.
	Northern Manchester CAMS (2007): **River Irwell WLMU (WLMU 1)** - See above. **Upper Roch (WLMU 5)** - No water available at low flows. 2013 target status is no water available. Applications may be considered for winter-only abstraction or for non-consumptive use.
ICMP = Integrated Catchment Management Plan; WRMU = Water Resource Management Unit (for surface water). **References: Environment Agency (2003, 2007a-c, 2008a-b).**	

4.6.8 Considerations of Space

If there is plenty of space available then the cheapest option may be to bury horizontal loops in shallow trenches (up to 2 m deep). For coiled "slinky" systems, the average length of trench is 10.5 m per kW of peak output (Banks, 2008). If there is little space available then a vertical borehole-based system may be more appropriate. It is often easier to incorporate ground source heating/cooling at the design (or possibly refurbishment) stage of a development.

If a new ground source heating/cooling scheme is proposed close to an existing one then it will be necessary to consider the potential for the schemes to thermally "interfere" with each other, reducing their efficiency.

4.6.9 Pond- and Lake-Based Systems

If a pond or lake is ecologically sensitive then a significant change in water temperature (as may result from a ground source heating/cooling scheme) may not be acceptable. With closed loops there is a risk that the loop may be damaged, allowing toxic antifreeze to leak into the surrounding water. This risk may not be acceptable in an ecologically-sensitive setting or in a lake used to store drinking water. Low-toxicity biodegradable fluids are available for use in closed loop systems (Banks, 2008).

4.6.10 Air-Based Systems

Air source heat pumps can also be used. These take air in and heat it to generate space heating. However, at present air source pumps have less efficiency than ground heat pumps as the air temperature varies more than ground temperature throughout the year. In particular air temperature is lowest when most heating is required in the winter - hence the air heat pump works less efficiently than ground heat pumps which tap a more stable temperature source. However, the space requirements are much less for air heat pumps than ground source heat pumps and the costs much less. Air source heat pumps are suitable for most properties as they can be installed on outside walls. They are however, visible, if installed on the outside of buildings.

Air source heat pumps can be used to heat water for circulation in conventional radiator systems. Generally, radiator systems have a higher flow temperature than under floor systems meaning that they are slightly less efficient, but may be more practicable in existing properties. Air source heat pumps linked to radiators have been installed in a number of non-mains gas areas where they are a viable option.

Noise from air source heating can occasionally be a problem; selection of equipment and ensuring that it is located in a suitable place can ensure the potential for noise reverberation is avoided. A number of air source heat pumps have been installed in Kirklees Council area on a project with Community Energy Solutions. Additionally there is considerable experience in the wider region with over 500 air source heat pumps installed on projects managed by Community Energy Solutions in the Yorkshire and Humber and North East of England Regions.

4.6.11 Feedstock - Ground Source Heating

As indicated in the maps developed there is the potential for ground source heating across the whole of the Partnership Area as the ground has similar temperature properties across the area.

Ground source heating installations take heat out of the ground and have the potential to make the ground colder (ground source cooling systems do the opposite). Hence where installations (e.g. boreholes) are located very close to each other there is the potential for systems to interfere, with a corresponding reduction in the efficiency of each system. This has potentially become a problem in London, where there are a large number of ground source heat/cooling systems. However, this is not likely to be a significant problem while ground source heat uptake remains limited. If it is proposed to locate a new system near to an existing system (or to develop a system comprising a number of boreholes/coils) then detailed assessment and modelling of the system should be undertaken to ensure that it will function without interfering with other installations.

As an approximate figure a separation of domestic closed loop systems should be at least 10m to avoid undue interference (Banks D., 2008). However, if a high uptake is planned (for instance in a new development) then possibly a higher figure should be considered given the potential for the overall ground temperature to be lowered where there is a significant net heat load (rather than a balanced heating and cooling load - as might be the case in office developments). Domestic developments are likely to have a predominant heating load. For such cases a more site specific assessment, including the properties of the ground and typical installations should be undertaken. The requirement for separation of installations means that where housing density is very high (e.g. in terrace housing stock) installations could probably only be installed at a maximum of one in every three properties (assuming a typical terrace house may be around 4m wide); but in most cases this level of uptake would not be practicable.

Generally they are most efficient as a low temperature heating system, such as under floor heating rather than hot water radiator systems as the efficiencies for heating water to radiator temperature are significantly lower.

A ground source heating system typically provides around 80% of space heating - for really cold periods top-up heating may be required. Around 50% of hot water requirements may also be obtained from ground source heating (IT Power, 2005).

4.6.12 End user connectivity - Ground Source Heating

Ground source heating systems are heating systems not electricity generation and as such do not suffer from problems of connectivity with a grid. They do require some electricity for pumping water or coolant and so a large number of systems may generate an increased demand in electricity when they replace other forms of heating power, such as oil or gas. If a very high uptake of heat pumps occurred this might require upgrading of the local grid in order to supply sufficient electricity.

The regional distribution network operator (DNO) should be consulted about heat pump installations. Depending upon the type and size of installation, the electricity demand of the heat pumps may exceed the design capacity of the local electricity network. In particular, the initial start-up current for some types of compressor can cause lights to flicker if the network is particularly weak. Where the electricity grid is old, or currently at capacity, the installation of heat pumps may result in overloading the local grid. In some circumstances this may mean that the local cabling or transformer requires upgrading. However, there are rarely problems with one-off installations, but the larger the number of heat pumps in the same street the greater the possibility of an upgrade to the network being required.

In the longer term a potential advantage of widespread uptake of GSHP is that it is a slowly reacting form of heat, so can tolerate short term interruptions to balance the electricity grid. If suitable controls were in place, aggregated large numbers of GSHPs could be partially controlled in this way for grid backup, so making them part of a future smart grid.

4.6.13 Financial - Ground Source Heating

Typical costs for ground source heat pump systems are around £4,000 for a horizontal heat exchanger installed in a trench and around £6,000 for a borehole (with a vertical heat exchanger). The electricity costs for pumping the water or coolant round the ground source systems are around £335 per year (assuming £0.07/kWh - 2005 prices (more recent prices are around £0.08/kWh so prices may have slightly increased since (**http://www.lovemoney.com/news/household-bills/are-gas-and-electricity-comparisons-accurate-715.aspx**)). The systems are fairly low maintenance. The efficiency of the system is around 300 - 400% for ground systems, which means that for every unit of electricity input around 3 or 4 units of heat are generated. In the future heat pumps with greater efficiencies may be developed, and this could result in air heat pumps being more efficient and systems being suitable for a wider variety of locations. Currently air source heat pumps cost in the region of £5,000 to £9,000 for a typical detached home (including installation); running costs are about £790 per year (space heating and hot water) - source http://www.energysavingtrust.org.uk/Generate-your-own-energy/Air-source-heat-pumps. These costs are not too dissimilar from ground source heating, although the running costs are higher.

4.6.14 Overall Assessment

All five Council areas have the potential to support borehole-based ground source heating schemes. Both open loop and closed loop systems could be employed, but uncertainties regarding borehole yield, abstraction licensing and groundwater quality mean that closed loop systems probably present the most straightforward option. There is also the potential to use surface water bodies for ground source heating/cooling. Ground source heating and cooling schemes are unobtrusive, and borehole-based schemes often take up very little space. This is a potential advantage compared to solar heating or biomass systems.

Overall Capacity Assessment

Generally it can be assumed (SQW energy 2009) that ground source heating is suitable and financially viable for all properties not on mains gas. These properties are generally in highly rural areas where the space may be available for installation of ground source heating.

For other existing housing the financial viability, at present, is less clear. However, it is estimated that it is technically feasible to use heat pumps on around 75% of detached and semi-detached properties. Installation is probably possible on around 50% of terraced properties and 25% of flats (SQW energy 2009). However, the space requirements for ground source heat pumps mean that it is likely that only the less efficient air heat pumps can be used on terraced housing stock, so that the an uptake rate for GSHP of 25% of terrace houses is likely to be unfeasible. However, it is possible that technical improvements in heat pumps in the future may make air heat pumps more efficient and therefore more cost effective.

In our assessment (Table 4-35), we have initially used the SQW (2009) uptake assumptions to assess the 'Theoretical Maximum Energy Generation'. As stated above there maybe significant barriers in achieving the uptake rate in terrace housing, so this study has developed its own lower uptake rates of 0% for terrace houses (based on IT Power's (2005) research in Burnley) to take account of this. This was used to produce our 'conservative maximum uptake rate'. In addition to these rates, a further uptake rate based on the proportion of off-gas properties has been calculated; this is explained later in the section, and it is an attempt to suggest the level of uptake that might be expected if solely driven by economic conditions.

Table 4-35 Potential for Domestic Ground Source Heating

		Total Households	Uptake Households	Theoretical Maximum Energy Generated (MW)	Conservative Maximum uptake (MW)	Off gas properties driven uptake)[6]
Burnley	Detached	4952	3714	19	19	1
	Semi-detached	11077	8308	42	42	3
	Terrace	20654	10327	52	0	0
	Flats	2921	730	4	4	1
	Total	39604	23079	115	64	6
Calderdale	Detached	12820	9615	48	48	4
	Semi-detached	23784	17838	89	89	7
	Terrace	37529	18765	94	0	0
	Flats	13704	3426	17	17	4
	Total	87838	49644	248	154	15
Kirklees	Detached	35989	26992	135	135	11
	Semi-detached	21021	15766	79	79	6
	Terrace	58296	29148	146	0	0
	Flats	62170	15542	78	78	19
	Total	177476	87448	437	292	36
Pendle	Detached	4776	3582	18	18	1
	Semi-detached	8534	6401	32	32	3
	Terrace	22550	11275	56	0	0
	Flats	2498	625	3	3	1
	Total	38358	21882	109	53	40
Rossendale	Detached	9167	6875	34	34	3
	Semi-detached	6964	5223	26	26	2
	Terrace	16379	8190	41	0	0
	Flats	3020	755	4	4	1
	Total	35530	21043	105	64	6
5 Councils	Total			1015	627	103

Notes.

1. Generally around 75% of detached and semi-detached housing will be suitable for heat pumps, 50% of terraced properties, and 25% of flats - based upon SQW, 2009. A more conservative uptake is proposed by IT Power 2005 which suggests that terrace housing is generally not appropriate for ground source heating and so our assessment discounts all terrace houses as potential GSHP sites. Similarly of the suitable semi-detached houses possibly only every other house might be suitable to avoid interference.
2. Generally all properties not on mains gas will be suitable for ground source heating.
3. Assuming that on average generation is 5kW electric for domestic properties (SQW 2010). This is less than the peak load, but would supply background space heating.
4. Burnley and Pendle Household Numbers from 2001 Census, others from council surveys
5. For conversion to GWh multiply by hours in year and divide by 1000.
6. Assumptions behind pragmatic off gas calculation shown in Table 4-36. The 'off gas' proportion is assumed to be the same for all housing types.
7. For Kirklees - excludes housing within the National Park

The installation costs for ground source heating, the provision of space (rather than radiator heating) and the use of electricity to power the pumps means that the uptake may be limited. These figures can be compared with the total proposed for the north west of England (Arup, July 2008 - NWRA renewable heat targets):

- 1.03 GWh/yr ground source heating by 2010 - 0.12MW
- 51.3 GWh/yr ground source heating by 2020 - 5.9MW

These clearly relate to a much lower uptake scenario than that envisaged by SQW, 2009.

A lower pragmatic minimum uptake based on the number of 'off gas' properties is presented in the last column of Table 4-35. This was derived from information about the proportion of households which were not gas consumers in 2008 (DECC Website) and comparing it to the total number of households to estimate the proportion of properties 'off gas' (Table 4-36). Where properties are off gas, ground source heating technology may be more economically viable and the proportion of uptake could be high. This figure therefore represents a pragmatic minimum uptake if the only incentive is an economic one. It does not take into account the possibility of higher uptake rates amongst new builds or schemes not developed solely for economic reasons. The calculation to estimate the proportion of 'off gas' households is laid out in Table 4-36.

Table 4-36 The proportion of 'off gas' properties by Council

Area	Domestic Gas customers 2008*	Households 2008**	Not-on-gas' households	Proportion of not on gas households %
Burnley	38,000	40,585	2,585	6
Pendle	37,500	39,665	2,165	5
Rossendale	29,200	30,417	1,217	4
Calderdale	85,300	91,459	6,159	7
Kirklees	168,000	175,400	7,400	4
Total	358,000	377,526	19,526	5

*DECC **http://www.decc.gov.uk/en/content/cms/statistics/regional/gas/gas.aspx**
**http://www.wastedataflow.org/

A calculation to assess the potential for commercial properties to take up ground source heating was undertaken. The size of a commercial property will affect the capacity of the ground source heating system that can be installed; therefore some estimated quantification of the size of the commercial properties was required. 2009 IDBR (Inter-departmental Business Register was used to collate the properties on the basis of the average number of employees based in an average property for a sector (e.g. the average number of employees in a commercial property used for the manufacturing of electronic equipment). This was used to give an estimate of the number of properties in the following categories:

- Number of commercial properties in a sector with an average of under 15 employees,
- Number of commercial properties in a sector with an average of 15 - 50 employees,
- Number of commercial properties in a sector with an average of over 50 employees.

From these categories an estimate of the maximum theoretical and pragmatic uptake of ground source heating systems across the study area was made (Table 4-37). The estimates of the size of commercial properties will be subjected to a number of errors (e.g. it is calculated by taking an average of the employee size for a property in a commercial sector, the full range of property sizes is not accounted for, and the number of employees does not directly equate to property size), however it is assumed that these errors compensate each other to give a usable estimate of commercial property size.

Table 4-37 Estimation of Theoretical and Pragmatic Uptake of Ground Source Heating for Commercial Properties

			Commercial properties in a sector with an average of under 15 employees	Commercial properties in a sector with an average of 15 - 50 employees	Commercial properties in a sector with an average of over 50 employees	Total
Number Commercial Properties by average number of employees in a sector		Calderdale	6885	1050	110	8045
		Kirklees	12490	1520	200	14210
		Burnley	2380	495	0	2875
		Pendle	2680	305	45	3030
		Rossendale	2495	240	10	2745
Theoretical Maximum	Ground Source Heating Uptake*	Calderdale	1721.25	787.5	110	2619
		Kirklees	3122.5	1140	200	4463
		Burnley	595	371.25	0	966
		Pendle	670	228.75	45	944
		Rossendale	623.75	180	10	814
	Capacity (MW)**	Calderdale	8.60625	3.9375	11	24
		Kirklees	15.6125	5.7	20	41
		Burnley	2.975	1.85625	0	5
		Pendle	3.35	1.14375	4.5	9
		Rossendale	3.11875	0.9	1	5
Conservative Maximum	Ground Source Heating Uptake***	Calderdale	0	525	82.5	608
		Kirklees	0	760	150	910
		Burnley	0	247.5	0	248
		Pendle	0	152.5	33.75	186
		Rossendale	0	120	7.5	128
	Capacity (MW)**	Calderdale	0	2.625	8.25	10.88
		Kirklees	0	3.8	15	18.80
		Burnley	0	1.2375	0	1.24
		Pendle	0	0.7625	3.375	4.14
		Rossendale	0	0.6	0.75	1.35

*Based on 25% under 15 employees properties uptake, 75% between 15 -50 employees properties uptake and 100% of over 50 employees properties uptake
** Average 5kw schemes for under 15 and 15-50 employees properties and a 100kw scheme for over 50 employees properties (modified from SQW 2010)
***Based on 0% of under 15 employees properties, 50% of 15-50 employees properties uptake and 75% of over 50 employees property uptake

In summary the potential for ground source heating is shown in Table 4-38. This presents two different totals; the total conservative maximum and the total pragmatic. The total pragmatic represents a low baseline uptake rate, which will be achieved with minimal proactive encouragement; allowing current economic conditions to be the main driver of uptake. The conservative maximum total represents what could be achieved through a step change in the way buildings are heated in the area in buildings which have the potential to accommodate GSHP systems. It is likely that the actual rate of uptake in the future will lie somewhere between the two (potential future uptake rates for all technologies is discussed in sections 7 and 8).

Table 4-38 Ground Source Heating Capacity Potential Summary

	Theoretical Maximum Commercial uptake (MW)	Conservative Theoretical Maximum Domestic uptake (MW)	Total Conservative Maximum Uptake (MW)	Pragmatic Commercial uptake (MW)	Domestic (off gas) uptake	Total Pragmatic Uptake (MW)
Burnley	4.8	64	68.8	1.2375	6	7
Calderdale	23.5	154	177.5	10.875	15	26
Kirklees	41.3	292	333.3	18.8	36	55
Pendle	9.0	53	62.0	4.1375	5	9
Rossendale	5.0	64	69.0	1.35	6	7
Totals	83.7	627.0	710.7	36.4	103.0	139

Notes:
Total conservative maximum uptake represents estimate of future capacity if there is significant investment in ground source heating in the study area.
Total Pragmatic Uptake Capacity represents a lower uptake scenario with current economic conditions as the main driver of uptake.

4.7 RLC Potential - Hydro Power

4.7.1 Introduction

There are a number of advantages of hydropower, compared to some other sources of renewable energy sources such as solar or wind, which include high efficiency, high capacity factor (actual output over time compared to potential output over the same period), high level of predictability, slow rate of change and well-established and reliable technology.

A recent EA report (2010) identified a total of 25935 'barriers with sufficient drop to provide a hydropower opportunity across the UK. The total potential capacity of all these barriers is nearly 1200MW, which could provide a maximum of about 1% of the UK's projected electricity demand in 2020. In reality, the practical potential will be a fraction of this, due to practical and environmental constraints, which means that only 16% of the identified structures are likely to be feasible for development. The limited maximum capacity of hydropower means that this resource is only ever likely to provide a small contribution to renewable energy generation in the UK.

Schemes are generally categorised into low (<10 m gross head), medium (10 to 50 m) and high head (>50 m) schemes based upon the vertical distance through which the water falls to generate the power. Most small hydropower stations are low or medium head, run-of-the-river schemes which use the available flow in the river and the power therefore varies as the flow in the river varies. Such schemes offer the highest development potential.

In a run-of-the-river scheme there is no dam and therefore no water storage capacity. Any river weir structure is usually small and is only required to divert a proportion of the river flow. The environmental impact of a small weir can generally be mitigated to an acceptable level. The Environment Agency (EA) supports environmentally sustainable hydropower schemes[34] that do not increase flood risk, damage ecology, damage the fish population or obstruct fish migration and which comply with environmental regulations such as the Water Framework Directive and the Salmon and Freshwater Fisheries Act (1975). Large dams or reservoirs are usually the only components that are required for larger storage hydropower schemes. The power available is proportional to the available head and the flow.

Components of a small hydropower river scheme typically consist of headworks, which include: an intake and often debris screens, sometimes a headrace or small channel to carry the water, a penstock or pressure pipe to drop the water under pressure, a powerhouse containing the turbine and a tailrace to discharge the water back to the river.

Useful notes and guidance on developing a scheme can be obtained from the British Hydropower Association (BHA)[35]. Within the Pennines area there are many existing weirs developed by mills over the last few centuries. The potential for hydropower is mainly from existing weir structures so the environmental impact is potentially similar to that at present. There can be an opportunity (and potentially a requirement) to improve the environmental situation e.g. constructing a fish pass if there isn't one already. If new weirs are to be constructed a fish pass will be required where fish stocks may be affected.

4.7.2 Technology - Hydro Power

There are many installations in the UK though most of the current UK hydro capacity is in Scotland. The construction of new weirs for the construction of small scale hydropower can be thwarted by significant planning requirements and environmental constraints. However, a growing number of schemes have used existing weir structures on rivers that were developed during the industrial revolution for mills. Hydropower offers the possibility of redeveloping these sites for a use that was originally intended.

In the UK a number of smaller schemes have been constructed privately on estates with watercourses favourable for hydropower development. However, there is a growing interest in the development of community based hydro schemes. Anarget Hydro in Ireland is an

[34] http://www.environment-agency.gov.uk/business/topics/water/32022.aspx
[35] British Hydropower Assocation, www.british-hydro.org

example of one of the early community developed scheme[36]. More recently the New Mills hydro site in Derbyshire is a good example of a community developed scheme. A group called Water Power Enterprises was involved in the New Mills site and are assisting in the development of other community owned hydropower schemes[37]. There can be financial incentives for developing hydropower in this way.

Settle Hydro was established as an 'Industrial and Provident Society for the Benefit of the Community' which is a not for profit organisation. The scheme is a 50kW Archimedean screw at the Settle Weir near Bridge End Mill. It is installed close to the original water wheel and uses part of the existing mill race. The scheme will generate approximately 165,000kWh of electricity. The total cost of the scheme was £410,000, the annual revenue is forecast to be approximately £28,000, and the pre-tax surpluses are forecast to be £11,000 to £15,000 per year (out of which loan repayments, tax and return to shareholders must be met). (Note: this income is likely to be substantially increased with the new Feed in Tariffs (per comms 4x4 lecture 2010).

The Lancashire and Yorkshire Renewable Energy Planning Study (LYREPS) estimated that approximately 6.2 GWh/yr would be available for the whole of Lancashire with 22.9 GWh/yr for West Yorkshire. This was a small proportion compared to other renewable energy sources. These figures were taken from an earlier report completed in 1989 which looked into the hydropower potential for the whole of the UK[38]. The EA mapping hydropower opportunities report (2010) states that the North West Region has the potential hydropower capacity of 196 MW and the Yorkshire and Humber Region has a potential capacity of 179 MW. These figures however, are based on all the barriers identified in the study being developed for hydropower, including high sensitivity sites. Therefore, the EA figures represent an upper boundary for the potential for hydropower in the country.

