LOW/ZERO CARBON

RENEWABLE ENERGY FOR UTTLESFORD

WIND ENERGY

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January 2008

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3. WIND ENERGY

SUMMARY

Wind energy is one of the fastest growing energy sectors and at the end of 2006, some 74 GW of wind generating capacity had been installed. The UK has the largest land-based and offshore wind energy resource in Europe, with 40% of the European land based potential. According to the British Wind Energy Association, at the time of writing there were over 1800 grid-connected wind turbines in the UK with a combined capacity of over 2.2 GW, generating electricity sufficient for 1.23 million homes. The exploitation of wind energy for electricity generation involves minimal impact on land use, as farming can continue around the turbines, and can provide an income for landowners. Windmills were a traditional form of energy technology in Uttlesford and Essex, with evidence of many former windmills and mill mounds as well as a few examples still standing.

Factors influencing the viability of wind energy include:

- the annual mean wind speed
- the wind speed frequency distribution
- topographic features
- the proximity of appropriate electric power lines
- the capital cost of the turbine & installation & unit price of electricity

Until recently, sites with annual mean wind speeds (AMWS) of below 6.5 metres/second were considered uneconomic and most wind farm developers prefer higher mean wind speeds (7 m/s or more). Because of the inland location of Uttlesford the wind speed resource is not as great as in coastal regions, but because of recent improvements in aerodynamic and mechanical efficiency together with the availability of taller towers and lower 'cut-in wind speeds', inland sites are becoming more viable. Much of Uttlesford is undulating terrain with hills and valleys so there are fewer suitable wind energy sites compared to plains. Analysis of the UK NOABL database of annual mean wind speeds (AMWS) indicates that there are a considerable number of OS 1-km grid squares with annual mean wind speeds (AMWS-45) of over 6 m/s at a height of 45 m above ground level (AGL) and much of the non-wooded high ground in Uttlesford has promise if modern medium/low wind speed specific wind turbines are employed and mounted on relatively tall towers. Other sites could potentially be exploited through pilot community wind energy projects.

The Uttlesford District could potentially accommodate an installed capacity of over **1200 MW**, generating approximately **2,900 to 3,700 GWh per year - enough electricity for 630,000 to 780,000 homes**. These estimates are for the maximum that may be technically feasible but there is uncertainty as to whether certain of the turbines included in this total would be affected by Stansted Airport being located within Uttlesford and by constraints from air traffic control issues. The latter factor has an influence throughout Uttlesford and is also affected by turbine heights, so these factors would need to be reviewed according to the individual project characteristics. It will also affect the estimates of wind energy given below. One of the constraints is a zone (which extends out 15 km) that requires that the airport authorities are consulted if structures are proposed that exceed 90 m above ground level so ball bark assessments of wind energy potential were also estimated for turbines below this maximum height.

Community wind energy projects also provide scope for rural communities to earn income from wind energy; alternative approaches include outright ownership, community companies and joint ventures with the local council and Energy Service Companies (ESCOs) or Wind Energy Service Companies (WESCOs).

The towns and certain larger villages in Uttlesford could consider a small group of wind turbines at locations on their periphery to supply carbon-free electricity for all or a large proportion of the houses in their boundaries. Such Town or Village Wind Energy Schemes could considerably reduce the carbon footprints of these towns.

In addition there would be potentially scope to plan to use wind energy to reduce the CO_2 emissions and costs of personal transportation in the District. This would require vehicle users (domestic and

non-domestic private, public and fleet operators) to opt for the new 'plug-in hybrid electric vehicles' or *PHEVs*.

To see what numbers of wind turbines would be involved if the energy needs within the Domestic Sector in Uttlesford were to be powered by wind energy, further assessments were carried out to estimate the scale of development that would be needed to match the current energy needs. Clearly it would make sense to try and reduce the demand and that should be encouraged, but for the assessment, it was assumed that current levels of electricity consumption based on the UK average household electricity demand of 4,700 kWh/y were used.

To provide the electricity demand of the 30,000 households in Uttlesford, it was estimated that it would require **21 to 32 E82 turbines**[1] or **32 to 42 V82 turbines**[2]. These turbines would then abate around **121,000 tonnes of CO_2 per year**. If we were to aim initially to generate electricity equivalent to around **20%** of current electricity demand then this would require **5 to 7 E82 turbines** or **7 to 9 V82 turbines** which would abate around **24,200 tonnes of CO_2 per year**. Generating electricity equivalent to **50%** of current household electricity demand would require **11 to 16 E82 turbines** or **16 to 21 V82 turbines** and would abate around **60,000 tonnes of CO_2 per year**.

The electricity needs (based on UK average demand of 4.7 MWh/y) of the households in the parish of Great Dunmow could be supplied by electricity equivalent to output from **2 to 3 E82 turbines** or **3 to 4 V82 turbines** and abate around **7,900 tonnes CO_2/year.** Saffron Walden by **5 to 7 E82 turbines** or **7 to 9 V82 turbines** (and abate **16,800 tonnes CO_2/y**), Stansted Mountfitchet by **2 to 3 E82 turbines** or **3 to 4 V82 turbines** (and abate **6,000 tonnes CO_2/y**), Thaxted by **1 E82 turbines** or **2 V82 turbines** (and abate **2,800 tonnes CO_2/y**).

To see what numbers of turbines would be needed to offset heating demand, an estimate of the numbers of turbines was made assuming the Domestic space heat and hot water demand for the households in Uttlesford was met by heat pumps. Whilst heat pumps would not be able to be utilised universally, the estimates give an indication of what might be considered.

To estimate the average household demand the average domestic gas consumption of 21,400 kWh/y (from *DUKES06*) for Uttlesford was used as a guide. Clearly there could be substantial potential for reduction in the space heating demand if an effective thermal performance upgrade programme was carried out, but the current value was used in the assessment. To determine the electricity production required, heat pumps with a coefficient of performance (COP) of 3 were assumed.

On this basis, to provide the space and water heating demand of the 30,000 households in Uttlesford, it was estimated that it would require **34 to 49 E82 turbines** or **51 to 62 V82 turbines**. These turbines were estimated to abate almost **137,000 tonnes of CO_2 per year** assuming all of the households were off-setting gas condensing boilers. If 64% were offsetting gas condensing boilers and the 36% were offsetting oil fired boilers, the CO_2 abatement would then be of the order of **159,000 tonnes of CO_2 per year**.

If the wind turbines are used to provide electricity for heat pumps (COP 3) for just the electrically heated (Economy 7) households in Uttlesford, it would require **4 to 6 E82 turbines** or **6 to 8 V82 turbines** and abate almost **34,000 tonnes of CO_2 per year**

Using the *wind energy + heat pump* option is a potentially useful strategy (using current technologies) for using an indigenous CO_2-free source of energy which, if combined with heat storage, could also provide a useful way to exploit and store energy from the variable winds.

To provide <u>both</u> the estimated electricity needs plus the space and water heating needs, it was estimated that it would require **56 to 80 E82 turbines** or **83 to 106 V82 turbines**. These turbines are estimated to abate almost **258,000 tonnes of CO_2 per year** (assuming heating energy is offset from gas condensing boilers).

Plug-In Hybrid Electric Vehicles (*PHEVs*) are Hybrid Electric Vehicles that have a sufficiently sized battery pack to enable them to operate as emission-free electric only vehicles (EVs) for a certain range (after being recharged by plugging-in in a similar manner to recharging a mobile phone) enabling them to achieve very high MPG values.

To see what the use of PHEVs might require in terms of wind energy, it was

[1] 82 metre diameter Enercon E82 turbines rated at 2050 kW.
[2] 82 metre diameter Vestas V82 turbines rated at 1650 kW.

assumed that there would be one PHEV/household and a UK average daily range of 24 miles/day (38.7 km/day). It was assumed that they would have the same energy consumption (7.5 km/kWh) as the *Tesla Roadster* manufactured in East Anglia by Lotus.

To provide the electricity demand for 30,000 PHEVs in Uttlesford, it was estimated that it would require **9 to 13 E82 turbines** or **14 to 17 V82 turbines**. These turbines would then abate around **55,000 tonnes of CO_2 per year** assuming the vehicles offset are ICE cars with an emission rate of 130 gCO_2/km. If they were off-setting ICE cars with an emission rate of 185 gCO_2/km, then they would be estimated to be abating over **78,000 tonnes of CO_2 per year**.

It remains to be seen as to whether it is feasible, but using the *wind energy + PHEV* option is a potentially useful strategy for solving a difficult problem by using an indigenous CO_2-free source of energy which, if combined with PHEVs, could also provide a useful way to exploit and store energy (with smart metering) from the variable winds. If there is sufficient uptake of PHEVs, this use of wind energy could also be potentially very economically attractive, given the cost of petrol.

As a result of these estimates it is also possible to see how many turbines would be needed to provide the estimated electricity needs plus the space and water heating plus *PHEVs* in Uttlesford. It was estimated that it would require **64 to 87 E82 turbines** or **96 to 114 V82 turbines**. These numbers of turbines are estimated to abate almost **313,000 tonnes of CO_2 per year** (assuming the heating energy offset is from gas condensing boilers, and the PHEVS are offsetting ICE (internal combustion engine) vehicles with 130g/km).

Unless it is severely constrained because of potential conflicts with aviation and/or radar (because of the proximity of Stansted Airport), wind energy in combination with other renewable energy resources has an important potential role to play in Uttlesford with regard to electricity provision and also potentially for the supply of heat and transportation energy from local CO_2-free source. **Table 3-1** shows the numbers of wind turbines for a range of scenarios for Uttlesford household energy needs.

Table 3-1: Wind Energy Scenarios for Uttlesford Household Energy Needs

Numbers of Wind Turbines for Range of Uttlesford Scenarios - Unconstrained by Maximum Height					
Scenario	demand %	# E82 WTs #	# V82 WTs #	Energy Generated MWh/y	CO_2 Abated tCO_2/y
Wind energy generation to provide electricity for present uses	100%	21 to 32	32 to 42	141,000	121,000
	50%	11 to 16	16 to 21	70,500	60,000
	20%	5 to 7	7 to 9	28,200	24,200
Wind energy generation to provide space and hot water heating demand by means of heat pumps (COP = 3)	100%	34 to 49	52 to 62	216,000	137,000
	50%	17 to 25	26 to 31	108,000	68,500
	20%	7 to 10	11 to 13	43,200	27,400
Wind energy generation provide to recharging of one PHEV per household	100%	9 to 13	13 to 17	57,000	55,000
	50%	5 to 7	7 to 9	28,500	27,500
	20%	2 to 3	3 to 4	11,400	11,000

Limiting the maximum height of the turbines to 90 m AGL would reduce the output of each turbine and also result in an increased number of turbines to generate the equivalent energy.

To generate an equivalent amount of electricity as the needs for the 30 k households in Uttlesford (assuming UK average of 4.7 MWh/y) would require **32 to 38 E82** turbines or **38 to 45 V82** turbines at **49 m hub height**. To provide an equivalent amount of electricity to operate heat pumps to provide heat for 30 k households would require **49 to 55 E82** turbines and **58 to 65 V82** turbines. Also to provide an equivalent amount of electricity to charge 30 k PHEVs would require **13 to 16 E82** turbines or **15 to 18 V82** turbines. To provide electricity + space & water heating + PHEVs for 30 k households would require **94 to 104 E82** turbines or **110 to 123 V82** turbines operating at 49 m hub height.

Table 3-2 shows the numbers of wind turbines for a range of scenarios for Uttlesford household energy needs assuming constrained by maximum height of 90 metres.

Table 3-2: Wind Energy Scenarios for Uttlesford Assuming turbines constrained to 90 m max height.

Nos of Turbines for Range of Uttlesford Scenarios - Constrained by Max. Height of 90 m AGL (49 m HH)					
	demand	# E82 WTs	# V82 WTs	Energy Generated	CO_2 Abated
Scenario	%	#	#	MWh/y	tCO_2/y
Wind energy generation to provide electricity for present uses	100%	32 to 38	38 to 45	141,000	121,000
	50%	16 to 19	19 to 23	70,500	60,000
	20%	7 to 8	8 to 9	28,200	24,200
Wind energy generation to provide space and hot water heating demand by means of heat pumps (COP = 3)	100%	49 to 55	58 to 65	216,000	137,000
	50%	25 to 28	29 to 33	108,000	68,500
	20%	10 to 11	12 to 13	43,200	27,400
Wind energy generation provide to recharging of one PHEV per household	100%	13 to 16	15 to 18	57,000	55,000
	50%	5 to 7	7 to 9	28,500	27,500
	20%	3 to 4	3 to 4	11,400	11,000

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3.1.1 Definition

Differential solar heating of the Earth's surface causes pressure differences in the atmosphere which induce convection and create the air movements known as winds. Winds contain kinetic energy which can be transferred to sailing boats, windmills or modern wind turbines by exploiting aerodynamic forces.

The principal use of modern wind turbines is for generating electricity but some are used for water pumping.

Currently available wind turbines range in size from small micro turbines of about 50 watts to megawatt class machines rated at 2 to 5 MW[3] and can be used individually or in groups known as wind farms.

3.1.2 Wind Energy in the UK

The UK has the largest land based and offshore wind energy resource potential of any European country, 40% of the land based wind energy potential in the EU is located in the UK and the national land based potential wind energy resource exceeds the current national electricity demand.

According the British Wind Energy Association, at the time of writing there were over 1800 grid-connected wind turbines in the UK with a combined capacity of over 2.2 GW, generating electricity sufficient for 1.23 million homes. This amount of wind generated electricity avoided emissions of 4.97 million tonnes of CO_2, 58,000 tonnes of SO_2 and 17,000 tonnes of NO_x.

Two centuries ago there were 10,000 windmills in operation in the UK. If there were 10,000 wind turbines[4] now but using the latest designs and sizes, this number of wind turbines would give a combined installed capacity of 30 to 40 GW[5].

3.1.3 Environmental Benefits of Wind Energy

The exploitation of wind energy for electricity generation involves no atmospheric or water pollution, no radiation hazard, no toxic contamination of land, no contribution to climate change, no contribution to tanker spills, minimal land use impact (wind turbines can be installed on the periphery of fields so farming can continue as normal) and therefore does not require vast square kilometres of land to have a significant impact.

Wind turbines do not require water to function (unlike steam turbine based power stations) and so can contribute to water conservation when utilised in sufficient numbers.

Wind turbines can be installed in nature reserves or wilderness areas or ecologically sensitive sites and provide an income to maintain the reserves or help to avoid more ecologically damaging development taking place by providing a sustainable income. If wind turbines are installed in Britain in sufficient numbers,

[3] Wind turbines are available in a range of sizes which include the very small micro wind turbines rated at a few watts, small scale wind turbines at about 1 to 50 kW, medium scale from 100 to about 800 kW and large scale turbines rated between 1 MW and about 3 MW (with 4 and 5 MW wind turbines under development).
[4] This equates to about 0.037% of the number of cars in the UK!
[5] With wind turbines sizes under development this would be even larger.

their effect could be to help to protect areas of outstanding natural beauty and sites of special scientific interest as they will also reduce the amount of acid rain impacting these areas and associated water courses.

As the Intergovernmental Panel on Climate Change (IPCC) has recognised, the exploitation of wind energy is probably the most cost effective and most rapid method of reducing anthropogenic carbon dioxide emissions.

As with any new development, the addition of wind turbines changes the view of the landscape in which they are set. The visual effect is subjective and whether or not the public will be in favour of this change depends in part on their visual attitudes and whether or not they understand the environmental benefits. It is very important that wind energy developments are carried out sensitively and that the local population or the local countryside is able to benefit from the wind energy development.

3.1.4 Historical examples of windmills in Uttlesford and Essex

As in many other parts of the UK, windmills have been a traditional form of energy technology within Uttlesford and Essex. They were principally used for milling grain. Several traditional windmills are still standing (**Figure 3-1**) and a number of local groups are active in maintaining and demonstrating these historical examples.

The windmill (John Webb's Mill) at Thaxted is an example of a tower windmill that used to mill grain.

Traditional windmills continue to be a popular tourist attraction and motivate many renovation and preservation societies to sustain them.

Figure 3-1: Traditional windmill in Uttlesford (John Webb's Mill – Thaxted)

3.1.5 Types of wind turbines

The most common types of modern wind turbines (see **Figure 3-2**) have between one and three blades[6] which resemble aircraft propellers[7] and share a horizontal axis rotation shaft with traditional windmills from which they evolved. Horizontal axis wind turbines with large numbers of blades are used for water pumping and, after a period of falling out of favour, wind pumps are beginning to be employed again - due to increasing awareness about water conservation and due to land owners[8] desire to provide water on land without having to use conventional energy sources.

The other main type of wind turbines are the cross-flow vertical axis wind turbines (VAWTs) which take advantage of winds from all directions but which to date have not been widely manufactured. They have a variety of forms including a range of the more efficient '*Lift Driven'* variants (see **Figure 3-3**) (some of which have lower visibility compared to conventional HAWTs) and the less efficient and heavier '*Differential-Drag Driven*' variants that include Savonius Rotor types (see **Figure 3-4**). A number of lift-driven VAWTs with helical shaped blades have appeared recently but it remains to be seen how viable and cost effective these may be. Apart from the *H-Type VAWTs*, most VAWTs are designed to operate at low level, so may not be widely applicable to Uttlesford where, because of the type of terrain and inland location, taller towers are likely to be a requirement.

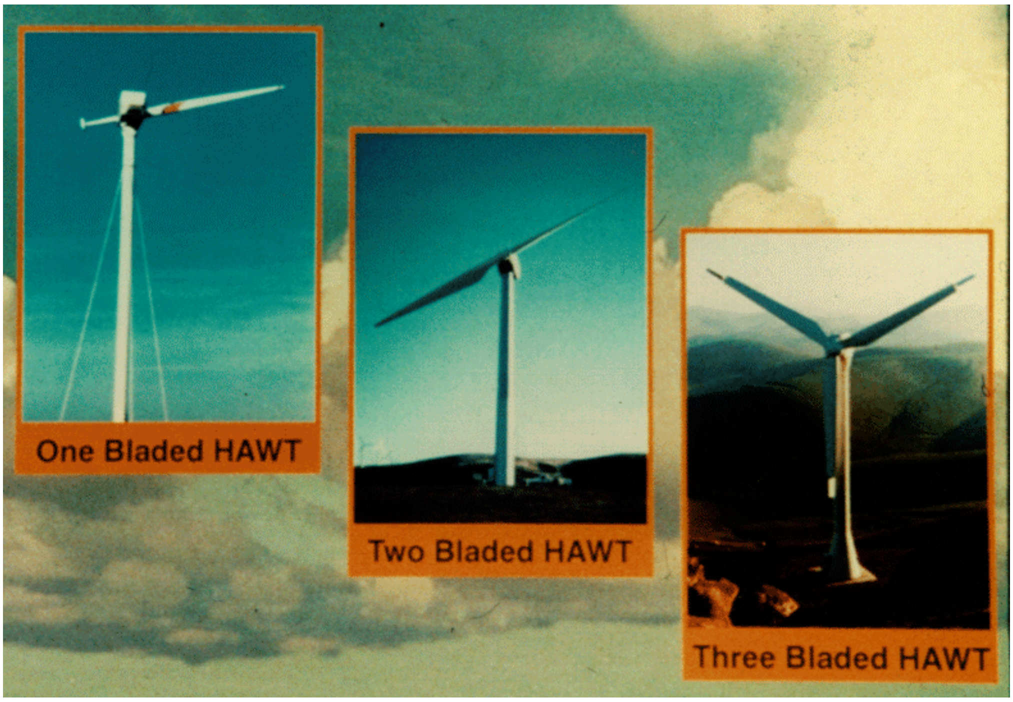

Figure 3-2: Various types of wind turbines

[6] By far the most common are three bladed rotors but some two bladed rotors are produced. At the present time 1-bladed wind turbines are something of a rarity but may become more widely used as large scale wind turbines increase in size (when blade costs may become a larger proportion of turbine costs) principally for offshore applications.
[7] The majority of wind turbines have rotors with 3 blades, but some have 2 blades and some have only 1 blade. Various small scale/micro scale wind turbines have 4, 5 or 6 blades to reduce rotation speed and improve starting torque.
[8] Including organisations such as the RSPB.

