Renewable and Low Carbon Energy Resource Assessment and Feasibility Study

APPENDICES ONLY

Presented to: The Councils of Stratford-On-Avon, Warwick, North Warwickshire, Nuneaton & Bedworth, Rugby, Solihull and Warwickshire County

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Appendix I: Glossary

Below is a table explaining the main technical terms used within the document.

GLOSSARY	
AD	Anaerobic Digestion; process in which organic materials are broken down in the absence of oxygen producing biogas which can be burnt to produce electricity and/or heat
AMR	Annual Monitoring Report: One of a number of documents required to be included in the Local Development Framework Development Plan Documents, submitted to Government via the Regional Government office by a Local Planning Authority at the end of December each year to assess the progress and the effectiveness of a Local Development Framework
BERR	UK Department for Business, Enterprise & Regulatory Reform, superseded in June 2009 by the Department of Business, Innovation and Skills
CHP	Combined Heat and Power; also known as cogeneration Generation of both heat and power from a single heat source by recovering waste heat from electricity generation
CHPA	Combined Heat and Power Association
CSH	Code for Sustainable Homes; also referred to as 'Code': The Code is the national standard in England for the sustainable design and construction of new homes. The Code aims to reduce carbon emissions and create homes that are more sustainable by measuring the sustainability of a new home against nine categories of sustainable design, rating the 'whole home' as a complete package. The Code uses a one to six star rating system to communicate the overall sustainability performance of a new home. From 1 May 2008 it is mandatory for all new homes to be rated against the Code and include a Code or nil-rated certificate within the Home Information Pack.
DECC	Department for Energy and Climate Change: Government department created in October 2008. It is responsible for all aspects of UK energy policy, and for tackling global climate change on behalf of the UK.
ESCO	Energy Service Company; This is a professional business providing a broad range of comprehensive energy solutions including designs and implementation of energy savings projects, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. The ESCO performs an in-depth analysis of the property, designs an energy efficient solution, installs the required elements, and maintains the system to ensure energy savings during the payback period The savings in energy costs is often used to pay back the capital investment of the project over a five- to twenty-year period, or reinvested into the building to allow for capital upgrades that may otherwise be unfeasible. If the project does not provide returns on the investment, the ESCO is often responsible to pay the difference.
FIT	Feed-in-Tariff: A UK Government cashback scheme outlined in the Energy Act 2008 effective from 1 April 2010 guaranteeing payment to people who generate small scale low carbon electricity.
GHG	Greenhouse Gas: Any gas that absorbs infra-red radiation in the atmosphere. The current IPCC (Intergovernmental Panel on Climate Change) inventory includes six major

GLOSSARY	
	greenhouse gases. These are Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6).
GIS analysis	Geographic Information System analysis; includes data that is referenced by spatial or geographic coordinates
GSHP	Ground Source Heat Pump: A heat pump installation that uses the earth as a heat sink to store heat or as a source of heat.
GWh	Gigawatt hour – 1,000,000 kWh. A convenient unit of energy for power generation equipment.
kW	Kilowatt – unit of power. Can be expressed as thermal power (kW_{th}) and electrical power (kW_e). The productive capacity of small scale renewable generation is usually measured in kW
kWh	kilowatt hour – unit of energy. Can be expressed as thermal energy (kWh_{th}) and electrical energy (kWh_e). A convenient unit for consumption at the household level.
kWp	kilowatt peak – maximum power output of a photovoltaic cell, occurring with intense sunlight.
Large wind	Large scale wind, for this study this is assumed as being above 1 MW in capacity (tip height typically greater than 100 m). Where appropriate, the default size of large scale wind turbines in 2.5 MW with a tip height of approximately 125 m.
LDF	Local Development Framework
LZC	Low and Zero Carbon
MLSOA	Middle Layer Super Output Area; Super Output Areas are a unit of geography used in the UK for statistical analysis. They are developed and released by Neighbourhood Statistics. Middle Layer SOAs have a minimum population 5000, and a mean population 7200. Built from Lower Layer SOAs. There are 7,193 MLSOAs in England and Wales
MOD	Ministry of Defence
MSW	Municipal Solid Waste: Waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area.
$MTCO_2e$	Million Tonnes of Carbon Dioxide Equivalent
MW	Megawatts. The productive capacity of electrical generation plant is often measured in MWe.
MW_e	Megawatts of electrical capacity.
MW_{th}	Megawatts of thermal capacity.
MWh	Megawatt-hour, equal to 1,000 kWh.
ODT	Oven Dried Ton; an amount of wood that weighs 2,000 pounds at zero percent moisture content[1][1]; common conversion unit for solid biomass fuel

GLOSSARY	
PPS	Planning Policy Statement
SHLAA	Strategic Housing Land Allocation Assessment
SHW / STHW	Solar Hot Water; also known as Solar Thermal Hot Water
Small wind	Small scale wind, for this study this is assumed as being below 500 kW in capacity (tip height typically less than 60 m)
Solar PV	Solar Photovoltaic
SPV	Special Purpose Vehicle; a legal entity set up for a specific purpose: to isolate financial risk from a lead organisation.
tCO_2/yr	Tonnes (metric) of CO_2 per year
TCPA	Town and Country Planning Association

Appendix II: Notes of Consultation Workshop

Warwickshire workshop 14th January 2010

Attendees

Zahir Lazcano	*Camco*
Ian Andrews	*Camco*
Robert Clark	*Camco*
Luke Purse	*Camco*
Roger Hey	Central Networks
Graham Paling	Central Networks
Matthew Rhodes	Encraft
David Fovargue	Entec
Michael O'Connell	Entec
Mark Hammond	Friends of the Earth
Ewan Calcott	Forestry
Alex Hales	Frampton
Darren Henry	Nuneaton and Bedworth Borough Council
Steph Chettle	Nuneaton and Bedworth Borough Council
Allison Crofts	Natural England
Chris Nash	North Warks Borough Council
Sue Wilson	North Warks Borough Council
Tim Margerison	Rugby Borough Council
Nick Freer	Rugby Borough Council
Stephen Games	Rugby Borough Council
Jamie Tallon	Rugby Borough Council
Sarah Fisher	Rugby Borough Council
Stephen Marks	Rugby Borough Council
Nick Ellison	Stratford upon Avon District Council
Paul Chapman	Stratford upon Avon District Council
Colin Staves	Stratford upon Avon District Council
David Biss	Solihull Metropolitan Council
David Wigfield	Solihull Metropolitan Council
Martin Fletcher	Solihull Metropolitan Council
Paul Slade	Waterloo
Jonathan Horsfield	Warwickshire County Council
Jacky Williams	Warwickshire County Council
Claire Parlett	Warwick District Council
Neil Gilliver	Warkwickshire Rural Housing Association
Colin Morrison	WSP
David Bolus	WSP
Katie Elmer	WSP
Bruce Hayball	Hasker Architects
Jonathan Rigall	Peter Brett
Andrew Hawkes	Gallaghers

Notes.

The following notes were recorded for the consultation event held at Benn Hall, Rugby, on the 14th January 2010. The principal purpose of the workshop was to review the draft recommendations that had been developed. A secondary objective was to review aspects of the analysis conducted and to identify where improvements could be made, e.g. with additional local information. The workshop agenda was as follows:

10.00 Introduction to workshop

10.05 Overview of study

11.00 Discussion sessions x 3

A. Carbon standards for new development

B. Opportunities and constraints for renewable energy generation

C. Non-planning measures & financing

14:15 Session Feedback & Plenary discussion

The discussion groups were held in rotating cabaret style such that each participant was able to engage with the three topic areas and also so that comments could be refined through subsequent review of previous discussions. Participants were also invited to raise other queries following the study overview and during the plenary session.

A range of issues were raised during the workshop and through additional information being sent to the steering group and consultant team (from Hasker Architects). The notes below collate the issues raised.

A. Carbon standards for new development

In general most attendees were supportive of accelerated carbon targets for new development and could see, with additional financial support, e.g. RHI & FiT that these could be achieved. However, opposing views were also expressed. The key issues raised were as follows:

- A number of attendees raised the issue of viability. Those representing development interests suggested that accelerated standards would be difficult for the market to achieve although no specific evidence was provided. Others felt that accelerated timescales, particularly with respect to larger schemes (which inherently have longer timescales) were reasonable since scheme phasing would require higher standards in any case. It was felt this should be further reviewed with the steering group. Themes explored under this issues included:
    - The need to balance carbon standards with other key housing objectives, e.g. affordable housing, educations, transport. Some stated that the market priorities are not CO2.
    - The scale of study area developments were not, in themselves likely to initiate market forces to bring down costs of developments
    - There was a division of opinion around whether to aim towards higher targets (accepting potential failures of achieving this , but content with an acceptable fall-back
    - UK zero carbon roadmap was already seen as challenging by some
    - Some stated that elevated CO2 standard should only be for specific developments
    - Land supply could dry up if land price absorb increasing costs of CO2 abatement
    - Defending policy is problematic/costly - better to encourage and provide incentives
        - Local Authority District Heating networks
        - Tax
        - Partnerships are key

        - Planning delivery grant if above target
        - Public land - can tender with requirements (e.g. EP) - Private land – much less opportunity to influence process / standards
- There should be a strong onus on the developer to prove targets could be achieved.

- Need for co-ordinated expertise across the study area to ensure good consistent delivery

- Local Authorities need to be attuned to the changing style of housing where higher carbon standards are required, e.g. modern materials, more 3-storey housing, sustainable technology Eco-ghetto house types changing within large developments

- It was important to support achievement of higher carbon standards that low carbon development issues trump other planning restrictions (e.g. E-W or N-S)

- A number of attendees suggested that developers would prefer clear targets applied to all (or most) development

B. Opportunities and constraints for renewable energy generation

These discussion groups involved detailed review of the analysis completed and the assumptions therein. There was a strong focus in these sessions on wind energy and biomass as the principal sources of low carbon generation identified. Along with discussions around the analysis a number of key issues where discussed:

- Wind energy:
    - The inclusion of MOD / civil aviation constraints for wind energy
    - Consultation of the land owners regarding future energy generation, e.g. wind, development could help to refine available land
    - Will the publishing of wind potential maps have adverse impacts (e.g. land price)
    - Assess the potential impacts of land allocation for wind development, in a similar fashion to that in which land is allocated for housing, mineral extraction… To reduce potential tensions and opposition from neighbouring land owners and property owners, they could be offered to participate in the development.
    - Low distance from housing to wind development from 600m to 400 m – Steering group suggest this is not changed from 600m
    - LA capability to carry out Landscape Assessments? Do they have the knowledge and training to do this?
    - Need to consider the proximity of grid to wind sites
    - Some doubt was expressed by representatives of Stratford Council over land availability due to previous discussion held with developers.

- Biomass:
    - Should potential resources from woodlands be better included in the analysis
    - The development of the market, particularly around biomass would be the key constraint to uptake
    - Opportunity for wood fuel, activate supply chain (AW brought into manage etc)
    - Encourage processing local timber within the region, diversify farms
    - Flagging up opportunities for potential development with communities (i.e. CHP)
    - Encouraging local funds for local communities

- Other:
  - Phasing of certain developments might affect viability of CHP/District Heating.
  - Educational/awareness campaign required to meet ambitious targets, since support at community level is essential. LA should explore the possibility of developing a community pilot project.

C. Non-planning measures & financing

A wide ranging discussion was held around this area particularly around a Carbon Investment Fund measure, the establishment of ESCO services, requiring annual carbon monitoring on specific development (and linking with a financial bond) and also Development Control to support low carbon delivery. There was good general support for a CIF mechanism but less so for an ESCO. Key issues raised were as follows:

- Carbon Investment Fund
  - A Carbon Investment Fund could be set up with the following advantages:
    - Support locally relevant carbon reduction initiatives (not just renewables)
    - Present 'least cost' solutions for carbon reduction, rather than 'on-site' renewables
  - The concern was raised that a CIF could be inequitable to new development but this was not widely shared
  - Concerns over additionality where raised, i.e. the scheme would need to be developed so as to avoid the funding of the developments that would have happened anyway
  - Contrary to the UK Roadmap the suggestion was made to devolve some of the on-site 70% "compliance" carbon reduction through to the CIF mechanism, i.e. if it is the least cost way then why not do it more through this mechanism?
  - Can community/social schemes be developed from the CIF investment
  - Accountability - will carbon saving/£ be efficient, i.e. how will developers be certain that the public sector will deliver efficiently (compared with what they may deliver)
  - Is Advantage West Midlands developing some kind of CIF facility?
  - Strategic finance initiatives could be considered, e.g. with support from Forum for the Future. Jonathan Horsfield (WCC) may have money to support this

- ESCO
  - Districts and other larger Authorities are quite different - e.g. North Warwickshire has very little housing development planned and the therefore may have little need for the ESCO services
  - Few were sure where ESCO services might support low carbon delivery

- Require performance annual monitoring (with financial bond)
  - Most considered that there needs to be more focus on monitoring
  - This was considered to be a reasonable proposition, but overwhelmingly the groups felt it would be difficult to establish such a scheme. Concerns raised included:
    - Difficult to judge bond value (needs to be significant but not present burden)
    - Seen as "messy" e.g. passing through compliance to new owners (from developer)
    - Breach of planning conditions was an alternative – but recognised that this power is rarely used
    - Mutually enforceable covenants is a further alternative

- Development Control – the discussion moved from non-planning measures towards improving practice in DC, the key issues being identified as follows:
  - Toolkit will help for DC control/scheme planning
  - Relationships between Planning Policy and DC need to be far better at a basic level to manage introduction of workable policy.

- Concerns that DC are simply not able to deliver existing standards let alone significantly shifted standards requiring, for example, time-intensive site visits.
- DC process needs to be delivered consistently, requiring training for staff to take on board these issues
- Communications between Building Control (monitoring delivery) and Planning
- Shared working would be encouraged (to share costs and stretch expertise to where it is needed.
- Shared Services should be considered
- Training is essential

ENDS.