These generating figures have not been reappraised in terms of the study area but the LYREPS report stated that a useful hydro source exists in the region with potentially more rainfall runoff in Lancashire than in Yorkshire. In areas of Burnley and Nelson average annual rainfall (AAR) is above 1240 mm. To the west of Halifax the AAR is above 1300 mm. As suggested by the LYREPS report the AAR drops to the east of the study area to about 650 mm. This suggests that the greater potential for hydro may be to the west of the study area. The LYREPS report lists 73 sites in the appendix to the report extracted from the earlier 1989 report. It is expected that other sites may now be viable with new developments which are discussed in Section 4.7.3. The report suggests that one site, Armitage Mills at Huddersfield on the River Holme, generates 200 MWh/yr.

Another report by Kirklees Council[39] identifies 150 weirs in the Kirklees study area. 5 low head sites were finally selected to the east and north of Huddersfield with a combined potential capacity of 240 kW. It is understood that the development of one site was pursued until financial and environmental constraints made the scheme non-viable.

4.7.3 Technology development

Hydropower is an old and well established technology but there is ongoing research into new turbines for small hydro sites. A recent development has been the development and application of the 70 kW Archimedean screw turbine at the New Mills hydro site in Derbyshire[40]. Ongoing research into siphonic turbines (small scale turbine generators for low head sites) may bring new opportunities especially since the scale of civil engineering works for such schemes is usually small. It is expected that this ongoing development will reopen possibilities for the redevelopment of some existing mill sites that are currently considered non-viable on economic grounds.

---

[36] www.irishhydro.com
[37] www.h2ope.org.uk
[38] ETSU SSH 4063 Small Scale Hydroelectric Generation Potential in the UK.
[39] Kirklees Hydropower Study, Part 2 Report for Kirklees Council, 2007, Renewable Devices Energy Solutions Ltd.
[40] www.foe.co.uk/campaigns/climate/case_studies/hydro_power.html

The development of turbines for installation in water supply pipelines are in early stages but may become more viable and be of benefit mainly for existing water supply companies.

An assessment methodology has been developed by Lancashire University and others called the 'North West Hydro Resource Model'[41] to address the barrier for deploying turbines, including factors like landscape and economic controls.

4.7.4 Potential sites in the Partnership region

A desk study of potential sites was carried out. The existing weirs that are shown on the Environment Agency (EA) NFCDD (National Flood and Coastal Defence Database) are shown in Figure A 15 where the weir heights have been shown in categories. The higher weirs generally have more potential for hydropower providing there is sufficient flow. Sites with lower weir heights will require a proportionately higher flow to make them viable. The development of schemes is therefore site dependent. EA (2010) research shows that approximately only 16% of potential hydro power sites that they identified were win-win sites (i.e. sites which would produce sufficient power to be a feasible project and have low environmental impacts). An estimated pragmatic uptake for hydropower sites within the study area has also been taken to be 16%, however this rate could vary spatially, and some areas might have the potential for a far greater uptake rate. However 16% uptake rate has been used in the assessment of the potential for hydropower across the whole of the area (Table 4-39) to give a broad scale indication of the resource available.

Table 4-39 Potential for Hydro Power

Council	Number of Weirs	Theoretical Maximum Capacity MW*	Pragmatic Capacity MW**
Burnley	15	0.945	0.1512
Calderdale	37	2.331	0.37296
Kirklees	25	1.575	0.252
Pendle	16	1.008	0.16128
Rossendale	141	8.883	1.42128
Total	234	14.742	2.35872
Notes - *Assuming that on average generation is 0.063MW - takes average figure from LYREPS report (1998). **Based on 16% uptake - 16% of EA (2010) study were shown to be 'win-win' sites For Kirklees - no sites were identified within the National Park			

There are a large number of reservoirs in the region. The development of hydro on these sites is likely to be limited particularly if they are used for water supply. Alteration to water levels for hydro operation may be prohibited by planning constraints. The most likely potential will be the installation of hydro turbines into existing water treatment works in the future. United Utilities plc has investigated potential sites.

The Lancashire and Yorkshire Renewable Energy Planning Study (LYREPS 1998) identified 5 potential sites in the study area. These sites show a potential to generate 0.315 MW. However, it should be recognised that sites with potential for hydro power have a number of planning hurdles (and associated cost) to overcome in order to actually be commissioned.

[41] http://www.lancs.ac.uk/fas/engineering/lureg/nwhrm/project/publications.php

Table 4-40 Potential Small Scale Hydro Schemes Identified by the LYREPS Report (1998)

Council	Scheme reference	Name	Northings	Eastings	Energy (MW)
Kirklees	60	Mirfield	421700	419800	0.108
	59	Mirfield	418500	420900	0.107
	Kirklees Total Energy				0.215
Calderdale	57	Sowerby Bridge	414300	422500	0.042
	55	Sowerby Bridge	405200	424000	0.030
	54	Sowerby Bridge	404100	424000	0.027
	Calderdale Total Energy				0.1
Combined Total					0.315

It should be noted that the EA was contacted to try to obtain council specific data from their recent study (2010). It was unavailable at the time due to rights issues which had to be resolved but it may become available in the future.

4.7.5 Landscape Sensitivity - Hydropower

One of the main constraints to potentially feasible hydro power sites being developed is the planning process.

Planning issues

Issues that a developer is likely to have to address include planning permission, abstraction licensing, impoundment licensing, land drainage consent, Sites of Special Scientific Interest (SSSI) or Areas of Outstanding Natural Beauty (AONB), environmental impact assessments, impact on fisheries, flood risk and consent for works to listed structures.

It should always be assumed that planning permission will be required for hydropower schemes.

A hydropower developer will have to obtain an abstraction licence from the EA to divert water from a water course even if the water is returned and this will specify how much water may be diverted and when. A compensation or minimum release flow is normally specified in the licence which means that not all the available water can be taken for power generation. The Water Framework Directive (WFD) has some potential challenges for hydropower generation which may include driving abstraction flows downwards and requirements to minimise change in water quality caused by turbine aeration. The Catchment Abstraction Management Strategies (CAMS) for water management within river catchments provide an indication of where abstraction licences may be more acceptable than others (see Table 4-34). Further details of the requirements for assessing the impact of hydropower on the environment are given in the 'Good Practice Guidelines Annex to the Environment Agency Hydropower Handbook on the Environmental Assessment of Proposed Low Head Hydro Power Developments' (2009[42]).

Sites in SSSI, AONB or other conservation areas[43], may not prohibit site development but may apply constraints on the development or on the methods of construction (see Section 21). With care structures can be designed to have minimal impact on the landscape.

The need for an environmental impact assessment (EIA) is to be expected. This is invariably required to support the application for an abstraction licence.

[42] **http://www.netregs.gov.uk/static/documents/Business/Low_Head_Hydropower_August_2009.pdf**
[43] The renewable energy centre, www.therenewableenergycentre.co.uk/hydroelectric-power/

The EA are responsible for all main rivers in England and will take into account the impact on fisheries particularly in times of low flows. The EA may stipulate safeguards or operating rules for the scheme to protect fisheries. For moving propeller or blade turbines fish exclusion systems are required which may include intake and tailrace screening. These may include the need for a fish bywash to allow smolts (juvenile salmon migrating to the sea) to pass the scheme safely during turbine operation.

If river structures are to be altered or built, the EA may require an assessment of the change in flood risk and stipulate mitigation if there is a change in risk.

Some weirs may be listed and this can prohibit or limit alteration work to the existing structure.

A report on the Ardchattan scheme in the Oban Times describes some of the rigours of the planning process for small hydro schemes[44] and the potential heavy cost in consultant's fees.

4.7.6 Feedstock - Hydro Power

Hydro power relies on a water supply. Given an adequate design of the system the available water is likely to be present for most of the time. However, systems are likely to have reduced (or no) capacity for generation at times of low flow - for instance when hands off flows are encountered in rivers at times of drought.

4.7.7 End User Connectivity - Hydro Power

Hydropower schemes generate electricity which generally requires a grid connection. Typical hydropower schemes are likely to be around small (less than 5MW) or micro (<100kW) size.

4.7.8 Financial - Hydro Power

New hydropower schemes are eligible for renewable obligation certificates (ROCs and FIT) under the obligation for electricity generators to supply a proportion of their energy from renewable sources.

The British Hydropower Association (BHA) advises that for domestic developers and other non-commercial owners, the government has reduced the VAT payable on hydro-electric plant to 5% for systems supplying buildings which are either residential or used for charitable purposes.

4.7.9 Recommendations

Recommendations for further work for the identification of viable hydropower sites include;

- Screen weir sites according to height.
- Low flow and mean flow analysis for weir sites.
- Power output and energy generation estimates.
- Ownership identification and willingness to develop.
- Site visits for the most likely sites.
- Schedule of the likely development issues.
- Screening of sites considered to be most viable.

A similar process of site review has been recently carried out by the Yorkshire Dales National Park Authority for which a report is available[45].

[44] www.obantimes.co.uk/news/fullstory.php/aid/8521/Ardchattan_looks_forward_to_a_hydro_future.html
[45] http://www.yorkshiredales.org.uk/index/living/planning_1/planning_applications/renewable_energy/hydro-power_feasibility_study_july2009.htm

4.8 RLC Potential - Micro-Generation - Overview

There is no single definition of the term micro-generation; however a useful definition for our purposes is that it refers to technologies which are integrated into the building or small community (e.g. via a heat network) they serve. A maximum capacity of 50kw or 100kw has been suggested as an upper limit of the size of an installation that can be defined as a micro-generator[46] though the majority of installations with households will be much smaller that this.

Microgeneration has a small but important role to play in spreading distributed electricity and renewable heat schemes across the region. In a 'theoretical maximum' scenario, it could reduce the overall demand for grid-connected electricity and heat in the Partnership Council Areas. The potential for individual micro-technologies has been included in the calculations in earlier sections.

The upfront costs of installing micro renewable energy systems are currently very high compared to equivalent conventional commercially driven generating systems and this has tended to deter consumers from installing them (Arup, July 2008). However, this is likely to change with the new feed in tariffs (FITs) from April 2010.

Entec (2007) has estimated the potential maximum contribution of micro-generation in offsetting the average household's energy demand, assuming that the proposed changes to the Permitted Development rights are taken forward:

- Heat pumps, biomass and micro CHP schemes could provide 100% of an average household's heating and hot water needs:
- Micro CHP could also provide up to 30% of an average household's electricity demand, within the Permitted Development rights.
- Solar PV could generate 30-50% of an average household's electricity,
- Solar hot water could provide 40-60% of an average household's hot water.
- Micro wind is described as the most complex in terms of its planning impacts, but might meet 15-20% of the average household electricity needs using equipment that is sufficiently unobtrusive to come within the definition of Permitted Development.

While these savings may be significant for individual households, it is currently relatively expensive to install these technologies, although some grants and incentives are available. The uptake is likely to depend upon the economic case for converting to micro-renewables and the availability of capital grants and favourable feed-in tariffs. The new feed-in tariffs and proposed renewable energy incentives are likely to make these technologies more economic. Where micro generation does not require planning permission (as is increasingly likely to be the case) uptake is likely to be greater. It is currently difficult to monitor the uptake of micro-renewables, however, the new feed-in tariff system may make monitoring uptake easier.

There have been studies undertaken in the area which consider small scale renewable energy schemes including solar. A study in Burnley (IT Power, 2005) concluded that:

- Energy efficiency measures were one of the key measures to introduce for reducing energy consumption and carbon emissions.
- Biomass community heating brings some of the greatest CO_2 savings and is technically and economically feasible for existing terrace housing.
- New build housing has the potential to have a very high level of energy efficiency.
- Solar water heating, biomass community heating and solar photovoltaics can be incorporated into both existing and new housing.

The findings of this study are interesting as they are within the project area, even though the report is now a number of years old.

[46] http://www.eci.ox.ac.uk/research/energy/downloads/bmt-evidence-microgeneration.pdf

However, generally micro-renewables are not as efficient as larger scale generation plants. The electricity supplied from a large scale generation plant (e.g. 50% efficiency for new build plant), or a large-scale optimised renewable project, are far in excess of a micro-renewable project. To illustrate, micro-wind efficiencies are only likely to achieve a 10% to 17% capacity factor for a typical site, way below that of a large-scale commercial wind farm (British Energy Group 2006). However, generally micro wind and commercial wind are not likely to be competing for the same sites. Micro wind, as it is smaller, is suitable for a larger number of sites.

Figures given in the British Energy Group report indicate the following costs for micro generation:

- PV - 53-118p/kWh
- Micro wind - 20p/kWh
- Micro CHP - 6p/kWh
- Compared to the following for other low carbon options:
- <4p/kWh for nuclear
- ~4-5p/kWh for coal plus carbon capture and storage.

This indicates the importance of feed-in tariffs to make micro generation financially feasible (see Section 4.1.4).

4.9 Grid Capacity and Constraints

4.9.1 Electricity Transmission and Distribution

Context

Our electricity network is one that has seen many alterations, innovations and expansions since creation over 120 years ago. These changes have been to accommodate the rises and mixed use in demand together with the variety of generation methods used.

Transmission is the 'bulk' movement of electricity at high voltages of 400kV and 275kV, over long distances from the larger power stations to distribution companies. Transmission electricity flows predominately from the north of the UK to the higher electricity demands in the south. The National Grid operates this network (as the Transmission Network Operator – TNO) in England and Wales. The Distribution Network Operators (DNOs) operate the electricity networks that provide the majority of customers with electricity via localised networks operating at 132kV and below.

The distribution network combines electricity from both large and small generating units. The transmission network provides the distribution networks with 'back-up' supply, if required. The distribution network can provide access for generating units with outputs of up to 20MW, which provides opportunity for a whole range of RLCs identified in this study. In terms of generating output connecting to necessary network, the general rule is:

- Up to 300kW output, usually connect to 415V, 6.6kV or 11kV lines
- Up to 7MW output, usually connect to 11kV,33kV or 66kV lines
- Up to 20MW output usually connect to 132kV lines

But in some instances if there is not a capacity issue the DNO may recommend connection to a higher voltage system that is closer to National Grid source, as overall connection costs may be lower.

The increase in RLCs as a generating source has posed challenges to the DNOs and their networks. Adapting the distribution networks is a challenging process, as the current system does not work in a fully networked way. Like a tree, power flows from root to tip, with little interlinking between branches. Ideally the branches would be interlinked, and in essence this is what Distributed Generation (DG) aims to achieve.

Electrical losses are an inevitable consequence of the transfer of energy across electricity distribution networks. On average, approximately 6% of electricity transported across the distribution networks is reported as losses (specific data is unobtainable from the DNOs). Several DNOs have suggested that some networks should be replaced for example 6.6 kV replaced with 11 kV[47], as higher voltages require lower current to transport electricity and therefore a reduction in loss.

Networks face two main challenges, the first is the renewal of ageing grid infrastructure nearing the end of its life (as most was built in the 1950s and 60s close to coal mining regions) and the second is reconfiguration, adapting the existing network to incorporate RLCs. Reconfiguration can be challenging, smaller scale generation can have large voltage fluctuations, faults, reverse power flows and so on: all must be managed to ensure reliability. The UK operates a centralised system by way of reliable, large power stations with economies of scale. But with climate change influenced levies, legislation and regulations a more decentralised system is predicted. This system will encourage better efficiencies, but with an increase in the challenges on the reliability of newer technologies and the distribution networks.

Renewal and reconfiguration, particularly for RLCs comes at a cost. These network operating costs are passed onto consumers, and depending on location, can range from 4% - 17% of

[47] http://www.ofgem.gov.uk/NETWORKS/ELECDIST/POLICY/DISTCHRGS/Documents1/1362-03distlosses.pdf

domestic bills[48]. The Office of Gas and Electricity Markets (Ofgem) regulates these charges, by setting caps on revenues every 5 years called 'Price Control Reviews'. There has been significant investment in ageing networks resulting from unlocking revenue gained from Price Controlling set by Ofgem. Mainly this investment is required to assist with rising demand, but in part, to allow for RLC sources to better access the distribution network. So in theory opportunities for RLC should have improved.

The fourteen regions throughout England, Wales and Scotland, are managed by seven companies (EDF Energy; Central Networks; CE Electric; Western Power Distribution; Electricity North West; Scottish Power; and Scottish and Southern), known as Distributing Network Operators (DNO).

A DNOs role is to:

- connect new customers
- reinforce the network to accommodate changing demand
- inspect and maintain the existing assets
- fix the networks when they go wrong
- refurbish networks to extend their life where appropriate
- replace the assets when end of their life is reached
- improve customer service
- prepare for emergencies
- protect the environment, including the impacts of climate change, and
- enable local generation.

The role of both the TNOs and DNOs is to maintain, operate, and reinforce these electricity networks in line with regulations set by Ofgem and laid down in law; Electricity Supply Act 1989, Utilities Act 2000, Electricity Supply, Quality and Continuity Regulations 2002. There are two DNOs responsible for the distributing networks in the South Pennine area. Yorkshire Electricity Distribution plc (YEDL) owned by CE Electric and Electricity North West Limited (ENW) who owns and through United Utilities, operates and maintains the electricity distribution network.

The Maslen (MEL) team have been in close contact with representatives of the DNOs, and key development agency contacts, including Howard Kirk CE Electric UK, Market Development Manager, Brian Harrison, Terms & Conditions Engineer, United Utilities Electricity Services Ltd (on behalf of ENW) and Geoff Owen, Senior Business Development Manager Grid, Envirolink NW and Jo Adlard Co2sense (formerly FEY) who is 'internal reviewer' on this study. They provided useful information important for this section of the study, including access to maps, data and provided professional experiences of RLC generators connecting to the distributing networks.

Electricity Distribution Network in the Study Area

Yorkshire Electricity Distribution plc (YEDL) and Electricity North West (ENW) DNOs operate a number of networks at varying capacities in the South Pennine study area[49]. Using map data provided by these DNOs, MEL has mapped the extent of these networks; these range from 33KV up to 132KV (See Figure A 16 for reference). Using Figure A 16 as reference, YEDL currently operates 33kV, 66kV and 132kV networks in Calderdale and Kirklees. There is a small 66kV network available in the south east of Kirklees, 66kV networks are uncommon in distribution networks across the UK. ENW currently operates 33kV and 132kV networks in Pendle, Burnley and Rossendale.

[48] Dolan.S POSTnote 2007, p2
[49] http://www.enwltd.co.uk/about.htm

Opportunities for new generation

In general there are no particular grid connection and transmission restrictions on the development of RLCs in the South Pennine area. The DNOs assess each case on its merits, where local issues may arise. The South Pennine area is unlike parts of Cumbria for example which generates a high level of electricity through both renewable and large power stations on the west coast. As a result, the opportunities for new generation in the west are more restricted than elsewhere, as the system is heavily loaded in transporting the existing generation output to the national grid.

Using the Electricity Distribution Network 11kV - 132kV map as reference, conclusions can be drawn as to the transmission and distribution limits on potential RLCs. As each DNO assesses each application on a site by site basis, the main limiting factor is location relative to the network. Table 4-41 highlights the costs associated with upgrading and connecting to the closest network. Essentially the further away from this network the RLC project is, the higher the cost. With this in mind and referencing the 11kV - 132kV map, in general terms the west side of Calderdale, south of Kirklees, and north area of Pendle are limited to no more than 7MW RLC generators, as the closest networks are 33kV. Potential for higher RLC generating capacity is more feasible towards increasingly dense urban areas such as Bradford and Burnley where 132kV networks are available.

Arup (July 2008) commented on RLC generating capacity through ENW networks, as follows:

'In general, ENW considered that the electricity distribution network in the North West "will not be a barrier to connection of renewable electricity generators. However, with a high rate of connections, there may be delays in providing connections and upstream adaptations to the network to comply with engineering standards... When generators trigger the need for network development, they will be charged a proportion of the costs. The unit cost of connection involving work at 132kV and 400kV would be higher than at 33kV or 11kV." The company suggests that the theoretical maximum level of biomass, hydro, landfill and sewerage schemes "can be accommodated by the distribution network in normal project timescales without delaying the project". No comment is made in relation to onshore wind at this time... "

Barriers to RLC Generation

The DNOs role is central to understanding the feasibility of RLC sources connecting to the local distribution networks. RLCs cannot connect to the grid without consulting the network owner - the DNO. The distribution networks often have limited spare connection capacity and may require upgrading or modified to allow connection of an RLC. Therefore the generators can only connect to the distribution network subject to a DNO connection contract. The tasks involved in obtaining connection vary with the size of the generation plant that is being developed: in general, the larger the plant, the more complex the connection requirements. There is an exception for micro-generation projects, also referred to as Small Scale Embedded Generation (SSEG), who are not required to enter into a contract with the DNO. SSEG generators tend not to cause any network connection issues as they are up to 16A per phase: too low to have any serious impact on the network.

Planning to Construction (The Five Phases)

Grid Connection Planning is vital for the success of RLC projects and is sometimes overlooked by the developer. This is a process that requires a high degree of interaction between the developer and the DNO. For larger generators (above 16A per phase), the connection process comprises five key phases: Project Planning, Information, Design, Construction, and Testing & Commissioning phases.

Phase One: Project Planning

The developer formulates its plans for the generation scheme and consults published information, such as DNOs' Long Term Development Statements (LTDSs), to identify the opportunities for the connection of generation to a DNO's network. Within this stage the developer may carry out a Feasibility Study. A Feasibility Study is an 'upfront' cost and will assess possible connection layouts and indicative costs for an RLC project. This can be carried out by the DNO itself or a DNO approved contractor.

Phase Two: Information

The developer submits information about the proposed generating plant to the DNO. The DNO in turn explains the configuration of the distribution network in the vicinity of the proposed connection site and the potential design issues and costs involved in connecting generation at that point. It is difficult to pre-empt exactly what these might be, and therefore vary considerably overtime and from site to site.

Phase Three: Design

The developer submits a formal Connection Application to the DNO (it is possible to jump straight to this stage if technical details are known, this sometimes happens if the generator is experienced and has an approved track record). This application must include:

- Full contact details
- Completed DNO application form
- Proposed development timescale
- Details of existing on-site electricity supply
- Scaled location map/plan
- Proposed Generator characteristics
- Intended operational characteristics e.g. 24/7.

The DNO produces detailed connection designs and costings, and identifies how much of the connection construction work could be carried out by a third party (the Contestable Work) and how much the DNO must undertake itself (the Non-Contestable work).

