*LOW/ZERO CARBON*

# *RENEWABLE ENERGY FOR UTTLESFORD*

# *BIOFUELS*

**Derek Taylor**

January 2008

Altechnica

Study undertaken for Uttlesford Futures

**Altechnica**
85 Waterside Peartree Bridge, Milton Keynes, MK6 3DE
Tel 01908 668797 email info1.altechnica@virgin.net

## REPORT AUTHOR

**DEREK TAYLOR ☼ ALTECHNICA**

Dr Derek Taylor is Principal of Altechnica - an independent multidisciplinary architectural and renewable energy innovation practice established in 1990 and specialising in the fields of renewable energy technologies and ultra low energy building concepts. He is also a visiting lecturer in *renewable energy + design* at the Open University. He is a chartered architect and holds a Masters Degree from the Royal College of Art in industrial design engineering and a Doctorate from the Open University in renewable energy.

Derek Taylor has been involved with renewable energy technologies and low energy building design since 1972. He has worked on innovative vertical and horizontal axis wind turbines since that time and has invented and patented a number of innovative novel wind energy devices. He is responsible for the wind energy section of the Open University's renewable energy courses and he was a recipient of the 1996 British Wind Energy Association's *Wind Energy Pioneer Award* in recognition of his contributions to wind energy development in the UK.

Dr Taylor has expertise in the design of ultra low energy buildings and has designed one of the most energy efficient houses in the UK - currently under construction in Herefordshire. He has a special interest in the zero energy design of buildings and has been researching Building Integrated Renewable Energy Technologies (in combination with demand reduction) as a means of creating buildings which aim to achieve zero net energy consumption.

Altechnica has carried out a wide range of projects in renewable energy for a variety of organisations including government departments, government agencies, companies, local authorities, universities, housing associations, charities, architects and private clients.

--------------------------------------------------

# 5 BIOLOGICALLY DERIVED ENERGY SOURCES

## SUMMARY

Biologically derived energy sources are stores of energy produced as a result of biological processes. These can be used as fuels in much the same way as conventional fuels derived from fossil fuels.

This section covers a diverse range of Biofuels as they are collectively known. In Uttlesford the range of Biofuels include fuels derived from woody materials, fuels derived from biological processing of food wastes or plant based materials. In addition there are various forms of processing which can yield gaseous and liquid fuels.

There are a range of biofuel resources available within Uttlesford and these can be utilised for a variety of applications and employ a range of technologies, some of which are available now and some are imminent.

### WOODY FUELS

Woody fuels can be obtained from forest residues, existing coppice, and woody energy crops such as willow and poplar cultivated as short rotation coppice (SRC). Use of both existing wood resources and new energy crops has recently been promoted by DEFRA.

Historically Essex was classed as 'forest' at the time of the William I, though this term is used in its medieval sense of 'wild land or hunting land' and does not mean that it was all densely wooded, though it is thought Hatfield Forest (and the New Forest in Hampshire) is fairly representative of medieval forest land.

Traditional coppice is practised at Hatfield Forest and this involves cutting certain trees back to their bases. The trees are then allowed to re-grow as shoots and then subsequently re-cut a few years hence according to a range of coppice cycles depending on size of wood required. Pollarding (or 'eye level coppicing') is also used in Hatfield and involves cutting the trees above browsing height but allows grazing and browsing animals to share the same land.

The products of coppicing and pollarding formed the basis of a wide range of wood based industries and also was one of the main sources of firewood. The National Trust continues this practice and sells timber and firewood harvested at Hatfield.

As well as the ancient forest of Hatfield and vestiges of other ancient wood lands, there are around 1700 hectares of woodland within Uttlesford which are managed for a wide range of purposes and there is some limited informal production of firewood and logs predominantly for wood burning stove or log fire enthusiasts. Tree surgeons also produce firewood and logs as a by-product of their activities but by and large this is also sold to the same market and the amounts involved are difficult to quantify. According to the Forestry Commission there is of the order of **280,000 oven dry tonnes/year** of wood fuels available from forest thinnings and a further **71,300 ODT/year** from arboricultural arisings throughout the East of England. They also estimate that there are of the order of **24,500 tonnes/year** of wood by-products available annually in the East of England.