Appendix III: CO_2 emissions for the study area

The tables below illustrate CO_2 emissions sources for the study area, taken from DECC's NI186 data. The colour coding illustrates the categories which were assumed to relate to electricity, thermal, transport, and other energy sources.

Dataset name	Full Local CO_2 emission estimates, sector and fuel details
Year	2007
Release date	17/09/2009
Units	kt CO_2 unless otherwise stated

RegionName	LARegionName	Year	A. Industry and Commercial Electricity	B. Industry and Commercial Gas	C. Industry and Commercial Large Gas Users	D. Industry and Commercial Oil	F. Industry and Commercial Solid fuel	G. Industry and Commercial Process gases	H. Industry and Commercial Wastes and biofuels	I. Industry and Commercial Non fuel	J. Industry Offroad	K. Diesel Railways	L. Agriculture Oil	M. Agriculture Solid fuel	N. Agriculture Non fuel
	North Warwickshire	2007	221	70	-	23	7	0	-	-	16	12	4	0	0
	Nuneaton and Bedworth	2007	145	41	-	13	4	9	-	0	19	4	1	-	0
	Rugby	2007	277	82	-	21	567	0	43	716	19	6	7	0	0
	Solihull	2007	309	149	-	27	1	-	1	0	41	8	2	0	0
	Stratford-on-Avon	2007	183	41	-	42	11	1	0	-	24	11	19	0	0
	Warwick	2007	264	55	-	19	0	1	0	0	30	13	4	0	0
West Midlands Total		2007	8,886	3,516	339	984	972	276	89	1,174	1,115	246	300	1	3

RegionName	LARegionName	Year	O. Domestic Electricity	P. Domestic Gas	Q. Domestic Oil	R. Domestic Solid fuel	S. Domestic House and Garden Oil	T. Domestic Products	U. A-Roads Petrol	V. A-Roads Diesel	W. Motorways Petrol	X. Motorways Diesel	Y. Minor Petrol	Z. Minor Diesel	ZA. Road Transport Other
	North Warwickshire	2007	71	70	5	3	0	2	43	64	142	383	39	35	2
	Nuneaton and Bedworth	2007	125	144	1	3	1	3	30	24	12	39	68	48	1
	Rugby	2007	108	114	3	3	1	2	64	86	62	197	51	43	2
	Solihull	2007	227	265	6	3	1	5	58	50	75	183	144	97	3
	Stratford-on-Avon	2007	161	107	22	10	1	3	89	107	81	191	69	68	2
	Warwick	2007	150	154	6	5	1	3	87	88	65	151	63	50	2
West Midlands Total		2007	5,585	6,122	346	221	35	137	2,173	2,407	1,140	3,042	2,493	1,966	53

RegionName	LARegionName	Year	ZB. LULUCF Emissions Soils & Deforestation	ZC. LULUCF Emissions Other	ZD. LULUCF Removals	**Grand Total**	**Population ('000s, mid-year estimate)**	**Per Capita Emissions (t)**	**Domestic emissions fom energy**	**Domestic per capita emissions (t)**
	North Warwickshire	2007	1	22	- 19	1,217	62.2	19.6	149	2.39
	Nuneaton and Bedworth	2007	0	6	- 5	735	121.2	6.1	273	2.25
	Rugby	2007	2	28	- 18	2,483	91.0	27.3	228	2.50
	Solihull	2007	1	18	- 11	1,664	203.6	8.2	501	2.46
	Stratford-on-Avon	2007	6	88	- 58	1,279	117.8	10.9	300	2.55
	Warwick	2007	1	28	- 21	1,221	134.6	9.1	315	2.34
West Midlands Total		2007	66	1,092	- 784	43,994	5,382	8.2	12,273	2.28

LARegionName	Year	Electrical	Thermal	Transport	LULUCF	Other	TOTAL
North Warwickshire	2007	292	183	735	5	2	**1,217**
Nuneaton and Bedworth	2007	269	216	244	1	4	**735**
Rugby	2007	385	840	528	12	719	**2,483**
Solihull	2007	536	455	659	7	7	**1,664**
Stratford-on-Avon	2007	344	253	642	36	4	**1,280**
Warwick	2007	414	245	550	9	4	**1,221**

Key

- Electricity emissions source
- Thermal emissions source*
- Transport emissions source
- Other emissions source

* Assumptions have been made as to which categores constitute a thermal energy

Appendix IV: Growth projections – new development

Modelled build programme for residential developments (no. of dwellings)

Year (financial, beginning)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
North Warwickshire	167	142	106	140	140	150	150	170	170	160	160	155	155	150	150	150	150	145	145	145	**3,000**
Nuneaton and Bedworth	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	**10,800**
Rugby	494	1,429	701	469	230	488	582	523	618	760	770	770	770	770	550	550	450	450	450	450	**12,274**
Solihull	784	606	579	731	402	526	733	549	690	690	690	690	690	690	690	690	690	690	690	690	**13,190**
Stratford-upon-Avon	455	394	265	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	**5,602**
Warwick	465	580	410	269	235	743	712	710	640	590	570	570	570	570	570	547	547	547	547	547	**10,939**

Modelled build programme for non-residential developments (m^2 floor area)

Year (financial, beginning)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
North Warwickshire	0	0	0	0	7,556	7,556	7,556	7,556	7,556	7,556	7,556	7,556	7,556	10,000	10,000	10,000	10,000	10,000	10,000	10,000	**138,000**
Nuneaton and Bedworth	0	0	0	0	8,360	8,360	8,360	19,660	19,660	19,660	7,393	7,393	7,393	7,393	7,393	7,393	7,393	7,393	7,393	7,393	**157,994**
Rugby	0	0	0	87,500	87,500	87,500	133,724	49,590	82,924	79,557	76,190	42,857	42,857	42,857	42,857	42,857	42,857	42,857	42,857	42,857	**1,070,200**
Solihull	15,870	15,870	15,870	15,870	41,853	41,853	41,853	41,853	41,853	41,853	41,853	41,853	41,853	25,447	25,447	25,447	25,447	25,447	25,447	25,447	**618,287**
Stratford-upon-Avon	30,667	30,667	30,667	24,800	24,800	24,800	24,800	24,800	24,800	24,800	24,800	24,800	24,800	25,714	25,714	25,714	25,714	25,714	25,714	25,714	**520,000**
Warwick	34,576	43,127	30,486	20,002	17,474	55,247	52,942	52,793	47,588	43,870	42,383	42,383	42,383	42,383	42,383	40,673	40,673	40,673	40,673	40,673	**813,384**

Appendix V: Energy projections

North Warwickshire

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing residential - thermal (GWh)	437	432	427	422	418	413	408	403	399	394	389	384	380	375	370	365	361	356	351	346
Existing residential - electrical (GWh)	132	131	130	129	128	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113
Existing non-residential - thermal (GWh)	606	602	600	597	595	592	590	587	585	582	580	577	575	572	570	567	565	562	560	557
Existing non-residential - electrical (GWh)	411	410	408	406	405	403	401	399	398	396	394	393	391	389	387	386	384	382	381	379
New build residential - thermal (GWh)	0.9	1.6	2.5	3.4	4.4	5.4	6.5	7.6	8.6	9.7	10.7	11.7	12.6	13.6	14.6	15.6	16.5	17.4	18.4	18.4
New build residential - electricity (GWh)	0.6	1.0	1.5	2.1	2.7	3.3	3.9	4.6	5.2	5.8	6.5	7.1	7.7	8.2	8.8	9.4	10.0	10.6	11.1	11.1
New build non-residential - thermal (GWh)	0.0	0.0	0.0	0.0	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.7	9.9	11.0	12.1	13.2	14.3	15.5
New build non-residential - electricity (GWh)	0.0	0.0	0.0	0.0	0.5	1.1	1.6	2.1	2.6	3.2	3.7	4.2	4.8	5.5	6.2	6.9	7.6	8.3	9.0	9.7
Thermal energy (GWh/yr)	1,043	1,036	1,029	1,023	1,018	1,012	1,007	1,002	996	991	985	980	975	969	964	959	954	949	943	937
Electrical energy (GWh/yr)	544	542	540	538	536	534	533	531	530	528	527	525	523	522	521	519	518	516	515	513
Total (GWh/yr)	1,588	1,578	1,569	1,561	1,554	1,547	1,540	1,533	1,526	1,519	1,512	1,505	1,498	1,491	1,485	1,478	1,472	1,465	1,458	1,450

Nuneaton & Bedworth

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing residential - thermal (GWh)	848	838	829	820	811	801	792	783	774	765	755	746	737	728	719	709	700	691	682	673
Existing residential - electrical (GWh)	232	231	229	227	225	224	222	220	218	217	215	213	211	210	208	206	204	203	201	199
Existing non-residential - thermal (GWh)	379	377	375	374	372	371	369	368	366	364	363	361	360	358	356	355	353	352	350	349
Existing non-residential - electrical (GWh)	270	268	267	266	265	264	263	262	261	259	258	257	256	255	254	253	252	250	249	248
New build residential - thermal (GWh)	2.8	5.6	8.4	11.3	14.1	16.9	19.7	22.5	25.3	28.2	31.0	33.8	36.6	39.4	42.2	45.0	47.9	50.7	53.5	53.5
New build residential - electricity (GWh)	1.8	3.5	5.3	7.1	8.9	10.6	12.4	14.2	16.0	17.7	19.5	21.3	23.1	24.8	26.6	28.4	30.1	31.9	33.7	33.7
New build non-residential - thermal (GWh)	0.0	0.0	0.0	0.0	0.9	1.9	2.8	5.0	7.2	9.4	10.2	11.1	11.9	12.7	13.6	14.4	15.2	16.0	16.9	17.7
New build non-residential - electricity (GWh)	0.0	0.0	0.0	0.0	0.6	1.2	1.8	3.1	4.5	5.9	6.4	6.9	7.4	8.0	8.5	9.0	9.5	10.0	10.5	11.1
Thermal energy (GWh/yr)	1,230	1,221	1,213	1,205	1,198	1,191	1,184	1,178	1,172	1,167	1,159	1,152	1,145	1,138	1,131	1,124	1,117	1,109	1,102	1,092
Electrical energy (GWh/yr)	504	503	501	500	500	499	499	499	499	500	499	498	498	497	497	496	496	495	494	492
Total (GWh/yr)	1,733	1,723	1,714	1,705	1,698	1,690	1,683	1,677	1,672	1,666	1,658	1,651	1,643	1,635	1,628	1,620	1,612	1,604	1,597	1,584

Rugby

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing residential - thermal (GWh)	685	679	674	668	662	656	651	645	639	633	628	622	616	610	605	599	593	587	582	576
Existing residential - electrical (GWh)	201	200	199	198	197	196	195	194	193	192	191	190	189	188	187	186	185	184	183	182
Existing non-residential - thermal (GWh)	2,167	2,154	2,145	2,136	2,127	2,118	2,109	2,100	2,091	2,082	2,073	2,064	2,055	2,046	2,037	2,028	2,019	2,010	2,001	1,992
Existing non-residential - electrical (GWh)	516	514	512	510	508	505	503	501	499	497	495	493	490	488	486	484	482	480	478	475
New build residential - thermal (GWh)	9.8	14.6	17.9	19.5	22.8	26.8	30.4	34.7	39.9	45.2	50.5	55.8	61.1	64.9	68.6	71.7	74.8	77.9	81.0	81.0
New build residential - electricity (GWh)	5.9	8.7	10.7	11.6	13.6	16.0	18.1	20.7	23.8	27.0	30.1	33.3	36.4	38.7	41.0	42.8	44.7	46.5	48.3	48.3
New build non-residential - thermal (GWh)	0.0	0.0	0.0	9.8	19.6	29.4	44.4	49.9	59.2	68.1	76.7	81.5	86.3	91.1	95.9	100.7	105.5	110.3	115.1	119.9
New build non-residential - electricity (GWh)	0.0	0.0	0.0	6.1	12.3	18.4	27.7	31.2	37.0	42.6	47.9	50.9	53.9	56.9	59.9	62.9	65.9	68.9	71.9	74.9
Thermal energy (GWh/yr)	2,862	2,848	2,837	2,833	2,832	2,831	2,834	2,829	2,829	2,829	2,828	2,823	2,818	2,812	2,806	2,799	2,792	2,785	2,778	2,768
Electrical energy (GWh/yr)	723	722	721	725	730	736	744	747	753	758	764	767	770	772	774	776	777	779	781	781
Total (GWh/yr)	3,585	3,571	3,558	3,558	3,562	3,566	3,578	3,576	3,582	3,587	3,591	3,590	3,588	3,584	3,580	3,575	3,570	3,564	3,559	3,549

Solihull

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing residential - thermal (GWh)	1,583	1,570	1,556	1,543	1,530	1,517	1,503	1,490	1,477	1,463	1,450	1,437	1,423	1,410	1,397	1,384	1,370	1,357	1,344	1,330
Existing residential - electrical (GWh)	424	422	419	417	415	413	411	409	407	405	403	401	399	397	395	393	391	389	386	384
Existing non-residential - thermal (GWh)	1,098	1,091	1,087	1,082	1,078	1,073	1,068	1,064	1,059	1,055	1,050	1,046	1,041	1,036	1,032	1,027	1,023	1,018	1,014	1,009
Existing non-residential - electrical (GWh)	576	573	571	568	566	564	561	559	556	554	552	549	547	544	542	540	537	535	532	530
New build residential - thermal (GWh)	3.7	7.2	11.7	14.1	17.3	21.8	25.1	29.3	33.5	37.7	41.9	46.1	50.3	54.5	58.7	62.9	67.1	71.3	75.5	75.5
New build residential - electricity (GWh)	2.3	4.4	7.2	8.7	10.6	13.4	15.4	18.0	20.6	23.2	25.7	28.3	30.9	33.5	36.0	38.6	41.2	43.8	46.4	46.4
New build non-residential - thermal (GWh)	1.8	3.6	5.3	7.1	11.8	16.5	21.2	25.9	30.5	35.2	39.9	44.6	49.3	52.1	55.0	57.8	60.7	63.5	66.4	69.2
New build non-residential - electricity (GWh)	1.1	2.2	3.3	4.4	7.4	10.3	13.2	16.2	19.1	22.0	25.0	27.9	30.8	32.6	34.4	36.2	37.9	39.7	41.5	43.3
Thermal energy (GWh/yr)	2,686	2,672	2,660	2,646	2,636	2,628	2,618	2,609	2,600	2,591	2,582	2,573	2,564	2,553	2,542	2,532	2,521	2,510	2,499	2,484
Electrical energy (GWh/yr)	1,003	1,001	1,001	999	999	1,001	1,001	1,002	1,003	1,004	1,005	1,006	1,007	1,007	1,007	1,007	1,007	1,007	1,007	1,004
Total (GWh/yr)	3,689	3,673	3,661	3,645	3,636	3,628	3,619	3,611	3,603	3,595	3,587	3,579	3,571	3,561	3,550	3,539	3,528	3,517	3,506	3,488