These costs obviously depend on what the specifications are and where the site is. In general terms the engineer will look at the application on a site by site basis and will consider areas such as:

- Voltage Level Headroom – electrical current allowed on the network.
- Physical sign of assets – current infrastructure in the area, its condition, does it need upgrading.
- Integration with National Grid (NG) – cannot export to NG without an agreement, the RLC generator has an agreement with the DNO and also has an agreement with NG known as a TEC (Transmission Entry Capacity).

This design phase can take up to 90 calendar days for the engineer to process the application[50].

Phase Four: Construction

The developer enters into contracts with the DNO and, if so desired, a third party contractor for the construction of the connection and these parties carry out the necessary physical works.

Phase Five: Testing & Commissioning

The DNO and the developer complete the necessary Connection and Use of System Agreements, the developer tests and commissions the generating plant (noting that the DNO may wish to witness these tests) and the DNO carries out the necessary tests on the connection and 'energises' it, thereby connecting the developer's plant to the distribution network.

Connection Costs and Charges

As soon as the developer involves the DNO it can start to incur charges. For example at the planning phase**,** where a feasibility study is carried out or after the Connection Application (at

[50] Jarrett,K, et al. DTI, Feb 2004

the design phase). In all cases the DNO must offer fair terms for providing suitable connection services for the proposed generation scheme (regulated by Ofgem), and will only cover the DNO's costs.

A United Utilities Electricity Connections Engineer quoted the following indicative prices for the costs of feasibility studies carried out by the DNO; it is clearly dependent on the generating capacity. Up to and including 1MVA = £1,240+VAT, in stages to 40MVA - 100MVA = £16,000+VAT.

Costs of connection infrastructure

The connection cost for a generation scheme depends on the nature and extent of the works to be carried out. The following table provides indicative costs for some of the main elements of this work.

Table 4-41 Indicative costs for Connection Works

Works	Approx. Cost
Cable trenching and reinstatement	
in public highway (tarmac)	£50-£100 per metre
in fields or rough ground	£20-£40 per metre
11kV equipment* (up to 5MW capacity)	
underground cable	£20-£50 per metre
Overhead line	£10-£45 per metre
Switching substation (no transformer)	£15,000-£50,000
33kV equipment* (up to 20MW capacity)	
underground cable	£20-£100 per metre
Overhead line	£20-£55 per metre
Switching substation (no transformer)	£100,000-£250,000
*costs include supply, installation, testing and commissioning, but excludes O&M. 132kV costs vary widely and indicative costs cannot be presented	

For costs such as trenching and cabling it depends greatly on the length of circuit or distance required. The lower unit costs in the table only apply to cases where several kilometres of circuit are needed. Developers should note that these are estimates and relate only to the cost of the infrastructure on the DNO side of the 'point of supply' and is possible that not all of the reinforcement costs will have been included.

In addition to the DNO connection charges (within the five planning to construction phases), there are a number of other charges which developers should be aware of, these can include:

Distribution use-of-system charges – charges vary in accordance with Price Control Reviews carried out by Ofgem.

Top-up and stand-by charges – Top-up supplies cover any routine shortfall between the output of the generator and the on-site demand. Stand-by supplies cover demands in exceptional circumstances such as generator outages or to cover the generator's own auxiliary load during start-up.

Metering and data management charges - Distributed generation is bound by certain metering and data management requirements - the developer must contract services of Meter Operators.

Charges for use of the National Grid transmission system - If NG needs to carry out work on the NG system in order to accommodate the generating plant, connection may be delayed. NG will generally charge their connected customer - the DNO - for the work it carries out. The DNO is likely to pass this cost on to the developer.

After analysis and discussions with the DNOs, it was said that the less experienced generators regularly overlook considerations of how they must connect their generating plant to the distribution network - particularly the 90 day application process time at design phase. It is a complicated process and therefore communication between the developer and DNO is critical, particularly in providing detailed input into the site-level feasibility studies.

4.9.2 Gas Transmission and Distribution

The UK's indigenous gas supply is diminishing. In 2006 the UK became a net gas importer; by 2020 up to 80% of the UK's gas will be imported. The Government believes that increasing the diversity of gas suppliers and supply routes is key to achieving security of supply[51].

Gas in the British Isles is delivered to the seven reception points (called beach terminals) by gas producers operating Offshore Facilities. After treatment and a safety checks it is transported through 275,000km of mains pipeline.

The National Transmission System (NTS) is the high pressure part of the National Grid's transmission system and consists of over than 6,600km of piping transporting gas at high pressures to 40 power stations, large industrial consumers and the twelve Local Distribution Zones (LDZs) that contain pipes operating at lower pressure which eventually supply the consumer. The twelve LDZs are managed within eight gas distribution networks. The South Pennine study area crosses two of the gas distribution networks, including North West LDZ - responsibility of the National Grid and the Yorkshire LDZ responsibility of Northern Gas Networks, who have contracted operational activities to United Utilities Operations.

Gas Distribution Network in the Study Area

Northern Gas Networks (NGN) and the National Grid (NG) operate gas networks in the South Pennine Study area. Data was received free from NGN which allowed MEL to generate maps of Calderdale and Kirklees (Figure A 17), this indicates the extent of NGNs gas distribution network. NG is the operator for the remaining three study areas (Pendle, Burnley and Rossendale); however its system for obtaining gas distribution network data is more difficult. NG data is only available on cd/dvd at a cost of £192.02+vat from GL Industrial Services UK Ltd the broker who requires a formal licence agreement to be signed and returned. Having reviewed and analysed the NGN data set it was found there were a number of failings in its use for this study (see data interpretation below). Therefore having taken a judgement based on costs, potential time delays and benefits to the study, we opted not to apply for the NG data sets.

The Calderdale and Kirklees map clearly show that the gas network coverage correlates with the extent of urban areas. This provides no surprising results, as networks would have been installed/upgraded as new domestic/commercial properties were built. What it does show is where there is no gas distribution coverage at all and a high-level view of which properties are 'off-grid'. The data provided by NGN could not show exactly which properties were off-grid, however assumptions can be made. The table below, although based on a number of assumptions, highlights the number of households within the study area without a gas connection and shows that approximately 5% of households in the study area are without gas. This 5% are typically located in more remote upland areas, and poses potential opportunities for RLC heating technologies such as GSH and biomass heating. Biomass potential capacity is analysed under Section 4.4 of this study.

[51] 2004, Parliamentary Office of Science and Technology POSTnote no. 230, London

Table 4-42 On and off-grid gas connected households

Study Area	A: No. 'on-grid' gas households 2008	B: No. households 2008	C: No. 'off-grid' households 2008	% of households 'off-grid'
Burnley	38,000	40,585	2,585	6
Pendle	37,500	39,665	2,165	5
Rossendale	29,200	30,417	1,217	4
Calderdale	85,300	91,459	6,159	7
Kirklees	168,000	175,400	7,400	4
Total	358,000	377,526	19,526	

Notes:
A: No. of 'on-grid' households 2008 - data obtained from DECC website
B: No. of households 2008 - data obtained from Wastedataflow.org
C: No. of 'off-grid' households 2008 - based on assumption that all households connected to the gas grid (A), minus all households (B), equals the number of households 'off-grid' (C).
This method assumes that only gas is used for heating these households and therefore does not consider the number of households with other forms of heating such as electricity.
The assumption does not take into account commercial premises.

Potential for renewable gas

Currently, renewable gas production in the form of landfill gas and sewage gas represents a well utilised proportion of renewable energy generation in the UK. Approximately 1.4bcm (billion cubic meters) of renewable gas is produced in the UK at present, and could meet around 1% of total UK gas demand, further securing supply. However due to incentives such as the ROC (the Renewable Obligation Scheme), all of this gas is used to generate electricity, with efficiencies of around 30% demonstrated. This is clearly a potential growth area, if the gas was to be injected into the gas grid, this could be delivered straight into consumers' homes and utilised for heating creating efficiency rates in excess of 90%. Despite the urgent need to find alternatives to overseas and North Sea gas supplies (which is almost diminished) the UK has someway to go to make this a reality.

Before renewable gas can be injected into the network, it must be "upgraded" to meet UK gas pipeline specifications. The purpose of this is to remove unwanted gases such as carbon dioxide and hydrogen sulphide to leave an almost pure (~98%) methane gas. This upgraded gas is often termed biomethane. Renewable gas upgraded to biomethane followed by injection into the gas grid is a technology which is already being deployed in many countries in Europe – including Germany, France and Austria[52].

The technology most widely used to produce biomethane is anaerobic digestion (AD). This is discussed more in Section 4.3.11.2. AD is more suited to producing renewable gas from all manner of wet and dry wastes, plus energy crops. The advantage of AD is that it is a well established technology and is already used in most sewage works and waste processing plants in the UK.

The main barrier to capitalising on biomethane injection has been a lack of public sector investment, which has been significantly lacking compared to other RLC technologies, connecting to the electricity networks. It is expected that a new Renewable Heat Policy (RHI) together with a regulatory framework is planned.

Companies like Ecotricity[53] are taking a proactive approach to renewable gas: in November 2009 it committed to plans to offer low carbon biogas for its customers, (the only company in the UK to do so) and also develop the next generation of AD plants using fast-growing algae as a feedstock to release biogas.

In a guidance note produced by DECC titled 'Biomethane into the Gas Network: A Guide for Producers', December 2009, states:

[52]http://www.nationalgrid.com/NR/rdonlyres/9122AEBA-5E50-43CA-81E5 8FD98C2CA4EC/32182/renewablegasWPfinal1.pdf;
[53] http://www.ecotricity.co.uk/about/

"Given the potential for biomethane identified by other EU Member States, we are proposing to work with Gas Transporters (including National Grid and the Gas Distribution Networks) and Ofgem to make a more detailed assessment of the legal, technical and regulatory requirements for flowing biomethane directly into the gas pipe-line system. We will make this document publicly available as a guide for interested parties."

As mentioned there are huge efficiency benefits of using biogas injection into the grid for heating homes. The real payback biogas poses is the offsetting of CO_2 generated by conventional fossil fuel methods. Biogas injection to the gas grid is seemingly a long way off, and although 'biogas to heat' creates high efficiencies, 'biogas to electricity' is still the most feasible. The practicalities of such arrangements using current incentives have there challenges, for example current incentives like ROCs do not allow 'gas injection' then subsequent electricity generation to be claimed. If more suitable incentives were made available then 'biogas to electricity' could go a long way to meeting the UKs renewables targets. In addition biogas does not necessarily have to be injected (after upgrading) into the gas network. It can instead be utilised on-site, in combined heat and power (CHP) units, or in combined cycle gas turbines (CCGT) or upgraded to biomethane and used directly as a vehicle fuel or for the generation of power.

Moving forward the Government intends to provide financial support for renewable heat under a new RHI. It consulted in January 2010 for how biomethane injection into the gas grid could be supported and expects to introduce the RHI by April 2011. .

In summary biomethane in gas networks is well proven, the technology and know-how is available. The feasibility has demonstrated great potential for biomethane in the UK has been well documented in independent and government commissioned studies. The Government is committed to investing in this as a source renewable energy from 2011 onwards and the South Pennine region should prepare and position itself to attract such investment from sources such as RHI.

4.10 Decentralised Generation

Depending upon the level of take-up of micro technologies there may, in the future, be millions of homes with micro-CHP or micro-renewables, all individually generating electricity to sell back into the grid. At the household level this would require smart meters (and connection to the distribution network and balancing and settlement arrangements). This would also pose a huge challenge for controlling the overall supply and demand balance across millions of (chaotic) generators. The current national grid system manages generation (supply) across a relatively small number of generators (numbering hundreds at most), and matches this to demand. This is a workable structure with a proven track record. While it might be possible to achieve a new type of intelligent grid system (i.e. if enough money was available), there inevitably would be a cost penalty: and it is not clear who should pay this (British Energy Group, 2006).

The British Energy Group (2006) suggests that micro-generation offers a security back-up for grid failures. This is not the case because most failures of the public electricity supply arise in local distribution systems, to which micro-generating units would also be connected. Micro-generation must shut down if there is a local grid failure so that repair to the grid can be undertaken (note also that some of the micro-generation systems and some low carbon heating e.g. ground source heating, actually require an external source of grid electricity to run). However, micro-generation has a positive effect on the security of supply in other ways, notably as it contributes electricity at times that can reduce the peak load demands (in the morning and evenings). This could reduce the need for expensive peak load generation in the public electricity supply; though the requirement for base load plant output would remain unaffected.

However, the power output from a number of micro systems, e.g. wind, PV are intermittent, hence they cannot fully provide a replacement to a grid supplied electricity. Overall the British Energy Group study suggested that even with distributed micro-generation there will still be a strong reliance on a centralised grid system.

Most electricity losses occur in the local distribution system (6% in the local system compared to losses in the national transmission system of only 1.5%). Electricity used by a micro-generation unit directly in the home will avoid all national and local transmission losses, but once a system sells electricity back to the local distribution grid, it will be subject to a high level of local distribution losses, as is the case for centrally generated electricity.

4.10.1 Decentralised Generation in Practice

The Merton Rule

The 'Merton Rule' developed and adopted in 2003 is an innovative planning policy, pioneered by the London Borough of Merton. It is focussed on building more sustainable buildings and requires the use of renewable energy onsite to reduce annual carbon dioxide (CO^2) emissions in the built environment. Merton worked closely with other authorities, professionals and industry to embed the Merton Rule.

The policy stipulated that ‘the council will encourage the energy efficient design of buildings and their layout and orientation on site'. All new non-residential development above a threshold of 1000 sqm was expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. All new residential development where 10 or more buildings were constructed, are expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. Its impact was so great that the Mayor of London and many councils have since implemented it e.g. Calderdale MBC (see section 2.1.3); it has also become part of national planning guidance (Companion Guide to PPS22[54]).

The Merton rule has largely been superseded by the Code For Sustainable Homes and now the Feed-in Tariff provides a far greater incentive for developers and home owners to install on-site renewable energy systems.

[54] http://www.communities.gov.uk/publications/planningandbuilding/planningrenewable

On 18 December 2007 changes to the planning system were published requiring all councils to set out rules in their local plans to back on-site renewable energy and local community energy schemes. The new planning rules (PPS Climate Change) expect all councils to put policies in place that will drive locally-distributed energy schemes in their plans.

Woking Borough Council off-grid system case study

Woking Borough Council with a population of less than 90,000 has reduced its CO^2 emissions by 77% since 1990 by decentralising its energy at no extra cost in the long term. Woking has over 60 local generators, including co-generation and tri-generation plant (heating, cooling and electricity), photovoltaic arrays and a hydrogen fuel cell station, to power, heat and cool municipal buildings, social housing and many town centre businesses.

The generators are connected to users via private electricity wires owned and operated by a company set up by the Council. Although ultimately connected to the National Grid the council's electricity infrastructure is 99% self-sufficient. Woking was able to raise capital for energy infrastructure development initially through energy efficiency savings. The substantial financial savings made by reinvesting money saved through energy efficiency measures allowed the council to invest millions in energy supply innovation. The Woking model shows that renewable technologies and co-generation are highly complementary and lend themselves to flexible engineering approaches as finances allow. In 2008, the Council's energy consumption fell by nearly a third from levels measured in 1990, with carbon dioxide emissions down by 29% during the year 2007/08[55].

Gleeson Homes, Sheffield increase property values using PV

A Gleeson Homes Development in Sheffield incorporated renewable energy systems into the design and construction of new build houses. Two identical townhouses were built, one with photovoltaic roof tiles, the other without. The property with the PV tiles sold for 8% more than its neighbour thus showing that the construction/installation costs can be offset by increased market value. The tiles generate 800kwh per annum which is 25% of the yearly household requirement (Case Study from TCPA Policy to Practice Seminar, City Hall, London, 26th July 2006).

'Powering ahead - delivering low carbon energy for London'

In October 2009, London's Mayor launched 'Powering ahead - delivering low carbon energy for London'. This prospectus supports the expansion of the decentralised energy market in London which has set a target to supply a quarter of its energy from decentralised sources by 2025. This will achieve an annual CO^2 reduction of 3.5 million tonnes, representing a tenfold increase in generating capacity and requiring a total of £5-7 billion of investment over the whole programme. The London Heat Map (**www.londonheatmap.org.uk**) is an important resource for this programme, helping to identify decentralised energy opportunities to boroughs, generation companies and developers. The London Development Agency (LDA) has allocated up to £16 million for decentralised energy over the next four years (from 2009/10) to identify and facilitate potential projects and to attract private sector finance on key schemes. With the LDA's support it is expected an additional £64 million will be made available through the JESSICA (Joint European Support for Sustainable Investment in City Areas) fund to unlock the development of decentralised energy in London.

Currently the largest scheme is the London Thames Gateway Heat Network, which will capture heat from Barking Power Station and pump low carbon heat through a district heating network to up to 120,000 homes[56]. Further work is being carried out, through further assessment within the London Thames Gateway, Royal Albert Basin, Crystal Palace Park, South Bank, Olympic Fringe, Kings Cross, Pimlico & Whitehall.

---

[55] **http://www.actoncopenhagen.decc.gov.uk/en/ukaction/business/case-studies/woking-council**
[56] **http://www.lda.gov.uk/server.php?show=nav.00100h00c001**

German concepts to decentralising energy systems

Germany is a world leader in the area and has been promoting the use of decentralised energy supply for a number of years now. Since 2000 Germany has had a foundation set up to solely promote the use of renewable technologies, and it is important to note that they have a dedicated Renewable Energy Sources Act (Erneuerbare Energien Gesetz) and the combined Heat-Power Cogeneration Act (Kraft-Wärme-Kopplungsgesetz)[57].

Using a decentralised energy supply means there is greater efficiency through the use of combined heat and power and use of renewable energies, furthermore skills and expertise continues to grow in this area. Different technologies can also work together: this is evident in the example of the German 'combined renewable energy power plant' that uses 36 wind, solar, biomass and hydraulic plants spread throughout Germany. Through joint control of small and decentralised plants, it is possible to provide a reliable source of electricity to meet requirements.

The objective of this type of combined approach is to combine and benefit from the advantages associated with various renewable energies. The volume of electricity generated by wind turbines and solar heating systems depends on how much wind and sun is available, biogas power plants and hydraulic turbines are used to supply energy at times of peak demand. With a sophisticated control strategy, it is possible to achieve a fully decentralised energy supply through renewable energy alone. This is clearly an innovative project concept but demonstrates the UK is behind in its thinking compared to some of our European counterparts.

[57] **http://www.efficiency-from-germany.info/EIE/Navigation/EN/Technologies/industry,did=254280.html**

5. Site Specific Case Study Assessments and Visualisations

5.1 Selection of Case Study Sites

To develop greater understanding of the potential impact from the setting of onsite renewable energy generation targets in local development planning policy, five case studies have been produced which look at the additional development cost of installing onsite renewable and low carbon energy technologies compared against the indicative 'normal' cost of the development (see Appendix C).

Five case study sites were selected from current and recently permitted applications in consultation with the Partnership and respective planning officers. Case study sites were selected to help examine the potential effects on the financial viability of site development across a broad range of different types and scales of development.

Case study sites were selected as follows:-

- **Large commercial/industrial** - Burnley Bridge Business Park - Large commercial development site of strategic importance adjacent to motorway network located in the Burnley Authority area. Outline planning permission granted for a mix of uses including commercial, offices, hotel and associated uses. The proposal also includes 94 new homes.
- **Mixed use/office** - Rising Bridge Business and Enterprise Village - Development of 9 office units in an urban/rural fringe location located in the Rossendale Authority Area. At the time of this report the development was being constructed.
- **Site adjacent to watercourse** - Mill Stream Drive - Residential development site situated adjacent to a beck in a rural town location in the Calderdale Authority Area. Phase 2 of the scheme was being built at the time of this study.
- **Medium residential** - Clovercroft - Residential development of 33 properties situated in the conservation area in the rural village of Higham located within the Pendle Authority Area. The development was being constructed at the time of this report.
- **Small residential** - The Maltings - Development of 14 detached properties on the residential edge of Shepley in the Kirklees Authority area completed in 2007/8.

Each selected case study site was visited and its planning history reviewed. The estimated energy consumption of each site was calculated from published benchmark figures for commercial and residential development. 10% and 20% onsite renewable energy targets were then derived from the estimated energy consumption figures for each development type.

Working with Bracken Developments (Leeds) indicative costings were produced for each development to enable the impact of the extra over cost of installing renewable technologies to be assessed balanced against the budget build cost of the development to current building regulation standards.

5.2 Impacts for Financial Viability of sites

The increase in development costs arising from a potential policy requirement to install RLC technologies to meet a proportion of a site's energy requirements are broadly similar across the developments in proportion to the scale of the development except where hydropower is proposed on a site adjacent to a watercourse.

The additional costs can vary considerably on an individual site depending on the technology choices made. The estimated additional costs of the selected case study sites are as follows:-

- **Large commercial/industrial**

  Commercial development build cost – £39.4m - Percentage cost increase 2.5%-13%

Residential development build cost – £7.2m - Percentage cost increase 7%-12%

- **Mixed use/office**
  Development build cost – £2.8m - Percentage cost increase 1%-7%
- **Site adjacent to watercourse**
  Development build cost – £2m-£2.5m - Percentage cost increase 12%-31%
- **Medium residential**
  Development build cost – £2m-£2.5m - Percentage cost increase 4%-6%
- **Small residential**
  Development build cost – £1m-£1.2m - Percentage cost increase 3%-5%

The additional development costs could be construed as a significant barrier to development. However when long term financial revenues from the Renewable Obligation Certificate, Feed in Tariff or the Renewable Heat Incentive schemes are taken into consideration the potential long term guaranteed returns could act as an incentive to developers. This will require developers to alter the way they cost and manage developments, particularly residential schemes where quick turnover of sites and low profit margins are common practice.