#### Wood pellets

Wood pellet fuelled boilers seem to be the most likely candidates for utilising biofuels at a domestic scale, initially because of their relative 'user friendliness' and generally consistent quality compared to some of the other fuels (particularly wood chips) and resources and the fact that they can be relatively easily substituted for oil and solid fuel based systems. Wood pellet stoves may have some appeal to users (including some with gas based systems) who wish to have a 'fireplace feature' - or wish to have a backup form of heating in reserve in the event of possible gas shortages or power cuts - but have recognised that open fires are very inefficient conventional wood stoves may not be particularly efficient and also do not wish to collect firewood or chop logs etc.

From a capital cost point of view wood pellet boiler based systems are likely to be more competitive than ground source heat pumps that are probably the main other renewable energy competitor for the oil and solid fuel heated houses, but it also depends on the costs of providing the flue/chimney, fuel store and any automatic loading systems.

At the present time there are no sources of wood pellets produced in Uttlesford, though if the mobile wood pelletting technologies employed to pelletise wood chips become viable then there could well be some locally produced pellets from wood chips produced as a by-crop from the various woods within Uttlesford or from arboricultural trimmings from tree surgeons and the like. However it seems probable that wood pellets will mainly be imported into Uttlesford from elsewhere which may not be a major issue at the present time if the wood pellets are sourced from East Anglia, East Midlands or parts of the South East because wood pellets have a higher energy density compared to wood chips (pellets have about three times the energy density (more if the chips are not dry)). Care should be taken to check the sources as many wood pellets are imported form overseas. So if wood pellets do become very popular, there may well be need to develop some form of robust accreditation, if one is to achieve $CO_2$ savings by using such fuels.

**Wood chips**

Wood chips are more suitable for larger houses and other larger properties as they require more care and maintenance compared to wood pellet based systems though there are systems with automatic loaders and hoppers which improve their operation.

Wood chips are available from much of East Anglia from a variety of sources ranging from forest thinnings, arboricultural trimmings under-managed woodlands and from tree surgeons. Improvements to the supply chain by a number of organisations such as Anglia Wood Fuels, the Forestry Commission, Renewables East and the Deer Iniative amongst others should improve the take up of wood chips.

According to the land suitability maps produced by DEFRA much of the land available in Uttlesford to grow wood based energy crops based on short rotation coppice is not optimal (i.e. would result in 'medium yields' rather than 'high yields'), so it seems unlikely that this method of producing wood chips would be attractive to farmers or land owners in Uttlesford. The appeal of supplying the annual 1,820 million tonnes wood chip requirements for the 2 MW wood chip boiler being planned as part of an extension to Stansted Airport remains to be seen, but it might stimulate local interest in the production of the fuel.

Whilst the short rotation coppice (SRC) may not be ideal, the use of an updated form of wood pasture/pollard system could potentially be viable as it has extensive historical precedence (e.g. Hatfield Forest). Whilst it would not have the yields of SRC and would operate over different cycles, it is more of an 'agroforestry' approach which does not displace food production and there is increasing awareness of its wildlife friendly attributes based on low inputs and likely more robust tolerance to the effects of climate change. It may not be appealing to farmers at the present time due to the difficulties being experienced by conventional livestock farmers elsewhere in Britain, but is an approach that does have a number of ecological/ biodiversity/ sustainability attributes on longer time scales.

**Miscanthus**

The conventional woody energy crop that does, according to DEFRA yield maps, seem to be suitable for growing within Uttlesford is **Miscanthus** a perennial grass which has attributes more akin to conventional agricultural crops so is likely to be more appealing to farmers and it can at the present time produce a higher annual yield than SRC[1].