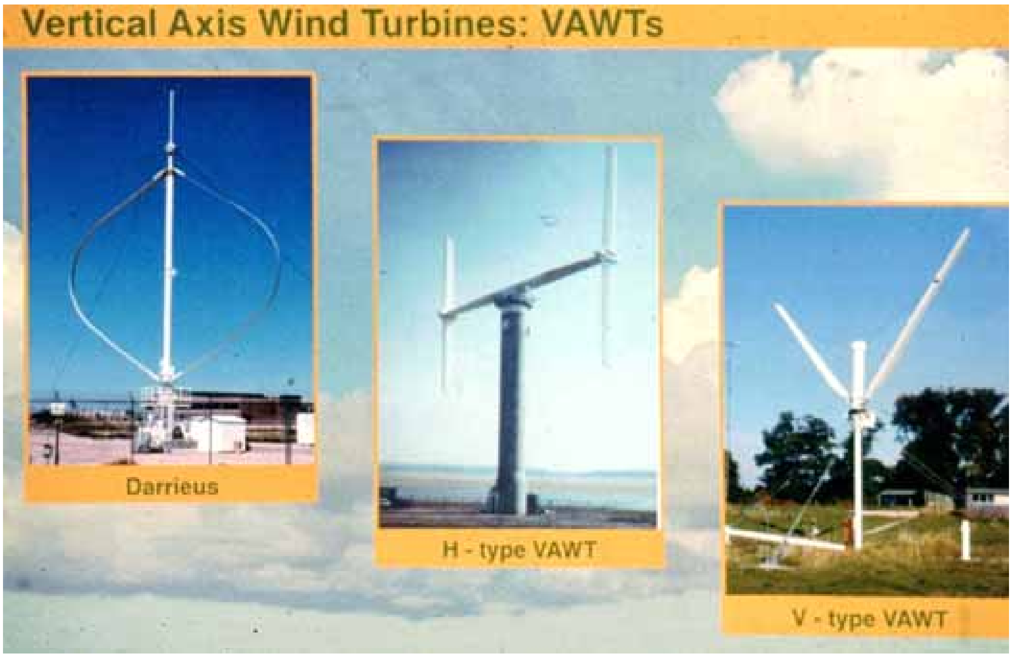

Figure 3-3: Some Examples of '*Lift Driven*' Vertical Axis Wind Turbines

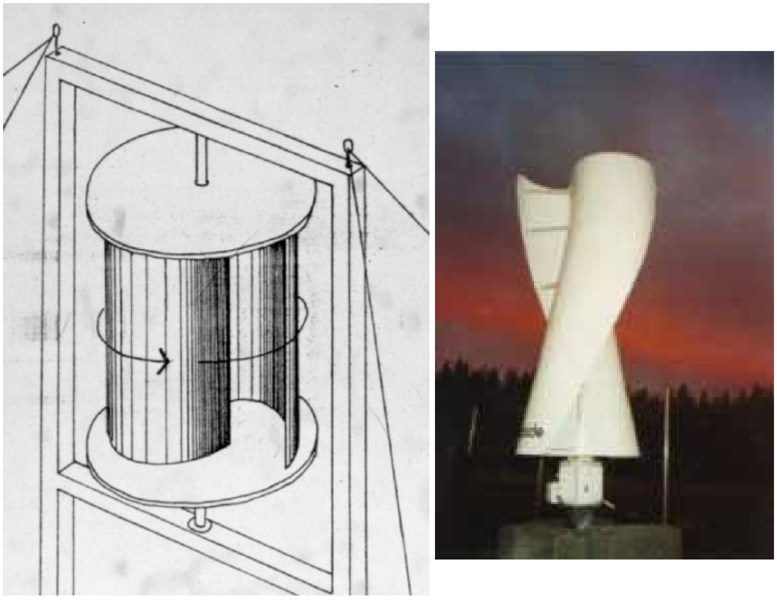

Figure 3-4: Some Examples of '*Differential Drag Driven*' Vertical Axis Wind Turbines

Other forms are augmented wind turbines which utilise associated devices or structures to increase the wind flow through the turbine which increases power production (see the section on building integrated wind turbines).

3.1.6 Existing wind turbines in Uttlesford

There are a few small wind turbines located around Uttlesford but at the present time there are no medium or large scale wind turbines installed.

3.1.7 Factors influencing the viability of wind energy development

The principal factors that influence the viability of wind energy include: -

- the annual mean wind speed (AMWS) at the site
- the wind speed frequency distribution (WSFD) at the site
- the topographic features of the site
- the proximity of appropriate electrical power lines
- the capital cost[9] in £/kW (pounds per rated kilowatt) of the turbine & installation
- the cost of connection
- the operation and maintenance costs
- the price paid for electricity generated and sold
- the duration of generation contract
- the price of electricity off-set in the case of energy saving wind turbines
- the cost of the finance (e.g. interest rates) for the project
- the length of time required to obtain a financial return

Until recently, it has usually not been economic to consider annual mean wind speeds (AMWS) below 6.5 m/s for wind energy exploitation and higher velocities are usually preferable. However, as the aerodynamic efficiency and mechanical/electrical efficiency has improved, power ratings of wind turbines have increased (resulting in reductions in capital costs on a £/kW basis) and as the tower heights have become taller, sites with annual mean wind speeds at the lower end will become increasingly more viable. These sites will generally be less economic than windy coastal sites, and the taller towers will incur a cost penalty, but nowhere near as great as for off-shore projects.

Another factor which will influence the viability of lower wind speed sites will be increases in the price of conventional electricity (together with increases in primary fuel costs[10]) or increases in the climate change levy and the like. A further factor that can influence the viability of lower wind speed sites is that of local ownership and whether or not security of supply becomes an important criterion.

Wind turbines will also tend to have a longer operational life-time (in terms of years) on lower wind speed sites as they will have fewer rotation cycles per year compared to higher wind speed sites.

Wind turbines on lower wind speed sites may also be viable when there is a possibility to earn revenue from visitors wishing to climb the turbine tower to reach a viewing platform for interesting panoramic views. This approach has been successfully employed on a number of sites in the UK and overseas – including Swaffham in Norfolk.

A further factor that has the potential to improve the viability of lower wind speed sites is the use of augmented wind turbines[11], which employ various aerodynamic techniques to accelerate the undisturbed wind speed. However whether such an approach is feasible will depend on the extra cost of the augmenting device.

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[9] Current costs of wind turbines ranges from about £600 / kW to £1,200 / kW (or 60 p / W to 120 p / W).
[10] If further increases in the price of gas occur then this may have an influence as the proportion of electricity coming from gas fuelled power stations increases.
[11] See section on building integrated wind turbines.

3.2 Wind Energy Potential in Uttlesford

Geographical and topographical characteristics of sites which are suitable for wind energy exploitation include both hilly terrain and flat plain terrain. The latter is typical of parts of Denmark and the Netherlands where large numbers of wind turbines have been successfully installed. The higher annual mean wind speed sites in Uttlesford occur in the hilly terrain, so this in principle offers opportunities for wind energy in much of the district.

3.2.1 WIND ENERGY MAPS FOR UTTLESFORD

3.2.1.1 European Wind Atlas

The European Wind Atlas was developed as an atlas for each of the countries in the EU and is based on a computer model of annual mean wind speed using wind speed data obtained from Meteorological Stations in each country.

According to the European Wind Atlas (**Table 3-3** and **Figure 3-5** and **3-6**) the annual mean wind speed in Uttlesford ranges from 4.5 to over 8 m/s at a height of 50 metres above ground level. However the upper value is likely to be extremely optimistic as it applies to 'hills & ridges' topography. The AMWS-50 values of 4.5 to 5.0 for sheltered terrain and 5.5 to 6.5 for open plain are probably more likely, however the undulating terrain of parts of Uttlesford may result in higher values than 'open plain'.

On this basis much of the hilly regions in Uttlesford would appear to have some promise for making use of wind energy with the modern types of wind turbines.

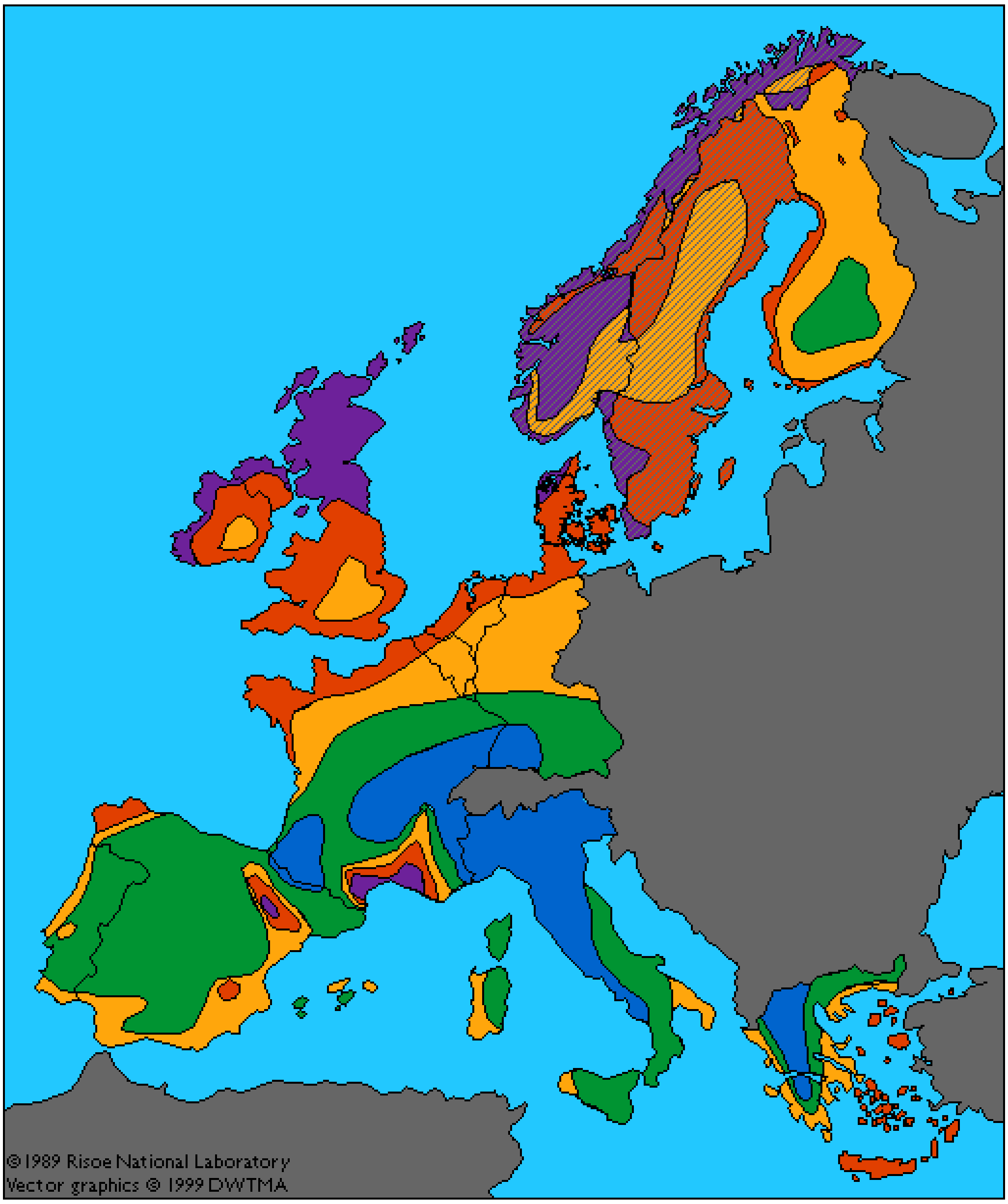

Figure 3-5: European Wind Atlas of Annual Mean Wind Speeds at 50 m above ground level (AGL)
Source: European Wind Atlas, RISO National Laboratory

Table 3-3: Wind resources at 50 metres above ground level for three different topographical conditions that relate to Uttlesford (Yellow region) based on the European Wind Atlas. (Refers to **Figures 3-5** and **3-6**.)

Terrain	Annual Mean Wind Speed m/s
ST	4.5 to 5.0
OP	5.5 to 6.5
HR	8.5 to 10

ST = Sheltered terrain
OP = Open plain
HR = Hills and ridges

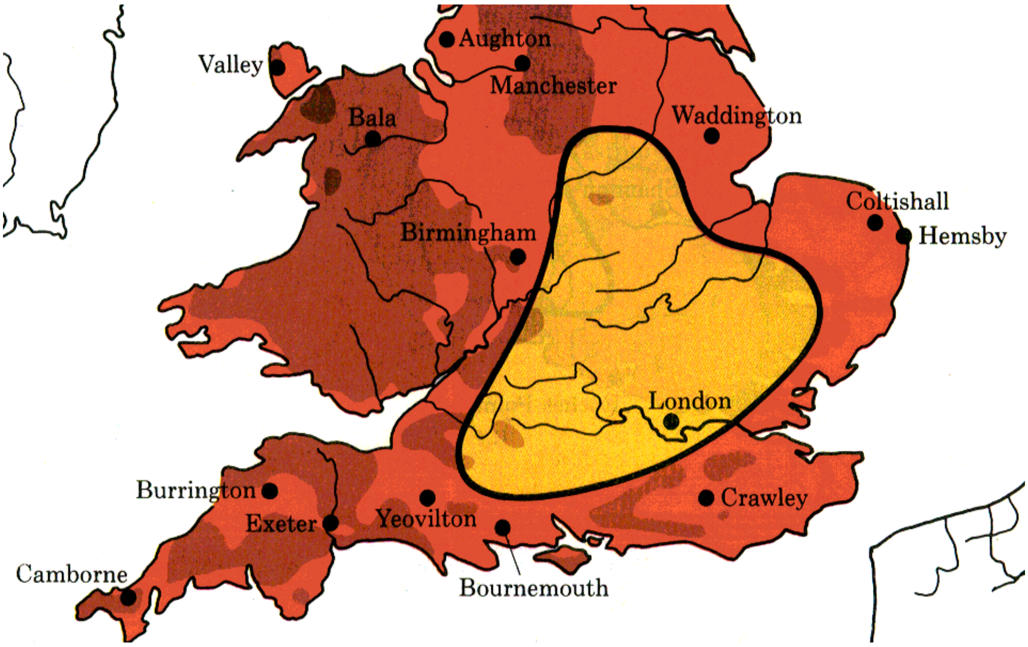

Figure 3-6: European Wind Atlas (England & Wales) of Annual Mean Wind Speeds at 50 m A.G.L. (RISO). Uttlesford is located in the less windy yellow region.
Source: European Wind Atlas, RISO National Laboratory

3.2.1.2 NOABL Data Atlas

Another method of estimating wind speeds is based on the NOABL (Numerical Objective Analysis of Boundary Layer) computer model and this can be used to estimate an annual mean wind speed[12] averaged for 1 km Ordnance Survey grid squares.

There is quite good correlation between the areas identified in the previous section. **Figure 3-7** shows the estimated annual mean wind speeds (AMWS) for 1 km x 1 km OS grid squares in Uttlesford at a height of 45 metres above ground level (AGL). As can be seen at this height the annual mean wind speeds (AMWS-45) range from around 5.5 m/s band to 6.7 m/s.

Excluding grid squares that contain urban areas (shown light grey) and Stansted Airport[13] (dark grey), there are 57 grid squares with a NOABL estimated annual mean wind speed of 6 ms at 45 m AGL (light green); 57 squares with 6.1 m/s (olive green); 148 squares with 6.2 m/s (yellow); 111 squares with 6.3 m/s (orange); 96 squares with 6.4 m/s (red); 46 squares with 6.5 m/s (brown); 16 squares with 6.6 m/s (purple); 5 squares with 6.7 m/s (dark blue). Grid squares with AMWS-45 below 6 m/s are shown in cream.

Figure 3-7 shows that there are many 1 km grid squares which have AMWS-45 which lie between 6 – 6.7 m/s with the windiest groups of grid squares being located in the north, north west and central parts of the district. There also

[12] Knowing the annual mean wind speed of a site is not of itself a sufficient criteria because of the cubic relationship between wind speed and the power in wind. Relying on the annual wind speed alone may give a false indication and if economic criteria (rather than a desire to be green regardless of economics) is an important factor in deciding whether or not to proceed with a project, it is also important to have some knowledge of the number of hours per year (or even better for each month of the year) that the wind blows for each 1 m/s wide wind speed band (e.g. the number of hours the wind is blowing between 5 and 6 m/s, between 6 and 7 m/s, between 7 and 8 m/s and so on).
[13] The exclusion zone included may need to be greater than shown subject to the airport's requirements for effects on approaching and departing aircraft and radar. The exclusion zone also does not take account of any future expansion of Stansted Airport so if this is permitted the exclusion zone would also need to be reviewed.

appears to be three distinct 'diagonal' bands of grid squares with AMWS-45 of 6.3 m/s or greater.

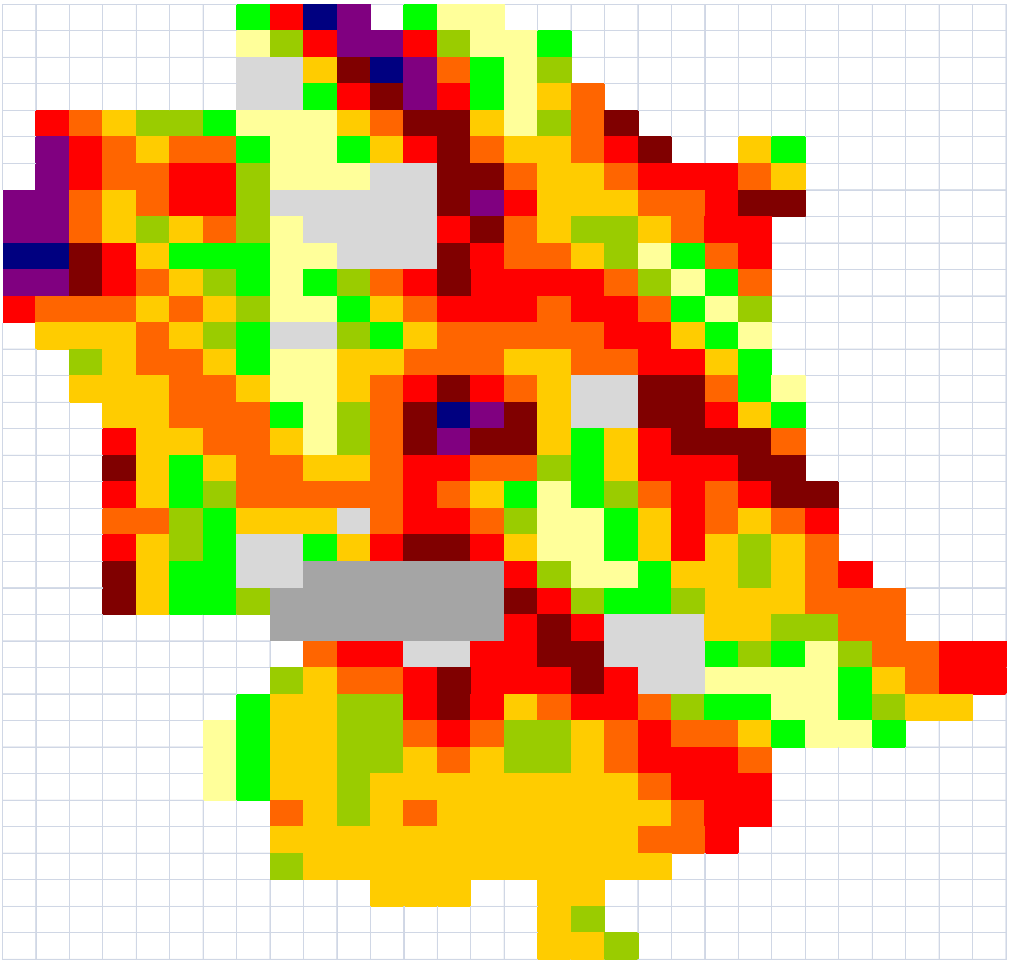

Figure 3-7: Annual mean wind speed at 45 m above ground level (AMWS-45) for 1 km x 1 km OS grid squares in Uttlesford - based on NOABL computer model. (Source ETSU NOABL Wind Atlas). *The appendix contains a similar map (overlaid on to an Ordnance Survey map of Uttlesford) prepared in collaboration with Lee Harrington - Uttlesford DC.*

3.3 Scope for wind farm installations in Uttlesford

In order to ascertain what these AMWS-45 indicate in terms of wind energy; two representative wind turbines designed for operation on medium/low wind speed sites were used in this investigation. Each of these turbines has a diameter of 82 m diameter, one rated at 1650 kW (Vestas V82 1650) and the other rated at 2050 kW (Enercon E82 2050) (see **Figure 3-8**). As of 2006, Vestas had around 28% and Enercon had around 15% of the international market share for wind turbine sales.