Technicalities of installing RLC technologies on site

When developer's purchase land or take an option to develop a plot of land they calculate the value of that land as follows:-

Residual land value = Final development value (value of residential property sales or revenue from commercial/industrial unit leases) minus cost of abnormals minus overheads and profit minus extra over cost of meeting design codes.

Abnormals are special cost items required to make a development buildable. These could include the cost of new traffic junctions, bridges (e.g. New bridge over canal at Burnley Bridge Business Park), dealing with contaminated land etc. Abnormal development costs add a premium to the development cost and in turn reduce the value of the land.

Design codes such as the Code for Sustainable Homes, BREEAM add additional cost to the development. These are set to become increasing stringent in terms of efficiency and RLC generation. Installing renewable and low carbon energy technologies on site will be viewed as an additional 'abnormal' cost.

Faber Maunsell's study "Integrating renewable energy into new developments: Toolkit for planners, developers and consultants" supports this view.[58]

Whether or not the abnormal cost of installing RLC technologies on a development acts as a barrier to development depends upon when the developer knows they are required by policy to implement these measures.

If a developer is aware of an onsite renewable requirement prior to purchasing or taking an option on a piece of land then the abnormal cost will be taken into consideration in the calculation of the land value.

If a developer is told to meet a renewable target on a site part way through a phased development, or on sites where the sale of the land has already been negotiated the extra over cost of installing renewable technologies may act as a barrier to that development or a significant financial burden. However this will depend on a number of factors such as whether the build cost has increased since the land was purchased and whether the land value has also increased or remained static.

The geographic location of development will also be an important factor when meeting renewable energy targets. In some areas onsite renewables could be an added incentive for buyers/tenants who may be attracted by a development's 'green credentials' and be willing to pay a premium as a result. In such situations the developer may be able to pass the cost of

[58] London Renewables. Integrating renewable energy into new developments: Toolkit for planners, developers and consultants. Faber Maunsell September 2004.

onsite renewables (or a proportion of it) directly on to the purchaser or leasee of a property (per comms Bracken Developments). However in areas of multiple deprivation this is unlikely to be possible and the cost is likely be borne by the developer and therefore may ultimately affect the land value and the regeneration of these areas.

There are many questions about the technicalities of how renewable technologies are installed on sites; particularly residential sites. Who owns the equipment? Who is responsible for its upkeep? Who benefits from it? These questions need answering at the masterplanning stage of a development and certainly prior to the planning submission stage. This is essential so that there is a measurable system put in place that local authorities can monitor to ensure that renewable targets are being met.

Mechanisms need to be put in place to manage the operation and maintenance of renewable technologies and manage the long term financial obligations such as the distribution of revenue back to householders or shareholders and bank loan repayments.

There are many examples of different ways of achieving these objectives. For example, at Settle in North Yorkshire where an 'Industrial and Provident Society for the Benefit of the Community' was established with the specific purpose of owning the Settle Weir Hydro Electric Scheme[59]. The Society generates revenue by selling 'green' hydro-electricity and through money earned through the Feed in Tariff Scheme. Revenue is used for loan repayments with surplus revenue used for the benefit of the local community to promote environmental sustainability and regenerate the local economy.

An alternative method of managing the long term responsibilities of onsite renewables is through an Energy Service Company (ESCO). These are Special Project Vehicles established to implement and manage community renewable schemes. ESCOs can have wide ranging responsibilities such as design and implementation of renewable energy projects, energy conservation, energy infrastructure selection, power generation and energy supply, and financial and risk management including distribution of revenues. Developers may wish to establish an ESCO for each of their developments or alternatively contract with an established ESCO to manage the site or all their sites for them.

If changes to planning policy require a percentage of a development's energy requirements to be met through onsite renewables, then a step change will be required in the way development is approached and managed by developers and also in how the planning application process and planning policy at the local authority level is managed so that renewables are monitored.

It is essential that renewables at the site scale are viewed by developers and planners as an essential part of a site's infrastructure and that the implementation of renewable targets is achieved collectively on a site in its entirety not on a piecemeal unit by unit basis (per comms Bracken Developments). It is the adoption of this holistic development approach that will ultimately determine whether onsite renewables development policies are a barrier or an incentive to development.

5.3 Visualisations

The implementation of renewable energy targets could potentially lead to widespread change to the visual amenity and landscape character. To promote discussion about this change three visualisations locations were selected to illustrate the potential change in the landscape in sensitive areas chosen as follows:-

- Location of strategic importance – Carrs Industrial Estate. Existing commercial development situated adjacent to the motorway network potentially visible from a wide area.
- Conservation area – Nelson - Terraced housing area adjacent to a conservation area.

[59] **http://www.greensettle.org.uk/hydro/index.html**

- Urban/Rural upland fringe – Blackshaw Head. Area with potential for widespread small scale wind development.

The visualisations can be found in Appendix C.

6. Code for Sustainable Homes

The Code for Sustainable Homes (CSH) is an environmental assessment method for rating and certifying the performance of new homes. It is a national standard for use in the design and construction of new homes with a view to encouraging continuous improvement in sustainable home design and building. The CSH was launched in December 2006 and became operational in April 2007 in England as a voluntary standard.

The CSH uses a one to six star rating system to communicate the overall sustainability performance of a new home. CSH level 1 represents a small improvement on minimum regulatory standards while CSH level 6 is an extremely challenging and exemplary standard. The CSH replaces the EcoHomes scheme developed by the Building Research Establishment (BRE).

From 1st May 2008 it became mandatory to have a CSH rating for all new build homes however a developer can elect not to carry out an assessment and a zero-rating certificate can be supplied which states that the homes was designed and built to current Building Regulations. This mandatory requirement came into effect for all developments where a local authority received the building notice, initial notice or full plans application after 1st May 2008. Developments where a local authority had received these stages on or before 30 April 2008 are exempt.[60]

The CSH complements the system of Energy Performance Certificates for new homes, which were introduced in April 2008 under the Energy Performance of Buildings Directive (EPBD). Where an assessment is carried out, the CSH also gives new homebuyers better information about the environmental impact of their new home and its potential running costs.

The CSH measures the sustainability of a home against nine design categories, rating the 'whole home' as a complete package. The design categories are:

- Energy and CO2 Emissions,
- Pollution,
- Water,
- Heath and Wellbeing,
- Materials,
- Management,
- Surface Water Run-off,
- Ecology,
- Waste.

Within each of the above nine design categories there a number of environmental issues which have a potential impact on the environment. The issues can be assessed against a stated performance target and awarded one or more credits. Performance targets are more demanding than the minimum standard needed to satisfy Building Regulations or other legislation.

The CSH is only applicable to new build homes and is not suitable for assessing the performance of refurbished or converted buildings. It is important to note that the CSH is specific to individual dwellings and not the overall development. Where a development consists of multiple different types of dwellings and the developer is aiming to achieve a rating against the CSH each different dwelling type must be assessed against the CSH.

The CSH sets minimum performance standards for some environmental issues. A single mandatory requirement is set for four of these environmental issues which must be met whatever CSH level rating is sought. No credits are awarded for these mandatory

[60] Code for Sustainable Homes Technical Guide Version 2, Department for Communities and Local Government, May 2009

requirements. Confirmation that the performance requirements are met for all four is the minimum requirement for achieving a CSH level 1 rating. The four un-credited issues are:

- Environmental impacts of materials,
- Management of Surface Water Runoff from developments,
- Storage of non-recyclable waste and recyclable household waste,
- Construction site waste management.

If these minimum performance standards are met for the four above compulsory issues, three further mandatory issues need to be considered. For two of these, credits are awarded for every level of achievement recognised within the CSH, with performance standards progressively increasing for each of the six CSH levels.

The two categories with increasing performance standards are:

- Dwelling emission rate (DER),
- Indoor water use.

The final issue required for Level 6 of the CSH is:

- Lifetime Homes[61].

Renewable technologies, termed Low or Zero Carbon technologies (LZC) within the CSH are considered within the Energy and CO2 Emissions design category and are not a compulsory requirement in their own right. A developer may choose to meet the DER for the CSH level they are pursuing through careful design and specification. It is only at the higher CSH levels that it becomes increasingly likely that a developer will have to make use of some form of LZC technology to meet the increasingly challenging DERs. A total of two credits are available where energy is supplied from local renewable or low carbon energy sources funded under the Low Carbon Building Programme (or similar), or is designed and installed in a manner endorsed by a feasibility study prepared by an independent energy specialist.

Where a developer opts to install renewable and low carbon technologies on a site, one credit is awarded where there is a 10% reduction and two credits are awarded where there is a 15% reduction in the carbon emissions of the dwelling resulting from the use of renewable and low carbon technologies.

The number of credits awarded for LZC technologies together with the number of credits awarded for the other environmental issues considered within the Energy and CO2 Emissions design category are added together and divided by the total number of credits available for that section and a weighting factor applied to give a percentage score. This is then added to the percentage scores from the other design categories to give an overall percentage score. The overall score is then converted to a CSH rating.

6.1 Code for Sustainable Homes - Cost Analysis

Following the launch of the Code the Government has commissioned three cost reviews to study the extra-over cost of building to each CSH level. In 2007 the first cost analysis[62] was carried out and subsequently reviewed in 2008 following publication of the CSH Technical Guidance[63] and a revised 'Green Guide to Specification'[64].

The aim of the cost analysis was to update previous cost analysis work of building to the Code[65] and:

---

[61] See **http://www.lifetimehomes.org.uk/** for further details
[62] 'A cost review of the Code for Sustainable Homes', English Partnerships and the Housing Corporation, February 2007
[63] Code for Sustainable Homes Technical Guide, Department for Communities and Local Government, October 2008
[64] 'The Green Guide to Specification', Jane Anderson, David Shiers and Kristian Steele, BREPress, 2009
[65] Cost Analysis of the Code for Sustainable Homes Final Report, Department for Communities and Local Government, July 2008

- Provide greater confidence in the analysis of the cost implications of achieving the energy standards in CSH levels 4, 5 and 6
- Provide analysis of the overall cost implications of achieving CSH level 6
- Assess the potential for reductions in the cost of meeting different CSH levels arising from increased uptake of the key technologies
- Provide overarching cost information on achieving each level of the CSH together with a semi-quantitative evaluation of likely trends in cost

The costs implications of meeting each CSH level are presented in comparison to the baseline build costs of a home constructed to 2006 Building Regulations.

Costs are presented for four different house types; Detached, semi-detached/end-terrace, terrace and flat across four generic development scenarios; Small-scale, city infill, market town and urban regeneration.

The analysis found that the costs of achieving the higher code levels can vary quite substantially as a result of dwelling type, development type and site characteristics (e.g. ecological value and flood risk). The range in per dwelling cost estimates varies from £19k to £47k per unit with lower costs typically seen for developments where there is potential for site wide carbon saving technologies (e.g. CHP systems) more likely to be feasible on sites with higher numbers of densities of development.

Further research in 2009, published in March 2010[66] updated previous cost data. The revised cost analysis considers the same dwelling types and an extended range of development scenarios.

Baseline build costs for the dwelling types are as follows:-

Table 6-1- Baseline build costs for the dwelling types

Dwelling type	Gross Floor area (m^2)	Total Capital Cost (£)	Cost (£/m^2)
2 bed mid-floor flat	61	£59,725	£980
2 bed mid-terraced	73	£86,470	£1,185
3 bed semi-detached	88	£93,940	£1,070
4 bed detached	118	£99,975	£850

Note
1. Source: Code for Sustainable Homes: A Cost Review. Department for Communities and Local Government, March 2010
2. Costs exclude VAT, professional fees and any abnormal costs/foundation costs such as piling works.
3. The costs are comparable with costs used in Section 5 - Site Specific Case Study Assessments.

[66] Code for Sustainable Homes: A Cost Review. Department for Communities and Local Government, March 2010

Table 6-2 Summary of extra-over costs of building to each level of the Code in each of the dwelling types and for a range of development scenarios.

Code Level	2 bed Flat		2 bed Terrace		3 bed Semi		4 bed Detached	
	E/O Cost	%	E/O Cost	%	E/O Cost	%	E/O Cost	%
Small brownfield (20 dwellings at 80 dwellings/hectare)								
1	£310	0.5%	£230	0.3%	£360	0.4%	£310	0.3%
2	£1,670	2.8%	£1,620	1.9%	£1,040	1.1%	£970	1.0%
3	£2,460	4.1%	£2,420	2.8%	£3,020	3.2%	£2,680	2.7%
4	£5,610	9.4%	£7,360	8.5%	£8,140	8.7%	£6,030	6.0%
5	£17,740	29.7%	£24,370	28.2%	£26,830	28.6%	£30,130	30.1%
6	£28,510	47.7%	£34,810	40.3%	£38,730	41.2%	£42,770	42.8%
Medium urban (350 dwellings at 80 dwellings/hectare)								
1	£260	0.4%	£170	0.2%	£260	0.3%	£270	0.3%
2	£1,560	2.6%	£1,500	1.7%	£890	0.9%	£810	0.8%
3	£2,340	3.9%	£2,000	2.3%	£2,900	3.1%	£2,510	2.5%
4	£5,440	9.1%	£7,190	8.3%	£7,970	8.5%	£5,860	5.9%
5	£17,570	29.4%	£24,200	28.0%	£26,650	28.4%	£29,960	30.0%
6	£19,580	32.8%	£26,550	30.7%	£28,390	30.2%	£31,230	31.2%
Large Urban (3600 dwellings at 80 dwellings/hectare)								
1	£250	0.4%	£160	0.2%	£250	0.3%	£260	0.3%
2	£1,550	2.6%	£1,490	1.7%	£890	0.9%	£810	0.8%
3	£2,340	3.9%	£2,000	2.3%	£2,890	3.1%	£2,510	2.5%
4	£6,360	10.6%	£6,200	7.2%	£6,580	7.0%	£6,470	6.5%
5	£16,640	27.9%	£23,210	26.8%	£25,580	27.2%	£28,790	28.8%
6	£23,210	38.9%	£29,920	34.6%	£32,390	34.5%	£36,040	36.0%
Small greenfield (10 dwellings at 40 dwellings/hectare)								
1	£320	0.5%	£230	0.3%	£330	0.4%	£320	0.3%
2	£1,620	2.7%	£1,560	1.8%	£990	1.1%	£880	0.9%
3	£2,160	3.6%	£2,120	2.5%	£2,720	2.9%	£2,380	2.4%
4	£5,350	9.0%	£7,150	8.3%	£7,860	8.4%	£6,910	6.9%
5	£17,310	29.0%	£26,970	31.2%	£29,260	31.1%	£32,270	32.3%
6	£27,650	46.3%	£37,400	43.3%	£40,800	43.4%	£45,230	45.2%
Medium edge of town (650 dwellings at 40 dwellings/hectare)								
1	£270	0.5%	£190	0.2%	£370	0.4%	£290	0.3%
2	£1,550	2.6%	£1,500	1.7%	£920	1.0%	£810	0.8%
3	£2,090	3.5%	£2,050	2.4%	£2,650	2.8%	£2,310	2.3%
4	£5,280	8.8%	£7,080	8.2%	£7,800	8.3%	£6,840	6.8%
5	£17,240	28.9%	£26,900	31.1%	£29,190	31.1%	£32,200	32.2%
6	£24,080	40.3%	£31,250	36.1%	£33,090	35.2%	£36,180	36.2%
Large edge of town (3300 dwellings at 40 dwellings/hectare)								
1	£270	0.5%	£180	0.2%	£370	0.4%	£290	0.3%
2	£1,550	2.6%	£1,490	1.7%	£920	1.0%	£810	0.8%
3	£2,090	3.5%	£2,050	2.4%	£2,640	2.8%	£2,310	2.3%
4	£5,280	8.8%	£7,080	8.2%	£7,790	8.3%	£6,830	6.8%
5	£17,230	28.8%	£26,890	31.1%	£29,190	31.1%	£32,200	32.2%
6	£27,710	46.4%	£34,620	40.0%	£37,090	39.5%	£40,990	41.0%

Notes
Source: Code for Sustainable Homes: A Cost Review. Department for Communities and Local Government, March 2010
E/O costs = Extra-over costs

The study found that there is significant variation in the extra-over costs of building to each CSH level across the dwelling types and development scenarios considered. Typically, however, the extra-over costs expressed as a percentage of base build cost are:

- Code level 1 - <1%
- Code level 2 - 1 to 2%
- Code level 3 - 3 to 4%
- Code level 4 - 6 to 8%

- Code level 5 - 25 to 30%
- Code level 6 - 30 to 45%

The study highlighted that *"the most critical factor in determining the total cost of building to the Code is the approach taken to meeting the mandatory reduction in carbon emissions. At the lower Code levels (up to Code level 3) fabric improvement measures may be sufficient to achieve the required reduction in Dwelling Emission Rate (note that calculation of Dwelling Emissions Rates have been performed using SAP 2005). However, from Code level 4 and above it becomes necessary to employ some form of low or zero carbon technology to meet some or all of the dwelling's thermal and / or electrical demands. These costs tend to dominate the overall expense of meeting a given Code level for all dwelling types."*

The study goes on to state that the variation in cost of building to the different Code levels across the development scenarios considered *"is largely a result of the variation in energy strategy costs, which can be dependent on the development's scale and density. This is particularly the case when the energy strategy is based around some common, site-wide infrastructure, such as a district heating system. Furthermore, development scale and / or density may restrict the technology options available. For example an attractive means of meeting the very high DER reductions required at Code Levels 5 and 6 can be to utilise a biomass CHP system connected to a district heating network but, due to current limitations on technology availability, a large heat load (i.e. a significant scale development) is required for this strategy to be available. Limited availability of biomass CHP technology at smaller scales and the constraints on installation of medium to large-scale wind turbines in many development sites mean that the Code Level 6 energy strategy is very challenging."*

6.2 Driving change

At present a variety of different approaches are being used to drive on-site renewable energy generation and CO2 emission reductions. Building Regulations set the minimum legal standards for domestic and non-domestic construction in the UK. Part L (Conservation of Fuel and Power) deals specifically with energy consumption, regulating areas such as air-tightness, solar gains, and energy for heating, lighting and ventilation. Approved Documents for Part L were last revised by amendments that came into effect on 6 April 2006 introducing [67]new energy performance requirements amongst other things. New Approved Documents (L1A, L1B, L2a, and L2B) will replace the current editions on 1 October 2010. These building regulations will require a reduction in a dwelling's emissions by 25% compared to 2006 building regulations, which is equivalent to Code Level 3 (Energy Savings Trust pers. comm.).

The 'Merton Rule', named after one of the first London Boroughs to implement a planning requirement that all major developments use on-site renewable energy generation to supply 10 per cent of their energy requirements. Since Merton, about 80 local authorities have implemented similar policies, with a further 70 or so expressing an intention to do so, supported by PPSs 1 & 22 which enable Local Authorities to set 'Merton Rule' style policies in their local development documents. However, the draft consultation PPS Planning for a Low Carbon Future in a Changing Climate states that changes to planning regulations are likely to make the setting of authority wide targets for decentralised energy supply to development will become unnecessary in the future.

BREEAM (BRE Environmental Assessment Method) is an environmental performance standard that has encouraged better non-domestic building performance standards. English Partnerships require BREEAM assessments for projects they fund and English Central Government has requirements for BREEAM assessments for its estate.

The introduction of RLC energy policies into local planning policy needs careful consideration in order to select the best approach. For domestic buildings the introduction of a compulsory CSH rating for all new build homes e.g. Code level 3 may result in developers meeting the

[67] http://www.communities.gov.uk/documents/planningandbuilding/pdf/1499780.pdf

reduction in DERs through improved design and material specification without renewables being installed on sites; a view supported by the Code cost review. Setting a mandatory CSH Level 4 standard and above is likely to mean that developers will have to use some form of RLC technology to achieve the required DER reduction. This may have an impact on development in areas where sale values cannot support the increased build cost as indicated through the case studies.

In April 2010 BREGlobal published "Using BREEAM and the Code for Sustainable Homes within local planning policy"[68] which provides guidance to LPAs introducing Code and BREEAM minimum standard ratings into local planning policy and stipulating specific code and BREEAM credits.

In the 2008 Budget the Government pledged that from 2019 every new non-domestic building will be zero carbon[69]. In November 2009 the Government consulted for a second time on its policy options for zero carbon new non-domestic buildings[70]. The consultation closed in February 2010 and a formal response has not been published yet. It is likely that the framework used for the Code for Sustainable Homes will be adopted and appropriately amended for use with non-domestic buildings to reflect the much wider variety of building types, the often more complex nature of non-domestic buildings compared to domestic buildings and the potential greater potential for on-site renewables e.g. more roof space).

The five case study sites considered within this study looked at the additional extra over cost of meeting a proportion of the site's energy requirements through installing RLC technologies; A 'Merton Rule style approach'. The percentage additional costs of installing RLC technologies estimated in the case studies are broadly inline with the extra over costs for building to Code Level 3 to 4 estimated in the Code cost review[71].

In order to achieve the Government's aim of new homes being zero carbon by 2016 and new commercial buildings by 2019 planning policies need to be introduced that take progressive steps towards achieving these goals. The announcement on 27/07/2010[72] by the Housing Minister outlining the intention to introduce a new community energy fund will give local authorities and developers a simplified way to meet increasingly challenging eco-standards. The fund will allow developers to pay into a community energy fund which Councils can use to support community energy schemes such as district heating and wind farms.

[68] "Using BREEAM and the Code for Sustainable Homes within local planning policy", BREGlobal. April 2010
[69] http://www.direct.gov.uk/en/Nl1/Newsroom/Budget2008/DG_073094
[70] Zero carbon for new non-domestic buildings. Consultation on policy options. Department for Communities and Local Government, November 2009
[71] Code for Sustainable Homes: A Cost Review. Department for Communities and Local Government, March 2010
[72] http://www.communities.gov.uk/newsstories/housing/1652701

7. Scenarios and RLC Potential

7.1 Introduction

The following Section considers three future scenarios involving the uptake of RLC across the Partnership Area. Each of the Council areas is considered individually and scenarios are based upon the potential to support RLC technologies in each. This ability or potential for each studied technology has been identified earlier in Chapter 4.