In principle it would seem possible to provide Miscanthus fuel to all of the oil and solid fuel households (at current average space and water heating demands) in Uttlesford from around **2,300 ha** or around **41%** of the Uttlesford Set-aside land area (abating around **38,500 tonnes $CO_2$/y**). If average space and water heating demand was reduced by 30%, the amount of miscanthus required could potentially be grown on around **29%** of Uttlesford Set-aside land (abating around **39,500 tonnes $CO_2$/year**). Whether it would be sufficiently 'user friendly' for smaller boilers remains to be seen, though at least one UK miscanthus grower is developing miscanthus pellets - however they are <u>not</u> suitable for use in current wood pellet boilers.

[1] Though more productive strains of willows are being researched at number of sites including some in the East of England.

## STRAW

The main form of land use in Uttlesford is the growing of cereals followed by oil seed rape. There is thus a considerable amount of **straw** available to provide a potential heating fuel without conflicting with food production. There is considerable research underway to develop straw pellets as a fuel, particularly in Denmark - and in north America they have been experimenting with grass pellets. Whilst all of these have some substantial promise, they do produce much more ash and clinker than wood pellets and can be corrosive so it is not advisable to use them in wood pellet boilers. However the boilers designed to burn corn or grain can apparently cope with these characteristics and such boilers are available in the UK.

To provide the current average space and water heating needs for all of the oil and solid fuel households in Uttlesford would require straw from approximately **38%** of the current Uttlesford wheat crop land (abating around **38,500 tonnes $CO_2$/y**). With a 30% reduction in demand for space and water heating the required land area would reduce to around 27% of the current Uttlesford wheat crop area (abating around **39,500 tonnes $CO_2$/year**). As such there may be surprising scope for the use of locally grown straw pellets for the heating of the oil or solid fuel heated households in Uttlesford - provided adequate guidance about the factors involved are made available. Perhaps a few demonstration installations within the district to monitor the performance and remedy any shortcomings would be worth consideration in some Uttlesford properties.

## BIOFUEL MICRO-CHP

Micro-CHP (micro combined heat and power) is a technology which is still under development and undergoing field trials, though when driven by gas they have not proved to be as effective in reducing $CO_2$ emissions as anticipated. However if they are able to be powered by biofuels then they could potentially achieve substantial $CO_2$ abatement. A range of technologies are under development which can use a variety of biofuel sources. The most likely candidate is a Micro-CHP unit fuelled by rape seed oil based fuels including Biodiesel and straight vegetable oils (SVO).

If oil seed rape (OSR) was grown on **50%** of Uttlesford Set-aside land (and if **50%** of the current OSR being grown) and the oil extracted from the OSR and used to fuel Micro-CHP units, they could supply **3,780 households** (assuming average UK electricity demand of 4.7 MWh/y) or **5,920 households** (at 3 MWh/y average electricity demand). In terms of current average heat demand the OSR Micro-CHPs could supply around **2,250** households, or **3,190** households (assuming space and heating demand reduced by **30%**), or around **4,500 households**.

This level of OSR based Micro-CHP would abate of the order of **10,000 tonnes of $C0_2$/year** offsetting electricity plus **9,560 tonnes** of $C0_2$/year (Micro-CHP heat output assumed to be offsetting 90% efficient gas fired boilers). If the OSR straw is also used as a fuel a further **9,200** tonnes of $C0_2$/year.

## STRAW FUELLED CHP

As well as having potential in the form of pellet fuels, straw has potential to supply energy in distributed or district scale combined heat and power stations of a similar size range to Danish Straw-CHP stations, the first of which began operating in 1989.

If the straw from the 50% of the Uttlesford wheat crop area plus straw form the current OSR crop area and OSR grown on 50% of Uttlesford Seta-aside was used in Straw Fired CHP stations, this would provide electricity for around **8,170 households** (at 4.7MWh/y per household) or **12,800 households** (at 3 MWh/y average electricity demand) and abate around **16,,200 tonnes** $CO_2$/year. Similarly the heat derived from the Straw-CHP could supply around **4,360 households** (at current space and water heating demand consumption), around **6,400 households** (assuming 30% space and water heating demand reduction) or **8,700 households** or around 60% of the housing stock (assuming 50% space and water heating demand reduction) and abate around **18,500 tonnes $CO_2$/year.**

## FOOD WASTE ANAEROBIC DIGESTER CHP

The kitchen and green wastes emanating from Uttlesford have potential for converting the biological waste stream into useful renewable energy by processing in an Anaerobic Digester. Using the South Shropshire Biowastes Digester as a guide, indicates that Food Wastes AD could generate **390,320 kWh/y** of net electricity (and abate around **220 tonnes $CO_2$/year**) and around **574,520 kWh/y** of net heat output (abating **1,210 tonnes $CO_2$/year**).