The first of these wind turbines is the latest version of a wind turbine model used extensively on wind farms in the UK and throughout Europe and is available in a range of hub heights (HH) between 60 and 80 metres. The second turbine is an upgraded version of the wind turbine that has been successfully operating at Swaffham in Norfolk since 1999 and is available in a range of hub heights between 60 and 138 metres. This turbine is one of the more efficient available and has a gearless direct drive generator.

These are not the biggest turbines available but they are representative of some of the options potentially suitable for medium/low wind speed sites.

Figure 3-8: Vestas V82 1650 Wind Turbine (Left) and Enercon E82 2050 Wind Turbine (Right). (Sources: Vestas and Enercon)

Wind speed increases with height according to the 'wind shear profile' at the site and the increase in wind speed with height is greatest over rougher terrain or urban areas because of the effect of 'surface roughness' on wind speeds.

There are two main calculation methods used for adjusting wind speed with height. One is based on a logarithmic relationship and the other on a power law. Both methods were reviewed but as the power law method gave the lowest increase in wind speed, this method was used in the study to adjust the wind speed values to the various hub heights applicable to the turbines in question.

The NOABL wind speed model also provides AMWS values for 10 m AGL and 25 m AGL but applying the wind speed adjustment factor to the AMWS-45 values gave the least increase in wind speed with height, so again, to be conservative these values were used for the height adjusted wind speeds for the various wind turbine hub height wind speed estimates.

Every wind turbine has a specific wind speed (instantaneous <u>not</u> mean) to power output curve usually known as the ***'power curve'*** and the turbines produce their maximum rated power at and above the rated wind speed up to a shut down or cut-out wind speed.

In order to predict the likely annual electricity production that a wind turbine will generate at a particular site, one ideally needs to know not only the details of the turbine's power curve, but also the wind speed frequency distribution (i.e. the number of hours that the wind blows at each incremental wind speed). For a project to proceed it is important to carry out wind speed measurements as close as possible to the intended hub height, however for the purposes of this study we can use a standard Rayliegh distribution that can be applied to an AMWS value to approximate wind speed frequency distribution to enable the calculation of ball park estimates of electricity production according to AMWS adjusted to the various hub heights HH-AMWS.

A 'seven diameter' spacing between turbines results in a maximum of 'wind turbine density' of 4 wind turbines in a 1 km grid square. However with the undulating topography typical of most of the suitable sites and taking into account the proximity to houses etc, the numbers of turbines in a 1 km grid square is generally only one or two wind turbines, though a few squares could potentially accommodate three turbines and fewer still grid squares could accommodate four turbines. In some situations it might be possible to reduce the spacing distance between turbines by mixing turbines at different hub heights but that has not been considered here. In the grid squares which can accommodate only one wind turbine (according to the filtering method applied), larger rated turbines could be considered without affecting the spacing density so it might also be possible to increase the maximum installed capacity and annual electricity production of the District in that way, but that has not been considered here.

From the point of view of the estimates produced here, only grid squares with AMSW-45 of 6 m/s or greater were considered.

As an indication of the electricity production potentially possible, the V82 wind turbines at an 80 m hub height (HH) were estimated to produce of the order of between 4.1 and 14.8 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.0 m/s AMWS-45 grid square to between 4.9 and 17.9 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.7 m/s AMWS-45 grid square.

For comparison, the E82 wind turbines at an 80 m hub height (HH) were estimated to produce of the order of between 4.8 and 17.5 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.0 m/s AMWS-45 grid square to between 5.9 and 21.4 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.7 m/s AMWS-45 grid square.

At 100 m hub height, the E82 wind turbines were estimated to produce of the order of between 5.1 and 18.7 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.0 m/s AMWS-45 grid square to between 6.2 and 22.6 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.7 m/s AMWS-45 grid square.

If one was to opt for the E82 wind turbines at an 130 m hub height (HH), these would be estimated to produce of the order of between 5.5 and 20.1 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.0 m/s AMWS-45 grid square to between 6.6 and 24.1 GWh/km^2 per year (for 1 to 4 wind turbines) per 6.7 m/s AMWS-45 grid square.

A filtering process was carried out on the grid squares used to estimate the potential wind generated electricity estimates. This took account of the topography and only sites near the higher ground were included, also potential sites with less than approximately 400 m to buildings were excluded as were sites in close proximity to villages. Grid squares including large areas of woodlands were in general excluded. Grid squares including radio masts were also excluded in the calculations (depending on the type of radio services involved it might also be necessary to exclude portions of the adjacent grid squares in consultation with the relevant authorities). Similarly if there are other airfields (other than Stansted) in use within or adjacent to a grid square, this will need to take account of the airfield's requirements. There may need to be some further adjustments according to landscape designations and other factors, but it does permit a first order assessment of the wind energy potential in Uttlesford.

Figure 3.9 shows a map of revised grid squares for AMWS-45 after the filtering exercise.

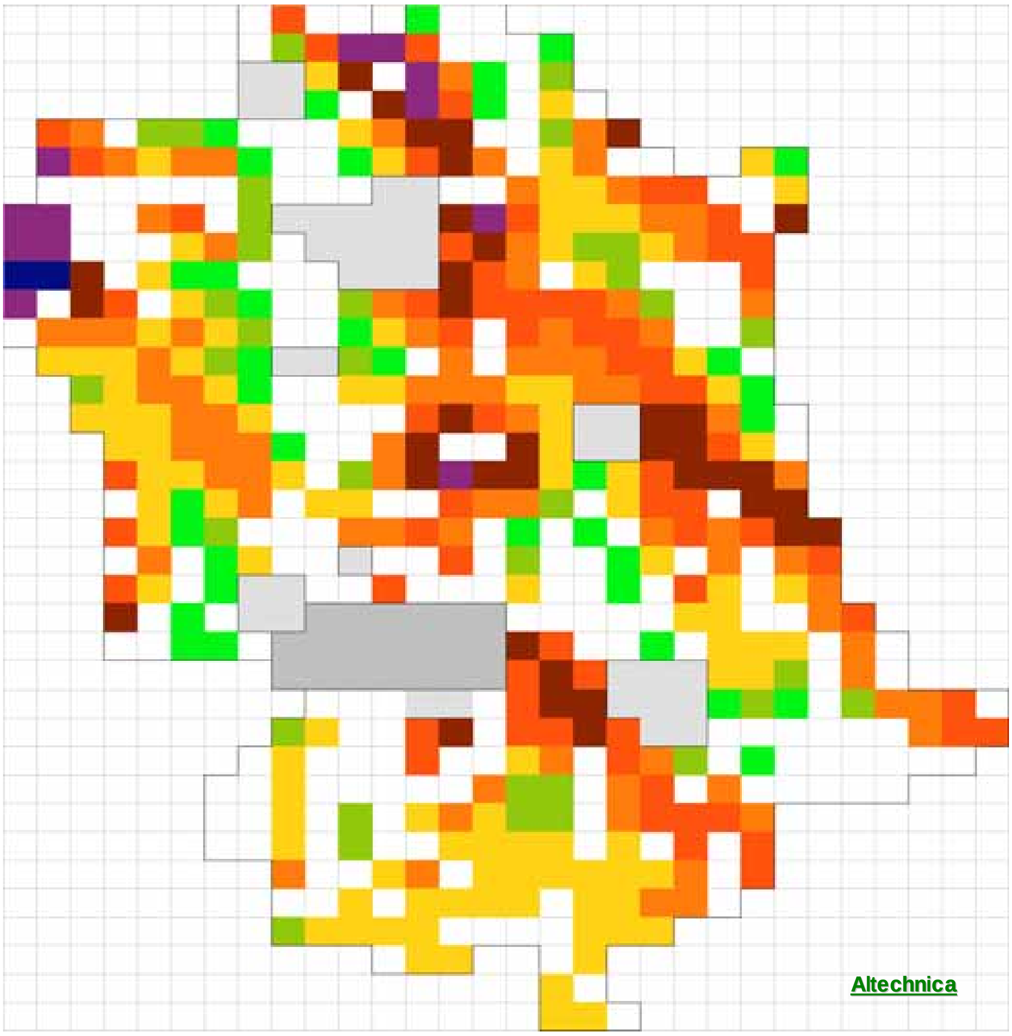

Figure 3-9: Annual mean wind speed at 45 m above ground level (AMWS-45) for 1 km x 1 km OS grid squares in Uttlesford after filtering for suitability for siting wind turbines. **Altechnica**

Figure 3-10 shows a map of revised grid squares for AMWS-45 after this further filtering exercise, taking account of the above factors, appropriate turbine spacing and the numbers of 82 m diameter wind turbines,

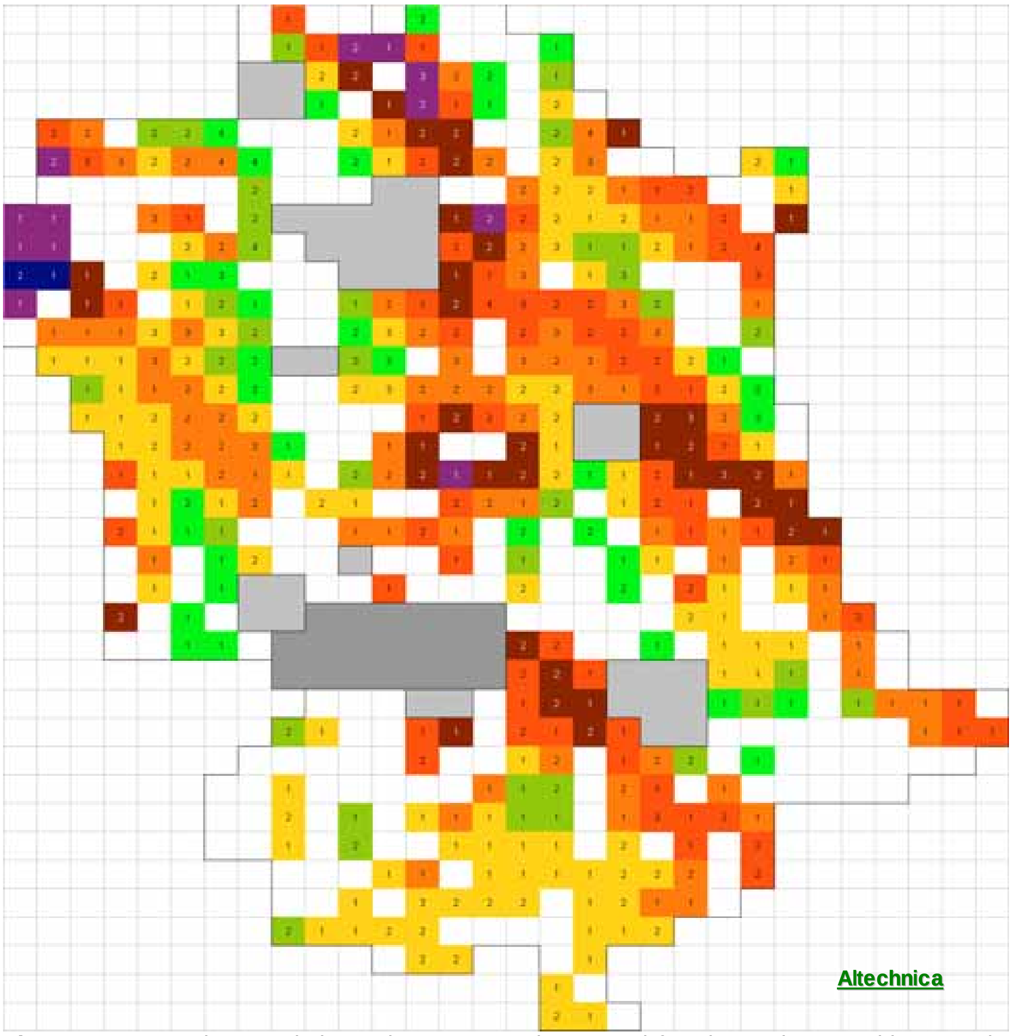

Figure 3-10: Annual mean wind speed at 45 m AGL (AMWS-45) for 1 km x 1 km OS grid squares in Uttlesford after filtering for suitability for siting wind turbines. Values in each square indicate maximum feasible numbers of 82 m diameter turbines. **Altechnica**

3.3.1 Ball Park Estimates of Potential of Wind Generated Electricity from Large Wind Turbines in Uttlesford

3.3.1.1 Based on Vestas V82 1650 Wind Turbines

In order to estimate the maximum feasible amounts of annual electricity that could be generated in Uttlesford, the wind generated electricity was calculated based on the above filtered grid squares and the above numbers of wind turbines per grid squares.

Figure 3-11 shows the spread of maximum feasible wind turbine capacity based on V82-1650 turbines according to combined totals in the grid squares with the same AMWS-45 values.

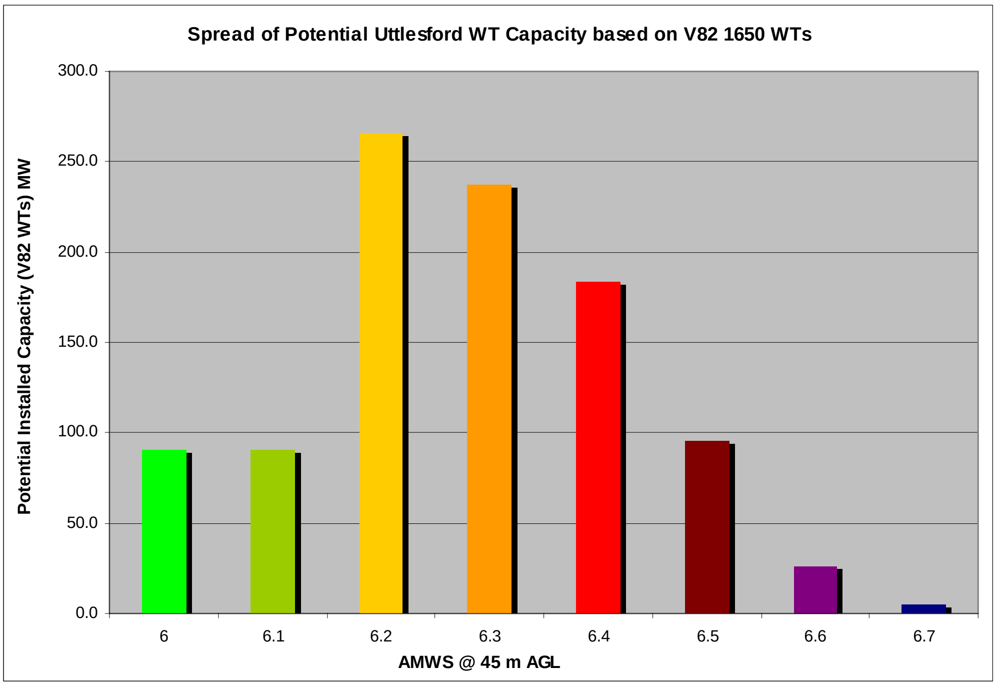

Figure 3-11: The spread of estimated maximum feasible wind turbine capacity based on V82-1650 turbines combined totals in the grid squares with 6 to 6.7 AMWS-45. **Altechnica**

Table 3-4 shows the estimated annual electricity production at a range of hub heights and for cumulative numbers of grid squares with the same AMWS-45 values.

Table 3-4: Ball park estimates of the maximum feasible potential annual wind generated electricity in Uttlesford using Vestas V82 1650 Wind Turbines (each rated at 1670 kW). **Altechnica**

Max Potential for Wind Energy in Uttlesford using V82 Turbines						
Filtered # of Squares by topography & Proximity						
Vestas 82 1650 @ 60 to 80 m HH				AMWS 6 to 6.7 m/s @ 45 m AGL		
1650 MW 82 m Dia Wind turbines @ min 7 dia Spacings						
Max # WTs = 603				Combined Capacity = 995 MW		
				HH in m AGL		
AMWS 45 m AGL	WTs #	Capacity kW	Capacity MW	60 MWh/y	70 MWh/y	80 MWh/y
6.0	55	90,750	91	187,100	195,910	203,640
6.1	55	90,750	91	193,390	202,280	210,060
6.2	161	265,650	266	584,390	610,600	633,490
6.3	144	237,600	238	538,880	562,470	583,020
6.4	111	183,150	183	439,990	458,320	474,230
6.5	58	95,700	96	229,900	239,480	247,790
6.6	16	26,400	26	65,160	67,810	70,100
6.7	3	4,950	5	12,540	13,030	13,460
RndedTotal =	603	994,950	995	2,251,300	2,349,900	2,435,800

Table 3-4 shows that, assuming V82 1650 wind turbines with a combined capacity of 995 MW, they would generate of the order of **2,250 GWh/year** at a hub height of 60m; **2,340 GWh/year** at a hub heght of 70m and **2,430 GWh/year** at a hub height of 80m. Reading along the rows, the table also shows the combined total for all of the filtered grid squares of a given AMWS-45 value.

Figure 3-12 shows a graphical representation of the ball park estimates of the maximum feasible potential annual wind generated electrcity in Uttlesford using V82 1650 wind turbines at 80m hub height and showing the combined total for the grid squares with AMSW-45 between 6.0 to 6.7 m/s.

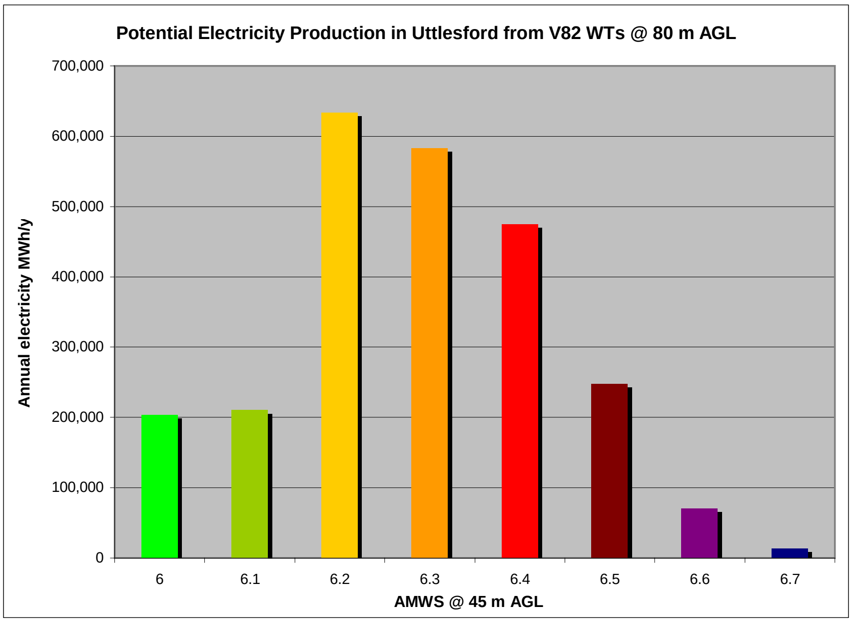

Figure 3-12: Distribution of potential annual wind generated electricity from V82 1650 wind turbines at 80 m hub height by combined totals in grid squares with AMWS-45 values between 6 and 6.7 m/s. **Altechnica**

If we assume the currently accepted rates of carbon dioxide emissions of 860 g/kWh[14] of electricity used by the British Wind Energy Association and confirmed by the National Grid, we can calculate the estimated levels of annual carbon dioxide abatement that would be achieved by these amounts of wind generated electricity. These are shown in the following **Table 3-5** and **Figure 3-13**.

Table 3-5: Ball park estimates of abated CO_2 emissions that could be offset with the maximum feasible potential wind generated electricity in Uttlesford using Vestas V82 1650 Wind Turbines.