Stratford-on-Avon

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing residential - thermal (GWh)	952	941	931	921	910	900	890	879	869	859	848	838	828	817	807	797	786	776	766	755
Existing residential - electrical (GWh)	255	253	252	250	248	246	244	242	240	238	236	234	232	230	228	227	225	223	221	219
Existing non-residential - thermal (GWh)	655	651	649	646	643	640	638	635	632	629	627	624	621	619	616	613	610	608	605	602
Existing non-residential - electrical (GWh)	361	360	358	357	355	354	352	351	349	348	346	345	343	342	340	339	337	336	334	333
New build residential - thermal (GWh)	3.5	5.8	8.1	10.4	12.7	15.0	17.4	19.7	22.0	24.3	26.6	28.9	31.3	33.6	35.9	38.2	40.5	42.8	45.2	45.2
New build residential - electricity (GWh)	1.9	3.2	4.5	5.8	7.1	8.3	9.6	10.9	12.2	13.5	14.8	16.0	17.3	18.6	19.9	21.2	22.5	23.8	25.0	25.0
New build non-residential - thermal (GWh)	3.4	6.9	10.3	13.1	15.9	18.6	21.4	24.2	27.0	29.7	32.5	35.3	38.1	41.0	43.8	46.7	49.6	52.5	55.4	58.2
New build non-residential - electricity (GWh)	2.1	4.3	6.4	8.2	9.9	11.6	13.4	15.1	16.9	18.6	20.3	22.1	23.8	25.6	27.4	29.2	31.0	32.8	34.6	36.4
Thermal energy (GWh/yr)	1,614	1,605	1,598	1,590	1,582	1,574	1,566	1,558	1,550	1,542	1,534	1,526	1,518	1,510	1,503	1,495	1,487	1,479	1,471	1,461
Electrical energy (GWh/yr)	621	621	621	620	620	619	619	619	618	618	617	617	617	616	616	616	615	615	615	613
Total (GWh/yr)	2,234	2,226	2,219	2,210	2,202	2,194	2,185	2,177	2,168	2,160	2,152	2,143	2,135	2,127	2,118	2,110	2,102	2,094	2,086	2,074

Warwick

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing residential - thermal (GWh)	933	926	918	910	902	894	886	879	871	863	855	847	839	832	824	816	808	800	792	785
Existing residential - electrical (GWh)	280	279	277	276	275	273	272	271	269	268	267	265	264	262	261	260	258	257	256	254
Existing non-residential - thermal (GWh)	484	481	479	477	475	473	471	469	467	465	463	461	459	457	455	453	451	449	447	445
Existing non-residential - electrical (GWh)	492	489	487	485	483	481	479	477	475	473	471	469	467	465	463	461	459	457	455	453
New build residential - thermal (GWh)	3.6	6.1	7.8	9.2	13.8	18.2	22.6	26.6	30.2	33.8	37.3	40.8	44.3	47.9	51.2	54.6	58.0	61.4	64.8	64.8
New build residential - electricity (GWh)	2.2	3.7	4.8	5.7	8.5	11.2	13.8	16.3	18.5	20.7	22.8	25.0	27.1	29.3	31.4	33.4	35.5	37.6	39.6	39.6
New build non-residential - thermal (GWh)	0.9	1.9	2.8	4.3	5.7	7.2	8.6	10.1	11.5	13.0	14.5	15.9	17.4	19.9	22.3	24.8	27.3	29.8	32.3	34.7
New build non-residential - electricity (GWh)	0.6	1.2	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1	9.0	9.9	10.9	12.4	14.0	15.5	17.1	18.6	20.2	21.7
Thermal energy (GWh/yr)	1,422	1,415	1,408	1,401	1,397	1,393	1,389	1,384	1,380	1,375	1,370	1,365	1,360	1,356	1,352	1,348	1,344	1,340	1,336	1,329
Electrical energy (GWh/yr)	774	773	771	770	770	770	770	770	770	770	769	769	769	769	769	769	770	770	770	768
Total (GWh/yr)	2,196	2,188	2,179	2,170	2,167	2,163	2,159	2,155	2,150	2,144	2,139	2,134	2,129	2,125	2,121	2,118	2,114	2,110	2,106	2,097

Appendix VI: Existing & planned renewables

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
Atherstone Wind	North Warwickshire	Small wind	2		Installed	DNO
Atherstone PV	North Warwickshire	Solar PV	82		Installed	DNO
Mancetter Road/Grange Road	North Warwickshire	Biomass heating		5,000	Planned	RESTATS
Packington Generation Plant Phase 3	North Warwickshire	Landfill gas	8,470		Installed	RESTATS
Pooley Country Park	North Warwickshire	Small wind	??		Unknown	Data collection form
Bedworth CHP	Nuneaton and Bedworth	Gas CHP	50		Installed	DNO
Biomass heat plant by Talbotts	Nuneaton and Bedworth	Biomass heating		150	Installed	REA Database
Chilvers Coton	Nuneaton and Bedworth	Solar PV	2		Installed	DNO
Eliot Park Innovation Centre / Paradise Farm	Nuneaton and Bedworth	Solar PV	105		Installed	REA Database
Hartshill Mini CHP	North Warwickshire	Gas CHP	165		Installed	Data collection form
Hartshill CHP	North Warwickshire	Gas CHP	2,900		Installed	RESTATS
Hartshill STW	North Warwickshire	Anaerobic digestion	190		Planned	Data collection form
Judkins Landfill site	Nuneaton and Bedworth	Landfill gas	2,880		Installed	RESTATS

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
Judkins Landfill Site Phase 3	Nuneaton and Bedworth	Landfill gas	1,150		Planned	RESTATS
Nuneaton CHP	Nuneaton and Bedworth	Gas CHP	90		Installed	DNO
NUNEATON wind	Nuneaton and Bedworth	Small wind	1		Installed	DNO
Ansty	Rugby	Biomass heating		240	Installed	Data collection form
Boughton Road	Rugby	Solar thermal		24	Installed	Data collection form
Boughton Road	Rugby	GSHP			Installed	Data collection form
Cattle Market	Rugby	Solar thermal		20		Data collection form
Coalpit Lane	Rugby	Landfill gas	950		Installed	RESTATS
COTESBACH LANDFILL GAS PROJECT	Rugby	Landfill gas	3,600		Installed	REA Database
Dunsmore	Rugby	Solar PV	2		Installed	DNO
KILSBY LANDFILL SITE	Rugby	Landfill gas	1,000		Installed	Renewables Map
Lawford Heath Landfill Gas	Rugby	Landfill gas	1,000		Installed	Data collection form
Long Lawford PV	Rugby	Solar PV	2		Installed	DNO
New Bold CHP	Rugby	Gas CHP	190		Installed	Data collection

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
						form
Newton PV	Rugby	Solar PV	3		Installed	DNO
Rugby Cement	Rugby	Energy from Waste	35,000		Planned	RESTATS
Rugby Wind	Rugby	Small wind	5		Installed	DNO
Ryton Pools Country Park	Rugby	Landfill gas	330		Installed	RESTATS
Warwickshire College	Rugby	Small wind	15			Data collection form
Willoughby PV	Rugby	Solar PV	2		Installed	DNO
Barston	Solihull	Energy from Waste	190		Installed	REA Database
Checkley STW	Solihull	Energy from Waste	165		Installed	REA Database
Dutton Solar PV	Solihull	Solar PV	2		Installed	REA Database
Haslucks Green School	Solihull	Solar PV	2		Planned	Data collection form
Kingfisher School	Solihull	Solar thermal		3	Planned	Data collection form
Langly School	Solihull	Small wind	6		Planned	Data collection form
Moat Lane Depot	Solihull	Biomass heating		??	Planned	Data collection form

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
SCH PVG 15 high rise blocks	Solihull	Solar PV	??		Planned	Data collection form
SCH PVG 7 high rise blocks	Solihull	Solar PV	??		Planned	Data collection form
Talbotts	Solihull	Biomass heating		150	Installed	REA Database
Talbotts	Solihull	Biomass heating		50	Installed	REA Database
Biomass heat plant by Talbotts at CV37 9NF	Stafford	Biomass heating		100	Installed	REA Database
Kinwarton PV	Stafford	Solar PV	8		Installed	DNO
Lighthorne PV	Stafford	Solar PV	2		Installed	DNO
Long Compton wind	Stafford	Small wind	6		Installed	DNO
Mark Williams	Stafford	Small wind	6		Installed	Data collection form
Mrs Anne Marie Harry	Stafford	Solar PV	5		Installed	REA Database
Oxhill Wind	Stafford	Small wind	6		Installed	DNO
Pillerton PV	Stafford	Solar PV	3		Installed	DNO
Snitterfield PV	Stafford	Solar PV	3		Installed	DNO
Southam PV	Stafford	Solar PV	2		Installed	DNO
Southam Wind	Stafford	Small wind	5		Installed	DNO

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
Southam Wind	Stafford	Small wind	20		Installed	DNO
Stratford PV	Stafford	Solar PV	3		Installed	DNO
Stratford PV	Stafford	Solar PV	5		Installed	DNO
Studley Landfill Gas	Stafford	Landfill gas	664		Planned	RESTATS
Ufton	Stafford	Landfill gas	1,006		Installed	REA Database
6 Thorn Stile Close	Warwick	Solar PV	3		Installed	REA Database
Ashton Court 1	Warwick	Small wind	1		Installed	Data collection form
Ashton Court 2	Warwick	Small wind	1		Installed	Data collection form
Ashton Court 3	Warwick	Small wind	1		Installed	Data collection form
Bishops Tachbrook PV	Warwick	Solar PV	2		Installed	DNO
Blackdown PV	Warwick	Solar PV	3		Installed	DNO
BUDBROOKE wind	Warwick	Small wind	1		Installed	DNO
Eden Court 1	Warwick	Small wind	1		Installed	Data collection form
Eden Court 2	Warwick	Small wind	1		Installed	Data collection form

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
Eden Court 3	Warwick	Small wind	1		Installed	Data collection form
Finham STW	Warwick	Anaerobic digestion	2,096		Installed	Data collection form
Hill Close Gardens	Warwick	Small wind	1		Installed	Data collection form
HillCrest Solar	Warwick	Solar PV	3		Installed	REA Database
Kenilworth PV 1	Warwick	Solar PV	3		Installed	DNO
Kenilworth PV 2	Warwick	Solar PV	2		Installed	DNO
Kenilworth PV 3	Warwick	Solar PV	2		Installed	DNO
Kenilworth Wind	Warwick	Small wind	1		Installed	DNO
Leamingington Spa PV	Warwick	Solar PV	1		Installed	DNO
Leamington Spa PV	Warwick	Solar PV	3		Installed	DNO
Leamington Spa PV	Warwick	Solar PV	4		Installed	DNO
Leamington Spa Wind	Warwick	Small wind	1		Installed	DNO
Leamington Spa Wind 2	Warwick	Small wind	1		Installed	DNO
Lillington Road	Warwick	Small wind	1		Installed	Data collection form

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
Lillington Wind	Warwick	Small wind	1		Installed	DNO
LILLINGTON wind 2	Warwick	Small wind	1		Installed	DNO
Mill Lane	Warwick	Small wind	1		Installed	Data collection form
Rowington PV	Warwick	Solar PV	1		Installed	DNO
Rowington PV	Warwick	Solar PV	2		Installed	DNO
Rowington PV	Warwick	Solar PV	3		Installed	DNO
Rowington PV	Warwick	Solar PV	4		Installed	DNO
Southorn Ct 1	Warwick	Small wind	1		Installed	Data collection form
Southorn Ct 2	Warwick	Small wind	1		Installed	Data collection form
Southorn Ct 3	Warwick	Small wind	1		Installed	REA Database
Sussex court PV	Warwick	Solar PV	2		Installed	DNO
Tannery Court	Warwick	Small wind	1		Installed	Data collection form
Warwick PV	Warwick	Solar PV	1		Installed	DNO
Warwick PV	Warwick	Solar PV	1		Installed	DNO

Project name	Local Authority	Technology	Electrical Installed capacity (kW)	Thermal Installed capacity (kW)	Planned / installed	Source
Warwick PV	Warwick	Solar PV	1		Installed	DNO
Warwick PV	Warwick	Solar PV	1		Installed	DNO
Warwick Wind	Warwick	Small wind	1		Installed	DNO
Wasperton PV	Warwick	Solar PV	2		Installed	DNO
Waverley Wood Farm Landfill Site	Warwick	Landfill gas	800		Installed	RESTATS
Waverley Wood II	Warwick	Landfill gas	2,402		Planned	RESTATS
Total			65,649	5,738		

Appendix VII: Large wind

Based on the GIS constraints analysis, the district was subdivided into constrained zones, i.e. absolute constraints which would definitely prevent wind energy developments, unconstrained zones and less constrained zones, i.e. constraints which would not necessarily prevent wind energy developments, but which would rather result in consultations with the respective stakeholders.

One example for an absolute constraint would be those areas in the district covered by woodland as illustrated in the map below.