## BIOMASS CHP & DISTRIBUTED ENERGY

Both the Straw-CHP and the Food Waste AD based CHP units could form part of a distributed heat and electricity network in combination with the more conventional CHP and link up with other renewable energies such as car port solar, solar streets, neighbourhood/community wind power and group scale ground coupled energy/ground coupled inter-seasonal storage or solar/ground coupled roads.

Such combinations together with heat mains and heat stores could also form the basis of a distributed energy network that facilitates the establishment of 'Private Wire' networks on the lines of that implemented at Woking in Surrey. These types of arrangements can also provide funding mechanisms to expand the use of renewable energy technologies but also help to fund some of the more difficult energy saving measures and infrastructure.

Straw-CHP (and the Food Waste AD based CHP) could provide a possible means of low carbon electricity for non gas communities or they could operate in tandem with gas-CHP stations in a distributed network in the settlements with gas available.

Also depending on the proximity of the plant to hard to heat houses and listed buildings, such a scheme would assist in reducing the $CO_2$ emissions from this difficult housing stock group.

**Table B-1** Summary of Biofuel Energy Technologies and ball park potential in Uttlesford

| | | Output (GWh/y) | | | $CO_2$ Abatement (tonnes/yr) | | |
|---|---|---|---|---|---|---|---|
| | | elect | heat | heat + elect | (elect.) | (heat) | (heat+ Elect) |
| **Biofuels** | | | | | | | |
| **Miscanthus in boilers** | | | | | | | |
| All oil + solid fuel heated households at current demand | Grown on 2,300 ha or 41% Setaside | | | | | | 38,500 |
| All oil + solid fuel heated households demand reduced by 30% | Grown on 29% Setaside land | | | | | | 39,500 |
| **Straw pellets in boilers** | | | | | | | |
| All oil + solid fuel heated households at current demand | Straw from 38% of wheat crop land | | | | | | 38,500 |
| All oil + solid fuel heated households demand reduced by 30% | Straw from 27% of wheat crop land | | | | | | 39,500 |
| **Bio Micro CHP** | | | | | | | |
| Rape seed oil or RME biodiesel fuelled MicroCHP units | | | | | | | |
| 3780 hses (elec @4.7MWh/HH) + 2,250 hses (Sp&WH) | OSR on 50% of Setaside | 17.8 | 47.3 | 65 | 10,000 | 9,560 | 19,560 |
| | (further 9,200 tCO2 abated if OSR straw used) | | | | | | |
| 5,920 hses (elec@3 MWh/HH) + 3,190 hses (Sp&WH @30% red demand) | (further 9,200 tCO2 abated if OSR straw used) | 17.8 | 47.3 | 65 | 10,000 | 9,560 | 19,560 |
| **Straw-CHP** | | | | | | | |
| 8,170 hses (elec @4.7MWh/HH) + 4,360 hses (Sp&WH) | 50%wheat crop+ 50%OSRstraw +OSR on 50%Setaside | 38.4 | 91.6 | 130 | 16,200 | 18,500 | 34,700 |
| 12,800 hses (elec @3MWh/HH) + 8,700 hses (SpWH demnd red by 30%) | 50%wheat crop+ 50%OSRstraw +OSR on 50%Setaside | 38.4 | 91.6 | 130 | 16,200 | 18,500 | 34,700 |
| 12,800 hses (elec @3MWh/HH) + 8,700 hses (SpWH demnd red by 50%) | 50%wheat crop+ 50%OSRstraw +OSR on 50%Setaside | 38.4 | 91.6 | 130 | 16,200 | 18,500 | 34,700 |
| **Food Wastes Anaerobic Digestion** | | | | | | | |
| Assuming 50% of UF food wastes est. to yield 250 t of biogas | | | | | | | |
| Elect for 80 Hses @ 4.7 MWh/y + heat for 26 Hses @ current demnd | | 0.39 | 0.574 | 0.964 | 220 | 1,210 | 1,430 |
| Elect for 130 Hses @ 3 MWh/y + heat for 37 Hses demnd red by 30% | | | | | | | |