Max Potential for CO_2 abatement from Wind Energy in Uttlesford using V82 Turbines						
Filtered # of Squares by topography and Proximity						
Vestas 82 1650 @ 60 to 80 m HH				AMWS 6 to 6.7 m/s @ 45 m AGL		
1650 MW 82 m Dia Wind turbines @ min 7 dia Spacings						
Max # WTs = 603				Combined Capacity = 995 MW		
				Based on BWEA Method @ 860 g/kWh		
					HH in m AGL	
AMWS	WTs	Capacity	Capacity	60	70	80
@ 45 m AGL	#	kW	MW	TonneCO_2/y	TonneCO2/y	TonneCO2/y
6	55	90,750	91	160,900	168,490	175,130
6.1	55	90,750	91	166,310	173,960	180,650
6.2	161	265,650	266	502,570	525,120	544,800
6.3	144	237,600	238	463,440	483,720	501,400
6.4	111	183,150	183	378,390	394,150	407,840
6.5	58	95,700	96	197,720	205,950	213,100
6.6	16	26,400	26	56,040	58,310	60,290
6.7	3	4,950	5	10,780	11,210	11,580
Total =	603	994,950	995	1,936,100	2,020,900	2,094,800

Table 3-5 indicates that the annual amounts of CO_2 emissions that could potentially be abated from wind generated electricity production from this number of V82 1650 wind turbines in Uttlesford are of the order of **1.9 million tonnes** with 60 m hub height, **2.02 million tonnes** with 70 m hub height and **2.09 million tonnes** with 80 m hub height.

[14] Note: this is higher than the values assumed in embedded forms of electricity generation (which assume a mix of fuels used in the UK electricity generation sector) such as the value of 568gCO_2/kWh used in the current UK Building Regulations for taking account of PV or Microwind generated electricity. Whereas wind generated electricity from wind farms is assumed by the BWEA and the National Grid Co to offset electricity from coal fired plant – hence 860gCO_2/kWh.

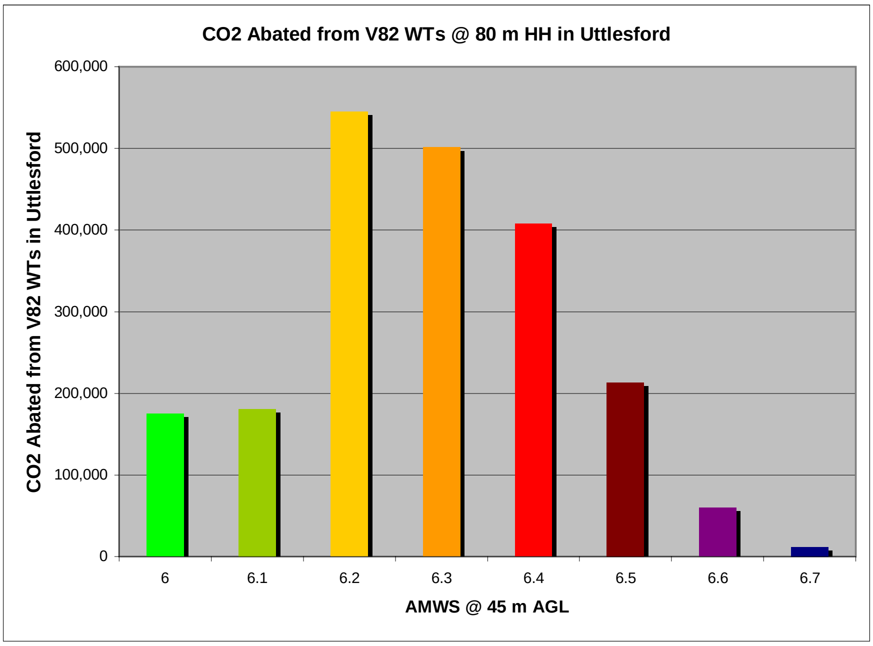

Figure 3-13: Estimates of the annual CO_2 abatement that could be offset by the estimated potential wind generated electricity from V82 1650 wind turbines at 80 m hub height by combined totals of fltered wind turbines in grid squares with AMWS-45 values between 6 and 6.7 m/s. **Altechnica**

3.3.1.2 Based on Enercon E82 2050 Wind Turbines

In order to have a comparative estimate of the maximum feasible amounts of annual electricity that could be generated in Uttlesford, a further estimate of the wind generated electricity was calculated (again based on the above filtered grid squares and the same numbers of wind turbines in the grid squares), but this time assuming Enercon E82 2050 wind turbines. These are available with hub heights between 60m and 138 m.

Figure 3-14 shows the spread of the estimated maximum feasible wind turbine capacity based on E82-2050 turbines according to combined totals in the grid squares with the same AMWS-45 values.

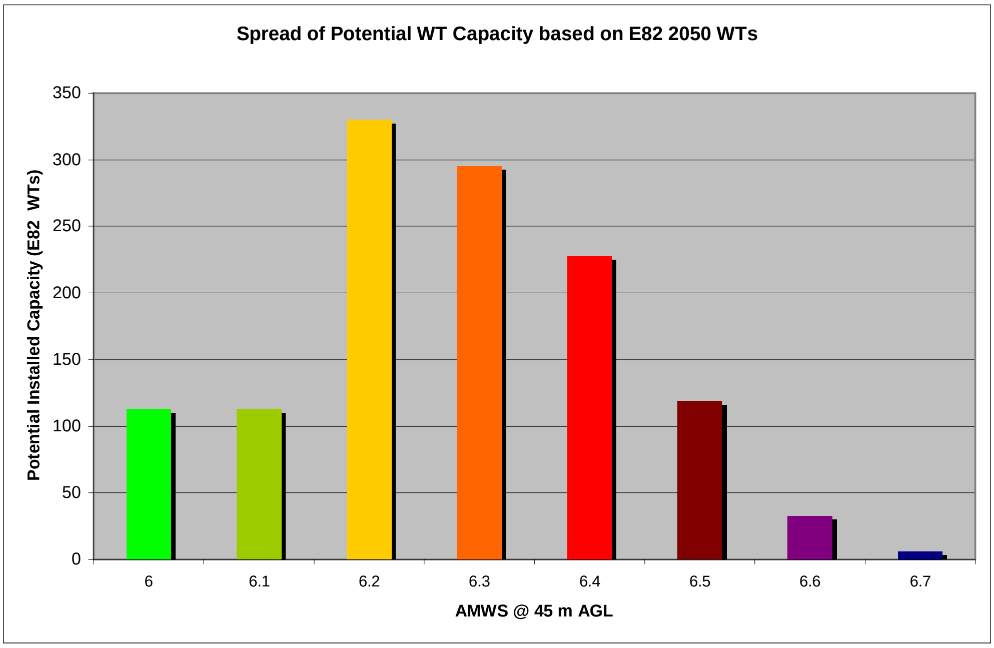

Figure 3-14: The spread of estimated maximum feasible wind turbine capacity based on E82-2050 turbines combined totals in the grid squares with 6 to 6.7 AMWS-45. **Altechnica**

Table 3-6 gives the estimated annual electricity production at a range of hub heights and for cumulative numbers of grid squares with the same AMWS-45 values.

Table 3-6: Ball park estimates of the maximum feasible potential annual wind generated electricity in Uttlesford using Enercon E82 Wind Turbines each rated at 2050 kW. **Altechnica**

Max Potential for Wind Energy in Uttlesford using E82 Turbines									**Ball Park Estimates of Annual Electricity Production**		
Filtered # of Squares by topography and Proximity											
Enercon E82 2050 @ 60 to 138 m HH						AMWS 6 to 6.7 m/s @ 45 m AGL					
2050 MW 82 m Dia Wind turbines @ min 7 dia Spacings											
Max # WTs = 603				Combined Capacity = 1,236 MW							
				HH in m AGL							
AMWS	WTs	Cap	60	70	80	90	100	110	120	130	138
45 m AGL	#	MW	MWh/y	MWh/y	MWh/y	MWh/y	MWh/y	MWh/y	MWh/y	MWh/y	MWh/y
6	55	113	245,290	257,280	267,830	277,240	285,740	293,490	300,600	307,170	312,090
6.1	55	113	253,840	265,980	276,640	286,140	294,700	302,500	309,650	316,260	321,200
6.2	161	330	767,990	803,900	835,380	863,410	888,660	911,620	932,660	952,070	966,590
6.3	144	295	709,070	741,490	769,870	795,100	817,810	838,440	857,330	874,740	887,750
6.4	111	228	580,420	605,780	627,930	647,580	665,220	681,210	695,830	709,290	719,330
6.5	58	119	303,280	316,530	328,110	338,370	347,590	355,950	363,590	370,620	375,860
6.6	16	33	86,070	89,750	92,950	95,800	98,350	100,650	102,760	104,700	106,150
6.7	3	6	16,580	17,270	17,880	18,410	18,890	19,320	19,720	20,080	20,350
Rounded Dn Total =	603	1236	2,962,500	3,098,000	3,216,600	3,322,000	3,416,900	3,503,200	3,582,100	3,654,900	3,709,300

Table 3-6 shows that E82 wind turbines with a combined capacity of 1236 MW would be estimated to generate of the order of **2,960 GWh/year** at a hub height of 60 m; **3,090 GWh/year** at a hub heght of 70 m; **3,210 GWh/year** at a hub height of 80 m; **3,320 GWh/year** at a hub height of 90 m; **3,210 GWh/year** at a hub height of 100 m; **3,500 GWh/year** at a hub height of 110 m; **3,580 GWh/year** at a hub height of 120 m; **3,650 GWh/year** at a hub height of 130 m; and **3,700 GWh/year** at a hub height of 138 m. Reading accross each row of the table also shows the combined totals for the grid squares of the same AMWS-45 values.

Figure 3-15 shows a graphical representation of the ball park estimates of the maximum feasible potential wind generated electrcity in Uttlesford using E82 2050 wind turbines at 130 m hub height and showing the combined total for the grid squares with AMSW-45 between 6.0 to 6.7 m/s.

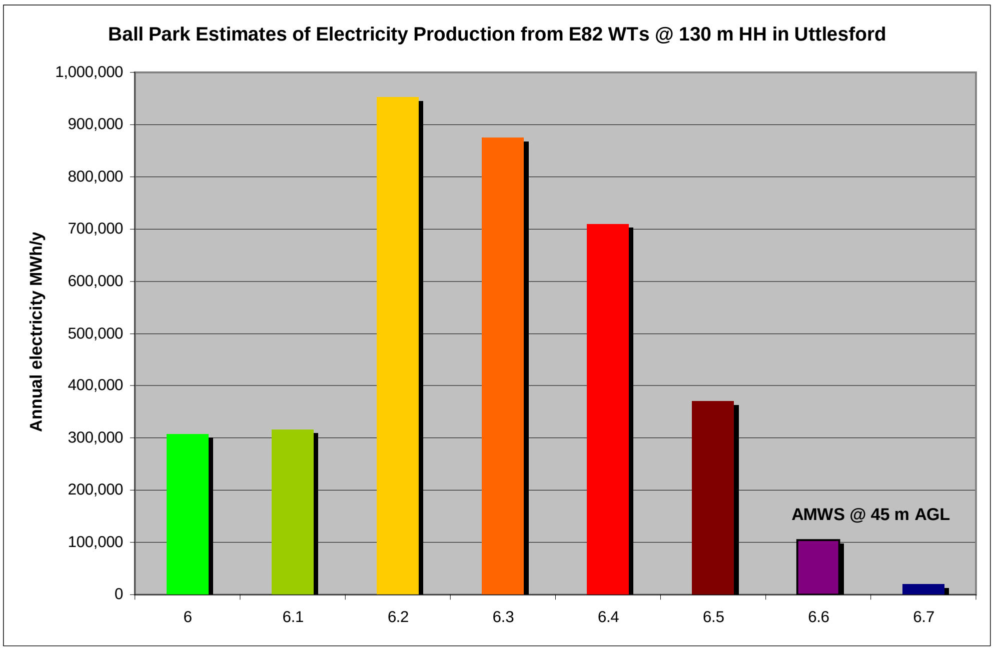

Figure 3-15: Distribution of potential wind generated electricity from E82 2050 wind turbines at 130 m hub height by totals in the filtered grid squares with AMWS-45 values between 6 & 6.7 m/s. **Altechnica**

If we assume the previously mentioned abatement rates of carbon dioxide emissions of 860 g/kWh, we can calculate the estimated levels of annual carbon dioxide abatement that would be achieved by these amounts of wind generated electricity. These are shown in the following **Table 3-7** and **Figure 3-16**.

Table 3-7: Ball park estimates of annual abated CO_2 emissions that could be offset with the estimated maximum feasible potential wind generated electricity in Uttlesford using Enercon V82 2050 Wind Turbines each rated at 2050 kW. **Altechnica**

Max Potential for CO_2 abatment from Wind Energy in Uttlesford using E82 Turbines
Filtered # of Squares by topography and Proximity
Enercon E82 2050 @ 60 to 138 m HH — AMWS 6 to 6.7 m/s @ 45 m AGL
2050 MW 82 m Dia Wind turbines @ min 7 dia Spacings
Max # WTs = 603 — Combined Capacity = 1,236 MW

			HH in m AGL		Tonnes CO_2/year Based on BWEA Method @ 860 g/kWh						
AMWS	WTs	Capacity	60	70	80	90	100	110	120	130	138
45 m AGL	#	MW	TCO2/y	TCO2/y	TCO2/y	TCO2/y	TCO2/y	TCO2/y	TCO2/y	TCO2/y	TCO2/y
6	55	113	210,950	221,260	230,330	238,430	245,740	252,400	258,520	264,170	268,400
6.1	55	113	218,300	228,740	237,910	246,080	253,440	260,150	266,300	271,980	276,230
6.2	161	330	660,470	691,350	718,430	742,530	764,240	783,990	802,080	818,780	831,260
6.3	144	295	609,800	637,680	662,090	683,790	703,320	721,060	737,300	752,280	763,470
6.4	111	228	499,160	520,970	540,020	556,920	572,090	585,840	598,420	609,990	618,620
6.5	58	119	260,820	272,220	282,170	291,000	298,930	306,110	312,680	318,730	323,240
6.6	16	33	74,020	77,180	79,940	82,380	84,580	86,560	88,380	90,040	91,290
6.7	3	6	14,260	14,860	15,370	15,830	16,250	16,620	16,960	17,270	17,500
Rounded Dn Total =	603	1236	2,547,800	2,664,200	2,766,300	2,857,000	2,938,600	3,012,700	3,080,600	3,143,200	3,190,000

Table 3-7 indicates that the estimated amounts of CO_2 emissions that could potentially be abated from wind generated electricity produced from this number of E82 2050 wind turbines in Uttlesford are of the order of **2.5 million tonnes** with 60 m hub height; **2.6 million tonnes** with 70 m hub height; **2.7 million tonnes** with 80 m hub height; **2.8 million tonnes** with 90 m hub height; **2.8 million tonnes** with 100 m hub height; **2.9 million tonnes** with 110 m hub height; **3 million tonnes** with 120 m hub height; **3.14 million tonnes** with 130 m hub height; and **3.19 million tonnes** with 138 m hub height.

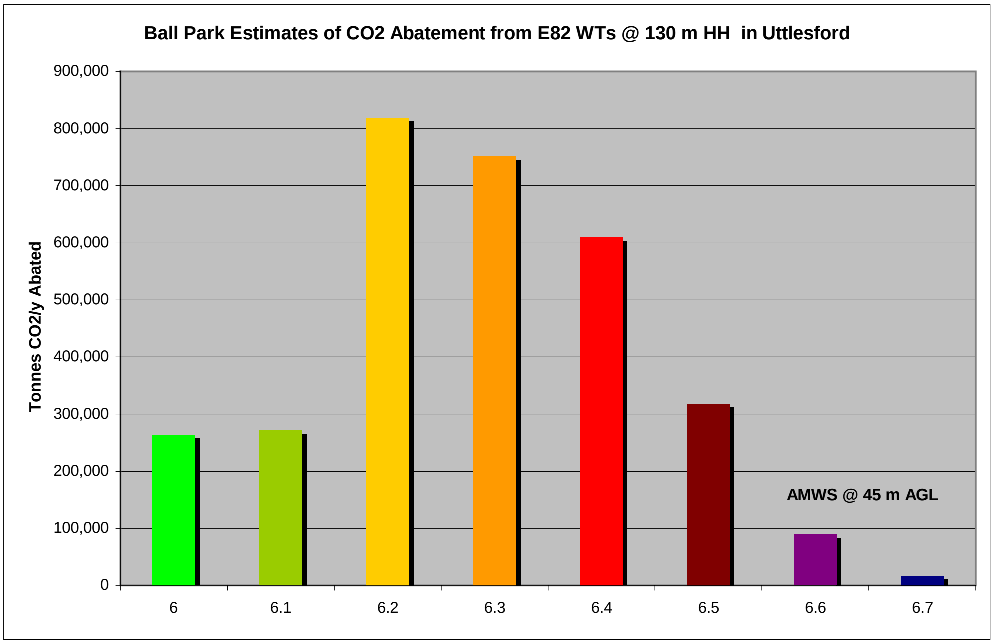

Figure 3-16: Estimates of the annual CO_2 abatement that could be offset by the potential wind generated electricity from E82 2050 wind turbines at 130 m hub height by combined totals of grid squares with AMWS-45 values between 6 and 6.7 m/s. **Altechnica**

3.3.1.3 Comparing Productivity of V82 and E82 Wind Turbines

Whilst in the previous section, the E82 wind turbines were shown to be the most productive in the Uttlesford situations considered, that is mainly because the E82 turbines are available with a range of taller towers allowing higher hub heights.

In order to compare more precisely the electricity production from both turbines at an 80 m hub height, they have been plotted on a series of graphs.

Figure 3-17 shows the comparative maximum wind power capacities for the different AMWS-45 grid squares.

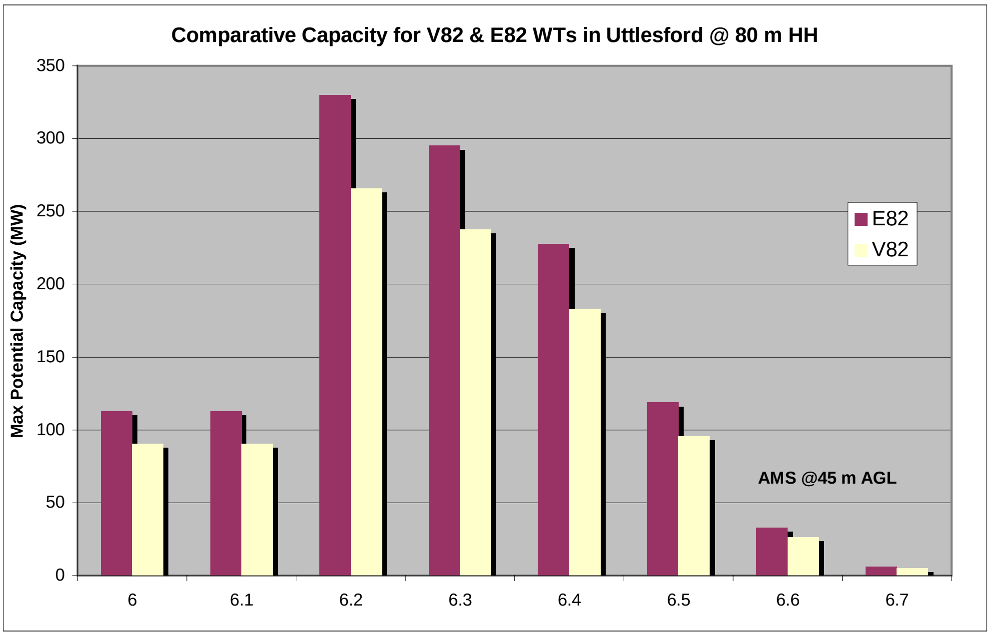

Figure 3-17: Comparative installed capacities of 603 x V82 1650 and 603 x E82 wind turbines installed in appropriate filtered grid squares with AMWS-45 values between 6 and 6.7 m/s

Figure 3-18 shows the estimated comparative annual electricity production from the maximum feasible potential capacities of V82 and E 82 wind turbines.