An example for a less constrained zone (i.e. one that would not necessarily prevent wind energy developments in the district, but which would rather result in consultations with the respective stakeholders) is illustrated in the GIS map below which shows those areas in the study possibly affected by radar issues.

Air safeguarding zones are ‘consultation zones’, i.e. Local Planning Authorities are required to consult the Civil Aviation Authority (CAA) upon any proposed developments with tall structures that would fall within safeguarding map-covered areas. Regarding this issue, the British Wind Energy Association’s (BWEA) ‘Wind energy and aviation guide’ points out that the aviation community has “procedures in place to assess the potential effects … and identify mitigation measures”. Furthermore, the guide states that while both wind energy and aviation are important to UK national interests, the ‘overall national context’ will be taken into account when assessing the potential impacts of a wind development upon aviation operations.

Therefore, the air safeguarding zones are only considered ‘consultation zones’ and were therefore excluded at this stage from the wind energy constraints analysis. Figure2 illustrates these consultations zones which cover the majority of the study area.

However, despite air safeguarding zones not being constraints per se, they need to be addressed by developers early in the process of wind energy site development. It is, therefore, advised for developers to start a pre planning consultation process with the relevant aviation stakeholders early in the feasibility process.

Figure1: Absolute constraint: Woodland areas in the study area

Woodland

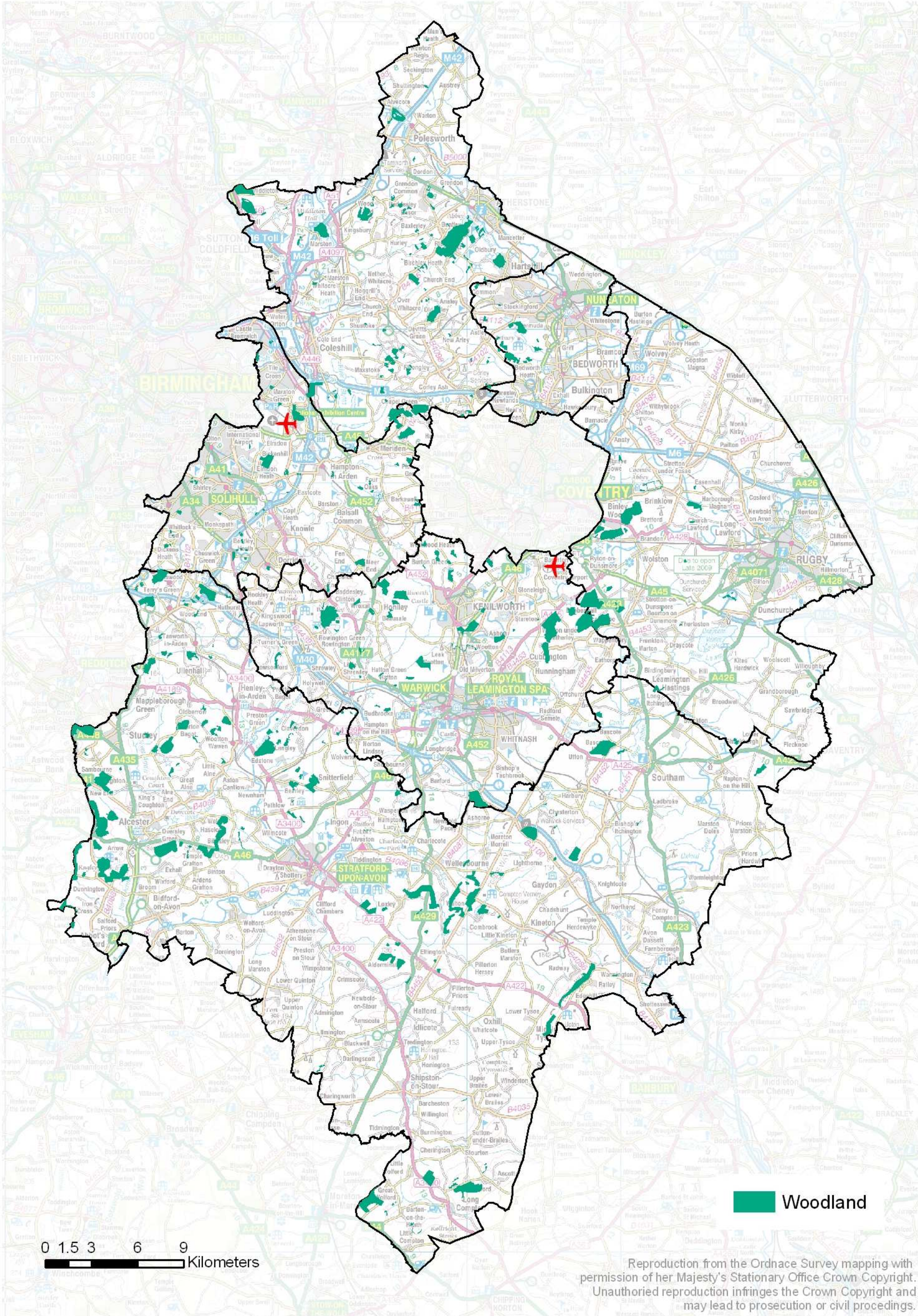
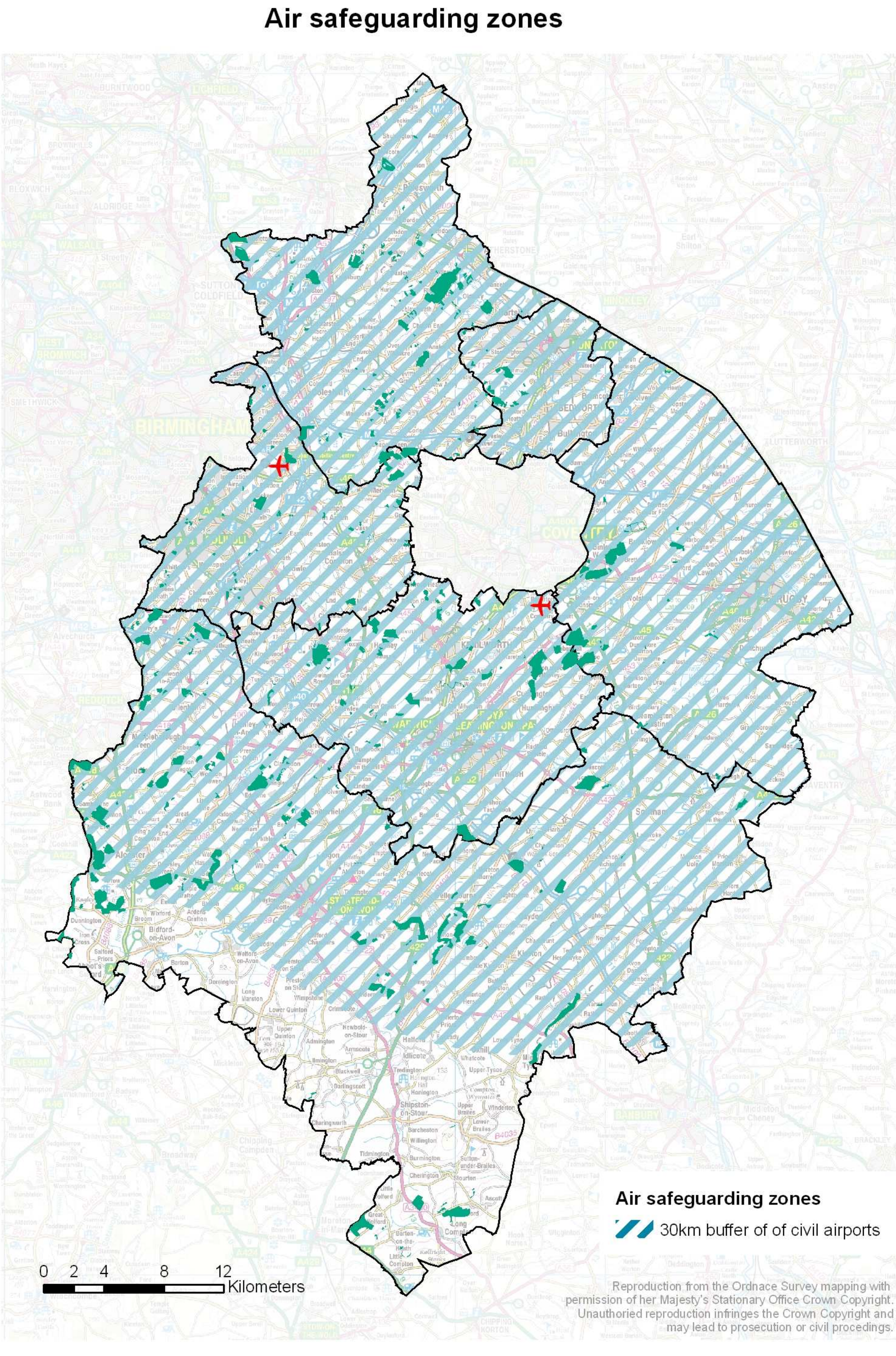


Figure2: Consultative zones: Air Safeguarding Zones in the study area



Distribution network within the district

When evaluating the feasibility of large renewable energy power generation, the distance from potential generation location sites to sections of the electricity network of suitable voltage is important. This does not account for capacity (thermal and load flow) characteristics of any particular connection point, which would need to be considered at the project level. Proximity to the electricity network (usually at the 11kV and 33kV level network) is a significant constraint to the viability of individual development sites.

Whilst in general the distance to the next grid connection point is necessary for the assessment of potential opportunities from all types of renewable energy developments that feed into the grid, such a distribution network map does not give an indication about the possible availability of connection capacity. This issue would normally only be addressed on an individual scheme basis and therefore has not be accounted for in this area-wide study.

Other aspects important with respect to grid connection for renewable energy projects include:

- Local loads
    - The more similar the generator capacity is to the magnitude of local loads, the more cost effective the grid connection; this is due to the network usually being designed and sized for the local load in a certain area.
    - The annual charges that the generator incurs when using the distribution system can be saved if the generation can be connected into an existing customer network.
    - Using energy on-site can triple its value as this is the equivalent higher factor that suppliers charge for selling energy in comparison to purchasing energy.
- Voltage
    - If the generating voltage differs from network voltages, transformers might be required which in turn, however, can increase connection costs significantly.
    - Purchasing additional equipment is generally only worth it if losses on the cables are significant; if that's not the case, connection should happen at the generator voltage.
    - Determining the most suitable connection voltage for various generator capacities can be done by applying the following rule of thumb:
        - Less than 3.6kW – 240V (1-phase)
        - Less than 400kW – 400V (3-phase)
        - Between 400kW and 8MW – 11kV
        - Over 8MW – EHV connection (33kV or higher)
- Switchgear and ratings
    - Extending an existing switchboard (used for isolation of electrical equipment) might be less cost effective than connecting into a cable with a ring main unit – depending on required civil works and distance from generation.
- Regulatory requirements
    - When connecting renewable generation to the distribution network, there are two Electricity Networks Association guidelines, i.e. G83 and G59.
    - G83 is for very small embedded generators (up to 16A per phase), whereas G59 is for medium-sized embedded generators, i.e. up to 5MW, connection up to 20kV.

- Connection applications
    - Generators installed under the G59 guidelines -or multiple smaller generators-, require the submission of a generator connection application to the local distribution network operator (DNO). Within a maximum of 90 days upon receipt of the application, the DNO will assess the effect of the proposed generation on the remaining network.
    - Upon successful detailed assessments, a connection offer will be made by the DNO indicating the non-contestable work and costs (to be undertaken by the DNO) and contestable work (to be undertaken by either the DNO or an accredited third party) and their respective timeframes.

Appendix VIII: Biomass – available resource & analysis assumptions

TOTAL TARGET POTENTIAL (decentralised generation + new build sites + existing buildings)

North Warwickshire

PRIMARY ENERGY (MWh) - NORTH WARWICKSHIRE											
	MSW		Agriculture								
Year	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw	Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
2010	1,097	1,552	776	21	9,714	0	0	46	2,632	104	15,942
2011	1,529	2,388	1,475	25	11,242	0	0	111	6,433	222	23,425
2012	1,973	3,229	2,174	29	12,769	0	0	176	10,235	343	30,927
2013	2,430	4,075	2,873	33	14,296	2,075	0	240	14,036	466	40,523
2014	2,899	4,925	3,571	37	15,824	4,149	0	305	17,838	590	50,139
2015	3,382	5,781	4,270	41	21,811	6,915	0	369	21,640	716	64,925
2016	4,109	6,133	4,969	41	22,606	9,681	0	480	25,441	844	74,303
2017	4,848	6,490	5,668	41	23,400	12,447	0	591	29,243	973	83,701
2018	5,600	6,852	6,367	41	24,194	15,213	0	702	33,044	1,105	93,118
2019	6,365	7,218	7,065	41	24,988	17,979	0	813	36,846	1,238	102,554
2020	7,143	7,590	7,764	41	25,783	20,745	0	924	36,846	1,373	108,207
2021	7,920	7,966	7,764	41	25,783	30,426	0	924	36,846	1,509	119,178
2022	8,710	8,347	7,764	41	25,783	40,107	0	924	36,846	1,647	130,169
2023	9,513	8,732	7,764	41	25,783	49,788	0	924	36,846	1,788	141,178
2024	10,329	9,123	7,764	41	25,783	59,469	0	924	36,846	1,929	152,207
2025	11,157	9,518	7,764	41	25,783	69,150	0	924	36,846	2,073	163,256