The three scenarios used in this Section consider RLC provision as a:

- High renewable energy uptake scenario
- Medium renewable energy uptake scenario
- Low renewable energy uptake – business as usual scenario

The approach considers overall renewable energy generation requirements for each scenario and the contributions that each technology can make to this.

This Section also considers notional indicative targets for each of the partner Councils based upon existing consumption patterns and national targets set out in the UK Renewable Energy Strategy. The scenario approach provides a way to consider how far each Authority might need to further promote renewable based energy generation to meet any such notional targets.

This Section of the report starts with examining where each Authority is currently positioned relative to notional targets derived from national targets.

7.2 Baseline Energy Assessment - Electricity

The current electricity consumption within the Partnership Area and existing renewable electricity generation are shown in the following table.

Table 7-1 Existing Electricity Consumption and Renewable Generation

Council	Electricity Consumed (MW)[1]	Renewable (installed and consented) Electricity Generation (MW)[2,3]	Notes
Burnley	42.3	5.396	
Calderdale	103	7.26	Includes 5 of the 12 turbines Crook Hill Wind Farm (i.e. the ones planned for Calderdale)
Kirklees	187.3	20.196	Includes Syngenta CHP (elec part) 10.24MW
Pendle	44.6	0.1	
Rossendale	42.9	10.77	Includes Reaps Moss Wind Farm
Totals	420.1	42.95	

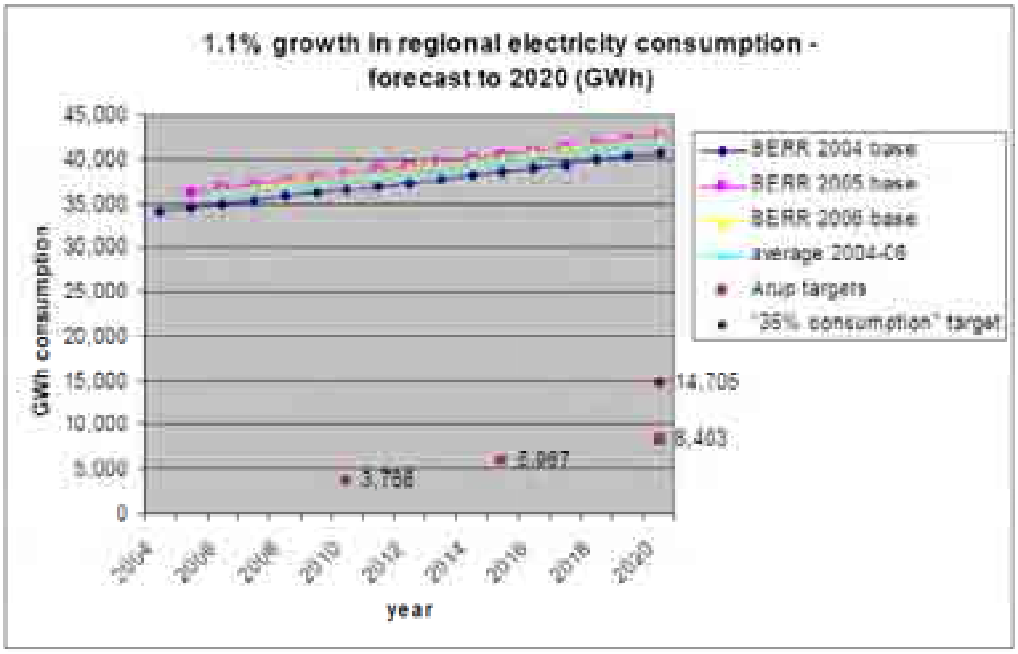
Notes
1. Electricity consumption figures from 2007 DECC Consumption statistics.
2. Renewable Energy generation stats - the DECC figures for 2007 are very low. So additional significant installations that we are aware of have been included in the renewable energy stats - see Appendix B and A.2 for more information. These include Scout Moor and other consented installations (which may not have started generating). The figures include CHP in Kirklees of 10.24MW.
3. These figure account for a capacity factor appropriate to each technology see section 2.2.3 and 7.7 for further details.
These figures do not include very small micro generators below 0.25MW.

The figures illustrate the spread of renewable electricity generation across the council areas and that Pendle's contribution to that consumed is low.

Growth in Electricity Consumption

The National Grid in its 'Seven Year Statement' in 2006 provides a summary of the projected electricity demand across the country over the period to 2012/13. Overall total annual electricity demand in Great Britain is projected to rise by 1.1% per annum over the period 2005/6 to 2012/13. This projected increase takes account of energy efficiency measures being implemented.

Figure 7-1 1.1% Growth in Regional Electricity Consumption forecast to 2020 (from Arup, 2008)



Arup (2008) in their North West Region Capacity Study used this rate of increase to predict future consumption rates for the region (Figure 7-1) (The figures shown as 'Arup targets' relate to 10%, 15% and 20% of annual consumption figures for 2010, 2015, and 2020 respectively).

The projections show that despite policy support and other incentives and mechanisms promoting improved energy efficiency for homes and in the commercial sector, electricity consumption is likely to rise.

National Policy Statement Energy-1 (NPS EN-1, 2009) states that whilst there are policies to reduce certain electricity demands in certain sectors, the savings are likely to be limited and offset by increases in other areas. This is because:

- As part of the move to a low carbon energy economy, more of the energy for heating and travel could come from electricity. Developments such as an increased reliance on electric heating and electric vehicles may increase the demand for electricity. The Low Carbon Transition Plan suggested that it was possible that demand for electricity could be 50% higher than current levels between 2030 and 2050 as a result of electrifying much of the UK's transport and heating;
- The commercial and lifestyle changes that businesses and people are willing to make, including the scale of change people are prepared to see in the way their homes look and are built, may also limit the scope for demand reductions;
- Growth in the number of households will be a key driver of electricity demand in the residential sector.

In summary when considering notional targets for renewable electricity generation, targets should take into account forecasts that indicate that consumption is likely to rise.

7.3 National Targets and Scenarios

The UK Renewable Energy Strategy (HM Government, 2009) states that:

- 15% of the UK energy must come from renewable sources by 2020 (EU commitment - equivalent to seven times the UK 2008 value). This figure will be split between heat, electricity and transport energy uses.
- Scenario modelling developed in the Strategy suggests that more than 30% of electricity energy could be generated from renewables (up from 5.5% in 2009) with much of this coming from wind power (with a significant proportion located off-shore), but also some biomass and hydro power. Around 2% of electricity is anticipated to come from micro generation - which would include solar PV. **This 30% lead scenario 'target' is used later in Local Authority notional target setting in this study.**
- Scenario modelling developed in the Strategy suggests 12% of heat could be generated from renewable and low carbon sources, up from the very low current levels. This would be expected to come from a range of biomass, biogas, solar and heat pump sources. **This 12% lead scenario 'target' is used later in Local Authority notional target setting in this study.**

7.4 Regional Targets

Since the recent revocation of the Regional Spatial Strategies, there are currently no standing regional and sub-regional targets for renewable energy generation. Studies produced by regional development authorities can still be used as part of a regional evidence base to inform local policies; this includes the Yorkshire and Humber RLC Energy Capacity Study which was commissioned in 2010.

7.5 Notional Local Targets for Renewable Electricity Generation

The study has developed notional or indicative local targets based on projections for 2020 electricity consumption and considered a 30% generation target for each council. Electricity consumption levels in 2007 (DECC website) were used as a baseline and the 1.1%pa growth rate for the North West projected consumption levels in the five councils up to 2020 (see Figure 7-1). This Study considers that the 30% target provides a likely upper limit on any immediate future targeting.

Figure 7-2: Council Electricity Consumption Projections until 2020

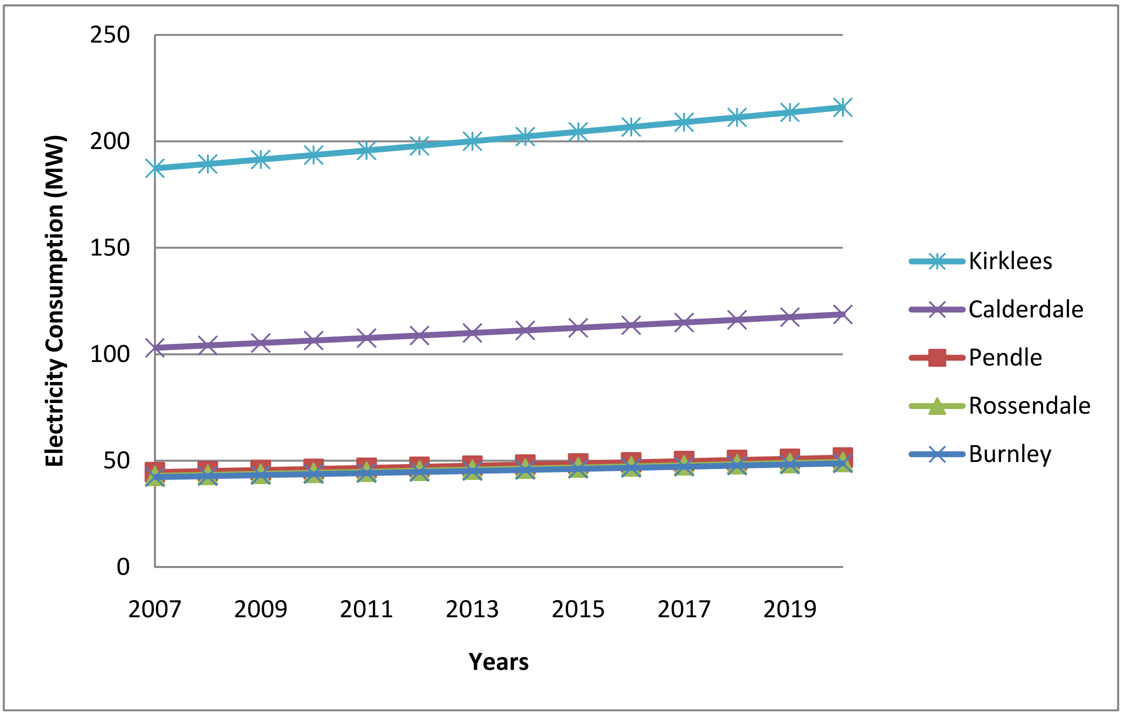


Table 7-2: Projected Electricity Consumption and derived Notional 2020 Target (MW)

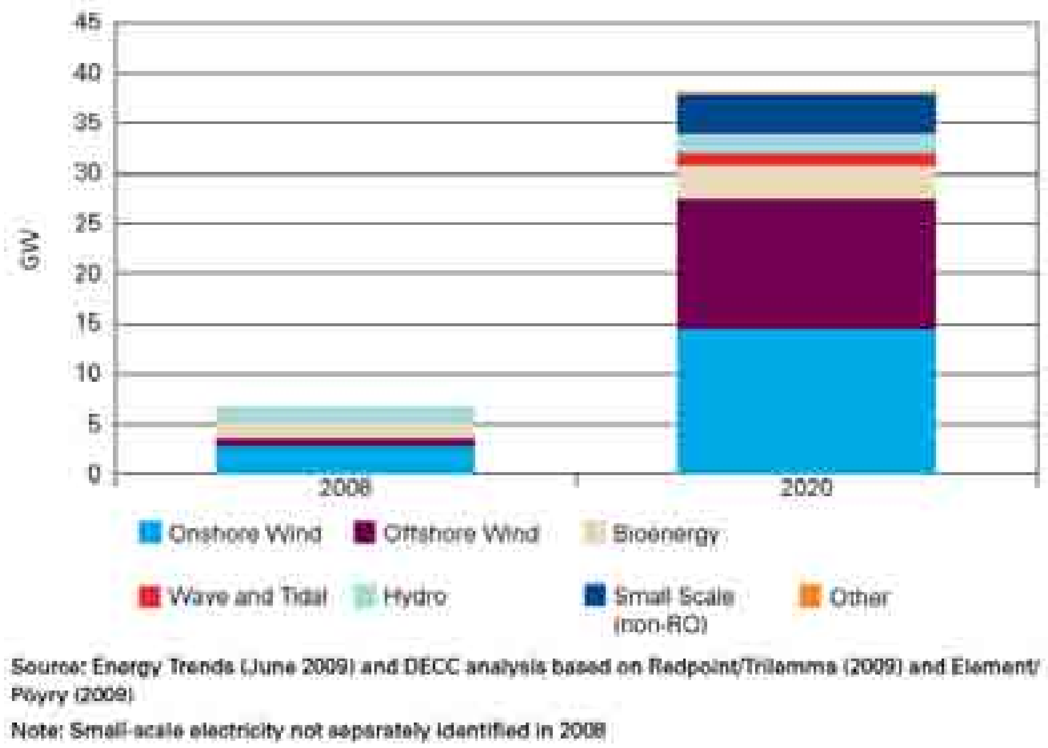
Council	2007 Electricity Consumption (MW)	2020 Projected Electricity Consumption (MW)	30% 2020 Electricity Generation Target (MW)
Burnley	42.3	48.7	14.6
Pendle	44.6	51.4	15.4
Rossendale	42.9	49.4	14.8
Calderdale	103.0	118.7	35.6
Kirklees	187.3	216.0	64.8

Under the 30% national lead scenario electricity generation target, a high proportion of the total generation is expected to come from off-shore wind (see Figure 7-3) (DECC, 2009). In the North West region, it is expected that to meet the 30% target, 13% of electricity demand will be met by off-shore wind and 17% of demand by on-shore technologies (4NW unpublished study). A similar split might be envisaged for Yorkshire and Humber. This means that across the North West (and Yorkshire and Humber) local authority targets might be set as low as 17% of demand. However, it is likely if/when Local Authority RLC targets are set, that a number of councils within the South Pennines area will have a higher target than 17% of their local demand for three reasons;

- Relative to other areas, there is a large potential for wind technology; and local authority targets might have to take into account local potential for technologies,
- Consumption levels in a number of the local authorities are relatively low due to low population densities; however these councils may be required to respond to their potential and support areas of higher consumption.
- Off-shore contributions to achieving targets may not be divided between all the authorities in a regional area.

This study has taken the 30% national figure as a likely upper limit for setting notional local authority scale targets as this is a robust figure, however it is possible that future electricity targets could be set as low at 17% of demand.

Figure 7-3: Installed Capacity in 2008 and Under a Possible UK Technology Basket in 2020 (DECC, 2009)



Existing RLC Generation and Notional Target

Table 7-1 outlined earlier the existing annual RLC generation produced in each council and Table 7-2 outlines the notional 30% targets. Table 7-3 shows the current shortfalls in generation against notional 2020 targets. Kirklees has the highest shortfall even though it has the largest existing generation levels; this is because the consumption levels are far higher in this council area.

Table 7-3 Current Shortfall from Notional 2020 Study Targets (MW)

Council	Existing Annual Generation (MW)	Notional 30% 2020 Electricity Generation Target (MW)	Current Shortfall from Notional Target (MW)
Burnley	5.40	14.6	9.20
Pendle	0.10	15.4	15.30
Rossendale	10.77	14.8	4.03
Calderdale	7.26	35.6	28.34
Kirklees	20.20	64.8	44.60

7.6 Notional Local Targets – Renewable Heat

This study considers the existing heat demands for the individual Councils in the Partnership, the projected heat demands for 2020 and a 12% target derived from the UK RES (2009).

There are no reliable data sources available to calculate the existing contribution that renewable heat sources make to the current heat demand.

7.6.1 Baseline Energy Assessment - Heat

Renewable or low carbon heat can be produced by solar thermal technology, ground source heat pumps (or heat from other natural sources) and from combustion of renewable fuels (or gases derived from fuels). When heat and electricity are generated together for use of both types of energy this is termed combined heat and power (CHP).

The current level of renewable heat use across the council areas is fairly low with the exception of the Syngenta CHP plant in Kirklees which provides a significant heat supply, although no figures for this are currently available.

The following table indicates existing heat demand, projected heat demand based upon regional housing requirements and the 12% national lead scenario 'target' figure which might be sourced from renewable or low carbon technologies as applied to the Partnership councils. Due to the constraints of transporting heat, achieving the 12% national heat target will require the generation of heat close to where it is demanded. Therefore future local heat targets are likely to be based upon local consumption rather than potential. This means that the notional heat target based upon consumption and presented in this study is likely to be robust.

Table 7-4 Total Domestic and Commercial Renewable Heat Requirements

Council	Total Heat Demand 2010 MW[1]	Projected Total Heat Demand 2020 MW[2]	12% of total heat in 2020 MW
Burnley	95.5	98.6	11.8
Pendle	93.5	97.9	11.8
Rossendale	71.8	77	9.2
Calderdale	216.5	232.3	27.9
Kirklees	416.3	456.3	54.8
Totals	893.7	962.2	115.5

Notes.
1. Total Heat Demand in 2010 – based on households consuming 0.00161 MW on spacing heating (http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=7287) plus an estimate of commercial each demand based on the UK average that the commercial sector uses 2.17 times less heat than the domestic sector (DECC Website)
2. Total Heat Demand in 2020 – based on the current housing numbers plus the numbers required under the revoked RSSs with the assumption that the commercial sector demand will grow at the same rate as the domestic sector
3. See Table A30 for more details

7.7 Capacity, Generation and Potential

The assessment of the potential for individual technologies in Chapter 4, calculated the capacity of each technology, in line with national guidance (DECC, 2010). However, the notional renewable targets (see Table 7-2), are set in generation, rather than capacity. Therefore to assess each technology's potential to aid in achieving the targets, capacities have been converted into generation.

The installed capacity of a particular plant represents its maximum output; however, plants do not run at 100% capacity all the time, therefore the generation produced by a plant is always less than its capacity (see section 2.2.3 for a fuller explanation). Large renewable developments tend have their capacity stated rather than the likely actual generation that the development will produce. Therefore, within Chapters 7 and 8, to assess the ability of each technology to aid in achieving the renewables targets, potential generation is estimated from the calculated capacity, through using a capacity factor (Table 7-5).

Table 7-5 Installed Electricity Capacity Factor

Technology	Capacity Factor[1]
Biomass	0.85
Co-firing of biomass with fossil fuel @ 5%	0.9
Biomass and waste using ACT (advanced conversion techniques)	0.85
Hydro (all types)	0.45
Sewage gas	0.4
Landfill gas	0.64
Onshore wind	0.27
Wind ≤ 50kW	0.1
Solar PV ≤ 50kW	0.08

Notes.
1. Source Arup, July 2008.
2. The amount of electricity generated is the installed capacity times the capacity factor.
3. Figures for biomass represent the amount of time typically required for maintenance of large scale plant which operates all the time. Domestic biomass burning, which is not planned to operate all of the time, will generate on average much less energy.
4. Some newer PV installations may have higher efficiencies of up to 20%; however, the local Burnley (IT Power, 2005) study assumes a capacity factor of around 4%. Similarly some newer wind farms located in particularly good locations may have a capacity factor greater than 0.27.

7.8 Summary of Technology Choices

The maximum theoretical potential for renewable energy generation for the Partnership Area has been calculated. This is set out in Tables A3 and A4 in Appendix A2 and expressed as a capacity. The table illustrates that the capacity is very large and irrespective of making an allowance for appropriate capacity factors the generation potential overall is also very large (shown in Table A 7 and Table A 8).

This theoretical maximum is however likely to be constrained by factors such as the local environment, planning policies, technical issues and costs. Therefore a 'pragmatic' approach has been taken in this Section accounting for realistic constraints.

Taking these into account more pragmatic maximums have been developed and shown in Tables A4 and A5. These continue to illustrate the large overall potential capacity. Once typical capacity factors have been taken into account the generation potential is determined as shown in Table A 9 and Table A 10.

The main conclusions to be drawn from these tables are the significance of commercial scale wind in providing capacity and, the apparent high capacity for solar PV. However the capacity factor for solar PV is very low and so installations will only generate limited electricity (though this may improve in future as the technology is developed). The capacity factor for wind is significantly better so wind is significantly better placed to make a major contribution to generation.

The following summarises each of the technologies available and Table 7-7 gives a summary of the pragmatic electricity generating potential for each council for each technology (based on Table A 9).

Large Scale Wind

The Study has identified that wind energy provides by far the largest potential for additional renewable energy in the Partnership Area. There is the potential for large scale wind to produce up to 192.67 MW of generation based upon a 'pragmatic' estimate using DECC Guidance (Section 4) However likely limitations based upon Landscape Capacity would reduce this to 40% of this total. Despite this the generation potential remains high. Utilising this proportion of the resource would allow Burnley, Pendle and Rossendale to reach the notional targets set in this Study. Kirklees has been identified as having only a small potential to develop commercial wind farms. This is due to settlement and the National Park covering a high proportion of the area where wind speeds are sufficient for wind farms to be installed.

Table 7-6 Commercial Scale Wind Farm Generation Potential in the Study Area

	Maximum Pragmatic Generation (MW)	Landscape Limited Generation (MW)[1]	Current Shortfall from Notional Target (MW)
Burnley	28.85	11.5	9.20
Calderdale	51.48	20.5	28.34
Kirklees	23.33	9.3	44.60
Pendle	38.45	15.3	15.30
Rossendale	50.56	20.1	4.03
Totals	192.67	76.8	

1. Landscape capacity figures have been derived from the Landscape Capacity Study for Wind Energy Development in the South Pennines prepared by Martin *et al.* 2010. Installed capacities have been calculated based upon the suggested number, groupings and sizes of wind turbines each capacity area can accommodate using an average from the high and low scenario. From this a density figure has been derived based upon the land area of the study area. Capacity figures were then converted to generated energy calculated using a 0.27 capacity factor.

Small Scale Wind

The Study has identified that there is some potential for small scale wind energy generation, with up to 6.6MW generation potentially available within the five council Partnership Area (see section 4.2.5). However, this would represent a very high number of turbines (over 10,000 6KW capacity units). Uptake of small scale wind turbines is very much dependant upon individuals and small businesses investing in the technology for personal consumption.