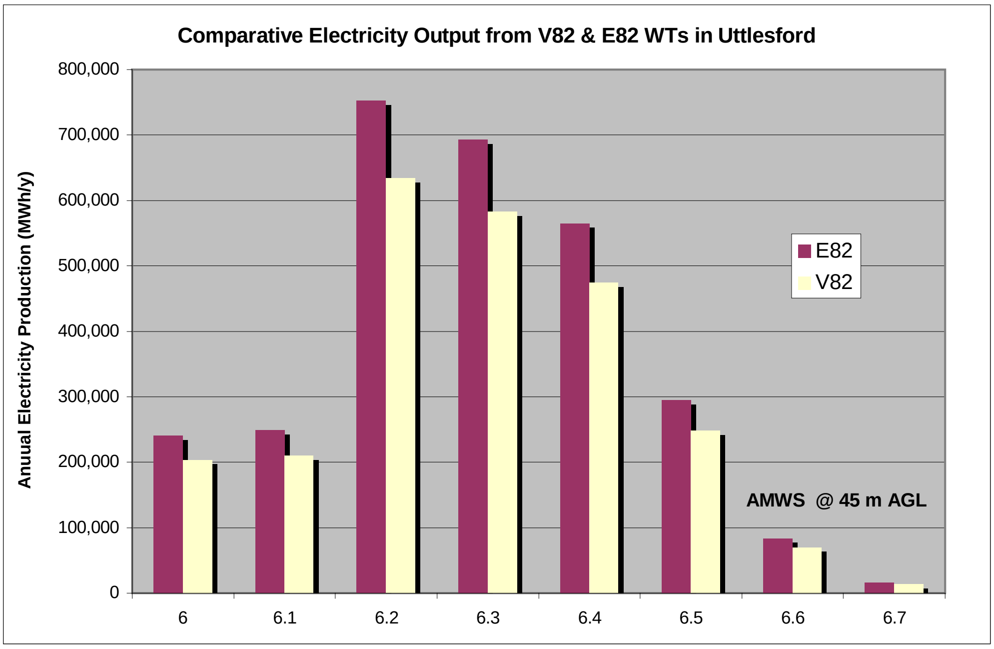

Figure 3-18: Estimated comparative annual electricity production from 603 x V82 1650 and 603 x E82 wind turbines all installed at 80 m hub height in appropriate grid squares with AMWS-45 values between 6 and 6.7 m/s

As can be seen from **Figure 3-18**, the E82 wind turbines are more productive in the considered conditions in Uttlesford even at the same hub height. However these are only two of the range of turbines available but they give a reasonable snapshot of the potential maximum feasible electricity production possible from wind energy in Uttlesford.

Clearly this level of wind energy exploitation is very unlikely, but the estimates show that even though Uttlesford is an inland district, there is potential for substantial wind exploitation so long as appropriate wind turbines are employed and mounted on tall towers on the higher ground regions of the district. There may be further constraints as to whether exploitation is feasible at some of the included sites, but if there is a commitment to reduce the CO_2 emissions in the district by utilising renewable resources then wind energy could play an important role in helping to achieve substantial emissions reductions.

3.4 Providing Domestic Energy Needs in Uttlesford from Large Wind Turbines

3.4.1 Providing Domestic Electricity Needs in Uttlesford from Large Wind Turbines

The previous sections have provided estimates of the maximum feasible electricity generation and CO_2 emissions abated that can potentially be achieved if all of the suitable filtered sites could be utilised.

A further analysis has been carried out in order to see what sorts of numbers of wind turbines would be needed to generate an equivalent amount of annual electricity for the number of households in Uttlesford – which for the purposes of this study has assumed to be 30 thousand households.

For the purposes of this study the UK average household electricity consumption of 4.7 MWh/y (4,700 kWh/y) is assumed, even though the average domestic electricity consumer in Uttlesford uses 5.8 MWh/y according to DUKES06. Both values are high compared to how much lower the annual electricity demand could be if there was wider adoption of more energy efficient appliances and low energy lighting. Nonetheless the UK average 4.7 MWh/y per household seems to be a reasonable starting point in order to begin to quantify how many turbines would be needed to match domestic electricity demand in Uttlesford. On that basis the combined total annual electricity demand for 30 thousand households would be equivalent to 141 thousand MWh/y or 141 GWh/y.

On that basis we can estimate the numbers of turbines needed to generate 141 GWh/y in Uttlesford. **Table 3-8** gives the estimated numbers of V82 1650 wind turbines needed according to AMWS-45 values and hub heights between 60 and 80 m AGL.

Table 3-8: Estimated Numbers of V82 1650 turbines (rated at 16050 kW) needed to provide annual electricity production equivalent to the needs of the 30 k Household in Uttlesford.[15] **Altechnica**

Nos of Wind Turbines to supply electricity for the houses in Uttlesford using V82 Turbines
Filtered # of Squares by topography and Proximity AMWS 6 to 6.7 m/s @ 45 m AGL
Vestas 82 1650 @ 60 to 80 m HH 1650 MW 82 m Dia Wind turbines
Electricity production needed for 30,000 houses @ 4.7 MWh 141,000 MWh/y
Combined Capacity = 53 to 70 MW
CO_2 abated **121,260 tCO_2/y**

AMWS @ 45 m AGL	Max # WTs #	# WTs 4 30k Houses @ 4.7 MWh/y 60 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 70 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 80 # WTs
6	55	42	40	39
6.1	55	41	39	36
6.2	161	39	38	35
6.3	144	38	37	34
6.4	111	36	35	32
6.5	58	36	35	32
6.6	16	35	34	32
6.7	3	34	33	31

Table 3-8 shows that the estimated numbers of V82 wind turbines in Uttlesford needed to generate an annual electricity production equivalent to the 30 k households in Uttlesford varies between around **32** and **42** according to AMWS-45 value and hub height.

Similarly **Table 3-9** gives the estimated numbers of E82 2050 wind turbines needed according to AMWS-45 values and hub heights between 60 and 138 m AGL.

Table 3-9: Estimated Numbers of E82 2050 turbines (each rated at 2050 kW) needed to provide annual electricity production equivalent to the needs of the 30 k Household in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply electricity for the households in Uttlesford using E82 Turbines
Filtered # of Squares by topography and Proximity AMWS 6 to 6.7 m/s @ 45 m AG 30,000 households
Enercon E82 2050 @ 60 to 138 m HH Electricity production needed for 30,000 houses @ 4.7 MW 141,000 MWh/y
2050 MW 82 m Dia Wind turbines
CO_2 abated **121,260 tCO_2/y**

AMWS @ 45 m AGL	Max # WTs #	# WTs 4 30k Houses @ 4.7 MWh/y 60 # WTs	# WTs 4 30k Houses @ 4.7 MWh/ 70 # WTs	# WTs 4 30k Houses @ 4.7 MWh/ 80 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 90 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 100 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 110 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 120 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 130 # WTs	# WTs 4 30k Houses @ 4.7 MWh/y 138 # WTs
6	55	32	30	29	28	27	26	26	25	25
6.1	55	31	29	28	27	26	26	25	25	24
6.2	161	30	28	27	26	26	25	24	24	23
6.3	144	29	27	26	26	25	24	24	23	23
6.4	111	27	26	25	24	24	23	22	22	22
6.5	58	27	26	25	24	24	23	22	22	22
6.6	16	26	25	24	24	23	22	22	22	21
6.7	3	26	24	24	23	22	22	21	21	21

Table 3-9 shows that the estimated numbers of E82 wind turbines in Uttlesford needed to generate an annual electricity production equivalent to the 30k households in Uttlesford varies between around **21** and **32** according to AMWS-45 value and hub height.

These numbers of turbines (e.g. 32 to 42 V82 turbines or 21 to 32 E82 turbines) are estimated to abate some **121 thousand tonnes of CO_2 per year**. As such these numbers of turbines could assist in making the householders net CO_2 neutral in terms of their electricity consumption.

[15] Hatched cells indicate that the numbers of wind turbines shown exceed the maximum number of turbines able to be used in the available AMWS-45 grid squares (given in the first column). The maximum number of turbines possible for the relevant row are given in the second column.

3.4.2 Providing Domestic Space and Water Heating Needs in Uttlesford from Large Wind Turbines

Apart from remote off-grid locations, it has not been feasible to consider the use of wind energy for space heating because it was difficult to compete economically with low cost gas fuelled central heating.

In fact, though that is still the case in many situations, circumstances are beginning to change such that it might make the consideration of wind energy for space and water heating worth consideration.

These include

- the fact that the UK is now an importer of gas;
- gas bills have been very variable of late and it seems reasonable to assume that they will increase over the longer term;
- there is growing awareness that as well as electricity generation having an impact on climate change so too does providing space and water heating by the combustion of fossil fuels in boilers;
- the availability of heat pumps with improved efficiency - including low temperature heat pumps – with coefficients of performance that permit the energy output of wind turbines to be effectively 'tripled' when provided for heating;
- heating hot water cylinders or heat stores is an effective method of storing variable wind energy and which uses currently available technology (even using electric resistance heating methods of heating water such as immersion heaters or thermal storage electric boilers could be viable for this purpose). These offer useful possibilities if smart-metering technologies become widely deployed;
- group heat pump schemes are now becoming possible which improve the cost effectiveness and could also incorporate larger scale heat stores to store excess wind energy – such systems could also form part of distributed energy/district heating schemes and CHP projects;
- more wind energy is available during the winter months - which matches the period of peak heat demand and also complements solar water heating technologies which produce most of their energy in the summer months;
- when buildings are not well insulated or adequately draught-proofed or not wind sheltered, heat loss increases with wind speed, so wind energy availability can match periods of peak heat loss;
- wind turbines have become aerodynamically, mechanically and electrically more efficient increasing their productivity;
- wind turbine rotors have become larger, increasing their productivity and cost effectiveness in £/kW terms;
- taller towers further increase wind turbine productivity and improve viability in lower/medium wind speed locations by taking advantage of the fact that wind velocity increases with height

For the purposes of this study the potential for utilising wind generated electricity to power heat pumps has been explored. A further analysis was done to see what sorts of numbers of wind turbines would be needed to generate an equivalent amount of annual electricity in order to power heat pumps for the number of households in Uttlesford – which for the purposes of this study has assumed to be 30 thousand households.

This is not to say that it would be necessarily possible to provide heat pumps for all of the households in Uttlesford, but heat pumps could be very widely deployed where appropriate ground, water or air sources where appropriate. Though the size of some schemes may not be feasible without also improving the thermal performance of the buildings to reduce the rating of the heating system.

From the householders' point of view reducing the heat demand usually makes more sense than changing the type of supply. On the other hand there are likely to be many properties that are difficult to insulate more, or to improve thermally, so such an approach may be more feasible as a first step in reducing the CO_2 emissions of such houses until such time as it becomes feasible or it becomes an imperative to reduce the heat demand.

According to DUKES-06 the average domestic gas consumption in gas-connected households in Uttlesford is of the order of 21,400 kWh/year (21.4 MWh/y). Whilst a proportion of the gas would be used for cooking, for the purposes of this study it is used as means of estimating the average space heating and hot water demand for households in Uttlesford.

Heat pumps (which are very similar in operation to refrigerators) have a characteristic criterion known as the coefficient of performance (COP) which is a measure of useful heat out, over electrical energy in and can range from 2 to 4 and in some special cases to 5. Heat pumps with a coefficient of performance of three have been used for the purposes of this study.

Therefore taking the average domestic gas consumption of 21.4 MWh/year as guide, with a COP of 3 for the purposes of this study this becomes an average annual heat pump electrical demand of **7.2 MWh/year**. Assuming 30k households, the annual electricity production required to match those needs would be 216,000 MWh/year or **216 GWh/year**.

On that basis we can estimate the numbers of turbines needed to generate 216 GWh/y in Uttlesford. **Table 3-10** gives the estimated numbers of V82 1650 wind turbines needed according to AMWS-45 values and hub heights between 60 and 80 m AGL.

Table 3-10: Estimated Numbers of V82 1650 turbines needed to provide annual electricity production equivalent to the heat pump requirements for the average space & water heating needs of the 30 k Household in Uttlesford.

Nos of Wind Turbines to supply space & water heat pumps for the houses in Uttlesford using V82 Turbines						
Filtered # of Squares by topography and Proximity					AMWS 6 to 6.7 m/s @ 45 m AGL	
Vestas 82 1650 @ 60 to 80 m HH					1650 MW 82 m Dia Wind turbines	
Electricity production for heat pumps for 30,000 houses @ 7.2 MWh (COP 3)						216,000 MWh/y
					CO_2 abated	**136,800 tCO_2/y offsetting gas**
		# WTs 4	# WTs 4	# WTs 4		
		30k Houses	30k Houses	30k Houses	{CO_2 abated	170,100 tCO_2/y if LPG offset}
	Max #	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	{CO_2 abated	202,500 tCO_2/y if oil offset}
AMWS	WTs	60	70	80	{CO_2 abated	202,500 tCO_2/y if oil offset}
@ 45 m AGL	#	# WTs	# WTs	# WTs	{CO_2 abated	243,000 tCO_2/y if coal offset}
6	55	64	61	59	{CO_2 abated	287,258 tCO_2/y if ERH offset}
6.1	55	62	59	57	{CO_2 abated	92,880 tCO_2/y if EHP offset}
6.2	161	60	57	55		
6.3	144	58	56	54	{CO_2 abated	574,515 tCO_2/y if CERH offset}
6.4	111	55	53	51	{CO_2 abated	185,760 tCO_2/y if CEHP offset}
6.5	58	55	53	51	ERH = electric resistance heating	
6.6	16	54	51	50	EHP = electric heat pump	
6.7	3	52	50	49	CERH = electric resistance heating from coal fired elec	

Table 3-10 shows that the estimated numbers of V82 wind turbines in Uttlesford needed to generate an annual electricity production equivalent in order to provide for heat pumps to supply the average space and water heating demand for the 30 k households in Uttlesford varies between around **51** and **62** according to AMWS-45 value and hub height.

Similarly **Table 3-11** gives the estimated numbers of E82 2050 wind turbines needed to provide for these heat pumps - according to AMWS-45 values and hub heights between 60 and 138 m AGL.

Table 3-11: Estimated Numbers of 2050 kW E82 2050 turbines to provide annual electricity equivalent to the heat pump requirements for the average space & water heating needs of the 30k households in Uttlesford. [16]

Nos of Wind Turbines to supply space & water heating heat pumps for the houses in Uttlesford using E82 Turbines										
Filtered # of Squares by topography & Proximity				AMWS 6 to 6.7 m/s @ 45 m AGL			30,000 households			
Enercon E82 2050 @ 60 to 138 m HH				Electricity production for heat pumps for 30,000 houses @ 7.2 MWh (COP 3) ~					216,000 MWh/y	
2050 MW 82 m Dia Wind turbines @ min 7 dia Spacings								**CO_2 abated**	**136,800 tCO_2/y** o/s gas	
		# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4
		30k Houses	30k Houses	30k Houses	30k Houses	30k Houses	30k Houses	30k Houses	30k Houses	30k Houses
	Max #	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y	@ 7.2 MWh/y
AMWS	WTs	60	70	80	90	100	110	120	130	138
@ 45 m AGL	#	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs
6	55	49	47	45	43	42	41	40	39	39
6.1	55	47	45	43	42	41	40	39	38	37
6.2	161	46	44	42	41	40	39	38	37	36
6.3	144	44	42	41	40	39	38	37	36	36
6.4	111	42	40	39	38	37	36	35	34	34
6.5	58	42	40	39	38	37	36	35	34	34
6.6	16	41	39	38	37	36	35	34	34	33
6.7	3	40	38	37	36	35	34	33	33	32

Table 3-11 shows that the estimated numbers of E82 wind turbines in Uttlesford needed to generate an annual electricity production equivalent to heat pump supply provision for the average space and water heating demand for the 30 k households in Uttlesford varies between around **34** and **49** according to AMWS-45 value and hub height.

The numbers of turbines required for providing space heating could be reduced considerably if the thermal performance standards of the existing housing stock was considerably improved. Of course this strategy should be given a higher priority than it is currently, but given the urgency that addressing climate change entails, together with the difficult requirements of upgrading much of the housing stock in Uttlesford, using wind energy to reduce CO_2 emissions in this way could potentially be a fairly rapid measure in the Uttlesford situation. Also if implemented with at least part community ownership or as WESCOs[17], such an implementation of wind energy could provide the resources (from the revenue stream from the sale of wind generated electricity) to invest in upgrading the insulation levels of the existing housing stock.

If these turbines are assumed to be offsetting gas fired condensing boilers at current consumption levels, these numbers of turbines (e.g. **51 to 62 V82** turbines or **34 to 49 E82** turbines) are estimated to abate almost **137 thousand tonnes of CO_2 per year**. **Table 3-12** also shows the potential levels of abatement according to types of heating and fuel sources.

[16] The cells in the table that are hatched indicate that the numbers of wind turbines shown exceed the maximum number of turbines able to be used in the AMWS-45 grid squares (given in the first column) corresponding to the relevant row. The maximum number of turbines possible for the relevant row are given in the second column.
[17] WESCO (Wind Energy Services Company)

Table 3-12: Levels of CO_2 abatement possible by providing domestic space and water heating by wind turbines supplying heat pumps for the households in Uttlesford.

CO_2 abated	**136,800**	**tCO_2/y** offsetting gas
{CO_2 abated	*170,100*	*tCO_2/y if LPG offset}*
{CO_2 abated	*202,500*	*tCO_2/y if oil offset}*
{CO_2 abated	*202,500*	*tCO_2/y if oil offset}*
{CO_2 abated	*243,000*	*tCO_2/y if coal offset}*
{CO_2 abated	*287,258*	*tCO_2/y if ERH offset}*
{CO_2 abated	*92,880*	*tCO_2/y if EHP offset}*
{CO_2 abated	*574,515*	*tCO_2/y if CERH offset}*
{CO_2 abated	*185,760*	*tCO_2/y if CEHP offset}*
ERH = electric resistance heating		
EHP = electric heat pump		
CERH = electric resistance heating from coal fired elec		
CEHP = electric heat pump from coal fired electricity		

Clearly the levels of abatement shown in **Table 3-12** would not be achieved because there is currently a mixture of fuels in use, with gas providing around 64% of the space and water heating needs in Uttlesford, but it does show the relative CO_2 emission impact of different heating methods and fuel types. However if we were to assume that the other 36% of Uttlesford households were using oil fired heating systems the CO_2 emissions offset from (64% gas & 36% oil heating) would be almost 159 thousand tonnes of CO_2 per year.

As such these numbers of turbines could assist in making the Uttlesford householders net CO_2-neutral in terms of their space heating.

There may be an issue as to whether it is appropriate to use this amount of electricity (216 GWh/y) for heating rather than electricity needs as it would abate around 185 thousand tonnes of CO_2 if abating electricity needs. It remains to be seen as to whether it is feasible, but using the wind energy + heat pump option is a potentially useful strategy (using current technologies) for solving a difficult problem by using an indigenous CO_2-free source of energy which, if combined with heat storage, provides a useful way to exploit and store energy from the variable winds.

3.4.3 Using Large Wind Turbines to Provide Energy for Personal Transport in Uttlesford

Although the application of wind energy for transport goes back thousands of years in terms of nautical sail power, the use of a practical form of transport suitable for modern needs from wind energy has been limited to a few niche situations such as off-shore islands and other remote off-grid locations where limited range electric vehicles have been used in combination with battery charging wind turbines.

There is growing interest in the use of hydrogen as a fuel to power vehicles either in an internal combustion engine (ICE) or via fuel cells (FC) (which exploit the electricity produced when hydrogen and oxygen are brought together). Cars that use hydrogen in ICEs have been built and are under development as are various FC vehicles, and whilst hydrogen can be produced from renewable sources such as wind, hydro-electricity, solar photovoltaics or from processing biofuels, the conversion losses involved are significant and hydrogen vehicles are likely to derive most of their hydrogen from fossil fuel sources for some time after their introduction. Whilst this may be a useful improvement in terms of emissions from vehicles, there will be a need to capture and reliably store the CO_2 contained in the fossil fuels and care will be needed to ensure a positive overall energy balance.

If renewable energy derived hydrogen is to be used effectively for transportation, there is a need to develop an infrastructure and address safety concerns.

Whether hydrogen becomes a practical option for transport which cuts emissions from that sector significantly and rapidly enough remains to be seen and if the conversion losses in various processes can be reduced, then wind energy can have a useful role to play in producing hydrogen.

However, whilst electric vehicle technology languished for most of the twentieth century and suffered from its '*milk-float'* image, there have been a number of developments of late that make the wind energy + electric vehicle option worthy of consideration and to plan to facilitate its use.