Nuneaton & Bedworth

PRIMARY ENERGY (MWh) - NUNEATON AND BEDWORTH											
	MSW		Agriculture								
Year	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw	Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
2010	1,833	2,574	91	6	1,940	0	0	4	3,049	173	9,670
2011	2,553	3,940	173	7	2,215	0	0	10	7,454	372	16,723
2012	3,295	5,314	254	8	2,491	0	0	16	11,858	573	23,809
2013	4,058	6,696	336	9	2,766	567	0	22	16,263	778	31,494
2014	4,842	8,085	418	10	3,042	1,133	0	28	20,667	985	39,211
2015	5,648	9,483	500	12	4,229	1,889	0	34	25,071	1,196	48,061
2016	6,862	10,071	581	12	4,345	2,644	0	44	29,476	1,409	55,444
2017	8,097	10,668	663	12	4,462	3,400	0	54	33,880	1,626	62,860
2018	9,353	11,272	745	12	4,578	4,155	0	64	38,285	1,845	70,308
2019	10,630	11,884	827	12	4,695	4,911	0	74	42,689	2,067	77,788
2020	11,929	12,504	908	12	4,811	5,666	0	84	42,689	2,292	80,897
2021	13,228	13,132	908	12	4,811	8,310	0	84	42,689	2,520	85,695
2022	14,547	13,769	908	12	4,811	10,955	0	84	42,689	2,751	90,526
2023	15,888	14,413	908	12	4,811	13,599	0	84	42,689	2,985	95,389
2024	17,251	15,064	908	12	4,811	16,243	0	84	42,689	3,222	100,285
2025	18,634	15,724	908	12	4,811	18,887	0	84	42,689	3,462	105,212

Rugby

PRIMARY ENERGY (MWh) - RUGBY											
Year	MSW		Agriculture			Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw						
2010	1,774	2,450	1,065	883	13,990	0	0	40	3,131	167	23,501
2011	2,471	3,696	2,024	1,060	16,107	0	0	96	7,654	360	33,469
2012	3,190	4,950	2,983	1,237	18,225	0	0	152	12,177	555	43,469
2013	3,928	6,212	3,942	1,413	20,343	2,484	0	208	16,699	753	55,983
2014	4,688	7,481	4,901	1,590	22,461	4,967	0	265	21,222	954	68,529
2015	5,468	8,758	5,859	1,767	31,061	8,279	0	321	25,745	1,158	88,415
2016	6,643	9,328	6,818	1,767	32,088	11,591	0	417	30,268	1,364	100,283
2017	7,838	9,905	7,777	1,767	33,115	14,902	0	513	34,790	1,574	112,182
2018	9,054	10,490	8,736	1,767	34,142	18,214	0	609	39,313	1,786	124,112
2019	10,291	11,083	9,695	1,767	35,169	21,526	0	705	43,836	2,001	136,073
2020	11,549	11,683	10,654	1,767	36,196	24,837	0	802	43,836	2,219	143,543
2021	12,806	12,292	10,654	1,767	36,196	36,428	0	802	43,836	2,440	157,219
2022	14,083	12,907	10,654	1,767	36,196	48,019	0	802	43,836	2,664	170,927
2023	15,381	13,531	10,654	1,767	36,196	59,609	0	802	43,836	2,890	184,665
2024	16,700	14,162	10,654	1,767	36,196	71,200	0	802	43,836	3,120	198,436
2025	18,040	14,801	10,654	1,767	36,196	82,791	0	802	43,836	3,352	212,237

Solihull

PRIMARY ENERGY (MWh) - SOLIHULL											
	MSW		Agriculture								
Year	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw	Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
2010	253	885	453	76	3,122	0	0	17	6,240	24	11,070
2011	352	2,026	861	91	3,545	0	0	42	15,253	51	22,221
2012	455	3,168	1,269	106	3,968	0	0	66	24,266	79	33,377
2013	560	4,311	1,677	121	4,391	656	0	90	33,279	107	45,193
2014	668	5,456	2,085	137	4,814	1,312	0	114	42,292	136	57,014
2015	779	6,601	2,493	152	6,720	2,187	0	139	51,304	165	70,540
2016	947	6,683	2,900	152	6,878	3,061	0	180	60,317	194	81,313
2017	1,117	6,765	3,308	152	7,036	3,936	0	222	69,330	224	92,091
2018	1,291	6,848	3,716	152	7,194	4,811	0	263	78,343	255	102,873
2019	1,467	6,933	4,124	152	7,353	5,686	0	305	87,356	285	113,660
2020	1,646	7,018	4,532	152	7,511	6,560	0	346	87,356	316	115,438
2021	1,825	7,105	4,532	152	7,511	9,622	0	346	87,356	348	118,797
2022	2,007	7,193	4,532	152	7,511	12,683	0	346	87,356	380	122,160
2023	2,193	7,282	4,532	152	7,511	15,745	0	346	87,356	412	125,528
2024	2,381	7,372	4,532	152	7,511	18,806	0	346	87,356	445	128,900
2025	2,571	7,463	4,532	152	7,511	21,868	0	346	87,356	478	132,277

Stratford-On-Avon

PRIMARY ENERGY (MWh) - STRATFORD-ON-AVON											
	MSW		Agriculture								
Year	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw	Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
2010	1,485	2,404	1,882	14,533	39,012	0	4,586	320	5,525	140	69,889
2011	2,069	4,083	3,576	17,440	43,981	0	5,228	769	13,507	301	90,954
2012	2,671	5,768	5,271	20,347	48,950	0	5,870	1,217	21,488	465	112,045
2013	3,289	7,460	6,965	23,253	53,919	10,814	6,512	1,665	29,469	630	143,977
2014	3,925	9,158	8,659	26,160	58,888	21,629	7,154	2,114	37,450	799	175,935
2015	4,578	10,863	10,353	29,067	82,600	36,048	7,796	2,562	45,431	969	230,267
2016	5,562	11,340	12,047	29,067	84,125	50,467	8,438	3,330	53,413	1,142	258,931
2017	6,563	11,823	13,741	29,067	85,651	64,887	9,080	4,099	61,394	1,318	287,621
2018	7,581	12,313	15,435	29,067	87,176	79,306	9,722	4,867	69,375	1,495	316,337
2019	8,617	12,809	17,129	29,067	88,701	93,725	10,363	5,636	77,356	1,676	345,079
2020	9,669	13,312	18,823	29,067	90,227	108,144	11,005	6,405	77,356	1,858	365,867
2021	10,722	13,821	18,823	29,067	90,227	158,612	11,638	6,405	77,356	2,043	418,713
2022	11,791	14,337	18,823	29,067	90,227	209,079	12,271	6,405	77,356	2,230	471,586
2023	12,878	14,859	18,823	29,067	90,227	259,546	12,904	6,405	77,356	2,420	524,485
2024	13,983	15,387	18,823	29,067	90,227	310,013	13,537	6,405	77,356	2,612	577,409
2025	15,104	15,922	18,823	29,067	90,227	360,481	14,170	6,405	77,356	2,806	630,360

Warwick

PRIMARY ENERGY (MWh) - WARWICK											
Year	MSW		Agriculture			Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw						
2010	926	1,927	376	168	8,973	0	2,293	79	4,465	87	19,295
2011	1,290	3,743	715	201	10,200	0	2,614	190	10,915	188	30,057
2012	1,665	5,564	1,054	235	11,428	0	2,935	301	17,365	290	40,836
2013	2,051	7,388	1,393	269	12,655	2,272	3,256	411	23,814	393	53,903
2014	2,448	9,216	1,731	302	13,883	4,545	3,577	522	30,264	498	66,987
2015	2,855	11,049	2,070	336	19,361	7,575	3,898	633	36,714	604	85,095
2016	3,468	11,346	2,409	336	19,833	10,605	4,219	823	43,164	712	96,914
2017	4,092	11,648	2,748	336	20,304	13,635	4,540	1,013	49,613	822	108,750
2018	4,727	11,953	3,086	336	20,776	16,664	4,861	1,203	56,063	933	120,602
2019	5,373	12,263	3,425	336	21,248	19,694	5,182	1,393	62,513	1,045	132,471
2020	6,030	12,576	3,764	336	21,719	22,724	5,503	1,583	62,513	1,159	137,906
2021	6,686	12,894	3,764	336	21,719	33,329	5,819	1,583	62,513	1,274	149,916
2022	7,353	13,215	3,764	336	21,719	43,934	6,136	1,583	62,513	1,391	161,942
2023	8,031	13,541	3,764	336	21,719	54,538	6,452	1,583	62,513	1,509	173,985
2024	8,719	13,870	3,764	336	21,719	65,143	6,768	1,583	62,513	1,629	186,044
2025	9,419	14,204	3,764	336	21,719	75,748	7,085	1,583	62,513	1,750	198,119

Total study area

PRIMARY ENERGY (MWh) - Total study area											
Year	MSW		Agriculture			Energy crops	Sawmill residues	Forestry residues	C&D + C&I wood waste	Commercial food waste	Total
	Paper&card + wood waste	Green waste + Food/kitchen waste	Animal manure -wet	Animal manure -dry	Straw						
2010	7,368	11,792	4,645	15,687	76,751	0	6,878	507	25,043	695	149,366
2011	10,265	19,876	8,825	18,824	87,291	0	7,841	1,217	61,215	1,494	216,849
2012	13,248	27,993	13,005	21,961	97,832	0	8,804	1,927	97,388	2,305	284,463
2013	16,316	36,142	17,185	25,099	108,372	18,868	9,767	2,637	133,560	3,128	371,074
2014	19,471	44,322	21,365	28,236	118,912	37,735	10,730	3,347	169,733	3,962	457,814
2015	22,711	52,535	25,545	31,374	165,781	62,892	11,693	4,057	205,906	4,808	587,303
2016	27,590	54,901	29,725	31,374	169,874	88,049	12,656	5,274	242,078	5,666	667,189
2017	32,555	57,299	33,905	31,374	173,968	113,206	13,619	6,492	278,251	6,536	747,205
2018	37,606	59,729	38,085	31,374	178,061	138,363	14,582	7,709	314,424	7,418	827,350
2019	42,743	62,190	42,265	31,374	182,154	163,520	15,545	8,926	350,596	8,312	907,625
2020	47,966	64,684	46,445	31,374	186,247	188,677	16,508	10,143	350,596	9,217	951,858
2021	53,186	67,210	46,445	31,374	186,247	276,727	17,457	10,143	350,596	10,134	1,049,519
2022	58,492	69,767	46,445	31,374	186,247	364,776	18,407	10,143	350,596	11,063	1,147,310
2023	63,884	72,357	46,445	31,374	186,247	452,825	19,356	10,143	350,596	12,004	1,245,231
2024	69,362	74,978	46,445	31,374	186,247	540,875	20,305	10,143	350,596	12,957	1,343,281
2025	74,926	77,631	46,445	31,374	186,247	628,924	21,254	10,143	350,596	13,921	1,441,461

BIOMASS ANALYSIS ASSUMPTIONS

Forestry residues

- It is assumed that yield and ratio of residues to volume of merchantable timber for Scots pine YC10 are representative of all conifers in the region. Similar assumptions are made that Birch YC6 are representative of all broadleaves in the region. Volume of residues generated per hectare have been derived using parameters from Cannel and Dewar (1996) and Forestry Commissions Yield Tables (1981), assuming rotations of 70 for Scots pine and 60 for Birch. Total volume of residues generated from thinnings over rotation and final harvest is divided by rotation to derive annual oven-dried tonnes (ODT/year). Therefore, it is assumed that all forestry age classes are represented equally.
- Slow initial uptake is assumed, to account for machinery and labour required and incorporation of residues extraction in forest management plans: 5% by 2010; 40% by 2015; and 100% by 2020.

Energy Crops

- The E4tech report models 4 case scenarios based on data from the Refuel project, all 4 scenarios consider that land available for energy crops will increase: area of arable land available for energy crops increasing from 605,000 Hectares in 2008 to 963-1334,000 Ha in 2030, and pasture area from 290,000 Ha in 2008 to 1200,000 Ha in 2030. However, for this study it has been considered appropriate to assume that land available for energy crops will remain constant over time and it is only equivalent to arable land currently out of production (i.e. no proportion in pasture land considered available), since:
    - The area of arable land not in production (the equivalent of bare fallow and un-cropped set-aside land in 2007) has fallen steeply, by over 62% between 2007 and 2008, (Defra Agricultural survey, 2008)
    - Defra abolished set aside land in 2008.
    - Current trends of expansion of organic agriculture and farming, which will require wider areas to obtain the same production volumes.
    - There are many environmental restrictions that make very unlikely the conversion of most pastures to energy crops (potentially significant loss of soil carbon, run-off and biodiversity to name a few).
- Very slow initial uptake is assumed, to account for required specialised machinery and labour, subsidy schemes, and delay of fist harvest (3 years for willow and 5 years for poplar): 10% by 2015, 30% by 2020 and 100% by 2025.

Sawmill residues

- The competing uses are the panel board industry, paper and pulp, exports and fencing. Currently, 12% of co-products are sold for bio-energy (Forestry Commission statistics 2009[1]). It is assumed that availability for bio-energy will increase up to 30% of current total resource by 2020, on the basis that:
    - Softwood availability in the United Kingdom continues to increase over the next 15 years from 12 million m^3 in the period 2007-2011, peaking in the period 2017-2021 at just over 14 million m^3 (Forestry Commission 2006[2]).

[1] *Forestry Commission statistics. 2009. http://www.forestry.gov.uk/website/forstats2009.nsf/TopContents?Open&ctx=92B74B2CCD24A56C8025731B0053FB26*
[2] *New forecast of softwood availability (Forestry Commission 2006). http://www.forestry.gov.uk/website/ForestStats2006.nsf/byunique/ukgrown.html*

    - Increasing recycling rates of waste wood from the construction and other industries will supply part of panel board industry and therefore release part of the sawmill resource

- Immediate uptake achievable as soon as the resource is made available
- Output of the sawmills in the study area remain constant.