A favourable planning policy environment including clear guidelines regarding areas most suitable for small scale wind and details of the level of assessment required for smaller turbines would be helpful for encouraging small scale wind energy. However, in a similar manner to large wind developments there may be local opposition to the visual impact of even small wind turbines, including the cumulative impact of large numbers of turbines.

Uptake for Biomass

The Study has identified that there is some potential for biomass generation, with up to 8.5MW generation, potentially available within the five council Partnership Area (see Table A 9). Different biomass feedstocks have differing potentials for uptake. They also have different levels of investment required for uptake.

There is potential for council policy to promote the uptake of biomass technologies by encouraging the development of both suppliers of biomass, distribution networks and biomass electricity generation. There is also the possibility of additional influence via the planning process for larger installations, waste management policies and waste management contracts. In contrast to other technologies the main constraint is the biomass resource available and a fairly high level of uptake of this resource should be possible. However, overall the resource is fairly small so even a high uptake does not result in very high levels of electricity generation. There is however, also the option of importing biomass. Another constraint to consider is the cumulative impact of biomass installations on air quality level. Uptake could be limited in areas with poor air quality.

Solar PV and Thermal

The Study has identified there is potential for solar PV generation with a pragmatic maximum generation of 20.3MW, however in reality this equates to uptake on over 90,000 domestic properties and 12,000 commercial properties. Solar thermal heat has the potential to generate 47.5MW heat, this in turn equates to uptake on over 90,000 domestic properties. This is a very high level of technology uptake.

Solar technologies depend mainly upon householders (for domestic systems) or businesses (for commercial systems) to purchase and install them. For both sectors the following factors are important:

- Financial viability of the installation - this to some extent is now guaranteed by the electricity feed in tariffs and the proposed renewable heat incentive.
- Ease of obtaining any required planning permission or permit. Generally solar technologies do not require planning permission, except in conservation areas where permitted development rights may be withheld.

Given the small typical size of installations, very high levels of uptake are required to have a significant impact. The mechanism for obtaining a high level of uptake on existing privately owned buildings (either domestic or commercial) is unclear. However uptake is likely to be significantly influenced by the willingness to invest and in turn subsidies or financial mechanisms to encourage this.

Ground Source Heating

The Study has identified that there is the potential for a high level of heat to be obtained from ground source heating (or lakes, or air): with the potential for 156MW. However this comprises installations at over 120,000 households and also uptake at nearly 10,000 commercial properties. This is a huge uptake and the practicalities and cost of the technology will limit this particularly whilst mains gas remains relatively cheap.

Ground source heating is suitable for many types of property (and where it is not appropriate air source heating may be suitable). The Renewable Heat Incentive is likely to encourage increased uptake of this technology, though under Action 13 of the DECC (2010) Annual Energy Statement, the Government 'will set out detailed proposals for taking forward the Government's commitment to renewable heat through the Spending Review'. This means the future of RHIs is likely to be set out after the spending review.

. The factors affecting its uptake are:

- Availability of mains gas: it is much more financially viable where mains gas is not available. Without a financial incentive mains gas is currently cheaper.
- The size of the property to be heated: larger properties are more cost effective (particularly for open source systems).
- Property infrastructure: ground source heating is most effective as under-floor heating; where a system has to be retrofitted this may be expensive. It may be most easily incorporated into major refurbishments or new builds.
- A very high level of uptake will result in an increased electricity demand in the area, which may require grid upgrades in certain localities.

Hydropower

The Study has identified Hydropower is only likely to provide a small energy generation contribution.

The main constraints for hydropower are the regulatory consents required by the Environment Agency and the expense of constructing the required environmental mitigation, such as fish passes. These requirements are very stringent, hence the likely uptake of hydropower is very low. A best estimate for uptake of hydropower generally is around 1% of the final electricity demand within England. Within the project area if a much greater uptake level, 16% of potential sites, is allowed for this only amounts to 1MW generation for the whole Partnership Area

.

Table 7-7 Total Pragmatic RLC Electricity Generation

Assessment	Commercial Scale Wind Energy	Small Scale Wind Energy	Energy Crops	Municipal Anaerobic Digestion	Waste Wood	Farm Anaerobic Digestion	Woodfuel	Potential for Solar Energy (PV)	Hydropower	SUM (MW)	SUM Excluding Commercial Wind (MW)
Unit / description	Potential Maximum Installed Generation (MW)	Potential Maximum installed Generation (MW)	Generation (5% of Grade Three Agriculture Land) (MW)	Potential Energy Source (MWe)	Theoretical Maximum Generator (MW) (Electricity Only)	Electricity only (MW)	Electricity Only (MW)	Total generation (commercial and domestic) MW	(MW)		
Burnley	28.85	0.60	0.08	0.23	0.51	0.05	0.06	2.18	0.07	32.51	3.18
Calderdale	51.48	2.20	0.16	0.60	1.02	0.12	0.33	4.88	0.17	60.96	7.28
Kirklees	23.33	2.67	0.58	0.00	2.13	0.16	0.81	9.36	0.11	39.14	13.14
Pendle	38.45	0.71	0.07	0.24	0.51	0.11	0.11	2.08	0.07	42.36	3.19
Rossendale	50.56	0.57	0.00	0.18	0.34	0.06	0.09	1.84	0.64	54.28	3.16
Total	**192.67**	**6.66**	**0.88**	**1.25**	**4.51**	**0.50**	**1.40**	**20.32**	**1.06**	**229.25**	**29.92**

Notes:

This table summarises the assessment of the pragmatic generation potential.

The potential pragmatic generation take into account significant practical constraints that limit uptake. However, there are a further set of constraints which will limit the proportion of this resource that will eventually be taken up.

Within Appendix A.2, Table A 5 summaries the pragmatic energy capacities for each technology by council. The values in this table are multiplied by the relevant capacity factor in Table A 11 to produce Table A 9 which estimates the generation potential for each technology.

Table 7-7 is a summarised version of Table A 9.

The pragmatic commercial potential in Table 7-7 does not take into account landscape impacts. If landscape impacts are taken into account a there is a lower potential for commercial windfarms in the area (see Table 7-6)

7.8.1 Scenarios for Renewable Electricity Development

Theoretical capacity is limited by physical, technical, economic, environmental and legislative constraints. The 'pragmatic' accessible resource therefore represents the resource that might realistically be utilised if all projects received planning consent and the financial, political, infrastructural and institutional barriers facing development were all overcome. The scenario development provides an opportunity to consider in more detail the extent to which the planning, political, institutional and infrastructural issues will really be met.

The following scenarios for renewable energy development within the Partnership Area are considered:

- High renewable energy uptake
- Medium renewable energy uptake
- Low renewable energy uptake - business as usual.

The medium and high uptake scenarios represent approaches where increasing levels of planning, technological and financial security for renewable energy will be required and are forthcoming. In developing these scenarios reference has been made to similar scenarios developed elsewhere in the country (Arup 2008, Centre for Sustainable Energy 2005).

High Renewable Energy Uptake Scenario

The high energy uptake scenario (Table A 13) projects a scenario in which uptake is at the upper end of what could be achieved i.e. 80% of the commercial wind resource, 100% of biomass and 50% of small scale wind, solar PV and hydropower resources would be utilised. To enable this high level of uptake, both institutional and financial factors would need to be very favourable.

- Institutional (capacity of planning system, local public/political acceptance and support) and infrastructure (grid) constraints are addressed, allowing more rapid deployment of all technologies.
- Full economic viability of key technologies delivered through combination of high technology earning rates (particularly for biomass) high fossil fuel prices and/or high government support.

This high level uptake would allow the notional 30% 2020 targets to be over-exceeded in four out of the 5 councils. This scenario however, would not enable Kirklees to achieve its target. There is not the potential for RLC technologies within the Kirklees area to meet 30% of electricity demand, even under this high uptake scenario. This is the result of Kirklees having high levels of electricity consumption but few areas which are suitable for commercial wind farm development. As a result, Kirklees for example may have to look to import biomass to reach the notional target or alternatively ensure the relatively low potential for RLC developments in the area is taken account of in target setting.

The levels of support for the above scenario would have to exceed those for the following Medium Uptake Scenario.

Medium Renewable Energy Uptake Scenario

The medium uptake scenario equates to a considerable but considered feasible uptake of renewable energy resources (as described in detail in Table 7-8). Under this scenario, 50% of the identified commercial and small wind resource is utilised, 50% of biomass and smaller proportions of the PV and hydropower resource are also utilised. In this scenario, in Rossendale council area, where there is already considerable renewable energy generation, a high remaining unutilised wind resource and relatively low levels of consumption, the notional target is easily exceeded in this scenario. Pendle, Burnley and Calderdale also exceed the notional targets. However Kirklees only achieves slightly over half its notional target.

In order to obtain the levels of uptake indicated in this scenario, the technical viability of new technologies (e.g. biomass with associated feedstock networks) needs to be demonstrated, and there are still institutional (capacity of planning system, local public/political acceptance and support) and infrastructure (grid) constraints for key technologies.

Revenue support for renewable heat (RHI - 2011) would provide some support for biomass CHP (Combined Heat and Power). This scenario also relies on a regional strategic approach to biomass supply chains and installations.

Low Renewable Energy Uptake Scenario

This is a baseline 'Business as Usual' scenario - it equates to the current situation largely persisting – i.e. wind, and waste technologies nationally remain as the main sources of renewable generation, and biomass (electricity generation) and solar technologies do not prove any more technically or commercially attractive at a large scale, though there will be some small capacity increase from demonstration projects.

This scenario assumes that commercial scale wind energy is limited by landscape capacity constraints. The potential for generation is slightly lower than the 50% uptake rate, in the medium level scenario but the proportions of the other technologies are much lower. This is in line with the difficulties faced in developing the other technologies. For example, small scale wind energy and PV installation is dependant on the decisions of individual households, and woodfuel and energy crops uptake is dependant on the development of a supply chain and end users. As commercial wind farm developments are dependent on developers proposed sites and planning decisions, the ability of the planning authorities to control uptake rates is far greater than smaller scale technologies.

The results of this scenario are similar to the medium uptake scenario, although, the low uptake scenario assumes that non-wind RLCs are developed to a lesser extent; their contribution only makes up a small proportion of the overall generation in both scenarios. This illustrates that the additional investment required to improve the uptake for non-wind RLC technology from a low level to medium level rate is not likely to produce a large amount of additional generation.

Summary of Uptake Scenarios

Details of the level of uptake of each technology and the amount of electricity generated are provided in tables in Appendix A2 (Table A 3 and Table A 5).

The following table illustrates the potential electricity generation arising from each scenario. It is based upon particular assumptions regarding technology uptake.

Table 7-8 Uptake Scenarios - Electricity Generation

Scenario	Total Generation MW (approx.)	Additional Generation Requirement to meet 2020/2021 Target (MW)	Technologies required	Comment
Burnley				
High Uptake	25.4	9.2	High level of commercial wind and other technologies	Potential to exceed the notional target by a significant margin
Medium Uptake	15.6		Some commercial wind, moderate uptake of other technologies	Potential to meet and exceed the target
Low Uptake	11.81		Some commercial wind, some biomass, some domestic installations.	Target met by a small margin.
Calderdale				
High Uptake	47	28.34	High level of commercial wind and other technologies	Potential to exceed the notional target by a significant margin
Medium Uptake	29.0		Some commercial wind, moderate uptake of other technologies	Potential to meet the target by a small margin
Low Uptake	21.4		Some commercial wind, some biomass, some domestic installations.	Target not met by a significant margin.
Kirklees				
High Uptake	28.4	44.6	High level of commercial wind and other technologies	Target not met by a significant margin.
Medium Uptake	16.7		Some commercial wind, moderate uptake of other technologies	Target not met by a significant margin.
Low Uptake	10.6		Some commercial wind, some biomass, some domestic installations.	Target not met by a significant margin.
Pendle				
High Uptake	33.2	15.3	High level of commercial wind and other technologies	Potential to exceed the notional target by a significant margin
Medium Uptake	20.5		Some commercial wind, moderate uptake of other technologies	Potential to exceed the target
Low Uptake	15.69		Some commercial wind, some	Target met by a small margin.

Scenario	Total Generation MW (approx.)	Additional Generation Requirement to meet 2020/2021 Target (MW)	Technologies required	Comment
			biomass, some domestic installations.	
Rossendale				
High Uptake	42.6	4.03	High level of commercial wind and other technologies	Potential to significantly exceed target due to high wind resource.
Medium Uptake	26.4		Some commercial wind, moderate uptake of other technologies	Potential to significantly exceed target due to high wind resource.
Low Uptake	20.6		Some commercial wind, some biomass, some domestic installations.	Potential to significantly exceed target due to high wind resource.

Notes
1. The High uptake scenario is taken as a very high uptake in all types of renewable energy. It allows for 80% of the pragmatic level of wind uptake - large scale and 50% small scale uptake, 100%of biomass, and 50% of the pragmatic solar PV and hydro resource. See Appendix A.2 Tables A12 to A15.
2. The Medium uptake scenario is taken as 50% uptake of commercial wind, 50% small wind, 50% uptake of biomass, 20% PV and 25% hydro. Rossendale, Pendle and Burnley have the potential to exceed their targets with moderate uptake, Calderdale will nearly reach their target but and Kirklees will fall short of the notional target.
3. The Low uptake scenario equates to business as usual and limited growth in renewable energy. It only allows for the level of commercial wind farms unlikely to have any significant visual impact (as per Martin et al 2010). The small scale wind is limited to 10% of the available resource. The PV uptake is limited to 1% of the resource. Other technologies are limited to around 20-25% of their potential capacity.
4. Additional Requirement to meet target consists of the notional 2020 30% target minus the existing renewable generation (see Table 7-3).

Achieving an improved Renewable Electricity Uptake

In considering what is likely to be required for the High uptake scenario most of the following will be required:

- Wide public and political acceptance of the need for renewable energy and in particular wind turbines. Wind energy has the greatest potential within the Partnership Area compared to other technologies.
- Planning permission to be granted for significant commercial scale wind farms.
- Wider public and political acceptance of biomass and energy from waste (EfW) technologies.
- Renewable supportive and focussed planning policies within Local Development Documents (LDD).
- Increased regional experience of biomass and advanced EfW technologies through regional demonstrator projects. Early development of biomass and EfW projects to enable longer lead in times to be accommodated before later 2020 targets.
- Improved waste segregation to allow optimum uses for waste materials and reduced levels of waste being treated in landfills.
- An acceptance of energy recovery via advanced EfW technologies as the primary means of dealing with secondary waste treatment.

- An increase in land use for biomass, based on adequate financial incentives, a corresponding increase in farmer enthusiasm for energy crops and a public acceptance of energy crops within the landscape.
- A significant expansion of biomass supply chains based on effective infrastructural support mechanisms.
- Continued and expanded government financial support for biomass technologies.
- Economic viability for biomass and advanced EfW technologies.

7.8.2 Scenarios for Renewable Heat Development

The overall pragmatic potential for renewable heat generation is presented in Table 7-9.

Table 7-9 Total Pragmatic RLC Heat Generation

	Energy Crops	Waste Wood	Farm Anaerobic Digestion	Woodfuel	Solar Energy	Ground Source Heating	SUM
Authority	5% of Grade Three Agricultural Land (see Table 4-19) (MW)	(see Table 4-22) (MW)	(see Table A1) (MW)	(see Table 4-25) (MW)	(see Table 4-32) (MW)	Total Conservative Uptake (See Table 4-38) (MW)	(MW)
Burnley	0.24	0.87	0.08	0.21	5.00	16.00	22.40
Calderdale	0.52	1.86	0.18	1.10	11.00	38.50	53.15
Kirklees	1.85	3.76	0.24	2.68	22.25	73.00	103.77
Pendle	0.22	0.86	0.17	0.37	4.75	13.25	19.62
Rossendale	0.00	0.64	0.08	0.31	4.50	16.00	21.52
Total	2.83	7.99	0.74	4.67	47.50	156.75	220.47

Notes: Table 6-9 is a summary of Table A 10.
The references to tables, in the column heading, are to the capacity assessments carried out in Chapter 4. To convert the capacity assessments into generation, the values were multiplied by the capacity factors in Table A 12.

In a similar way to Section 7.8.1, three uptake scenarios for heat generation have been developed by this study; their results are presented in Table 7-10. They show that under a medium level uptake scenario, all the councils exceed the 12% notional target. To achieve this would mean a significant uptake of the local potential which would require some of the measures discussed in the following section.

Table 7-10: Renewable Heat Generation Uptake Scenario Summary

Scenario	Total Generation MW (approx.)	12% Heat Generation Notional Target	Comment
Burnley			
High Uptake	22.4	11.46	Target significantly exceeded
Medium Uptake	16.8		Target exceeded
Low Uptake	5.01		Target not met
Calderdale			
High Uptake	53.15	25.99	Target significantly exceeded
Medium Uptake	39.86		Target significantly exceeded
Low Uptake	13.70		Target not met
Kirklees			
High Uptake	103.8	49.96	Target significantly exceeded
Medium Uptake	77.83		Target significantly exceeded
Low Uptake	29.09		Target not met
Pendle			
High Uptake	19.62	11.22	Target significantly exceeded
Medium Uptake	14.72		Target exceeded
Low Uptake	5.47		Target not met
Rossendale			
High Uptake	21.52	8.62	Target significantly exceeded
Medium Uptake	16.14		Target exceeded
Low Uptake	4.60		Target not met

Notes
1. The High uptake scenario is taken as a very high uptake in all types of renewable energy. It allows for 100% of the pragmatic generation potential of all sources/technologies to be utilised. See Table A27 for further details.
2. The Medium uptake scenario is taken as a moderately high uptake in all types of renewable energy. It allows for 75% of the pragmatic generation potential of all sources/technologies to be utilised. See Table A28 for further details.
3. The low uptake scenario is taken as a relatively low uptake in all types of renewable energy. It allows for 50% of the pragmatic generation potential of all sources/technologies to be utilised except ground source heating which uses 100% uptake amongst off-grid properties only, as under the current economic conditions GSH systems are viable. See Table A29 for further details.
4. A full explanation of the heat generation notional targets is presented in Table **7-4**

Achieving an improved Renewable Heat Uptake

Ground source heating has the most significant potential in all council areas; however the costs and practicalities may limit uptake. The next most significant source of renewable heat is solar heat, which has reasonable potential in all areas. Uptake of this is likely to be fairly high provided that the renewable heat incentive (2011) provides adequate financial incentive. Wood biomass (woodfuel and waste wood) have a moderate potential in most of the council areas: it is most significant in Kirklees and Calderdale and least important in Rossendale, Burnley and Pendle. Uptake of wood stoves is likely to be reasonably high, but for larger community heating systems more support for development of the required infrastructure is needed. Further details of the potential for renewable and low carbon heat are given in Table A 10.

For significant renewable heat uptake the following would be required:

- The initiation of the Renewable Heat Incentive (RHI) in 2011 to provide a financial support mechanism for renewable heat production.

- Sustained levels of grant funding available to support both capital and development costs for renewable heat projects - as is proposed by the FIT.
- Very significant growth in market penetration of pellet stoves and boilers into the domestic retro-fit market - this will require additional support for the wood pellet sector within the region.
- Targeting areas with highest off-gas heat loads with support programmes for renewable heat, including awareness raising and grant support.
- A significant adoption of community heating both for new build and existing buildings.
- Greater understanding of the potential mismatch between establishing new heat loads and the development of Combined Heat and Power (CHP) plants.
- Assessment of the potential for the co-location of biomass CHP with high heat loads, for example as part of the development of new or extended industrial estates.
- A significant utilisation of heat from large scale renewable CHP both within new build and existing buildings.
- Significant market penetration of heat pumps and biomass heating into the market for boiler replacement, driven by social housing for domestic buildings and public sector for non-domestic buildings.
- Increasing sources of wood fuel other than forest residues beyond 2010.
- Assessment of the development needs for pellet sector, in particular looking at ways to stimulate increased uptake of retro-fit domestic pellet boilers in off-gas areas.
- Analysis of the capital grant support required to “kick-start” biomass heating in the region; and design of a funding programme, with a clear exit strategy, with the aim of securing regional or national support.
- Support for renewable heat sector development in order to meet significantly increased installation rates for building-integrated technologies and protect installation quality.

7.8.3 New Development and On-site Generation

One area of additional renewable energy generation which is potentially directly influenced by planning policies and the grant of planning permission is the on-site renewables requirement associated with new developments.

Planning policies which require developers to produce a percentage of the energy needs for the development from on site generation are increasingly common. They are often referred to as the Merton Rule, after the London Borough which pioneered the approach. Considering the future housing targets for each council area one can estimate the additional generating capacity that might arise from the application of these policies. The following table illustrates this potential additional capacity (N.B. it assumes that housing provision will continue in line with the targets outlined the relevant revoked RSSs).

Table 7-11 On-site requirements for Renewable Energy Generation

Councils	Annual average net additions to the dwelling stock 2008 - 2026 (from Y & H RSS)	Annual Average rates of Housing Provision (Net of clearance replacement) (from NW RSS)	Approximate Total housing to be built by 2020 to meet RSS targets	New household consumption for 2020 (MW)*	10% Merton Rule Generation requirement for 2020 (MW)	20% Merton Rule Generation requirement for 2020 (MW)
Burnley		130	1300	3.4	0.34	0.73
Calderdale	670		6700	17.5	1.75	3.75
Kirklees	1700		17000	44.4	4.44	9.52
Pendle		190	1900	5.0	0.50	1.06
Rossendale		222	2220	5.8	0.58	1.24
Totals			27820	72.6	7.26	15.57

Notes: Annual average net additions to the dwelling stock based upon the revoked NW Regional Authority RSS 2008 and Yorkshire and Humber Regional Authority RSS 2008 targets
*Based on 2001 average household consumption (www.statistic.gov.uk)

Through the application of these policies the uptake of renewable energy technologies associated with new building development is more closely within the control of councils than uptake associated with existing buildings (either commercial or domestic). The requirement for incorporating a high level of renewable energy at the planning stage can have a significant impact on the financial viability of a development, particularly where this requirement is included late in the process of site acquisition, planning and design. These factors are considered in detail in Section 5.