These include

- Developments in variable speed AC and DC motors suitable for electric vehicles;
- Developments in regenerative braking technology to recover wasted energy;
- Developments in control systems to improve performance of electric vehicles;
- Reductions being achieved in vehicle weights;
- Much improved vehicle shapes for reduced aerodynamic drag;
- Substantial developments in battery technology (e.g. energy density, durability and fast charging) driven in part by the demands of mobile phones and computers;
- Increased familiarity and understanding from the point of view of users and consumers in the use of rechargeable electrical appliances and gadgets - which as well as mobile phones and portable computers, includes such things as iPods, PDAs, and a whole panoply of 'cordless' power tools;
- Development of a range of more acceptable models of electric vehicles rather than the various quirky designs that have characterised electric cars until recently. These include a range of high performance sports cars such as the *Tesla Roadster* (manufactured by Lotus in East Anglia for a US company), which has a range of over 200 miles (320 km) and comparable acceleration times to conventional Lotus sports cars;


Tesla Roadster

- The availability of the first generation of mass-produced hybrid-electric vehicles - which are based around a small ICE which charges a small battery pack and propulsion is achieved via electric motors. Whilst the *Toyota Prius* is the most well known, Honda also has a range of hybrid-electric cars and most of the major car manufacturers are rushing to develop hybrid-electric vehicles;

- Electric and hybrid-electric vehicles are exempt from London's Congestion Charge which is providing a motivation for Londoners to consider these vehicles and providing an economic framework and awareness for wider-scale adoption;
- Development of Plug-in Hybrid Electric Vehicle (*PHEV*) conversion kits primarily aimed at *Prius* vehicles which principally include larger energy capacity battery packs and 'plug-in connectors' that enable the vehicles' batteries to be charged from the mains or from a renewable power source as well as the vehicle's onboard internal combustion engine;
- Development in high performance PHEV technologies which aspire to facilitate vehicles with fuel consumption of the order of 250 MPG (by using the electrical charging input to extend the fuel consumption).

Plug-in Hybrid Electric Vehicles (*PHEVs*) (**Figure 3-21**) have been successfully demonstrated and, together with the availability of PHEV conversion kits and the growing numbers of PHEV conversion companies as well as the intention of car manufacturers to offer PHEV options to their range within the next year or so, it seems worthwhile to explore whether wind energy could provide a solution to the otherwise difficult to address problem of CO_2 emissions from cars.

Figure 3-19: Plug-in Hybrid (Source: Plug-in Partners)

PHEVs are an important development as they can operate as emission free electric vehicles (after being plugged-in for battery recharging in a similar manner to charging a mobile phone) but in addition, give the security and peace of mind to drivers, by being able to rely on the onboard ICE to allow longer travelling ranges without being concerned about not having enough energy stored in the battery to travel further.

Whilst biofuels will have a role to play in reducing the CO_2 emissions from cars and will work in cars with minimal modification, there are severe limitations to how much could be produced in the UK which will mean reliance on imported biofuels and unless robust auditing is implemented there are a whole raft of potential environmental problems and often questionable energy balances involved. There may also be issues of whether available land in the UK and overseas is allocated to produce fuel at the expense of food. There are additional issues that relate to security of supply.

The factors that may influence the expansion of biofuels for vehicles are not so dominant with the *wind energy + PHEV* option. The *wind energy + P*HEV option also makes it more feasible to produce sufficient biofuels within the UK for fuelling cars in the UK - if they are PHEVs - because of the significantly better fuel consumptions achievable.

For the purposes of this study the potential for utilising wind generated electricity to power PHEVs has been explored. A further analysis was carried out to see what sorts of numbers of wind turbines would be needed to generate an equivalent amount of annual electricity to power PHEVs for the number of households in Uttlesford in terms of one PHEV per household – which for the purposes of this study is assumed to be 30 thousand PHEVs, each with a daily mileage range of 24 miles/day (38.7 km/day) (UK average) or 8,760 miles/year (~14,000 km/year).[18]

The *Tesla Roadster* electric car achieves 7.5 km/kWh, so this energy rate has been used to estimate a value for annual electricity consumption of 1.9 MWh/y per PHEV based on 24 miles/day (38.7 km/day) which for 30 k PHEVs requires an annual electricity production of 57,000 MWh/y.

On that basis we can estimate the numbers of turbines needed to generate 57 GWh/y in Uttlesford. **Table 3-13** gives the estimated numbers of V82 1650 wind turbines needed - according to AMWS-45 values and hub heights between 60 and 80 m AGL.

Table 3-13: Estimated Numbers of V82 1650 turbines (each rated at 1650 kW) needed to provide annual electricity production to supply in 30k PHEVs in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply PHEVs for the households in Uttlesford V82 Turbines				
Filtered # of Squares by topography and Proximity			AMWS 6 to 6.7 m/s @ 45 m AGL	
Vestas 82 1650 @ 60 to 80 m HH		1650 kW 82 m Dia Wind turbines		
Electricity for 30k PHEVs for Avg 24 m/day @ 1.9 MWh/y (7.5 km/kWh) ~				57,000 MWh/y
		CO_2 abated ~	**55,000 tCO_2/y** (o/s 130g/km)	
		# WTs 4	# WTs 4	# WTs 4
		30k PHEVs	30k PHEVs	30k PHEVs
		1 / House	1 / House	1 / House
	Max #	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y
AMWS	WTs	60	70	80
@ 45 m AGL	#	# WTs	# WTs	# WTs
6	55	17	17	16
6.1	55	17	16	15
6.2	161	16	16	15
6.3	144	16	15	15
6.4	111	15	14	14
6.5	58	15	14	14
6.6	16	14	14	14
6.7	3	14	14	13

Table 3-13 shows that the estimated numbers of V82 wind turbines in Uttlesford needed to generate an annual electricity production for 30 thousand PHEVs in Uttlesford varies between around **14** and **17** according to AMWS-45 value and hub height.

Similarly **Table 3-14** gives the estimated numbers of E82 2050 wind turbines needed to provide for PHEVS - according to AMWS-45 values and hub heights between 60 and 138 m AGL.

[18] The Census information indicates that there may be around 44,000 domestic cars and small vans in Uttlesford but the average daily mileage in terms of the average distance travelled to work is much less than 24 miles, but the assumption of 30 k PHEVs with an annual mileage rate based on 24 miles/day seems to be a reasonable if challenging target and the daily range seems to be within PHEV performance levels.

Table 3-14: Estimated Numbers of E82 2050 turbines needed to supply 30k PHEVs in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply electricity for PHEVs for the households in Uttlesford using E82 Turbines										
Filtered # of Squares by topography and Proximity					2050 kW 82 m Dia Wind turbines			30,000 PHEVs		
Enercon E82 2050 @ 60 to 138 m HH				AMWS 6 to 6.7 m/s @ 45 m AGL						
	Electricity prod'n for 30k PHEVs Avg 24 m/day @ 1.9 MWh/y ~				57,000 MWh/y		**CO_2 abated ~**		**55,000 tCO_2/y** (o/s 130g/km)	
		# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4	# WTs 4
		30 k PHEVs	30 k PHEVs	30 k PHEVs	30 k PHEVs	30 k PHEVs	30 k PHEVs	30 k PHEVs	30 k PHEVs	30 k PHEVs
		1 / House	1 / House	1 / House	1 / House	1 / House	1 / House	1 / House	1 / House	1 / House
	Max #	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y	@ 1.9 MWh/y
AMWS	WTs	60	70	80	90	100	110	120	130	138
@ 45 m AGL	#	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs	# WTs
6	55	13	13	12	12	11	11	11	11	11
6.1	55	13	12	12	11	11	11	11	10	10
6.2	161	12	12	11	11	11	11	10	10	10
6.3	144	12	12	11	11	11	10	10	10	10
6.4	111	11	11	11	10	10	10	10	9	9
6.5	58	11	11	11	10	10	10	10	9	9
6.6	16	11	11	10	10	10	10	9	9	9
6.7	3	11	10	10	10	10	9	9	9	9

Table 3-14 shows that the estimated numbers of E82 wind turbines in Uttlesford needed to generate an annual electricity production for 30 thousand PHEVs in Uttlesford varies between around **9** and **13** according to AMWS-45 value and hub height.

Given the urgency that addressing climate change entails, together with the difficult requirements of addressing the emissions from vehicles, using wind energy to reduce CO_2 emissions in this way could potentially be a promising approach in the Uttlesford situation, if at the same time vehicle owners could be persuaded to switch to PHEVs, particularly if they can be made aware of the potentially much lower energy/fuel costs compared to conventional ICE vehicles.

Also if implemented with at least part community ownership or as WESCOs or as part of private wire schemes (such as that implemented in Woking), such an implementation of wind energy could provide the resources (from the revenue stream from the sale of wind generated electricity) to invest in providing recharging parking bays for PHEVs (and electric only vehicles EVs) so that they can be being recharged during the day when away from home with wind energy or solar photovoltaics.

With *smart metering* technology such parking bays/charge points could be used for Vehicle to Grid connections which allow the batteries of PHEVs and EVs to be used by the grid for in/out load management and for distributed energy storage. This arrangement could be potentially promising as there tends to be a diurnal trend with UK winds such that they tend to blow strongest during the day time, so vehicle to grid parking bays/charge points could potentially help to even out the variability of wind energy.

If these PHEVs are assumed to be replacing conventional ICE vehicles with a CO_2 emission rate of 130 gCO_2/km, these numbers of turbines (e.g. **14** to **17 V82** turbines or **9** to **13 E82** turbines) would be estimated to abate around **55,000 tonnes of CO_2 per year**. If offsetting larger less efficient vehicles with a CO_2 emission rate of 185 gCO_2/km, these numbers of turbines would be estimated to abate over **78,000 tonnes of CO_2 per year.**

As such these numbers of turbines could assist in making the Uttlesford householders net CO_2-neutral in terms of their motor vehicle usage (up to 24 miles/day or 38 km/day range) if they were to use PHEVs as their mode of transport.

3.4.4 Providing Domestic Electricity Needs plus Space & Water Heating Needs in Uttlesford from Large Wind Turbines

In previous sections the numbers of turbines were estimated to either provide for the estimated electricity needs or for the space and water heating (via heat-pumps) for the households in Uttlesford. This section estimates the numbers of turbines that would be required to provide <u>both</u> of these needs. Whilst these energy needs could be reduced by implementing energy conservation and energy efficiency measures, for the purposes of these estimates, they are assumed to be unchanged, but the numbers of turbines needed for these needs could be reduced proportionately.

Table 3-15 gives the estimated numbers of V82 1650 wind turbines needed to provide the electricity needs plus space and water heating (via heat pumps) needs for the households in Uttlesford according to AMWS-45 values and hub heights between 60 and 80 m AGL.

Table 3-15: Nos of V82 Wind Turbines to supply energy needs + space and water heating (heat pumps) needs for the households in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply electricity + heat pumps for the houses in Uttlesford using V82 Turbines

Filtered # of Squares by topography and Proximity — AMWS 6 to 6.7 m/s @ 45 m AGL

Vestas 82 1650 @ 60 to 80 m HH — 1650 MW 82 m Dia Wind turbines

Electricity production needed for 30,000 houses @ 4.7 MWh	141,000	MWh/y
+ Electricity for HPs for 30,000 houses @ 7.2 MWh	216,000	MWh/y

CO_2 abated	
121,260	**tCO_2/y**
136,800	**tCO_2/y** o/s gas CB
258,060	**tCO_2/y total**

AMWS @ 45 m AGL	Max # WTs #	# WTs 4 30k Houses @ 11.9 MWh/y 60 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 70 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 80 # WTs
6	55	105	101	97
6.1	55	102	98	93
6.2	161	99	95	90
6.3	144	96	92	88
6.4	111	91	87	83
6.5	58	91	87	83
6.6	16	88	85	81
6.7	3	86	83	79

Table 3-15 shows that the numbers of V82 turbines to provide both estimated electricity needs and space and water heating needs in Uttlesford range between **83** and **105** depending on AWS-45 values and hub heights.

Similarly, **Table 3-16** gives the estimated numbers of E82 2050 wind turbines needed to provide electricity needs plus space and water heating (via heat pumps) needs for the households in Uttlesford according to AMWS-45 values and hub heights between 60 and 138 m AGL.

Table 3-16: Nos of E82 Wind Turbines to supply energy needs + space and water heating (heat pumps) needs for the households in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply both electricity needs & Space+Water Heat Pumps for the households in Uttlesford using E82 Turbines

Filtered # of Squares by topography & Proximity AMWS 6 to 6.7 m/s @ 45 m AGL 30,000 households

Enercon E82 2050 @ 60 to 138 m HH Electricity production needed for 30,000 houses @ 4.7 MWh ~ 141,000 MWh/y

2050 MW 82 m Dia Wind turbines Electricity for heat pumps for 30k houses @ 7.2 MWh/y (COP 3) ~ 216,000 MWh/y

CO_2 abated
121,260 tCO_2/y
136,800 tCO_2/y o/s gas CB
258,060 tCO_2/y total

AMWS @ 45 m AGL	Max # WTs #	# WTs 4 30k Houses @ 11.9 MWh/y 60 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 70 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 80 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 90 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 100 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 110 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 120 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 130 # WTs	# WTs 4 30k Houses @ 11.9 MWh/y 138 # WTs
6	55	80	77	74	71	69	67	66	64	63
6.1	55	78	74	71	69	67	65	64	63	62
6.2	161	75	72	69	67	65	64	62	61	60
6.3	144	73	70	67	65	63	62	60	59	58
6.4	111	69	66	64	62	60	59	57	56	56
6.5	58	69	66	64	62	60	59	57	56	56
6.6	16	67	64	62	60	59	57	56	55	54
6.7	3	65	62	60	59	57	56	55	54	53

Table 3-16 shows that the numbers of E82 turbines to provide both estimated electricity needs and space and water heating needs in Uttlesford range between **56** and **80** depending on AWS-45 values and hub heights.

If these turbines are assumed to be offsetting conventional electricity supplies and gas fired condensing boilers at current consumption levels, these numbers of turbines (e.g. 83 to 106 V82 turbines or 56 to 80 E82 turbines) are estimated to abate almost **258 thousand tonnes of CO_2 per year**.

3.4.5 Providing Domestic Electricity plus Space & Water Heating plus PHEVs in Uttlesford from Large Wind Turbines

It is also possible to explore the potential numbers of turbines for providing the electricity needs plus the space and water heating (via heat-pumps) plus PHEVs for the households in Uttlesford.

This section estimates the numbers of turbines that would be required to provide all of these needs. Whilst the size of these energy needs could be reduced by implementing energy conservation and energy efficiency measures, for the purposes of these estimates, they are assumed to be unchanged, but the numbers of turbines needed for reduced needs could be reduced proportionately.

Table 3-17 gives the estimated numbers of V82 1650 wind turbines needed to provide electricity needs plus space and water heating (via heat pumps) needs plus PHEVs for the households in Uttlesford according to AMWS-45 values and hub heights between 60 and 80 m AGL.

Table 3-17: Nos of V82 Wind Turbines to supply energy needs + space and water heating (heat pumps) needs + PHEVs for the households in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply elect.+heatpumps+PHEVs for the houses in Uttlesford - V82 Turbines					
Filtered # of Squares by topography and Proximity					AMWS 6 to 6.7 m/s @ 45 m AGL
Vestas 82 1650 @ 60 to 80 m HH			1650 kW 82 m Dia Wind turbines		
Electricity production needed for 30,000 houses @ 4.7 MWh					141,000 MWh/y
+ Electricity for HPs for 30,000 houses @ 7.2 MWh					216,000 MWh/y
+ Electricity for 30k PHEVs for Avg 24 m/day @1.9 MWh/y					57,000 MWh/y
		# WTs 4 elec + HPs 4 30k Houses +30k PHEVs	# WTs 4 elec + HPs 4 30k Houses +30k PHEVs	# WTs 4 elec + HPs 4 30k Houses +30k PHEVs	**CO_2 abated**
					121,260 tCO_2/y
					136,800 tCO_2/y o/s gas CB
					55,000 tCO_2/y (o/s 130g/km)
	Max #	@ 13.8 MWh/y	@ 13.8 MWh/y	@ 13.8 MWh/y	**313,060 tCO_2/y total**
AMWS	WTs	60	70	80	
@ 45 m AGL	#	# WTs	# WTs	# WTs	
6	55	122	117	112	
6.1	55	118	113	108	
6.2	161	115	110	105	
6.3	144	111	106	102	
6.4	111	105	101	96	
6.5	58	105	101	96	
6.6	16	102	98	94	
6.7	3	100	96	92	

Table 3-17 shows that the numbers of V82 turbines to provide estimated electricity needs plus space and water heating needs plus PHEVs in Uttlesford range between **96** and **118** depending on AWS-45 values and hub heights.

Similarly, **Table 3-18** gives the estimated numbers of E82 2050 wind turbines needed to provide electricity needs plus space and water heating (via heat pumps) needs plus PHEVs for the households in Uttlesford according to AMWS-45 values and hub heights between 60 and 138 m AGL.

Table 3-18: Nos of E82 Wind Turbines to supply energy needs + space and water heating (heat pumps) needs + PHEVs for the households in Uttlesford. **Altechnica**

Nos of Wind Turbines to supply electricity needs + space & water heat pumps + PHEVs for the households in Uttlesford using E82 Turbines

Filtered # of Squares by topography and Proximity — AMWS 6 to 6.7 m/s @ 45 m AGL — 30,000 households

Enercon E82 2050 @ 60 to 138 m HH — 2050 kW 82 m Dia Wind turbines

Electricity production needed for 30,000 houses @ 4.7 MWh ~	141,000	MWh/y
+ Electricity production for heat pumps for 30,000 houses @ 7.2 MWh (COP 3) ~	216,000	MWh/y
+ Electricity prod'n for 30k PHEVs for Avg 24m/day @ 1.9 MWh/y (7.5 km/kWh) ~	57,000	MWh/y

CO_2 abated	
121,260	**tCO_2/y**
136,800	**tCO_2/y** o/s gas CB
55,000	**tCO_2/y** (o/s 130g/km)
313,060	**tCO_2/y total**

AMWS @ 45 m AGL	Max # WTs #	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 60 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 70 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 80 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 90 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 100 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 110 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 120 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 130 # WTs	# WTs 4 elect + HPs 4 30k Houses + 30 k PHEVs @ 13.8 MWh/y 138 # WTs
6	55	93	89	86	83	80	78	76	75	73
6.1	55	90	86	83	80	78	76	74	72	71
6.2	161	87	83	80	78	76	74	72	71	69
6.3	144	85	81	78	75	73	72	70	69	68
6.4	111	80	76	74	71	70	68	67	65	64
6.5	58	80	76	74	71	70	68	67	65	64
6.6	16	77	74	72	70	68	66	65	64	63
6.7	3	75	72	70	68	66	65	63	62	62

Table 3-18 shows that the numbers of E82 turbines to provide estimated electricity needs plus space and water heating needs plus PHEVs in Uttlesford range lie between **64** and **90** depending on AWS-45 values and hub heights.

If these turbines are assumed to be offsetting conventional electricity supplies, gas fired condensing boilers at current consumption levels, and the PHEVS are assumed to be offsetting conventional ICE vehicles with emission rates of 130gCO_2/km, these numbers of turbines (e.g. **96 to 118 V82** turbines or **64 to 90 E82** turbines) are estimated to abate over **313 thousand tonnes of CO_2 per year**.

3.5 Stansted Airport & Wind Energy

In consultation with representatives responsible for Safeguarding Stansted Airport, two official Safeguarding Maps were supplied and are included in the Appendix. These maps are intended to be used by Local Authorities as a filter for identifying which development proposals should be sent for assessment of their potential impact on aviation.

These are the 'Aerodrome Safeguarding Map, Stansted Airport' and the 'Safeguarding Map, Wind Turbine Developments'. The first deals with the potential height of developments and consists of a series of 1km coloured squares extending out to approximately 15km from the airport.

The 1km grid squares are colour coded to represent the height above which certain developments should be sent for consultation. The blue squares require any development exceeding 90m in height to be sent for assessment. Within the safeguarding zone the most critical area is the first 10km from the airport and any development falling within that zone is more likely to raise objection. This is due to the potential interference with Secondary Surveillance Radar (SSR).