Crop residues - Straw

- The availability factor of 35% for cereal straw (Wheat and Barley account for over 95% of land dedicated to cereals in the UK) is derived from the UK Biomass Strategy: "The UK cereal straw (Wheat and Barley) resource is significant (9-10 mt per annum) but much of this is recycled to livestock and much of the rest is ploughed into soil (it has a resource value as a fertiliser and organic matter supplement). It is estimated, that up to 3m tonnes could be made available in the long term without disrupting livestock use/buying costs". Supported by Biomass Energy Centre: "Most Barley straw is used for animal bedding and feed, and figures for Winter wheat straw suggest that in the UK around 40% is chopped and returned to the soil, 30% used on the farm (for animal bedding and feed), and 30% is sold". Wheat accounts for 70% of all land dedicated to cereals.
- It is assumed that up 60% of the straw available for bio-energy can be recovered from the filed. To account for technology limitations.
- Uptake assumption for cereal straw: 50% by 2010, 100% by 2015
- Uptake assumptions from DECC/E4tech for oil seed rape: 10% of this can be collected now, 20% in 2010, 50% in 2015, and 100% from 2020 in all scenarios. The uptake rate is relatively slow, as oilseed rape straw is not currently extracted in large quantities and is more difficult to handle than wheat and barley straw.
- Wheat parameters (yield, moisture and NCV) have been used for cereal straw since practically all cereal straw will come from wheat. Wheat accounts for 70% of all land dedicated to cereals.
- Area of land dedicated to cereal and rape seed oil assumed to remain constant over time.

Agricultural animal waste

- 15% of theoretical resource is excluded to represent technical limitations of manure collection and handling losses.
- Extraction rates were considered to be (E4tech):

  For dry poultry litter 18% now, 50% in 2010 and 100% in 2015.

  For wet manures, the rate was assumed to be lower, at 1% now, 10% in 2010, 50% in 2015 and 100% in 2020

  High uptake rates proposed by E4tech (especially for dry poultry litter) and no competing demands can be backed by the following facts:

    - Since digestate from Anaerobic Digestion has a higher nutrient value than manure, farmers are likely to provide manure at zero cost in exchange for returned digestate – which needs to be spread to land (E4tech).
    - Although much poultry litter has been spread on the land as a fertilizer, there has been evidence that when spread on land for cattle grazing or for hay or silage, this can cause botulism in cattle and the practice has been urged against by Defra. Defra advises either incineration or deep ploughing or burial.

    - Animal slurry is widely used as a fertilizer and there are a number of methods to spread it on land, though recent concerns about loss of ammonia to the air means that Defra now advises against broadcast spreading[3]

- As implied by uptake assumptions above, use of manure as fertiliser has not been considered has a competing demand.
- Number of livestock to remain constant over time.

Waste currently land-filled

- For this study, slow growth of waste arisings (0.75% annually over current levels) has been assumed. It is acknowledged by a number of sources (Waste Strategy for England 2007[4], ERM[5] and E4Tech reports) that there is great uncertainty regarding future arisings. E4tech assumes static, waste strategy suggests four scenarios (one of them no growth, 3 of them little growth with maximum of 2% a year).
- For paper and card recycling is supplied first. Overall recycling targets in the waste strategy for household waste assumed to be applicable to individual waste components. This is supported by EU directive that sets specific recycling targets for 2020 of 50% for glass, plastic, paper and metals.
- Maximum recovery levels are set based on best performance across Europe, under the basis that if it has been achieved elsewhere in Europe, it can theoretically be achieved in the study area. These are taken from Table B1.2 of the ERM report.
- Separability of waste will increase linearly to reach maximum recovery levels in 2025/26.
- Initial recovery potential = 5% over recycling rate.
- Alternative disposal routes for kitchen waste and green waste e.g. composting are not considered as competing demand.
- The Waste Strategy for England 2007 sets actions to stimulate energy recovery of wood waste rather than recycling. Therefore, all collectable wood waste over current recycling rates assumed to be available for energy. From the waste strategy it is clear that wood has relatively low embodied energy (energy consumed in extraction) but high calorific value. Though for some kinds of wood waste re-use or recycling are better options, use as a fuel generally conveys a greater greenhouse gas benefit than recovering the material as a resource (and avoiding primary production).

Green waste currently diverted

- Composting is not considered a competing demand. However, an uptake period of 5 years is assumed.

[3] •*Biomass energy centre http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,17976&_dad=portal&_schema=PORTAL*
[4] *Waste strategy for England 2007. http://www.defra.gov.uk/environment/waste/strategy/strategy07/index.htm*
[5] *Carbon Balances and Energy Impacts of the Management of UK Wastes (ERM 2006). http://randd.defra.gov.uk/Document.aspx?Document=WR0602_4746_FRA.pdf*

PROJECTED BIOMASS CHP FACILITY

Operational hours	8000 hours/yr
Capacity installed	2.5 MWe
Electrical efficiency	30%
Primary energy required	66,667 MWh
Feedstock used	Dry clean biomass

LA	Total clean biomass potential - primary energy MWh -2015	Contribution to project
Nuneaton	18,687	3,586
North Warwickshire	39,916	7,660
Rugby	52,533	10,082
Stratford	151,721	29,117
Warwick	49,824	9,562
Solihull	34,697	6,659
Total	**347,377**	**66,667**

Proportion diverted to proposed biogas plant	19%

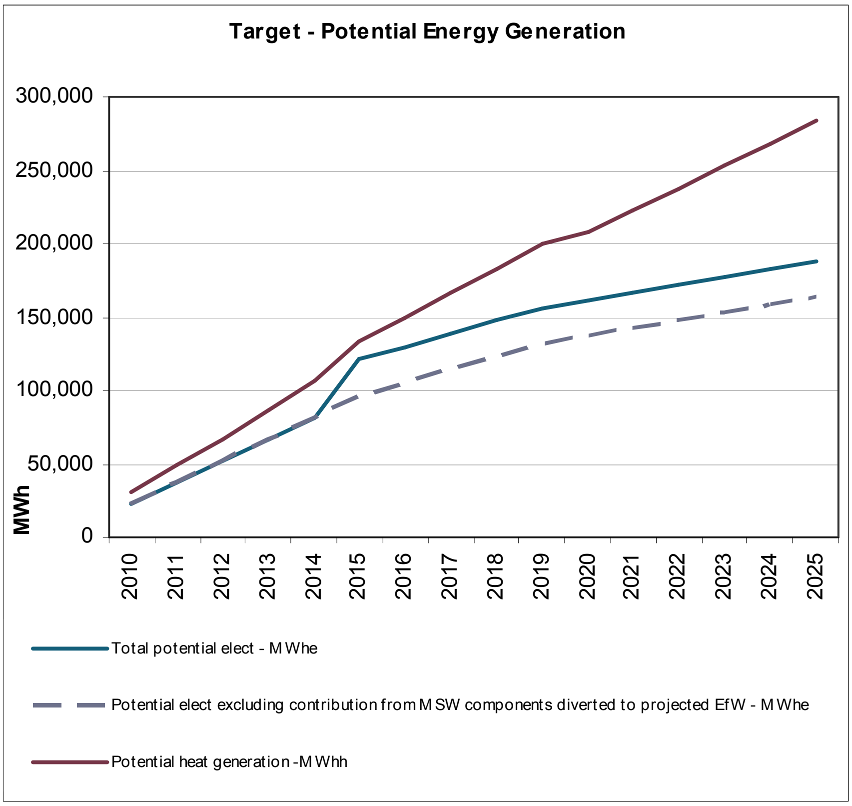
PROJECTED BIOGAS PLANT

Operational hours	8000 hours/yr
Capacity installed	2 MWe
Electrical efficiency	30%
Primary energy required	53,333 MWh

LA	Total AD potential - primary energy MWh -2015	
Nuneaton	44,077	9,098
North Warwickshire	30,773	6,352
Rugby	46,359	9,569
Stratford	58,381	12,050
Warwick	49,119	10,139
Solihull	29,678	6,126
Total	**258,388**	**53,333**

Proportion diverted to proposed biogas plant	21%

	Potential energy generation - Total		Potential energy generation - excluding contribution from MSW components diverted to projected EfW - Mwhe	
Year	MWh_e	MWh_h	MWh_e	MWh_h
2010	22,953	31,286	22,953	31,286
2011	37,257	48,717	37,257	48,717
2012	51,612	66,181	51,612	66,181
2013	66,271	86,291	66,271	86,291
2014	80,980	106,434	80,980	106,434
2015	121,110	133,060	96,364	133,060
2016	129,880	149,622	105,279	149,622
2017	138,701	166,218	114,244	166,218
2018	147,572	182,847	123,260	182,847
2019	156,494	199,511	132,327	199,511
2020	161,900	207,704	137,879	207,704
2021	166,943	222,808	143,089	222,808
2022	172,036	237,945	148,350	237,945
2023	177,180	253,115	153,662	253,115
2024	182,375	268,320	159,024	268,320
2025	187,620	283,559	164,437	283,559



Appendix IX: Small wind

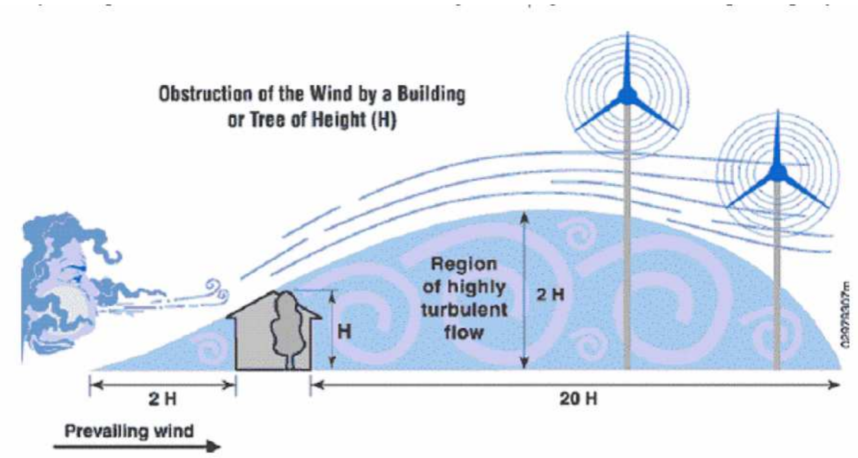
Small wind has not been explicitly reviewed in terms of generation potential within this study since the overall potential is limited. The following provides guidance on the key issues associated with small wind energy development. Key opportunities for small wind energy development include:

- Farms
- Public sector sites such schools
- Industrial parks and retail parks

When considering the potential for small wind energy schemes, which can include building-mounted wind turbines, the following aspects need to be taken into consideration:

- Surrounding obstacles create turbulence which a) decreases a wind turbine's output and b) increases both the load and vibration effects on the building / site. These turbulences are obviously mostly prevailing in urban areas, making these potential sites often less suitable for small wind turbines than areas in rural regions, such as farm houses, small rurally located hamlets or villages or locations on the edge of larger settlements. The figure below illustrates the turbulences that obstacles, such as buildings or trees create which can result in much lower wind speeds for small-scale wind turbines.

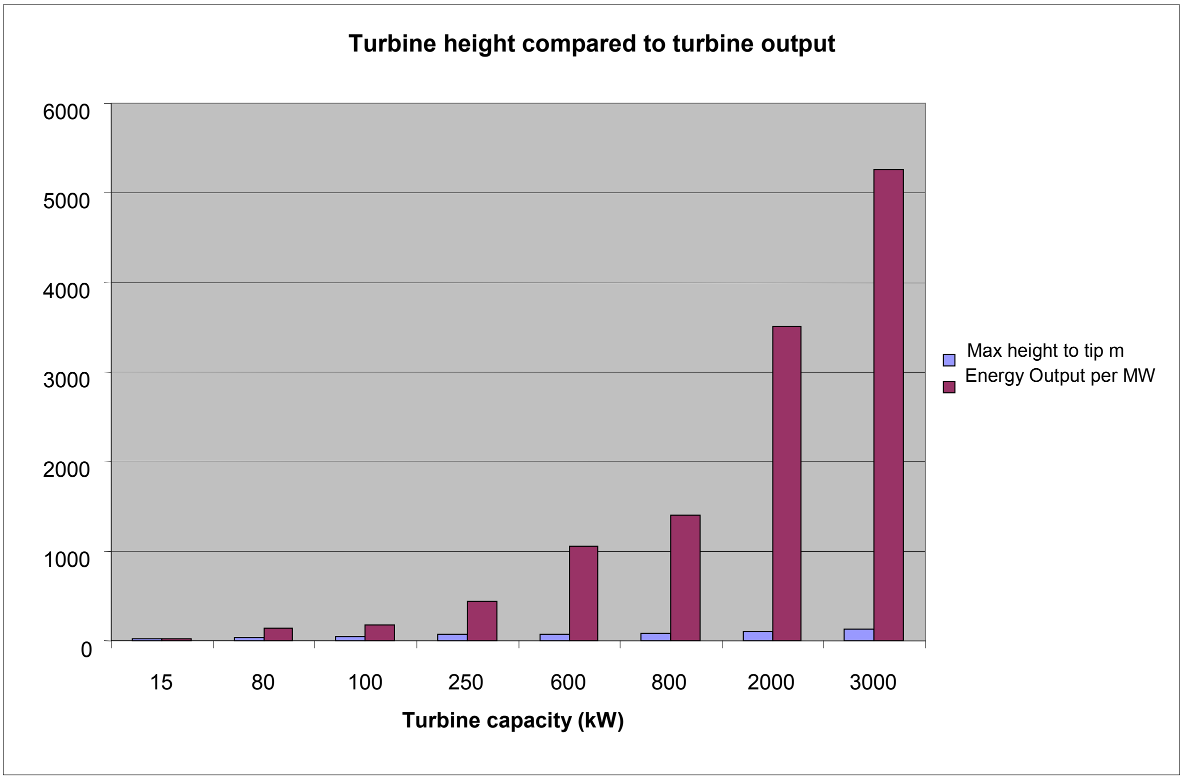
Figure3: Effects of wind shadowing (Source: www.awea.com)



- Wind imposes considerable dynamic loads on a roof-mounted wind turbine and conventional buildings are not designed to deal with these, so care must be taken when planning installations.
- It is much easier to install a wind turbine on a new building instead of retrofitting it to an existing building (structural engineers must be consulted in both cases).
- Access for inspection and maintenance is important for building-mounted wind turbines.
- The electricity for small scale turbines can either link to the grid or charge batteries, the former being more cost effective.