# CONTENTS

# BIOFUELS

### 5.1.1 Definition

Biologically derived energy sources consist of plant matter, such as plants, shrubs and trees, within which solar energy is stored. It also includes waste products derived from animals and the products of biological processing such as fermentation and digestion. Some of this stored energy can be captured by harvesting at the correct stage and processing it to produce what are collectively known as Biofuels (also often referred to as Biomass) and the conversion of these fuels into energy is known as Bioenergy or Biomass Energy.

### 5.1.2 Woody Fuels

These are solid and granular fuels derived from wood or wood by-products, but they also include fuels derived from woody grasses such as miscanthus (elephant grass) or canary reed grass and switch grass.

Woody fuels have been traditionally used in the form of firewood (bundles or logs) in open fires or more recently in wood stoves. Historically traditional woodland techniques such as traditional coppice and pollarding were practiced in Essex to sustainably produce wood for a variety of uses including firewood - Epping Forest and Hatfield Forest are examples of such traditional woodlands. There continues to be a niche market for these fuels in close proximity to the source of firewood supplies and there are now multi-fuel boilers and log wood boilers available to make use of this fuel more efficiently.

Processing wood into chips (**Figure 5-1**) improves its usability and makes it into more of commodity fuel and improves the energy density[2].

**Figure 5-1**: Wood chips

Thinning of plantations and trimming of felled trees often results in large volumes of forestry residues. These can be collected, dried and used as fuel for heating or

[2] Though it still remains one of the lowest energy density fuels.

electricity generation at both a domestic, community and industrial scale. When chipped by mechanical chippers to produce uniform 30-40 mm wood chips they are dry and easier to handle; nevertheless their bulk and high water content means that it is usually uneconomic to transport them long distances.

Wood chips can be used in wood fuel boilers and can be converted into a gaseous fuel (producer gas) by heating in a gasifier with a small amount of oxygen. Chips can also be processed into liquid fuels or charcoal by a process known as pyrolysis (also known as the distillation of wood) which involves heating wood chips[3] to a high temperature in the absence of air.

Wood wastes[4] can also be processed into pellets (5 mm diameter x 10 to 20 mm long) (**Figure 5-2**), which provides an even more usable form of wood fuel and which generally has a more consistent quality and as a result, has a higher and more consistent energy density (**4.7 to 5 kWh/kg** or 4,700 to 5,000 kWh/tonne - according to the Biomass Energy Centre)[5].

**Figure 5-2:** Wood pellet fuel.

However wood pellet fuel is not presently produced locally[6], though, according to the main UK supplier, there are plans to establish a countrywide network of wood pellet suppliers. There are also companies considering the marketing and franchising of small scale pellet making equipment.

The higher energy density of wood pellets means that fewer lorries are required to carry the same amount of calorific value of fuel (compared to wood chips). It can also be transported a greater distance for the same energy balance. The fuel can be delivered and stored in hermetically sealed 20 kg bags and, from the point of view of handling, is much more user friendly than wood chips. Pellet fuels are easier to store, easier to load into boilers and need less frequent fuel loading to feed boilers. Pellet boilers are more compact than wood chip boilers, have high efficiencies (of the order of 80 to 90%) and can fit into domestic properties. There are many suppliers and manufacturers of pellet boilers in the UK and a growing number of wood pellet suppliers. Small wood pellet stoves or room heaters are also available.