The second map identifies an area within which the airport should be consulted on wind turbine developments. Essentially any wind turbine development within 30km radius of the airport should be sent for assessment. While an objection would not be raised as a matter of course for any development which falls within the zones identified on the safeguarding maps there is a reasonable likelihood there may be concerns and the BAA will look carefully at individual proposals, in conjunction with their Air Traffic Service provider (National Air Traffic Services Ltd).

Conclusions will depend very much on the specific circumstances that apply in each case. It should also be noted that the coverage from aviation radar can extend much further than 30km (75km and beyond) and in some cases an objection may be raised outside the 30km zone identified on the map.

The extent of radar coverage is shown on maps contained on the BWEA[19] website. The radar systems which Stansted Airport use are owned and safeguarded by Nats En Route Ltd. (NERL). As such the radar coverage relevant to Stansted Airport is largely shown on these maps. NERL are responsible for safeguarding these radars and are statutory consultees in their own right so it is recommended that they should also be consulted when individual wind energy projects are proposed. It should be noted however that the issues that NERL may have will differ from the airport's as NERL's statutory function is to safeguard En Route air traffic, the airport on the other hand will safeguard aircraft specifically during the arrival and departures phase of flights to and from the airport. However, costs are likely to be charged for any advice obtained prior to a formal planning application being submitted.

The potential impact of wind turbine developments remains a concern to airports and the aviation industry though there is much cross industry research and funding from aviation, radar and wind energy stakeholders underway. Various techniques for mitigating the effects have been and are being investigated - including advanced radar processing, improved design of turbines (including stealth coatings) and changes to rules and regulations. According to the CAA, these

[19] British Wind Energy Association

remain largely unproven to date and a mitigation which is acceptable to the aviation safety regulator CAA has not yet been identified.

Whether the concerns of the CAA are justified remains to be seen. Also wind turbines and aviation appear to be able to coexist in nations with large numbers of wind turbines such as Germany and Denmark.

It is also worth noting that East Midlands Airport has applied for planning permission to install a small wind farm of four medium scale wind turbines sited on the airport. In addition, Liverpool Airport installed two 15 kW wind turbines on the site of the airport in December 2007 (**Figure 3-20**).

Figure 3-20: Wind turbines installed at Liverpool Airport
(Source: Liverpool Airport Environment Section)

3.6 Wind Energy Potential with Turbines - Max Heights up to 90 m

Whilst one of the main factors in maximising wind energy productivity in Uttlesford is increased tower height (60 to 138 m hub heights) the *Aerodrome Safeguarding Map for Stansted Airport* specifies a consultation zone (blue grid squares) that extends over much of Uttlesford for "All buildings, structures, erections and works exceeding 90 metres in height", meaning that the safeguarding officers responsible for Stansted Airport have to be consulted if any structures that exceed 90 m AGL are proposed.

Whilst this does not mean a blanket ban on wind turbines with a maximum height over 90 metres, it may be likely to mean that several turbines might only be acceptable in certain locations if they do not exceed 90m heights.

In order to see what impact that this possible constraint might impose on the wind energy potential in Uttlesford, the potential outputs were estimated based on the same two turbines as used in the above estimates but with hub height reduced to 49 m above ground level (even though this tower height is not a standard offering with these turbine models) to achieve a maximum height of 90 metres (e.g. when the rotor blades are top dead centre).

3.6.1 V82 Wind Turbines at 49 m Hub Height

Table 3-19 shows the estimated numbers of **V82** turbines to provide the electricity needs, space heating needs (via heat pumps) and electricity for plug in hybrid electric vehicles (PHEVs) for Uttlesford households - assuming the turbines are at 49 m hub height.

Table 3-19: Ball Park estimated numbers of V82 1650 turbines (49 m HH) to provide annual electricity equivalent to the electricity needs, heating needs (via heat pumps) and electricity to charge PHEVs for 30,000 households in Uttlesford.

Nos of Wind Turbines to supply electricity for the households in Uttlesford using V82 Turbines at 49 m Hub Height

Filtered # of Squares by topography and Proximity — AMWS 6 to 6.7 m/s @ 45 m AGL — 30,000 households

Vestas V82 1650 @ 49 m HH — Electricity production needed for 30,000 houses @ 4.7 MWh ~ 141,000 MWh/y

1650 kW 82 m Dia Wind turbines — Electricity for HPs for 30,000 houses @ 7.2 MWh ~ 216,000 MWh/y

Electricity for 30k PHEVs for Avg 24 m/day @ 1.9 MWh/y~ 57,000 MWh/y

AMWS @ 45 m AGL	Max # WTs #	Ann Output MWh/WT	# WTs 4 Electricity 30k Houses @ 4.7 MWh/y 49 # WTs	# WTs 4 Elec HPs 30k Houses @ 7.2 MWh/y 49 # WTs	# WTs 4 PHEVs 30k Houses @ 1.9 MWh/y 49 # WTs	# WTs 4 Elec+HPs 30k Houses @ 11.9 MWh/y 49 # WTs	# WTs 4 Elec+PHEVs 30k Houses @ 6.6 MWh/y 49 # WTs	# WTs 4 Elec+HPs+PHEVs 30k Houses @ 13.8 MWh/y 49 # WTs
6	55	3,550	45	68	18	112	62	130
6.1	55	3,674	43	66	18	108	60	126
6.2	161	3,798	42	64	17	105	58	122
6.3	144	3,922	40	62	17	102	57	118
6.4	111	4,165	38	58	16	96	53	111
6.5	58	4,165	38	58	16	96	53	111
6.6	16	4,285	37	57	15	93	52	108
6.7	3	4,404	36	55	15	91	50	105

Table 3-19 shows that to provide electricity equivalent to the annual household electricity requirements for 30,000 household in Uttlesford from **V82** wind turbines at 49 m hub height would require between **38** and **45 turbines**. To provide electricity equivalent to the space heating needs (via heat pumps) for 30 k households would require **58** to **65 V82** wind turbines. To provide electricity equivalent to the requirements to charge 30k PHEVs would need **15** to **18 V82** wind turbines. To provide electricity equivalent to the household electricity + space and water

heating + charging PHEVs for the 30 k households would require around **110** to **123 V82** turbines.

3.6.2 E82 Wind Turbines at 49 m Hub Height

Table 3-20 shows the estimated numbers of E82 turbines to provide the electricity needs, space heating needs (via heat pumps) and electricity for plug in hybrid electric vehicles (PHEVs) for Uttlesford households - assuming the turbines are at 49 m hub height.

Table 3-20: Ball Park estimated numbers of E82 2050 turbines (at 49 m HH) to provide annual electricity equivalent to the electricity, heating needs (via heat pumps) & electricity to charge PHEVs for 30,000 households in Uttlesford.

Nos of Wind Turbines to supply electricity for the households in Uttlesford using E82 Turbines @ 49 m HH

Filtered # of Squares by topography and Proximity — AMWS 6 to 6.7 m/s @ 45 m AGL — 30,000 households

Enercon E82 2050 @ 49 m HH — Electricity production needed for 30,000 houses @ 4.7 MWh ~ 141,000 MWh/y

2050 kW 82 m Dia Wind turbines — Electricity for HPs for 30,000 houses @ 7.2 MWh ~ 216,000 MWh/y

Electricity for 30k PHEVs for Avg 24 m/day @ 1.9 MWh/y~ 57,000 MWh/y

AMWS @ 45 m AGL	Max # WTs #	Ann Output MWh/WT	# WTs 4 Electricity 30k Houses @ 4.7 MWh/y 49 # WTs	# WTs 4 Elec HPs 30k Houses @ 7.2 MWh/y 49 # WTs	# WTs 4 PHEVs 30k Houses @ 1.9 MWh/y 49 # WTs	# WTs 4 Elec+HPs 30k Houses @ 11.9 MWh/y 49 # WTs	# WTs 4 Elec+PHEVs 30k Houses @ 6.6 MWh/y 49 # WTs	# WTs 4 Elec+HPs+PHEVs 30k Houses @ 13.8 MWh/y 49 # WTs
6	55	4,179	38	58	16	95	53	111
6.1	55	4,331	37	56	15	92	51	107
6.2	161	4,482	35	54	15	89	50	103
6.3	144	4,633	34	52	14	86	48	100
6.4	111	4,933	32	49	13	81	45	94
6.5	58	4,933	32	49	13	81	45	94
6.6	16	5,081	31	48	13	79	44	91
6.7	3	5,228	30	46	13	76	43	88

Table 3-20 shows that to provide electricity equivalent to the annual household electricity requirements for 30,000 household in Uttlesford from E82 wind turbines at 49 m hub height would require between **32** and **38** turbines. To provide electricity equivalent to the space heating needs (via heat pumps) for 30 k households would require **49** to **55 E82** wind turbines. To provide electricity equivalent to the requirements to charge 30k PHEVs would need **13** to **16 E82** wind turbines. To provide electricity equivalent to the household electricity + space and water heating + charging PHEVs for the 30 k households would require around **94** to **104 E82 turbines**.

3.7 Micro and Small Scale Wind Turbines

Micro wind turbines (**Figure 3-21**) are usually rated at a few watts, with diameters of around a metre or so and cost a few hundreds of pounds. There are several such micro wind turbines produced by several manufacturers in the UK. These devices are predominantly used for battery charging on boats and caravans or for remote telecommunications purposes, remote telephone boxes, non grid connected environmental centres and also for street lamps in some instances.

They will generally not be powerful enough to power a building - apart from occasional cabins - unless the building uses only a small number of low energy light bulbs, only low power electronic equipment and also avoids the use of high power appliances. In these circumstances and provided the wind speed characteristics of the site are sufficient, then it may be possible to utilise a few sub-kilowatt micro wind turbines.

Figure 3-21: An example of a micro wind turbine (50-watt Rutland Wind Charger). (Source: Altechnica)

[However as the result of government support for small scale technology, the term *micro-generation* has become applied to practically any renewable energy technology that is integrated into houses and such small wind turbines are also often described as Micro Wind Turbines.]

Small scale wind turbines rated at 1 kW to about 50 kW (**Figure 3-22**) have also generally been used for battery charging applications[20] at remote sites. These tend to be relatively expensive applications[21] and have only been viable on

[20] Or as wind-diesel hybrid applications.

[21] One can assume that including a battery bank may considerably increase the cost of an installation.

remote premises where the cost of connection to the mains is high. Because most buildings are connected to the electrical mains, such turbines have not been widely exploited in the UK, though there are a number of manufacturers of such wind turbines in the UK[22], USA and various European countries who have managed to create viable businesses selling such wind turbines.

Figure 3-22: An example of a small wind turbine (20-kilowatt Gazelle wind turbine).

When the buildings are some way from conventional gas supplies, part of the wind turbine's output can be used to power a heat pump[23] to provide space heating or hot water provision. If a large insulated hot water tank is employed then heat production can be stored from windy days to calm days. There are a few commercially available electric central heating systems that employ this approach for individual properties designed around off-peak electricity supply. A similar scheme could be based around immersion heaters, which would have lower capital cost, but the heat pump effectively multiplies the output of the wind turbine by a factor of 2 or 3 or more depending on the coefficient of performance of the heat pump.

Whilst on a per kilowatt basis, small wind turbines tend to be at the more expensive end of the market, there is growing interest in such devices as a means of generating CO_2 free electricity and if the viability of net metering[24] becomes established, as it has in other European countries, then the installation rate of small scale grid connected wind turbines can be expected to increase. Initially this

[22] Predominantly exporting to date.

[23] See section on ground source heat pumps.

[24] A net metering contract with the electricity provider permits the wind turbine (or other renewable electrical generator) owner to sell and purchase exported and imported electricity at the same price; and in essence run their electricity meter 'backwards', when exporting into the network. This would reduce their electricity bills and/or potentially also earn revenue if generating more than consumed on an annual basis.

would perhaps be at farms and non-domestic premises of organisations subject to the Climate Change Levy, and located in the regions of Uttlesford with appropriate wind conditions (annual mean wind speeds of around 6.5 m/s or greater – depending on the wind speed frequency distribution) and not surrounded by buildings or tall trees. Though to be viable they will invariably need relatively tall towers.

3.8 Energy Saving Wind Turbines

Prior to the development of the NFFO in the 1990s, a number of pioneer wind turbine projects were developed on the basis of energy saving by offsetting the electricity which would otherwise have to be purchased from the electricity supply company. Examples included an animal feed factory in Cumbria, a yoghurt making factory in Yorkshire and a hospital in Northumberland where a 225 kW wind turbine was installed in each case. Most medium or large scale turbines since then have been contracted under the NFFO and then the Renewable Obligation.

Depending on the price paid for electricity, the concept of an energy saving wind turbine could well become a viable proposition and may be viable at sites with relatively low annual mean wind speeds because of the higher value of electricity to a customer. Once the wind turbine has produced a cumulative amount of electricity equivalent to the value of the cost of the turbine installation (plus any interest payments if paid for via a loan), the customer could effectively obtain ‘free electricity’ for the rest of the lifetime of the turbine (20+ years) apart from operation, maintenance and service contracts.

The Climate Change Levy (CCL), which was introduced in April 2001, also has the potential to stimulate the use of energy saving wind turbines - as organisations affected incur a levy on each kilowatt-hour of electricity (gas or heating oil consumption are also subject to the levy although set at different rates), but if derived from renewable energy sources the climate change levy is exempt.

If the turbine is oversized relative to the electricity demand, there is also scope to earn revenue with a contract to export electricity to an electricity supplier or with one of the various ‘green electricity tariff’ organisations.

It may also be possible to obtain a wind turbine without the need for capital investment under a kind of ‘Energy Services’ scheme. In this instance the consumer has a wind turbine installed and agrees to purchase all or a proportion of the electricity produced. For larger turbines, the consumer may also earn a rental income (in a similar arrangement to that provided to farmers who have wind turbines installed on their land) from the siting of the wind turbine. The consumer also has the benefit of avoiding the levy.

The types of establishments or organisations that could take advantage of such energy saving wind turbines are many and varied and might include various forms of rural enterprises, factories, business parks, supermarket depots, industrial estates, schools, college campuses, retail parks, country estates, tourist attractions, leisure centres, farms, horticultural enterprises and hospitals.

To accurately predict the potential for these turbines would need information about organisations with both the appropriate level of electricity consumption and appropriate electricity unit price together with appropriate exposure and wind speed characteristics. However there is likely to be scope for a number of energy saving turbines in Uttlesford, especially if tall towers are acceptable, though as has been shown at the Wood Green Animal Shelter, **Figure 3-23,** (located close to Uttlesford) a conventional tower height of 25 m has enabled a viable wind powered energy saving project. So viability of such projects should take into account various factors, including reduction of CO_2 emissions. If the Climate Change Levy increases, and if gas, oil and electricity prices also increase, then there could be a number of installations and CO_2 savings could become important.

The size of turbine (225 kW) used at Wood Green is no longer available as most manufacturers now generally only manufacture turbines of 300 or 400 kW or bigger, but there is a healthy market in used and reconditioned 225 kW wind turbines from Denmark and other European countries as wind turbine owners there are upgrading to more powerful machines. The availability of these machines is variable, but they are likely to have lower capital costs than new machines, however potential customers should seek expert advice before purchasing.

There may be potential for Energy Saving wind turbines at a proportion of the schools within Uttlesford, so perhaps an assessment of the possibilities should be considered.

3.9 Community Wind Energy Projects

Community Wind Projects can take a variety of forms. They usually involve single turbines but can include clusters of wind turbines.

There is no specific definition about what constitutes a Community Wind Energy Project, but the key definition is that, unlike commercial wind energy projects (which are primarily privately owned projects designed principally to earn revenue or save money), it has some involvement with the immediate or wider local community or neighbourhood.

The extent of this involvement can vary and can include some of the following:-

- *Complete Ownership and Management* of the wind turbine(s);
- *Ownership of the turbine and Subcontracted Management* of the turbine(s);
- a *Joint Venture Partnership* between wind turbine operators and the local community and/or local authority;
- an *Arrangement with an ESCO* or *WESCO* in which part of the revenues from the sale of the generated electricity (exported to electricity or green tariff companies) are used to fund energy saving measures or other community related projects;
- establishment of a *Local Community Green Tariff Electricity Company* which distributes electricity to local customers and exports excess to generate income,
- establishment of *Community Village or Parish Turbines* for appropriate villages;
- establishment of *Community Town Wind Farms* for appropriately sited towns.

In addition there is scope for including community wind turbines in Community Energy ventures which are able to receive grant aid under a number of initiatives including those operated by EST such as the Low Carbon Buildings Programme.

Community wind turbines can provide a much needed revenue stream to fund a variety of initiatives in deprived areas and rural investment.

Figure 3-23 shows an example of a medium scale (225 kW) single wind turbine (comparatively small compared to current medium scale turbines which are usually rated at 300 or 400 to 800 kW) installed at the Wood Green Animal Shelter in Cambridgeshire and **Figure 3-24** shows an example of a larger (1.5 MW) single wind turbine[25] at an environmental centre in Swaffham in Norfolk. The Swaffham turbine, which also has viewing platform to which visitors can climb, proved to be very popular with the people of Swaffham, so much so that a second turbine was subsequently installed and the two turbines together are apparently able to generate electricity equivalent to around 50% of the households electricity needs reducing the net CO_2 emissions of the town.

To accurately predict the potential for community wind turbines would need information about local communities interested in installing their local community turbines. However, it seems likely that, given the wind resource identified in the previous sections, there is substantial potential for community wind energy schemes and there are a number of ways that such schemes could be realised and help to reduce the CO_2 emissions of the communities participating. If the Climate Change Levy increases, and if gas, oil and electricity prices also increase, then the number of installations and CO_2 savings could provide further incentives.

For new housing developments (or existing communities with suitable sites nearby) wanting to utilise wind energy, it will usually make more sense and be more cost effective to utilise a medium or large scale community turbine or turbines than providing individual turbines. Depending on the size of the turbine/s, it would be likely only to result in a small increase in the house price (or to the mortgage) but kW for kW this would be expected to be much less than including solar electric photovoltaic cladding.

Also, if the turbine was sized carefully, the houses could be sold as zero carbon in terms of electricity usage. Depending on the size of scheme, it may be possible to utilise group scale heat stores to utilise excess and store wind energy. Similarly if heating is provided with heat pumps the community turbine could be used to provide the electricity to power them enabling zero carbon heating and water heating (which can also complement solar water heating because of the seasonal differences in energy availability). In addition, if appropriately sized the community turbine/s could also be used to charge up PHEVs owned by community car clubs or householders reducing the CO_2 impact of personal transportation.

Such schemes could be managed by a community group or by an operating company for the community or they could be operated as an ESCO or WESCO scheme.

[25] This Enercon turbine, though the largest on land in England at the time of its installation, is a very quiet machine because it uses a direct drive generator and is sited close to the buildings without noise intrusion being an issue.

Figure 3-23: 225 kW medium scale Vestas wind turbine at Wood Green Animal Shelter (Altechnica)

Figure 3-24: 1.5 MW Enercon wind turbine at an environmental centre at Swaffham in Norfolk. (Altechnica)

3.10 Siting of Wind Turbines

Whilst a number of areas which have some potential for wind energy have been listed by OS 1 km x 1 km grid squares in **Figure 3-10**, many of the 1 km grid squares are located within Special Landscape Areas (SLAs)[26] so it is for others to decide on the exploitation of wind energy within these squares. It would have to be planned very carefully in any case with the collaboration of the local community and the landscape agencies and amenity groups involved. Where possible sites containing large tracts of woodland[27] (such as Hatfield Forest and the like) have been avoided and excluded from the grid squares considered in the wind energy estimates.

The wind energy should also benefit the maintenance of the SLAs. One approach could be the consideration of establishing pilot community wind energy projects which involved utilising some of the revenues generated to fund biodiversity management projects or other landscape enhancements within the relevant SLAs.

Given the urgency of cutting CO_2 emission levels, the issue of siting wind turbines in areas with landscape designation will need to be addressed.

A suggested approach would be to discuss the issues and implications with Uttlesford and Essex planners in order to evolve an appropriate approach and guidelines for wind energy in these areas.

3.11 Building Mounted and Building Integrated Wind Turbines

In urban areas the wind speed tends to be reduced by the increased 'roughness' of terrain created by the increased density and irregularity of buildings in the urban environment.