Overall the table illustrates there is only limited scope for new renewable generation associated with new development as only limited development is proposed. However, the exception is Kirklees where there is a higher level of proposed development.

Across all the councils the contribution that on-site generation can make through development towards meeting targets is small, although more significant in Kirklees.

The new Government plans to set up a new Community Energy Fund, as proposed by UK Green Building Council[73]. The Government is committed to all new homes being zero-carbon from 2016 and this could be done through regulation to increase building standard to reduce emissions but also through developers meeting their obligations through supporting local energy schemes under the Community Energy Fund, rather than through on-site measures.

[73] http://www.planningresource.co.uk/news/ByDiscipline/Environment/1018656/Shapps-set-community-energy-fund/

8. Technology mixes - baskets of technology

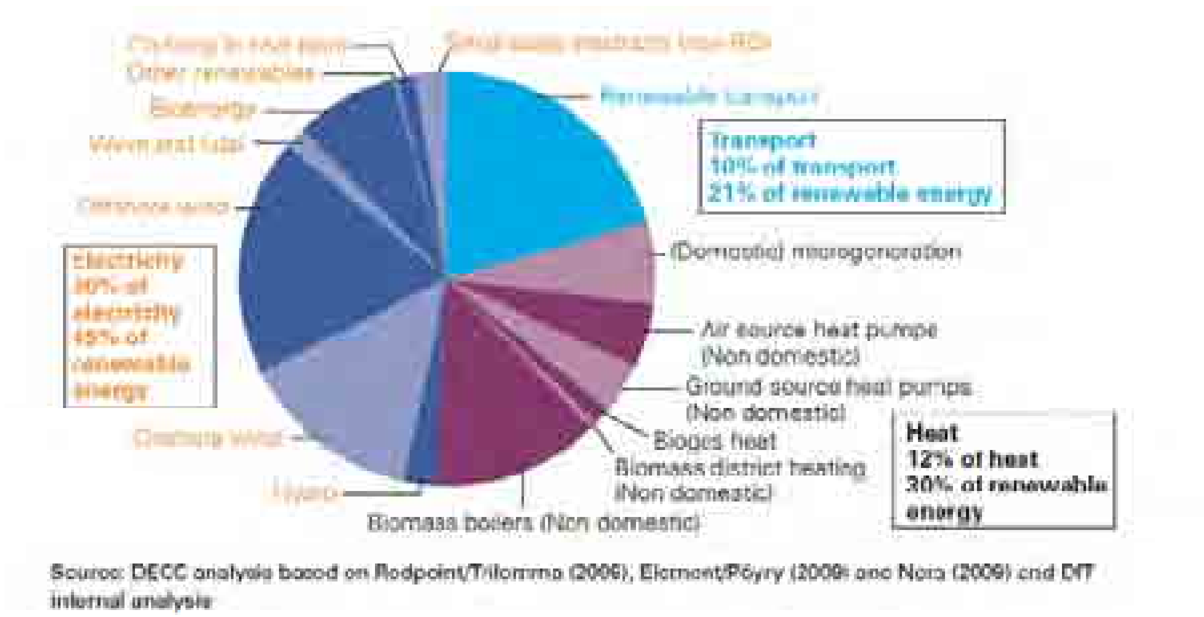
8.1 Baskets of Technology

Section 6 considered three uptake scenarios and how these relate to national targets. A complementary approach to provide a further level of understanding is to consider possible mixes of RLC technologies which might meet the notional targets set for each of the partner councils. In this study we refer to these as ‘baskets of technology’. This approach allows policy makers to consider more closely technology choices and preferences. This section uses the notional targets set in section 6. It firstly considers the national technology distribution mix and regional ‘envisaged’ mixes. It summaries the technology constraints across the Partnership and then leads into discussion on particular ‘baskets of technology’.

8.1.1 Technology Distribution Nationally

The range of technologies and the relative proportions that each is envisaged to contribute towards meeting the proposed UK targets is illustrated below.

Figure 8-1 Possible UK Technology Basket in 2020 (source UK Renewable Energy Strategy, 2009)



8.1.2 A Regional Technology Mix

At the regional scale the in-land technologies envisaged for the Yorkshire and Humber Region and the North West Region are:

- Biomass - approximately 33%
- Landfill gas - less than 25%
- Wind less than 25%
- Energy from waste less than 25%
- Small amounts of anaerobic digestion and PV.

(Source - Oxera Environmental, 2002)

The limited availability of biomass and waste within the Partnership Area, combined with the declining source of landfill gas mean that wind energy is likely to be the most significant source of renewable electricity.

Recent studies in Yorkshire and Humber (RES, 2009) suggest most renewable energy might come from wind and co-firing at major power stations with increasingly significant contributions from photovoltaics. It is possible that the balance of technologies will evolve over time dependant upon technology advances, available feedstocks and financial viability.

8.1.3 Local Context

In Section 6 each of the technologies was summarised. The following table summarises the constraints and suitability of different technologies for different locations. This provides further context on the suitability of particular mixes of technology for each council.

Table 8-1 Technologies particularly suitable for different contexts

Location	Description	Most Suitable technologies
City centre	High density urban location with mixed use activities including retailing, business and residential	District CHP (including biomass) Solar (PV and thermal)
Town centre	Medium density urban location with mixed use activities including retailing, business and residential	District CHP (including biomass) Solar (PV and thermal)
Non-residential urban	Mixed use non-residential urban areas	Merchant Wind (where a land owner allows an operator to build, run and maintain a turbine on their land), CHP (including biomass), Solar (PV and thermal), Sewage gas/sludge (if close to waste water treatment works)
Sub-urban residential	Sub-urban, primarily residential areas	Biomass boilers, Solar (PV and thermal), Geothermal (ground source heat pumps)
Small settlement / edge	Small existing town or village, or the edge of larger settlements	CHP (especially if linked with a local pool or similar use that has high heating demands) Biomass Solar (PV and thermal) Geothermal
New settlement / growth point	New large scale urban development proposal with opportunities to achieve integrated solutions to energy provision	District CHP (including biomass) Wind Passive solar (design) Solar (active PV and thermal) Geothermal Sewage gas/sludge (if new plant to be installed) Energy from waste
Green belt	Designated green belt designed to maintain a sense of openness and prevent urban sprawl	Domestic scale biomass Wind (small/medium/large scale)
Conservation Areas	Historic, landscape and environmental designations	Domestic scale biomass Geothermal Run of river hydro
Rural agricultural	Rural areas primarily in use for intensive agricultural activities	Large scale CHP (agricultural wastes and other biomass) Large scale wind Sewage gas/sludge Geothermal (where serving a

Location	Description	Most Suitable technologies
		local point of energy demand) Energy from waste
Rural - wild	Rural locations not farmed intensively	Large scale wind Hydro Biomass
Industrial - other	Uses including waste management, quarrying, mining and landfill	Energy from waste Sewage gas Large scale biomass (including co-firing) Large scale wind
National Parks and Areas of Outstanding Natural Beauty		Run of river hydro Geothermal Small scale biomass
Notes 1. Based upon Arup, July 2008. 2. Other technologies may be suitable in certain circumstances, e.g. solar in conservation areas, provided they are implemented appropriately.		

8.1.4 Electricity Technology Baskets

Three 'baskets' have been considered in this study:

- 'High Wind'
- 'Enough Wind'
- 'Maximised Non Wind'

All the baskets are rooted in their relationship to the available wind resources since this offers the most significant opportunities for renewable generation across the Partnership area.

There is only limited potential for development of biomass and hydropower within all the council areas so these are not technologies suitable for delivering a significant proportion of the required renewable energy targets (Table 7-7).

Each of the baskets considers a different mix of technologies and for each an assessment of its performance is made.

Each basket is described below with a summary table of its relative performance. Tables A22 -A26 describe fully the mixes and the assumptions made regarding particular technology contributions by each council.

'High Wind' uptake basket

The high wind basket considers 100% utilisation of the pragmatically available potential wind energy with some further uptake in non-wind technologies.

When you consider this approach and the notional targets for generation as a measure of performance then with the exception of Kirklees all the individual councils significantly out perform the target and collectively as a Partnership Area they exceed the combined targets.

Table 8-2 Generation Shortfall under the High Wind Uptake Basket

Councils	Generation Shortfall from Notional Target (MW)
Burnley	+20.7
Calderdale	+26.7
Kirklees	-16.45
Pendle	+24.47
Rossendale	+47.53
N.B. –ve equals shortfall and +ve equal exceedance	

Enough Wind

This basket considers the previously used medium level uptake rates for non-wind technology (used in Section 6 and Table A 14), it then considers that the notional target for each council is met with topping up from wind technologies.

The following summary table expresses as a percentage the proportion of additional wind resource required to reach the notional target.

Table 8-3 Proportion of Wind Resource Utilised under the Enough Wind Basket

Councils	Proportion of wind resource that would be utilised under this basket (%)
Burnley	29
Calderdale	48
Kirklees	100+
Pendle	36
Rossendale	6
N.B. Under is scenario Kirklees can not achieve its notional target	

Maximising Non-Wind

This basket considers that the potential generation from non-wind technologies is fully utilised, and compares the total generation to the notional targets. As in all these technology baskets existing generation has been accounted for.

The following table summarises this and additionally expresses the shortfall in the number of 2.5MW Capacity turbines that would be required to make up this shortfall in generation.

Table 8-4 Generation Shortfall and Required Turbines under the Maximising Non Wind Scenario

Councils	Generation Shortfall from Notional Target (MW)	Number of additional turbines required to meet the target
Burnley	-6.1	9
Calderdale	-21.1	31
Kirklees	-31.5	47
Pendle	-12.1	18
Rossendale	-0.88	1
N.B. –ve equals shortfall and +ve equal exceedance The number of additional turbine was calculated on the basis of a 2.5 MW capacity turbine, generating 0.675 MW of electricity (assuming a 27% capacity factor).		

8.1.4.1 Discussion of Electricity Baskets

If no additional large scale wind generation is undertaken then the realistic alternatives are photovoltaics and biomass technologies. Given the relatively low level of biomass resource available in the area, this technology does not provide the basis for a large potential for generation of renewable energy. The only way to increase the use of biomass further would be a very significant import of biomass. However, given the landlocked nature of the Partnership Area importing biomass from abroad might not be cost effective, and transporting UK biomass more than 40 km is not viewed as very cost effective (Oxera Environmental, 2002). However, the Pollington pellet mill is around 64 km from the centre of Huddersfield and could potentially provide some biomass (its total capacity is to be 50kt per year of pellets). However, overall it would be difficult to have very significant generation from biomass.

Generally nationally it is assumed that only around 2% of energy will be derived from micro-technologies, such as PV. To maximise non wind technologies assumes a much greater uptake of PV than this, and is perhaps therefore unlikely to be achieved. Moderate development of the PV available potential would require an incredibly high uptake from private individuals and businesses willing to invest in the technology. The mechanism for encouraging this level of uptake (even with the current feed-in tariffs) is unclear. PV requires a high level of capital investment at the start to purchase and install the equipment - this is likely to be beyond the means (or priorities) of many in the project area.

The potential for hydropower is limited technically. Development of additional high head hydropower based around high level reservoirs could potentially provide a higher capacity but this type of development is not easily feasible with current water management constraints.

Very significant financial mechanisms might need to be made available in order to enable the levels of uptake of non-wind technologies considered in the latter two baskets. Such a technology mix might also have a significant impact on the grid with numerous local connections which individually might be fairly small, but collectively could have implications for management of the grid locally.

Table 8-5 Potential for Non-Wind Technologies

Council	Non-Wind Generation (MW)	Shortfall from Notional Generation Targets (MW)
Burnley	3.2	-6.1
Calderdale	7.3	-21.1
Kirklees	13.1	-31.5
Pendle	3.2	-12.1
Rossendale	3.2	-0.88
Notes. Overall given that the sunshine hours in the Partnership area are lower than further south in the UK maximising PV in these regions may not overall represent the most economically viable option.		

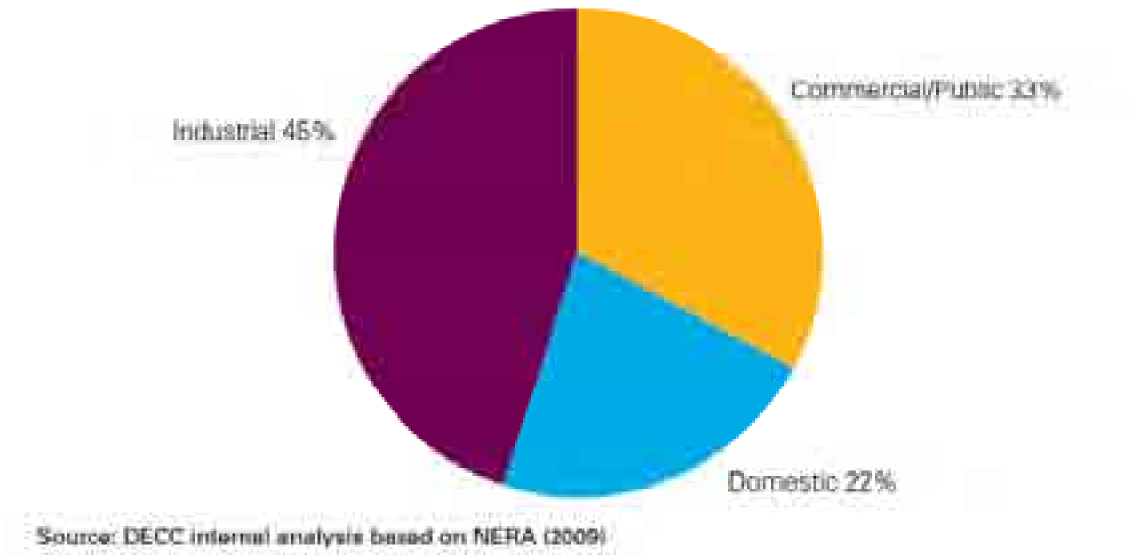
Generally the average wind farm takes around 3-4 years to get planning approval and to be commissioned. Large scale biomass plants also require some time to develop. In contrast installation of small scale PV on domestic and small businesses can be much faster. However, if a very large uptake of PV was envisaged there would probably be limitations with regard to supply of equipment and availability of installers.

Overall the most feasible basket of technology involves additional uptake of commercial wind energy in most of the council areas. [Further details are given in Appendix A.2.]

8.1.5 Heat Baskets

Nationally the proportion of renewable heat uptake by different sectors is as shown in the following figure (RES, 2009).

Figure 8-2 Illustrative Sector Contributions to Renewable Heat in 2020 (in the lead scenario, FES, 2009)



The existing heat requirements are set out in Table 6-4 (Section 6).

Earlier Sections of this study identified that:

- Woodfuel is significantly resource constrained,
- The constraints on solar water heating and heat pumps relate particularly to cost and the ability to install equipment on existing building stock;
- CHP is constrained by limited opportunities within the study area. For CHP systems to be effective they need a local reliable demand for the heat they produce;
- There is capacity for both ground source heating and solar thermal installations. Both have a reasonable capacity for heat generation. However, large numbers of each would be required to meet significant heat loads.

The study considers two heat baskets:

- 'Moderate solar heat uptake with High GSH'
- 'Moderate solar heat uptake with Low GSH'

The following two tables summarise the relative performance of these. Tables A32 and A33 set out the details for each.

Table 8-6 Renewable Heat Technology Baskets

Council	12% of total heat generation in 2020 (MW)	Moderate Solar PV and High GSH Uptake Basket Generation (MW)[1]	Moderate Solar PV Uptake and Off-gas Network GSH Uptake Generation (MW)[2]	Comment
Burnley	11.8	18.4	4.21	There needs to be a high level of uptake to reach 12% renewable or low carbon heat. Both solar heat and GSH are likely to be required in very high amounts. A significant number of properties with mains gas will need to take up ground source heating or other heat pump options. Importing biomass may be required. All councils have only between 4.3 and 5.9% renewable heat with the current assumptions regarding uptake.
Pendle	11.7	15.8	4.86	
Rossendale	9.2	17.9	3.76	
Calderdale	27.9	44.4	12.32	
Kirklees	54.8	86.0	26.67	
Totals	115.5	182.5	51.82	
Notes. 1. Assumes 100% GSH, 20% solar and reasonable biomass uptake (Table A 32). 2. Assumes, 20% solar, 100% uptake of GSH amongst off-gas households and reasonable biomass uptake (Table A 33).				

Generally overall a moderate level of uptake of both solar heat and ground source heating is not likely to meet required levels of renewable heat. In areas with non-mains gas (which have been assumed to have a 100% uptake in ground source heating (Table A 32)) there is the potential for a higher level of uptake and a higher level of low carbon heat (Table A 33). Additionally ground source heating may be suitable for district or community heating schemes as part of refurbishment or renewable projects where under-floor heating can be incorporated into the design. Ground source heating is less efficient at the higher temperatures required for radiators. The renewable heat incentive (due in 2011) may provide the required support for a higher level of ground source heating uptake - this would be required to meet a 12% renewable heat target.

These baskets assume a fairly high level of uptake of energy crops for fuel, and use of wood and other biomass products for heating. These have a much lower potential for generating heat than either solar or ground source heating technologies but nevertheless can provide a reasonable contribution to renewable or low carbon heating.

9. Conclusions

Renewable Electricity Generation

The study has revealed that there is the potential for significant renewable electrical energy generation in the Partnership Area. This potential is focussed on the following technologies (in order of significance):

- **Commercial scale wind - by far the most significant resource**, followed by
- Relatively small resources of:
    - Biomass utilising technologies, including Biomass use in Combined Heat and Power (CHP) to provide district heating.
    - Solar PV.
    - Small scale wind energy.
    - Very small amounts of hydropower.

Although there is a relatively large theoretical resource of solar energy for PV generation this cannot generate large amounts of electricity with current technology due to the low capacity factors available.

Commercial scale wind can provide between 6 and 7 times more renewable electricity generation than all the other available technologies combined.

Renewable Heating

The potential for renewable heat generation technologies is currently little developed within the Partnership Area.

The greatest potential for renewable heat is from ground source heating, although there is reasonable potential for solar hot water heating. In the longer term air source heating may be implemented more widely, particularly if technology efficiencies improve. Heat pumps are particularly applicable in non-mains gas areas. These resources have the long term potential to provide up to 12% of the heat requirements in the Partnership Area.

There is the potential for greater use of biomass from a variety of sources. However, the available land in the Partnership Area which could be used to cultivate biomass crops has limitations. This potential new source is not likely to be large.

Combined heat and power generation has the potential to provide both high grade and low grade heat in a very efficient manner. For large heat loads, e.g. large new developments or large buildings (e.g. hospitals, leisure centres), combined heat and power should be considered. If there is greater than 500kW electrical load CHP should be considered; and if there is greater than 50kW heat load CHP should also be considered.

Targets

As part of the study each of the individual Councils in the Partnership has been ascribed a target for the generation for renewable and low carbon generation in line with national targets. These targets however, are only notional as they do not take into account the contribution from off-shore wind, or the local potential for developing renewables in the area. The application of large wind technology involving significant numbers of new turbines offers the best opportunity to meet targets for electricity generation. However, Kirklees may not be able to achieve its notional local targets, even allowing for the full development of its wind resource.

Significant Constraints on Uptake

There is considerable experience within the Partnership Area of commercial wind development. However, to date this has also generated significant opposition due, particularly, to the visual and landscape impacts of wind farms. In order to meet the renewable energy targets outlined in this study using the available wind resource, further landscape impacts from wind farms will need to be accepted.

New Development and On-site Generation

The uptake of renewable energy technologies in association with new development through the application of planning conditions is possible. It offers the prospect of delivering improved capacity for renewable generation across the Partnership Area and most significantly in Kirklees. However, it could also adversely impact on the timing and profitability of development on sites.

Significant Actions to Promote Renewable Uptake

The two most important actions arising from the study are the need to promote greater acceptance, public and political, of the need for locally generated renewable energy and the continued expansion of long term government financial support for RLC development at all scales. Large scale RLC installations are likely to be more significant in meeting targets than small scale developments and a suitable planning regime is likely to be key in promoting these technologies in suitable locations and appropriate ways.