- The availability of grants (such as through the Low Carbon Buildings Programme[6]) for the installation of microgeneration technologies, can increase the affordability of the development of small wind schemes for potential target groups, such as community groups, schools, supermarkets, council buildings, industrial estates or other large commercial customers.
- At present national planning legislation requires that planning permission is obtained for domestic wind turbines and similar small wind energy installations, which do not benefit from Permitted Development Rights: different conditions and limitations apply depending on whether a small-scale turbine is fixed to a house, on a wall, to the roof or whether it is a free standing turbine. The main criteria that Local Authorities would take into consideration include turbine height; location, age and impact on the host building; shadow flicker; noise; interference with electromagnetic interference; highway safety; visual impact; environmental considerations and site access[7].
- With respect to potential sites for small-scale wind, the technology is particularly suitable for farms, but also for municipal buildings such as community centres or schools (above all in rural areas where the effects of wind shadowing would be smaller than in urban areas and where schools usually have more land to place the turbine on). An additional advantage of these "community" sites would support education.
- There is a significant difference in terms of electricity output based on the height and capacity of a turbine. The figure below illustrates that the energy output per MW installed grows exponentially with increasing turbine height.

Figure4: Turbine height compared to turbine output



[6] http://www.lowcarbonbuildings.org.uk/home/
[7] http://www2.valeroyal.gov.uk/internet/vr.nsf/AllByUniqueIdentifier/DOCC3B2E8B8DEF3AD2380257260005AB960

Appendix X: Photovoltaics (PV)

Solar photovoltaic (PV) panels are semi-conductor panels that convert light directly into electricity. This DC power is normally passed through an inverter which converts it into AC power which can be used to power the normal range of domestic appliances or be exported to the local electricity network. The amount of power that a PV panel will deliver is proportional to the amount of sunlight that falls upon it.

Solar energy can be exploited through three different means: solar photovoltaics (solar PV), active solar heating (solar thermal) and passive solar design. The least widespread of these is passive solar design: only a few thousand buildings in the UK have been designed to deliberately exploit solar energy - resulting in an estimated saving of around 10 GWh / year[8].

The key advantages of photovoltaics are:

- they can be integrated into buildings so that no extra land area is required,
- they can be used in a variety of ways architecturally, ranging from the visually unobtrusive to clear expressions of the solar nature of the building,
- they are modular in nature so that any size of system can be installed and
- there are fewer transmission losses since the electricity is used 'on site'.

Other important characteristics of photovoltaics:

- Compared to retrofitting existing buildings, it is significantly easier to integrate solar energy technologies into new buildings
- Building-integrated PVs offset some of the costs of the roof construction and save space. Some of the most promising applications include:
    - New, high profile commercial office buildings
    - New housing developments (preferably incorporating low energy design features)
    - Schools and other educational buildings
    - Other large high profile developments (such as sports stadiums)
- PV can be utilised in two ways:
    - Stand-alone PV – for remote uses such as monitoring and telemetry systems, where mains electricity is too difficult or expensive to supply.
    - Grid-connected PV – where the PV system is connected to and generates into the mains electricity system.

[8] *BERR, Digest of UK Energy Statistics 2007: http://stats.berr.gov.uk/energystats/dukes07_c5.pdf*

Appendix XI: Solar thermal hot water

Solar thermal hot water (STHW) systems (sometimes referred to as solar collectors, or active solar systems) convert solar radiation into thermal energy (heat) which can be used directly for a range of applications, such as hot water provision and low temperature heat for swimming pools.

The key advantages of solar thermal are:

- they can be integrated into buildings so that no extra land area is required,
- they can be used in a variety of ways architecturally, ranging from the visually unobtrusive to clear expressions of the solar nature of the building,
- they are modular in nature so that any size of system can be installed.

Appendix XII: Ground source heat pumps

According to the Energy Saving Trust[9], ground source heat pumps (GSHP) make use of the constant temperature that the earth in the UK keeps throughout the year (around 11-12 degrees a few metres below the surface). These constant temperatures are the result of the ground's high thermal mass which stores heat during the summer. This heat is transferred by (electrically powered) ground source heat pumps from the ground to a building to provide space heating and in some cases, to pre-heat domestic hot water. A typical efficiency of GSHP is around 3-4 units of heat produced for every unit of electricity used to pump the heat.

Characteristics of GSHP include:

- Sizing of the heat pump and the ground loop depends on the heating requirements.
- GSHP can meet all of the space heating requirements of a house, but domestic hot water will usually only be pre-heated.
- GSHP can work with radiators, however, underfloor heating works at lower temperatures (30-35 degrees) and is therefore better for GSHP.

[9] *http://www.energysavingtrust.org.uk/uploads/documents/myhome/Groundsource%20Factsheet%205%20final.pdf*

Appendix XIII: Hydro power

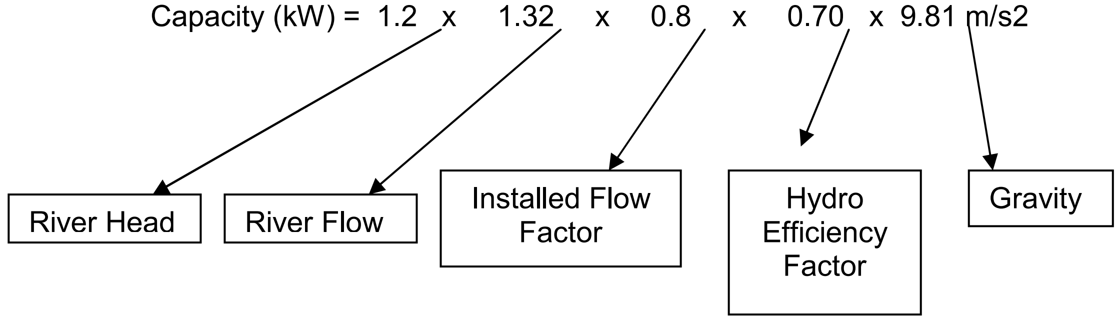
Study area potential

There are numerous weirs within the study area but these are assumed to have heads less than 2 metres as they were not included with a key reference report that reviewed the UK potential for small hydro in 1989[10]. Many weirs sites were identified within the report but discounted principally because of they had a 'head' height of less than 2 metres. Since this report there has been improvements in Hydro technology and so many recent hydro power studies have included sites with a 'head' height less than 2 metres, for example a recent report for Sheffield[11] used a minimum head for potential hydro developments as 1.2 metres.

The assessment of hydro energy potential sites in the study area was restricted to 3 sources of data: Volume 2 (Assessed Sites) and Volume 3 (Rejected sites) of the report above and the Small Hydro website[12].

In total 12 sites were reassessed which were all located either on the River Stour or River Avon. All these sites had heads less than 2 metres and for the purpose of this study a minimum head was assumed to be 1.2 metres and a maximum head of 2 metres. River flow data for The Avon and Stour was taken from the National River Flow Archive[13] and the formula below was used to generate potential capacities for each assessed site (based on basic hydro calculation[14]). From this hydro capacity factors were converted to annual generation (MWh).

Capacity (kW) = 1.2 x 1.32 x 0.8 x 0.70 x 9.81 m/s2



The results are summarised in the table below.

Warwickshire Potential Small Hydro Capacity (kW) and Annual MWh					
Local Authority	**Number of Sites**	**Estimated Minimum Capacity (kW)**	**Estimated Maximum Capacity (kW)**	**Estimated Minimum Annual (MWh)**	**Estimated Maximum Annual (MWh)**
North Warwickshire	0	0	0	0	0
Nuneaton and Bedworth	0	0	0	0	0
Rugby	2	21	34	171	284
Solihull	0	0	0	0	0
Stratford	4	134	224	1118	1863
Warwick	6	283	472	2358	3931
TOTAL	**12**	**438**	**730**	**3647**	**6079**

[10] *Small scale hydroelectric generation potential in the UK, Vol3, Department of Energy, 1989*
[11] *Sheffield City Council Renewable Energy Scoping and Feasibility Studyhttp://www.sheffield.gov.uk/planning-and-city-development/planning-documents/background-reports/renewable-energy-study*
[12] *http://www.small-hydro.com/*
[13] *The National River Flow Archive http://www.ceh.ac.uk/data/nrfa/index.html*
[14] *Renewable Energy UK: Calculation of Hydro Power http://www.reuk.co.uk/Calculation-of-Hydro-Power.htm*

Hydro power background and guidance

Power has been generated from water for centuries, and there is theoretical potential for energy generation wherever there is water movement or difference in height between two bodies of water. The resource available depends upon the available head, i.e. the height through which the water falls (in metres) and flow rates, i.e. the volume of water passing per second (in m^3/sec).

The figure below illustrates the concepts of head and flow graphically.

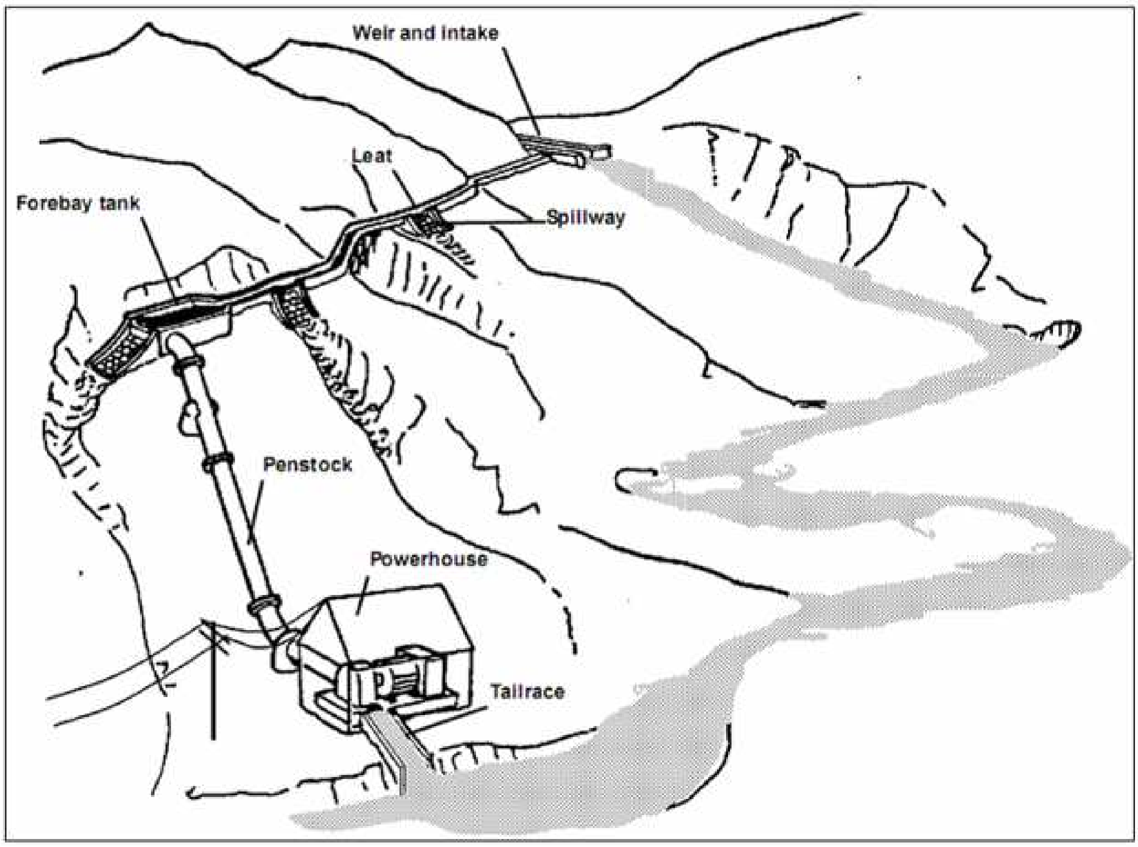
Figure5: Hydropower – Head and Flow (Source: British Hydropower Association – UK Mini Hydro Guide)

Power can be extracted by the conversion of water pressure into mechanical shaft power which, in turn, can drive a turbine to generate electricity. Power can also be extracted by allowing water to escape, for example, from a storage reservoir or dam through a pipe containing a turbine. The power available is in all cases proportional to the product of flow rate, head and the mechanical power produced by the turbine.

As for the efficiencies of hydro power schemes, these are generally in the range of 70 to over 90%. However, hydraulic efficiencies reduce with scheme size. Furthermore, schemes with a capacity of less than 100kW (micro-hydro) are generally 60 to 80% efficient.

There is a variation of different hydro energy site layout possibilities (e.g. canal and penstock; penstock only; mill leat; barrage), but, as illustrated by the figure below, a hydro energy scheme typically consists of the following components:

Figure6: Components of a hydro scheme (Source: British Hydropower Association – Guide to UK Mini-Hydro Developments)



The technology for realising the potential from hydro is well established in the UK. Most of the UK's hydropower comes from large hydro projects; these are defined as those greater than 10 MW. These days large hydro is generally discounted from consideration for new construction due to the high environmental impact associated with constructing large dams and flooding valleys.

There are a number of benefits of hydro schemes (adapted from British Hydro Power Association (BHPA)), including:

- No direct CO_2 emissions
- Small hydro schemes have a minimum visual impact on surrounding environment
- One of the most inexpensive ways to generate power
- Bigger hydro schemes can include a possibility to store energy (reservoir storage, pumped storage)
- Hydro schemes can have a useful life of over 50 years
- Hydro is the most efficient way of generating electricity, as between 70 and 90% of the energy available in the water can be converted
- Hydro schemes usually have a high capacity factor (typically > 50%)
- A high level of predictability (however, varying with annual rainfall patterns)
- Demand and output patterns correlate well, i.e. highest output is in winter

Technologies for sites with medium and high heads and flows are well established, however with some of the sites only having a low head, finding suitable technology entails having to rely on less established technologies, such as Archimedes Screw turbines or VHL turbine (which is a very low head Kaplan turbine). Generally, impulse turbines are used for high head schemes whereas reaction turbines are used for low head schemes.