In spite of this there has been recent promotion of so called Building Mounted Wind Turbines also called Micro wind turbines which may be appealing because they can be mounted on to a building and thus avoid the cost of towers and foundations. However as the power and energy generated by a wind turbine is directly related to the rotor swept area[28]), the rotor diameter will generally require to be more than two metres to generate useful amounts of electricity. Because of the roughness around buildings particularly in urban areas the AMWS at the height of a build roof is likely to be very low and as such, building mounted turbines in these situations are not likely to be very productive.

In rural areas building mounted turbines could be more viable provided the AMWS at the building roof is sufficient, though such positions will generally be in exposed and remote locations.

[26] Special Landscape Areas.
[27] If woodlands are not ancient, it may still be possible to consider siting wind turbines in wooded areas when utilising tall towers provided the wind speeds are high enough, though these have not been considered here and in general grid squares containing woodland likely to affect turbine performance have been excluded.
[28] In the case of HAWTs, the swept area is area of the circle swept by the rotating blades - in the case of VAWTs swept areas will have a different form.

However apart from small battery charging wind turbines (developed for boats and caravans which are generally rated at a few watts) a turbine with a useful power rating at an appropriate rated wind speed[29] will be likely to add significant bending moments to the structure from the wind loading on the turbine - as well as adding weight to the structure. As such, building structures need to be strong enough to absorb the increased loading and in addition, the type of building construction and materials also need to be taken into account with regard to avoiding possible transmission of vibrations.

However built up areas may be less of a constraint than in the past for the siting of conventional medium/large scale turbines because of the advances in large turbines supported on tall towers (60 to 138 metre tall towers are now available) which as mentioned in previous sections can reduce the effect of the roughness. In general (apart from mounting on tall buildings) it will usually be more appropriate to locate turbines on tall towers in built up areas for these reasons, though the surroundings of the turbine still need to take account of trees or other large obstructions.

Another approach to addressing the lower wind speeds in built-up areas is the use of augmenting devices to increase the wind speed by means of aerodynamic effects. To date augmenting devices have required a funnel shaped ducted housing surrounding the turbine. There have been various attempts to develop such devices but the cost of the annular housing has usually outweighed the benefits. However when operating in the urban environment, the ducted housing may be an acceptable additional cost.

Altechnica has patented and is researching a family of augmented wind turbine systems and hybrid wind and solar systems that use planar (wing-like) concentrators that offer potential savings compared to conventional augmented wind turbines. These include biplane and tri-plane concentrator systems and planar concentrators attached to building structures (including the *Aeolian Roof*™, *Aeolian Canopy*™ and the *Aeolian Tower*™). In the wind/solar hybrid variant (including the *AeroSolar Roof*™ and *AeroSolar Tower*™), PV modules[30] are incorporated into the upper or outer surface of the 'wing' which becomes a *SolAIrfoil*™.

The Altechnica *Aeolian Biplane*™ and *Triplane*™ concentrator systems can be configured horizontally or vertically and configured to yaw in response to changes in wind direction (**Figure 3-25**). The *Aeolian Biplane*™ or *Triplane*™ systems can be free standing from ground level or attached to the roofs of buildings.

[29] Some building mounted wind turbine manufacturers rate their turbines at relatively high rated wind speeds which in low medium wind speed locations may not be achieved, so the turbines are really physically too small for such power ratings except in high wind speed locations. There are plans to require manufacturers to provide an independently measured standardised power output value for the same wind speed point for all small or micro wind turbines so that users can more easily compare turbines, but that has yet to be adopted fully.

[30] And/or solar panels.

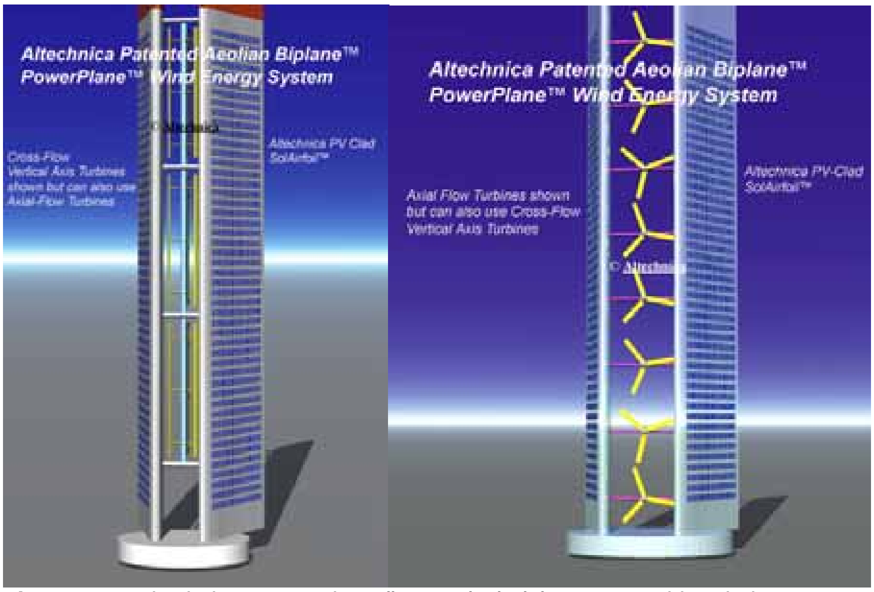

Figure 3.25: Altechnica Patented *Aeolian Vertical Biplane*™ Yawable Wind Concentrator (Altechnica)

The *Aeolian Roof* system (**Figure 3-26**) aligns a wing like plane parallel to the ridge of a pitched (with a curved ridge), curved, vaulted or membrane roof and positioned a small distance above it or as a parapet wall around or on flat roofs. Small cross flow or axial flow wind turbines are located in the slot between the 'wing' and the ridge. The roof shape in combination with the 'wing' accelerate the wind flow and thus increases the production of the turbines. It is estimated that the *Aeolian Roof* (and *SolAirfoil*) would generate a high proportion of the electrical requirements of a low energy house from both wind and solar energy interacting with the roof.

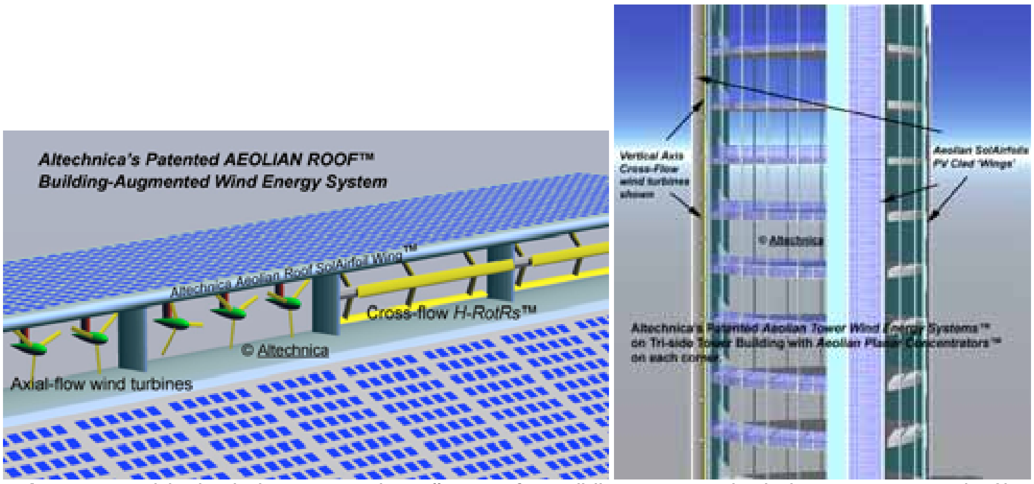

Figure 3-26: (a) Altechnica Patented *Aeolian Roof*™ Building Integrated Wind Energy System (Left) (b) Altechnica *Aeolian Tower*™ (right) (Altechnica)

This device can be applied to a variety of non domestic building types, ranging from warehouses, retail stores, barns and factory roofs etc. Initially only specially designed houses will be considered in the domestic sector. The *Aeolian Tower* is similar to the *Aeolian Roof* except in this arrangement it is configured vertically where the 'wing' is attached adjacent to the corner[31] of a tall building. Initially these devices will be incorporated into new buildings, but there is also considerable potential for retrofitting onto appropriate existing buildings.

[31] Or adjacent to the side of a cylindrical form of tall building or structure.

3.12 Wind Energy Conclusions

There are several opportunities for exploiting wind energy within Uttlesford. The ball-park estimated maximum annual potential production with the types of turbines assumed is approximately **2,900 to 3,700 GWh per year**.

The above estimates are based on the use of Enercon E82 2050 turbines - one of two different 82 metre diameter wind turbines used in the assessment that are reasonably typical of current technology wind turbines designed to operate in low/medium wind speed sites. They are not the largest sizes of turbine available but are of a scale that should be appropriate for Uttlesford - subject to the constraints imposed by Stansted Airport.

The E82 turbines are rated at 2050 kW and available with relatively tall towers to improve the energy capture in the Uttlesford wind regime. The different values are related to the different hub heights, the lower estimate if a hub height of 60 m and the second for a hub height of 138 m. The E82 turbine is the latest generation of the turbines used at Swaffham and because it is a gear-less machine it is quiet in operation and achieves a high conversion efficiency. These turbines were designed to operate in the relatively light wind regime in Germany, so should be suitable for Uttlesford.

The other 82 m diameter turbine used in the assessment is a Vestas V82 1650 and this is one of the latest models from Vestas the manufacturer currently with the largest international market share (and also the manufacturer of the much earlier and smaller turbine located at the nearby Wood Green Animal Shelter). These have a lower rated power of 1650 kW and are available with tower hub heights of 60 to 80 metres, but also designed to operate on low/medium wind speed sites.

Assuming Vestas V82 1650 turbines were used, they would be estimated to generate of the order of **2,250 to 2,450 GWh/y**.

Clearly there is substantial maximum ball park potential, and not all would be realisable or necessary for Uttlesford's energy requirements, but it does show that there is scope for a useful contribution from an indigenous CO_2-free energy resource from within Uttlesford, provided appropriate turbines are used and located carefully.

To see what numbers of wind turbines would be involved for the energy needs within the Domestic Sector in Uttlesford, further assessments were carried out to estimate the scale of development that would be needed to match the current energy needs.

To provide the electricity demand of the 30,000 households in Uttlesford, it was estimated that it would require **21 to 32 E82 turbines** (according to AMWS-45 values and hub heights) or **32 to 42 V82 turbines**. On this basis these turbines would then abate around **121,000 tonnes of CO_2 per year**.

To see what numbers of turbines would be needed, an estimate of the numbers of turbines was made assuming the domestic space heat and hot water demand for the households in Uttlesford was met by heat pumps. Whilst heat pumps may not be able to be utilised universally, the estimates give an indication of what might be considered.

To estimate the average household demand the average domestic gas consumption of 21,400 kWh/y (from *DUKES06*) for Uttlesford was used as a guide - even though this only represented 64% of the households in Uttlesford and some of the gas would be used for cooking. Nonetheless it seemed an appropriate level to evaluate assuming it was the average space heating and hot water demand for 30,000 households in Uttlesford. To determine the electricity production required, heat pumps with a coefficient of performance (COP) of 3 were assumed.

On this basis, to provide the space and water heating demand of the 30,000 households in Uttlesford, it was estimated that it would require **34 to 49 E82 turbines** (according to AMWS-45 values and hub heights) or **51 to 62 V82 turbines**. On this basis these turbines would then abate almost **137,000 tonnes of CO_2 per year** assuming all of the households were off-setting gas condensing boilers. If we assumed that the current proportion (64%) were offsetting gas condensing boilers and the other proportion (36%) were offsetting oil fired boiler based heating systems, the CO_2 abatement would be of the order of **159,000 tonnes of CO_2 per year**.

As such these numbers of turbines could assist in making the Uttlesford householders net CO_2-neutral in terms of their space heating and water heating. It remains to be seen as to how far it is feasible, but using the *wind energy + heat pump* option is a potentially useful strategy (using current technologies) for solving a difficult problem by using an indigenous CO_2-free source of energy which, if combined with heat storage, could also provide a useful way to exploit and store energy from the variable winds.

To provide <u>both</u> the estimated electricity needs and the space and water heating needs, it was estimated that it would require **56 to 80 E82 turbines** (according to AMWS-45 values and hub heights) or **83 to 106 V82 turbines**. These numbers of turbines are estimated to abate almost **258,000 tonnes of CO_2 per year** (assuming the heating energy is from gas condensing boilers throughout).

A further difficult problem to address in the Domestic Sector is that of CO_2 emissions from cars.

There are developments in Plug-In Hybrid Electric Vehicles (PHEVs) which are Hybrid Electric Vehicles that have a sufficiently sized battery pack to enable them to operate as emission-free electric-only vehicles (EVs) for a certain range.

To see what the use of PHEVs might require in terms of wind energy, it was assumed that there would be one PHEV per household - which travelled a daily UK average range of 24 miles/day (38 km/day).

To provide the electricity demand for 30,000 PHEVs in Uttlesford, it was estimated that it would require **9 to 13 E82 turbines** or **14 to 17 V82 turbines**. On this basis these turbines would then abate around **55,000 tonnes of CO_2 per year** if the vehicles that are offset are internal combustion engine (ICE) cars with a CO_2 emission rate of 130 gCO_2/km.

As such these numbers of turbines could assist in making the Uttlesford householders net CO_2-neutral in terms of their personal transportation. It remains to be seen as to whether it is feasible, but using the *wind energy + PHEV* option is a potentially useful strategy for solving a difficult problem by using an indigenous CO_2-free source of energy which, if combined with PHEVs, could also provide a useful way to exploit and store energy (with smart metering) from the variable winds. If there is sufficient uptake of PHEVs, this use of wind energy could also be potentially very economically attractive, given the cost of petrol.

As a result of these estimates it is also possible to gauge how many turbines would be needed to provide the estimated electricity needs plus the space and water heating needs plus PHEVs in Uttlesford. Under the previously listed assumptions, it was estimated that it would require **64 to 90 E82 turbines** or **96 to 118 V82 turbines**. These numbers of turbines are estimated to abate almost **313,000 tonnes of CO_2 per year** (assuming the heating energy offset is from gas condensing boilers throughout, and that the PHEVS are offsetting ICE vehicles with 130g/km).

Fewer turbines would be required if major energy efficiency measures were implemented (and such energy efficiency measure could potentially be paid for in part by an 'Uttlesford Energy Efficiency Fund' paid for from a proportion of the revenues from the sale of wind generated electricity). Also fewer turbines would be required if larger rated turbines were used instead of the ones used in this assessment (particularly the sites in the OS 1 km grid squares that can accommodate just one turbine (as shown in **Figure 3-10**) as this would not affect the turbine spacing greatly. Both Enercon and Vestas have 3 MW turbines available currently and are testing 4.5 MW machines. The power curves for the latter machines have not been made available yet but it seems reasonable to assume that they could be capable of generating considerably more power and energy compared to the E82 and V82 turbines used in this study, though they would be several metres greater in diameter and also taller.

The results presented in this report are based on the AMWS-45 values averaged for each OS 1 km grid square via the NOABL model and applied with a Rayleigh distribution. Where possible assumptions have erred on the conservative side, the estimates should be taken as first order ball-park assessments and if more precise information is required then it will be necessary to install anemometers to measure the wind speeds. This would be essential before real projects are undertaken, particularly with the type of terrain in Uttlesford.

Limiting the maximum height of the turbines to 90 m AGL (in order to take account of the possible constraints from Stansted Airport) would reduce the output of each turbine and also result in an increased number of turbines to generate the equivalent energy.

To generate an equivalent amount of electricity for the needs of the 30 k households in Uttlesford (assuming UK average of 4.7 MWh/y) would require **32 to 38 E82** turbines or **38 to 45 V82** turbines at **49 m hub height**. To provide an equivalent amount of electricity to operate heat pumps to provide heat for 30 k households would require **49 to 55 E82** turbines and **58 to 65 V82** turbines. Also to provide an equivalent amount of electricity to charge 30 k PHEVs would require **13 to 16 E82** turbines or **15 to 18 V82** turbines. To provide electricity + space & water heating + PHEVs for 30 k households would require **94 to 104 E82** turbines or **110 to 123 V82** turbines operating at 49 m hub height.

Nonetheless, the estimates show that as a result of recent improvements in wind turbine technology, combined with the need to combat climate change it is more feasible to install wind turbines in Uttlesford (which has lower annual mean wind speeds compared to western parts of Britain).

There are a number of areas in Uttlesford which are especially promising for wind energy and these could provide a means for economic investment into the host communities.

Community wind energy projects also provide scope for rural communities to earn income from wind energy; alternative scenarios include outright ownership, community companies and joint ventures with the local council and Energy Service Companies (ESCOs) or Wind Energy Service Companies (WESCOs).

The towns and certain larger villages in Uttlesford could consider a small group of wind turbines at locations on their periphery to supply carbon-free electricity for all or a large proportion of the houses in their boundaries. Such Town or Village Wind Energy Schemes could considerably reduce the carbon footprints of these towns and villages.

3.13 Wind Energy Recommendations

Recommendations are:

General and Educational

Publicise the importance of wind energy in combating climate change, acid rain and air pollution.

Familiarise planning officials and committees with the above benefits and explain the urgency and institutional responsibility of achieving substantial reductions in CO_2 emissions.

Organise visits for planning officials and councillors to successful wind energy developments.

Ensure that applications for planning consent for wind energy developments are not difficult and expensive, as development will be delayed and the benefits will not be realised if the costs of submitting a planning application for wind farms increase.

Identify Uttlesford sites that could host energy saving or community wind turbines.

Identify sites with appropriate panoramic views that could host wind turbines with viewing platforms at the top of the tower. Not only can these viewing wind turbines provide an extra income from visitors wishing to climb to the viewing platform but also they have a very important educational and informative role in explaining wind energy and its role in combating climate change.

Set up interpretation points at sites where wind energy is under consideration.

Rural Areas and Schools

Publicise the economic benefits for rural[32] communities from wind energy. Wind energy can provide a revenue stream to fund community projects, local energy efficiency measures, local amenities and local enterprises.

Identify appropriate villages for which a village wind turbine or village wind cluster could be installed.

Identify appropriately sited schools and colleges which could host energy saving wind turbines or community wind turbines.

Identify small towns for which a town wind farm could be installed. Publicise the benefits for towns that have their own wind farm.

Publicise the economic benefits of wind energy for farmers at a time when agriculture has increasing difficulties. Farmers can benefit from energy saving, rental income from turbine siting and a revenue stream from the export of electricity.

[32] Not only rural communities – as in the case of Town Wind Farms the town can also benefit from revenues.

Wind Energy + PHEVs

Consider the feasibility of promoting the uptake of PHEVs together with wind energy provision (vi a private wire or community wind energy projects as well as more conventional projects) for such.

Consider the feasibility of enabling wind/solar powered PHEV parking bays/charging points including Vehicle to Grid smart metering energy storage/load management.

Consider the promotion of PHEVs as even if using mains electricity they should have lower emissions compared to conventional vehicles.

Community Wind Turbines and ESCOs or WESCOs

Encourage the setting up of local wind energy co-operatives on the lines of those in Denmark, to help the local community benefit from wind energy.

Encourage the establishment of Wind Energy ESCOs where appropriate.

Encourage the developers of housing projects to consider (where the winds are appropriate) the inclusion of community wind turbines.

Uttlesford Energy Efficiency Fund

Consider the establishment of an Uttlesford Energy Efficiency Fund funded in part from a levy on current building projects but also to provide a mechanism for channelling part of the revenue streams from wind energy projects back into the community.

Private Wire Schemes including Wind Energy

Consider the feasibility for the establishment of a private wire network on the lines of that implemented at Woking. Such a network could facilitate a range of renewable energy technologies projects in addition to wind.

Industrial and Economic

Facilitate the establishment of local assembly of wind turbines, components and structures at appropriate locations in Uttlesford.

Encourage local sourcing of components and equipment for wind energy manufacture and developments within Uttlesford.

Wind energy on Uttlesford DC Estate/ Essex Estate

Consider the establishment of appropriate wind energy schemes on Uttlesford DC and or the Essex estate.

Wind Energy Appendices

Wind Energy Appendix 1:

Annual Mean Wind Speeds for 1 km Grid Squares in Uttlesford

Wind Energy Appendix 2:

'Safeguarding Map, Wind Turbine Developments'

Wind Energy Appendix 3:

'Aerodrome Safeguarding Map, Stansted Airport'


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complete architecture + renewables design service
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