Appendices

A. Figures

A.1 List of Figures

Figure A 1 - Environmental Designations

Figure A 2 - Biodiversity Action Plan Priority Habitats

Figure A 3 - Air Quality Management Areas

Figure A 4 - Wind Resources Map (10m above ground level)

Figure A 5 - Wind Resources Map (45m above ground level)

Figure A 6 - Commercial Scale Wind Energy Opportunities

Figure A 7 - Commercial Scale Wind Energy Constraints

Figure A 8 - Small Scale Wind Energy Opportunities

Figure A 9 - Small Scale Wind Energy Constraints

Figure A 10 - Agricultural Land Classifications in the Study Area

Figure A 11 - Forestry Commission Woodland Classifications

Figure A 12: Character Areas

Figure A 13 - Aquifers within the Study Area

Figure A 14 - Yearly Sum of Global Irradiation on Optimally Inclined Surfaces

Figure A 15 - NFCDD and LYRES Identified Weirs for Hydropower

Figure A 16 - Electricity Distribution Network in the Study Area

Figure A 17 - Gas Network

Figure A 18 - Large Renewable and Low Carbon Schemes in the Study Area

Figure A 19 - ROC Accredited Stations in the Study Area

Figure A 20 Conservation Areas

A.2 Appendix Tables

Table A 1 Potential Livestock Organic Waste and the Energy it could Generation Across the Study Area through AD

Table A 2 Existing RLC Capacity in the Study Area

Table A 3 Total Theoretical RLC Electricity Capacity

Table A 4 Total Theoretical RLC Heating Capacity

Table A 5 Total Pragmatic RLC Electricity Capacity

Table A 6 Total Pragmatic RLC Heating Capacity

Table A 7 Total Theoretical RLC Electricity Generation

Table A 8 Total Theoretical RLC Heating Generation

Table A 9 Total Pragmatic RLC Electricity Generation

Table A 10 Total Pragmatic RLC Heating Generation

Table A 11 Electricity Capacity Factors

Table A 12 Heating Capacity Factors

Table A 13 High Level Electricity Uptake Scenario

Table A 14 Medium Level Electricity Uptake Scenario

Table A 15 Low Level Electricity Uptake Scenario

Table A 16 High Wind Uptake Scenario Basket

Table A 17 Maximising Non-Wind Scenario Basket

Table A 18 No Additional Wind Scenario Basket

Table A 19 Existing and Planned Wind Energy and Landscape Capacity

Table A 20 All Wind in Planning Scenario Basket

Table A 21 Projected Electricity Consumption, Targets and Current RLC Installed Capacity

Table A 22 Burnley Electricity Scenario Baskets

Table A 23 Calderdale Electricity Scenario Baskets

Table A 24 Kirklees Electricity Scenario Baskets

Table A 25 Pendle Electricity Scenario Baskets

Table A 26 Rossendale Electricity Scenario Baskets

Table A 27 High Level Heating Uptake Scenario

Table A 28 Medium Level Heating Uptake Scenario

Table A 29 Low Level Heating Uptake Scenario

Table A 30 Estimated Domestic and Commercial Heat Demand for 2010 and 2020

Table A 31 Additional Housing Required by 2020

Table A 32 Heat Scenario - Moderate Solar Heat Uptake - High GSH

Table A 33 Heat Scenario - Moderate Solar Heat Uptake - Low GSH

Table A 34 Existing Small Scale Wind Turbines in Burnley

Table A 35 Sites with Planning Permission for Small Scale Wind Turbines in Calderdale

Table A 36 Existing Small Scale Wind Turbines in Kirklees

Table A 37 Existing Small Scale Wind Turbines in Pendle

Table A 38 Existing Small Scale Wind Turbines in Rossendale

The following table provides a description of Tables A3 to A33

Table No. and Titles	Description
Table A 3:Total Theoretical RLC Electricity Capacity Table A 4: Total Theoretical RLC Heating Capacity Table A 5: Total Pragmatic RLC Electricity Capacity Table A 6: Total Pragmatic RLC Heating Capacity	These tables collate the individual assessments on energy (electricity and heat) each technology can deliver together. The total theoretical capacity is the upper unconstrained capacity available and the pragmatic is the capacity available after the constraints within the individual assessment are taken into account. More detail on the differences between the Theoretical and pragmatic capacities is available with the individual assessments. The heating and electricity capacity do not take into account the fact that the resource could be used by the other. E.g. the wood fuel could be used to generate electricity or heat but each table assumes that the resource will be used entirely by both.
Table A 7: Total Theoretical RLC Electricity Generation Table A 8: Total Theoretical RLC Heating Generation Table A 9: Total Pragmatic RLC Electricity Generation Table A 10: Total Pragmatic RLC Heating Generation	These tables transform the capacities in Tables A3 to A6 into estimated generation through the capacity factors in Table A11 and A12. Tables A9 and A10 are very important to the rest of the assessment as the generations available in these tables are used to derive the potential future generation available based on different uptake rates or baskets of technologies that develop.
Table A 11: Electricity Capacity Factors Table A 12: Heating Capacity Factors	These tables contain the capacity factors used to estimate generation from the capacity assessments
Table A 13: High Level Electricity Uptake Scenario Table A 14: Medium Level Electricity Uptake Scenario Table A 15: Low Level Electricity Uptake Scenario	These tables take the generations in Table A9 and multiple it by a fraction referred to as the proportion of prag(matic) which indicate the proportion of the generation resource which might be used during a high, medium and low uptake scenario. The total generation under these uptake scenarios is then compared to the additional generation required to achieve the local notional target. The addition generation required is calculated in Table A21.
Table A 16: High Wind Uptake Scenario Basket Table A 17: Maximising Non-Wind Scenario Basket Table A 18: No Additional Wind Scenario Basket Table A 19: Existing and Planned Wind Energy and Landscape Capacity Table A 20: All Wind in Planning Scenario Basket	The Table A16 -18 are similar to Tables A13-15 but the proportion of prag(matic) values have been chosen to reflect three different future possible RLC baskets. The total generation under these baskets are then compared to the additional generation required to achieve the local notional target, like Table A13-14. Table A18 and A19 slightly differs from this with respect to the commercial scale column. Table A18 shows that some councils have windfarms already installed or have approved planning for and asks whether it is possible to achieve the local notional targets by fully utilising these and other renewable energy sources. Table A19 takes into account built, consented and planned (but not consented) wind farms in the area with a moderate uptake rate of other technologies. This aims to identify whether the councils will be able to achieve their

Table No. and Titles	Description
	targets without more wind farm developments being proposed. This basket shows that none of the councils could achieve their target. The short fall has been converted in the number of extra 2.5 MW turbines required to achieve the target.
Table A 21: Projected Electricity Consumption, local notional targets and Current RLC Installed Capacity	This is a key table which feeds into Tables A13-20. It sets out the projected consumption of electricity in 2020 (this has been estimated in a separate spreadsheet). The UK government has set a target that 30% of electricity generation by 2020 will be from renewable sources. The table estimates what 30% of consumption for the councils would be. Table A21 takes away the existing renewable generation (shown in Table A2 in fuller detail) from the local notional targets to give the required new generation (difference) to meet the target. There is an extra column (Non-wind installed generation) which is feeds into Tables A19 and A20.
Table A 22: Burnley Electricity Scenario Baskets Table A 23: Calderdale Electricity Scenario Baskets Table A 24: Kirklees Electricity Scenario Baskets Table A 25: Pendle Electricity Scenario Baskets Table A 26: Rossendale Electricity Scenario Baskets	Table A22 to A26 are similar to Table A16 and A17 but three scenarios are presented for each council in each table. These scenarios are 'High Wind', 'Enough Wind' and 'Maximise non-wind'. The proportion of prag(matic) rates vary between these scenarios. Notably, the enough wind scenario attempts to adjust the proportion of prag(matic) value so that the local notional target is just met.
Table A 27: High Level Heating Uptake Scenario Table A 28: Medium Level Heating Uptake Scenario Table A 29: Low Level Heating Uptake Scenario Table A 30: Estimated Domestic and Commercial Heat Demand for 2010 and 2020 Table A 31: Additional Housing Required by 2020	Table A27 to A29 outline three uptake scenarios (high, medium and low) and compares the heat generation from this to the expected demand in 2020 which is calculated in Table A30. The tables differs in their proportion of prag(matic) rates which controls whether the uptake rate is low, medium or high. The exception to this is Table A29 where the Ground Source heating generation is fixed at the lower GSH rate outlined in Table 4-38 which is based on off-gas properties. Table A30 estimates the domestic and commercial heating demand in 2010 and in 2020. Then is uses the UK government 12% of heat target to derive an indicative target for each council. Table A31 states the additional housing required for 2020 outlined in the revoked RSSs
Table A 32: Heat Scenario - Moderate solar heat uptake - High GSH Table A 33: Heat Scenario - Moderate Solar Heat Uptake - Low GSH	Tables A32 and A33 presents two basket scenarios with different prag(matic) uptake rates. These are then compared to the proportion of the estimated 2020 demand in a similar fashion to Tables A27.

B. ROC Accredited Stations

A search of ROC (Renewable Obligation Certificate) accredited stations within the study area was conducted. Information on the location of stations was obtained from **https://www.renewablesandchp.ofgem.gov.uk/** and ROC Accredited Stations within the study area found are listed in Table A 39 and shown in Figure A 19.

Table A 39: ROC Accredited Stations within the Study Area

Generating Station	Capacity (kW)	Technology	Organisation	Organisation Contact Address	Generating Station Address
Scout Moor Wind Farm	65000	On-shore wind (RO code = RQ)	Scout Moor Wind Farm Ltd	Peel Dome The Trafford Centre Manchester M17 8PL England	Scout Moor Rochdale Road Edenfield Bury BL0 0RQ England
Rossendale Power	1436	Landfill gas (RO code = RJ)	Viridis Energy (Norgen) Limited	Diamond Court 11 Daniel Adamson Road Salford M50 1DT England	Rossendale Power Horncliffe Quarry Landfill Site Bury Road Rossendale BB4 6EZ England
Ovenden Moor Windfarm - A	9200	On-shore wind (RO code = RQ)	Yorkshire Windpower Ltd	c/o Powergen Renewables Ltd Westwood Way Westwood Business Park Coventry	Ovenden Moor Windfarm Cold Edge Road Ovenden Halifax West Yorkshire
Hameldon Hill Wind Farm	6000	On-shore wind (RO code = RQ)	Npower Renewables Ltd (Wind)	Windmill Hill Business Park Whitehill Way Swindon SN5 6PB England	Hameldon Hill Wind Farm - A, E (01/02/07) Billington Road Hapton Burnley England BB11 5QQ England
Worsthorne Hydro at Worsthorne	87	Micro hydro (RO code = RD)	United Utilities Water plc	United Utilities Renewable Energy Dept Dawson House Liverpool Road Great Sankey, Warrington WA5 3LW England	Worsthorne Hydro at Worsthorne WTW-A,C,D United Utilities Worsthorne Water Treatment Works BB10 3LP England
Queens Park Energy	1850	Landfill gas (RO code = RJ)	CLP Envirogas Limited	CLP Envirogas Limited Unit 14 & 15 Queensbrook Bolton Technology Exchange Spa Road, Bolton BL1 4AY	Queens Park Energy Rowley Landfill Queens Park Road Burnley Lancas Burnley BB10 3LB England
Burnley CHP at Burnley	250	Sewage gas (RO code = RR)	United Utilities Water plc	United Utilities Renewable Energy Dept Dawson House Liverpool Road Great Sankey, Warrington WA5 3LW England	Burnley Sewage Treatment Works Wood End Lane Burnley BB12 9DS England

B.1 Large Food Processors

Below is a list of known large food processers within the study area. These may have the potential to supply anaerobic digesters with a feedstock.

- Rossendale,
    - Hollands Pies,
    - Mannings Bakery,
- Burnley,
    - Warburtons (Rossendale Rd Industrial Estate),
    - Tayabbah Bakery (Gannow Lane),
    - Cherry Tree Bakery (Rossendale Rd Industrial Estate),
    - Moorhouses Brewery (Accrington Rd),
- Calderdale (with a threshold of 10 tonnes of food produced per day),
    - Nestle Rowntrees at Albion Mills, Halifax,
    - McVities at Hopwood Lane, Halifax,
    - Key Country Foods at green Mills Industrial Estate, Mytholmroyd,
    - New Ivory Sauces at Ainleys Industrial Estate, Elland,
- 19 possible sites in Kirklees.
- Pendle,
    - Farmhouse Biscuits, Nelson
    - Cott Corporation, Lomeshaye Ind Estate
    - Neerock (Trading as Woodhead Bros), Colne
    - Hartleys Farm Foods, Lomeshaye
    - Oddies Bakery, Nelson

C. Case Studies and Visualisations

References

AEA Energy and Environment, 2007, Yorkshire and Humber Vision for Biomass, Report to Yorkshire and Humber Regional Energy Forum.

Aitkenhead, N., Barclay, W. J., Brandon, A., Chadwick, R. A., Chisholm, J. I., Cooper, A. H. & Johnson, E. W., 2002. British Regional Geology: the Pennines and adjacent areas. 4th edn., British Geological Survey, Nottingham, 206pp.

Anon., 2001, UK Electricity Networks, Parliamentary Office of Science and Technology POSTnote no. 163, London

Anon., 2004. House of Lords, Science and Technology Fourth Report **http://www.publications.parliament.uk/pa/ld200304/ldselect/ldsctech/126/12608.htm**, chapter 6.

Anon., 2004, Parliamentary Office of Science and Technology POSTnote no. 230, London

Arup February 2008, East of England Regional Assembly Placing Renewables in the East of England (Final Report) available from **http://www.eera.gov.uk/publications-and-resources/studies/topic-based-studies/renewable-energy-studies/**

Arup, July 2008, Towards Broad Areas for Renewable Energy Development, Final Report, v1.2, 4NW.

Aylott, M. J., Casella, E., Tubby, I., Street, N.R., Smith, P. & Taylor, G., 2008. Yield and Spatial Supply of Bioenergy Poplar and Willow Short-Rotation Coppice in the UK, New Phytologist vol178 p358-370

Banks, D., 2008. An Introduction to Thermogeology: Ground Source Heating and Cooling. Blackwell Publishing, 339pp.

BGS (British Geological Survey) - digital geological mapping at 1:625,000 scale.

Bionic, Bionic Newsletter 3, January 2010.

Britsh Biogen, Anaerobic Digestion Of farm and food Processing Residues - Good Practice Guidelines

British Energy Group plc, 2006, Decentralised generation: Independent analysis of the potential role of small scale distributed generation. Contributions by Paul Watkiss, Daniel Forster, Rebecca Woollam, Michael Laughton.

Butler, S. 2001, UK Electricity Networks - The nature of UK electricity transmission and distribution networks in an intermittent renewable and embedded electricity generation future. Imperial College of Science, Technology and Medicine Centre for Environmental Technology in collaboration with Parliamentary Office of Science and Technology (POST)

CE Electric., 2006. Code of Practice for Standard Arrangements for Customer Connections, CE Electric

Defra 2007, Air Quality Strategy for England, Scotland, Wales and Northern Ireland

Defra 2007, Opportunities and optimum sitings for energy crops, available at **http://www.defra.gov.uk/foodfarm/growing/crops/industrial/energy/opportunities/index.htm**

Defra 2006, Distribution of Pigs in UK on 02 June 2005 Version 1

Defra 2009, Density of Poultry and Poultry Premises Registered on the GB Poultry Register

Defra 2006, Distribution of Sheep in UK on 02 June 2005 Version 1

Defra 2007, Cattle Density on 01 July 2006 with Traditional Counties, Animal Health Divisonal Offices and major cities in England

Defra 2009: Part IV of the Environment Act 1995 Environment (Northern Ireland) Order 2002 Part III Local Air Quality Management Technical Guidance LAQM.TG(09)

Department of Communities and Local Government, Planning Policy Statement: Planning and Climate Change Supplement to Planning Policy Statement 1, ISBN 978 0 11 7539787, 2007.

Department of Communities and Local Government, Planning Policy Statement: Consultation Planning for a Low Carbon Future in a Changing Climate available at **http://www.communities.gov.uk/documents/planningandbuilding/pdf/1499780.pdf**

Department for Communities and Local Government, Domestic Installation of Microgeneration Equipment, Final report from a Review of the related Permitted Development Regulations, Entec, April 2007.

DECC 2009 Renewable and Low-carbon Energy Capacity Methodology - Methodology for the English Regions (Draft Final)

DECC., 2009 Biomethane into the Gas Network: A Guide for Producers, Department for Environment and Climate Change

DECC. 2009, Feed –in Tariffs – Government's Response to the Summer 2009 Consultation, Department of Energy and Climate Change

DECC. 2009, Act on Copenhagen, available from **http://www.actoncopenhagen.decc.gov.uk/en/ukaction/business/case-studies/woking-council**

DECC November 2009, Draft Overarching National Policy Statement for Energy (EN-1)

DECC 2010, Annual Energy Statement, available at http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/237-annual-energy-statement-2010.pdf

DECC February 2010, Renewable Heat Incentive - Consultation on the proposed RHI financial support scheme.

Dolan, S., 2007, Electricity in the UK, Parliamentary Office of Science and Technology POSTnote no. 280, London

E4tech 2010; Biomass prices in the heat and electricity sectors in the UK; a report for DECC

Energy Saving Trust, The Major PV Demonstration Programme, Final Report 2002-2007, 2007.

Energy Saving Trust, Integrating renewable energy into existing housing – case studies, 2006a.

Energy Saving Trust: Passive Solar Estate Layout, 2006b.

Energy Saving Trust: Meeting the 10 per cent target for renewable energy in housing - a guide for developers and planners, March 2006c.

Environment Agency, 2003. The Don and Rother Catchment Abstraction Management Strategy. October 2003, 35pp.

Environment Agency, 2007a. The Aire and Calder Catchment Abstraction Management Strategy. May 2007, 50pp.

Environment Agency, 2007b. The Northern Manchester Catchment Abstraction Management Strategy. May 2007, 50pp.

Environment Agency, 2007c. Integrated Catchment Management Plan for the Ribble. June 2007, 62pp.

Environment Agency, 2008a. Fact Sheet: the Aire and Calder CAMS Annual Update April 2008.

Environment Agency, 2008b. Fact Sheet: the Don and Rother CAMS Annual Update April 2008.

Environment Agency 2010. Opportunity and environmental sensitivity mapping for hydropower in England and Wales

Environment Agency website [Groundwater quality]:

http://maps.environment-agency.gov.uk/wiyby/wiybyController?value=Burnley%2C+Lancashire&submit=Search%09&lang=_e&ep=map&topic=wfd_groundwaters&layerGroups=default&scale=3&textonly=off#x=412221&y=433876&lg=1,7,9,&scale=3

Environment Agency website [Ground source heat pumps]:

http://www.environment-agency.gov.uk/static/documents/Research/(21)_GSHPs_mitigation_final.pdf

Environment Agency, Good Practice Guidelines Annex to the Environment Agency Hydropower Handbook, The Environmental Assessment of Proposed Low Head Hydro Power Developments, August 2009, **http://www.netregs.gov.uk/static/documents/Business/Low_Head_Hydropower_August_2009.pdf**

Ernst and Young., 2009, The potential for Renewable Gas in the UK, National Grid: http://www.nationalgrid.com/NR/rdonlyres/9122AEBA-5E50-43CA-81E5 8FD98C2CA4EC/32182/renewablegasWPfinal1.pdf.

Federal Ministry of Economics and Technology, Decentralised Supply, available from **http://www.efficiency-from-germany.info/EIE/Navigation/EN/Technologies/industry,did=254280.html**

V.A. Fry, 2009, Lessons from London: regulation of open-loop ground source heat pumps in central London, *Quarterly Journal of Engineering Geology and Hydrogeology*, v. 42; issue.3; p. 325-334

Forestry Commission 2007, A Woodfuel Strategy for England.

IT Power, RenewEL, A Renewable Energy Study for Housing in Burnley, Final Report, August 2005.

IT Power, RenewEL A Renewable Energy Study for Housing in Burnley, for Burnley Borough Council, August 2005.

Jarrett,K, et al. 2004. Technical Guide to the Connection of Generation to the Distribution Network, DTI.

Julie Martin Associates. Landscape Capacity Study for Wind Energy Development in the South Pennines, January 2010.

Jones, H. K., Morris, B. L., Cheney, C. S., Brewerton, L. J., Merrin, P. D., Lewis, M. A., MacDonald, A. M., Coleby, L. M., Talbot, J. C., McKenzie, A. A., Bird, M. J., Cunningham, J. & Robinson, V. K., 2000. The physical properties of minor aquifers in England and Wales. British Geological Survey (BGS) Technical Report WD/00/4, Environment Agency R&D Publication 68, British Geological Survey, Keyworth, Nottingham, 234pp.

Kavanaugh, S. P. & Rafferty, K., 1997. Design of Geothermal Systems for Commercial and Institutional Buildings. American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), 167pp.

London Development Agency (2009), Decentralised Generation available from **http://www.lda.gov.uk/server.php?show=nav.00100h00c001**

London Renewables. Integrating renewable energy into new developments: Toolkit for planners, developers and consultants. Faber Maunsell September 2004.

NNFCC (2008) A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems available from **http://www.nnfcc.co.uk/metadot/index.pl?id=7198;isa=DBRow;op=show;dbview_id=2457**

Northern Gas Networks. 2009, 'Long Term Development Statement' Leeds

North West Forestry Framework, North West Biomass Woodfuel Strategy **http://www.creativeconcern.com/iwood/pdf/biomass_strategy.pdf**.

North West Regional Development Authority (2006), North West Sustainable Energy Strategy

Office of the Deputy Prime Minister, Planning Policy Statement 1: Delivering Sustainable Development, ISBN 0 11 753939 2, 2005.

Office of the Deputy Prime Minister, Planning Policy Statement 22: Renewable Energy, ISBN 0 11 753924 4, 2004.

Pearce, R. Et al 2008. Low Carbon Energy Market Survey, Electricity North West, Cheshire.

Richter, G.M., Lovett, A., Sunnenberg, G., Dailey, A.G., Riche, A. & Karp, A., 2007. Intergration of Crop Models and Constraint Mapping for the Projection of Bioenergy Production, available from www.tsec-biosys.ac.uk/downloadfile.php?PHPSESSID...pdf=69.

RSPB in partnership with Wildlife Trust for Lancashire, Manchester & North Merseyside (LWT), Lancashire County Council, Natural England and the Merseyside Environmental Advisory Service (EAS), July 2008, Biomass Planting and Sensitive Bird Populations: A Spatial Planning Guide for Biomass Energy Crop planting in North West England.

SQW energy: Renewable and Low-carbon Energy Capacity Methodology: Methodology for the English Regions, for DECC. January 2010.

The Scottish Government, 2008, Measurement and Modelling of Fine Particulate Emissions (PM10 and PM2.5) from Wood-Burning Biomass Boilers.

Wrap 2005, Review of wood waste arisings and management in the UK - Summary Report.

Yorkshire and the Humber Government (2007), The Delivery Plan for the Regional Forestry Strategy for Yorkshire and The Humber Region.

YEDL., 2009. Connection Charging Methodology and Statement, YEDL, Newcastle

YEDL., 2009. Long-term development statement, YEDL, Newcastle

maslen environmental
part of the JBA Group

JBA Offices at

Atherstone
Doncaster
Edinburgh
Haywards Heath
Limerick
Newcastle upon Tyne
Newport
Northallerton
Northampton
Saltaire
Skipton
Tadcaster
Wallingford
Warrington

Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE

t:+44(0)1756 799919
e:info@jbaconsulting.co.uk

Jeremy Benn Associates Ltd
Registered in England 3246693

Visit our website
www.maslen-environment.com
www.jbaconsulting.co.uk