In turning the technical resource of hydro energy into a practical target, the important issues to consider are:

- Getting support from the Environment Agency (EA) will be crucial to the development for hydro energy schemes in the district; the EA is responsible for aspects such as licensing e.g. the water abstraction or for ensuring that each site has a fish passage
- Securing the necessary funds (possibly through a community-owned fund) will be important for project developers
- Economics of hydro energy schemes are absolutely site-specific, critically depending on the topography, geology, and hydrology of each site, which in turn requires feasibility studies for each potential site; this is especially important since civil works can be significantly more expensive for low head hydro developments
- Possible local resistance needs to be addressed accordingly
- For mill conversions it is important to ensure that all required hydro energy equipment and potential civil works could be integrated into the existing mill structure.
- Land ownership and water rights can be complex and time-consuming issues to be resolved
- In view of the complexity of developing hydro schemes, long lead times are required, most of all for hydrological studies, environmental impact assessments and getting the required permissions (flood prevention, fishery rights)

Appendix XIV: Gas-fired Combined Heat and Power (CHP)

Gas fired combined heat and power (CHP) is a technology which uses natural gas to generate electricity in the same way that many of our power stations do, albeit on a much smaller scale. These 'micro power stations' do, however, offer a significant advantage in that the heat that is generated can be used by nearby consumers. By utilising the heat benefits, as well as the electricity generated, this technology offers significant carbon benefits.

CHP systems with a community heating network enable sizable carbon reductions in new developments. However, the viability and effectiveness of CHP is dependent on how much of the heat and electricity can be utilised. This tends to hinge on three factors:

1. Scale of development. As a rule of thumb, community heating systems require a development of at least 300 dwellings, with improving economics as the scale of development increases.

2. Density of development. The suitability of community heating increases with the number of dwellings per hectare.

3. Mix of development. A good mix of residential, commercial and industrial building types is beneficial. Residential peak energy demand is early morning and evening. Commercial peaks tend to be during daytime hours. Adding the building uses together helps to provide a more even energy demand, which suits CHP.

The recent guide 'Community Energy: Urban Planning for a Low Carbon Future' produced by the Combined Heat and Power Association (CHPA) and Town and Country Planning Association (TCPA) provides a useful overview of the types of development that suit CHP and district heating and the range of issues that need to be considered in the development of CHP and district heating networks.

Biomass CHP is applied in this analysis in preference to gas CHP. This is due to the larger carbon savings available for the biomass option and that the current definition for the zero carbon homes[15] would essentially require biomass CHP, where possible rather than gas-fired CHP.

[15] *Prior to publications of the government consultation of the definition of the 'zero carbon'*

Appendix XV: Results of acceleration net costs assessments

Test 1: Code 3 with 10% test (additional costs of the Merton only)

Site name	Flat (city infill)	Flat (market town)	Flat (urban regeneration)	Mid terrace (small development)	Detached (small development)	Mid terrace (market town)	Detached (market town)	Mid terrace (urban regeration)	Detached (urban regeration)
SHW + BPEE*	£ 254	£ 224	£ 254	£ 272	£ 1,608	£ 272	£ 1,608	£ 272	£ 1,608
PV + BPEE	£ 492	£ 492	£ 492	£ 862	£ 1,906	£ 862	£ 1,906	£ 862	£ 1,906
GSHP +BPEE*	£ -	£ 358	£ -	£ 272	£ 115	£ 272	£ 115	£ -	£ -

% Capital cost									
SHW + BPEE*	0.3%	0.3%	0.3%	0.4%	1.7%	0.4%	1.7%	0.4%	1.7%
PV + BPEE	0.7%	0.7%	0.7%	1.3%	2.0%	1.3%	2.0%	1.3%	2.0%
GSHP +BPEE*	0.0%	0.5%	0.0%	0.4%	0.1%	0.4%	0.1%	0.0%	0.0%

Test 2: Code 4 with 20% test (additional cost of Merton only)

Site name	Flat (city infill)	Flat (market town)	Flat (urban regeneration)	Mid terrace (small development)	Detached (small development)	Mid terrace (market town)	Detached (market town)	Mid terrace (urban regeration)	Detached (urban regeration)
Gas CHP (80%) with BPEE*	£ 1,462	£ 567	£ 298	£ 1,936	£ 3,139	£ 756	£ 1,148	£ 232	£ 551
PV + BPEE	£ 384	£ 384	£ 384	£ 240	£ 578	£ 240	£ 578	£ 240	£ 578
PV + APEE	£ 1,978	£ 1,978	£ 1,978	£ 2,336	£ 5,310	£ 2,336	£ 5,310	£ 2,336	£ 5,310
SHW + APEE*	£ 2,730	£ 2,730	£ 2,730	£ 3,101	£ 6,201	£ 3,101	£ 6,201	£ 3,101	£ 6,201
Biomass heating (80%) + BPEE	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -
Biomass heating (80%) + APEE	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -
GSHP +APEE*	£ 1,924	£ 3,401	£ 1,924	£ 2,511	£ 4,410	£ 4,477	£ 6,500	£ 2,511	£ 4,410

% Capital cost									
Gas CHP (80%) with BPEE*	2.0%	0.8%	0.4%	2.9%	3.3%	1.1%	1.2%	0.4%	0.6%
PV + BPEE	0.5%	0.5%	0.5%	0.4%	0.6%	0.4%	0.6%	0.4%	0.6%
PV + APEE	2.7%	2.7%	2.7%	3.5%	5.6%	3.5%	5.6%	3.5%	5.6%
SHW + APEE*	3.7%	3.7%	3.7%	4.7%	6.6%	4.7%	6.6%	4.7%	6.6%
Biomass heating (80%) + BPEE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Biomass heating (80%) + APEE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GSHP +APEE*	2.6%	4.6%	2.6%	3.8%	4.7%	6.8%	6.9%	3.8%	4.7%

Test 3: Code 3 with 10% vs Code 4 with 20%

Solution	Flat (city infill)	Flat (market town)	Flat (urban regeneration)	Mid terrace (small development)	Detached (small development)	Mid terrace (market town)	Detached (market town)	Mid terrace (urban regeneration)	Detached (urban regeneration)
SHW + BPEE (CODE 3)*	£ 3,579	£ 3,579	£ 3,579	£ 4,819	£ 6,692	£ 4,819	£ 6,692	£ 4,819	£ 6,692
PV + BPEE (CODE 3)	£ 3,303	£ 3,303	£ 3,303	£ 5,118	£ 6,975	£ 5,118	£ 6,975	£ 5,118	£ 6,975
GSHP +BPEE (CODE 3)*	£ 8,862	£ 8,001	£ 5,858	£ 9,388	£ 13,093	£ 9,388	£ 13,093	£ 7,255	£ 10,654
Gas CHP (80%) with BPEE (CODE 4)*	£ -	£ 4,324	£ 3,622	£ -	£ 22,893	£ 5,749	£ 8,176	£ 4,758	£ 6,832
PV + BPEE (CODE 4)	£ 4,905	£ 4,905	£ 4,905	£ 6,273	£ 8,809	£ 6,273	£ 8,809	£ 6,273	£ 8,809
PV + APEE (CODE 4)	£ 9,787	£ 9,787	£ 9,787	£ 10,604	£ 16,439	£ 10,604	£ 16,439	£ 10,604	£ 16,439
SHW + APEE (CODE 4)*	£ 10,846	£ 10,846	£ 10,846	£ 11,127	£ 17,638	£ 11,127	£ 17,638	£ 11,127	£ 17,638
Biomass heating (80%) + BPEE (CODE 4)	£ 7,688	£ 4,550	£ 3,970	£ 10,718	£ 11,006	£ 5,847	£ 8,397	£ 5,221	£ 7,394
Biomass heating (80%) + APEE (CODE 4)	£ 12,562	£ 9,426	£ 8,845	£ 14,320	£ 17,492	£ 9,449	£ 14,884	£ 8,824	£ 13,881
GSHP +APEE (CODE 4)*	£ 15,399	£ -	£ 12,497	£ 16,321	£ 26,282	£ 16,959	£ 25,608	£ 13,195	£ 21,273

Minimum Code 3 + 10%	£ 3,303	£ 3,303	£ 3,303	£ 4,819	£ 6,692	£ 4,819	£ 6,692	£ 4,819	£ 6,692
Minimum Code 4 + 20%	£ 4,905	£ 4,324	£ 3,622	£ 6,273	£ 8,809	£ 5,749	£ 8,176	£ 4,758	£ 6,832
Difference	£ 1,603	£ 1,022	£ 320	£ 1,455	£ 2,117	£ 930	£ 1,485	-£ 61	£ 140
% Capex equivalent	2.2%	1.4%	0.4%	2.2%	2.2%	1.4%	1.6%	-0.1%	0.1%
Maximum Code 3 + 10%	£ 8,862	£ 8,001	£ 5,858	£ 9,388	£ 22,893	£ 9,388	£ 13,093	£ 7,255	£ 10,654
Maximum Code 4 + 20%	£ 15,399	£ 10,846	£ 12,497	£ 16,321	£ 26,282	£ 16,959	£ 25,608	£ 13,195	£ 21,273
Difference	£ 6,537	£ 2,845	£ 6,639	£ 6,933	£ 3,389	£ 7,571	£ 12,516	£ 5,940	£ 10,619
% Capex equivalent	8.9%	3.9%	9.0%	10.5%	3.6%	11.5%	13.3%	9.0%	11.3%

Test 4: Code 4 with 20% vs zero carbon

Solution	Flat (city infill)	Flat (market town)	Flat (urban regeneration)	Mid terrace (small development)	Detached (small development)	Mid terrace (market town)	Detached (market town)	Mid terrace (urban regeration)	Detached (urban regeration)
Gas CHP (80%) with BPEE (CODE 4)*	£ -	£ 4,324	£ 3,622	£ -	£ 22,893	£ 5,749	£ 8,176	£ 4,758	£ 6,832
PV + BPEE (CODE 4)	£ 4,905	£ 4,905	£ 4,905	£ 6,273	£ 8,809	£ 6,273	£ 8,809	£ 6,273	£ 8,809
PV + APEE (CODE 4)	£ 9,787	£ 9,787	£ 9,787	£ 10,604	£ 16,439	£ 10,604	£ 16,439	£ 10,604	£ 16,439
SHW + APEE (CODE 4)*	£ 10,846	£ 10,846	£ 10,846	£ 11,127	£ 17,638	£ 11,127	£ 17,638	£ 11,127	£ 17,638
Biomass heating (80%) + BPEE (CODE 4)	£ 7,688	£ 4,550	£ 3,970	£ 10,718	£ 11,006	£ 5,847	£ 8,397	£ 5,221	£ 7,394
Biomass heating (80%) + APEE (CODE 4)	£ 12,562	£ 9,426	£ 8,845	£ 14,320	£ 17,492	£ 9,449	£ 14,884	£ 8,824	£ 13,881
GSHP +APEE (CODE 4)*	£ 15,399	£ -	£ 12,497	£ 16,321	£ 26,282	£ 16,959	£ 25,608	£ 13,195	£ 21,273
PV + BPEE (ZC)	£ -	£ -	£ -	£ 9,537	£ 13,366	£ 9,537	£ 13,366	£ 9,537	£ 13,366
PV + APEE (ZC)	£ -	£ -	£ -	£ 11,557	£ 16,346	£ 11,557	£ 16,346	£ 11,557	£ 16,346
GSHP + PV + BPEE (ZC)	£ 13,457	£ -	£ 10,651	£ 15,368	£ 22,028	£ 15,368	£ 22,028	£ 12,417	£ 18,451
Biomass heating (80%) + PV + BPEE (ZC)	£ 9,249	£ 6,190	£ 5,624	£ 12,719	£ 13,283	£ 7,971	£ 10,740	£ 7,360	£ 9,763
Biomass heating (80%) + PV + APEE (ZC)	£ 14,065	£ 11,006	£ 10,440	£ 16,293	£ 18,334	£ 11,544	£ 15,790	£ 10,934	£ 14,812
Biomass CHP (80%) + BPEE 9ZC)	£ 7,827	£ 7,092	£ 6,723	£ -	£ -	£ 7,727	£ 11,900	£ 7,330	£ 11,264
Biomass CHP (80%) + APEE (ZC)	£ 10,267	£ 9,633	£ 9,265	£ -	£ -	£ 9,710	£ 15,289	£ 9,313	£ 14,654
Gas CHP (80%)+ PV + BPEE (ZC)	£ 9,027	£ 6,414	£ 5,744	£ 16,642	£ 25,128	£ 8,169	£ 11,582	£ 7,435	£ 10,417

Minimum Code 4 + 20%	£ 4,905	£ 4,324	£ 3,622	£ 6,273	£ 8,809	£ 5,749	£ 8,176	£ 4,758	£ 6,832
Minimum zero carbon	£ 7,827	£ 6,190	£ 5,624	£ 9,537	£ 13,283	£ 7,727	£ 10,740	£ 7,330	£ 9,763
Difference	£ 2,922	£ 1,866	£ 2,002	£ 3,264	£ 4,475	£ 1,978	£ 2,564	£ 2,572	£ 2,931
% Capex equivalent	4.0%	2.5%	2.7%	5.0%	4.7%	3.0%	2.7%	3.9%	3.1%
Maximum Code 4 + 20%	£ 15,399	£ 10,846	£ 12,497	£ 16,321	£ 26,282	£ 16,959	£ 25,608	£ 13,195	£ 21,273
Maximum zero carbon	£ 14,065	£ 11,006	£ 10,651	£ 16,642	£ 25,128	£ 15,368	£ 22,028	£ 12,417	£ 18,451
Difference	-£ 1,334	£ 160	-£ 1,845	£ 321	-£ 1,154	-£ 1,591	-£ 3,581	-£ 778	-£ 2,822
% Capex equivalent	-1.8%	0.2%	-2.5%	0.5%	-1.2%	-2.4%	-3.8%	-1.2%	-3.0%

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