[3] Or other biological materials including biological components of the municipal waste stream.
[4] Principally saw dust.
[5] For comparison, 2.2 kilograms of wood pellets can substitute for approximately 1 litre of heating oil.
[6] To produce wood pellets locally would require a sufficiently large source of sawdust or an economic (and energy efficient) means of processing wood into sawdust to make into pellets. Most pelleting equipment tends to be expensive, but there could be scope for part utilisation of pelleting equipment used in other industries such as that used for producing animal feed pellets.

There is also apparently research going on in the north of England into producing small granular wood chips which could potentially have most of the characteristics of wood pellets (subject to similar quality controls), but able to be produced from wood energy crops or from forest or arboricultural residues. These potentially may be able to be used in pellet stoves

Another approach which may be suitable for Uttlesford - if there is sufficient waste wood - and which has the potential to be set up on a small scale is that of briquetting of waste wood. This requires the use of a press that produces fuel briquettes of around 8 to 10 cm diameter. These are used overseas but have not been widely used in the UK. See also the Section on Crop Residues.

Wood-fired district heating systems burning waste wood, bark and chips, particularly those in the 1-2 MW capacity range, are common in countries such as Austria and Northern France, where there are also a number of small-scale CHP systems.

### 5.1.3 Crop Residues

Crop wastes such as straw are in common use as a heating fuel in Denmark, where there are many straw-fired district-heating systems in the 3-5 MW range in rural areas.

In the UK the burning of straw in the field was banned in 1992, while the potential energy resource from straw is as much as 1% of UK energy use. An example of a country estate making use of straw to provide most of its heating and hot water requirements is Woburn Abbey in Bedfordshire. Their system makes use of large straw bales, which are shredded and fed automatically to a boiler with a maximum heat output of 800 kW.

The world's largest straw-fired power station is the 36 MW Eilean power station located at Sutton near Ely in Cambridgeshire. This is fed by around 200,000 tonnes of straw per year in the form of 550kg Hesston straw bales from large farms within a radius of 80 km of the power station. This is not a CHP based station though there are plans to use the waste heat.

The Eilean power station has demonstrated the viability of straw fired electricity in the East Anglian context and has developed a system of collection, delivery and storage of straw for energy purposes. However it is a much large scale than would be needed for the Uttlesford context.

### 5.1.4 Biogas

See below for Anaerobic Digestion of Food and Green Wastes.

## 5.2 Woody Fuels

Wood fuels can be obtained from a variety of different sources, including forest residues, existing coppice, woody energy crops such as willow and poplar cultivated on a Short Rotation Coppice (SRC) basis, miscanthus (harvested annually), municipal and domestic tree and shrub trimmings (arboricultural arisings).

Use of both existing wood resources and woody energy crops such as willow, poplar and miscanthus to generate power and/or heat has been attracting increased attention in recent years. DEFRA has devoted considerable resources to promoting energy crops to farmers as a new source of income, with the periodic assistance of a range of grant schemes.

### 5.2.1 Existing Forestry and other Wood Sources

Historically Essex was classed as 'forest' at the time of William I, though this term is used in its medieval sense of 'wild land or hunting land' and does not mean that it was all densely wooded. It is thought Hatfield Forest (and the New Forest in Hampshire) is fairly representative of medieval forest land. Hatfield Forest is an extremely important example of ancient forest in which most of the components survive.

Traditional coppice is practised at Hatfield Forest and this involves cutting certain trees back to their bases. The trees are then allowed to re-grow as shoots and then subsequently re-cut a few years hence according to a range of coppice cycles depending on size of wood required. The management of traditional coppice involves protection from grazing and browsing animals but another system known as pollarding is also used in Hatfield which could be thought of as 'eye level coppicing' and involves cutting the trees above browsing height but permits grazing and browsing animals to share the same land. Pollarding of trees extends their life as well as producing fuel and food, creates the landscape typical of ancient forests such as Hatfield Forest.

The products of coppicing and pollarding formed the basis of a wide range of wood based industries in the past and also was one of the main ongoing sources of firewood. The National Trust continues this and sells timber and firewood harvested at Hatfield.

As well as the ancient forest of Hatfield and other vestiges of ancient woodland, there are around **1700 hectares** of woodland within Uttlesford which is managed for a wide range of purposes and there is some limited informal production of firewood and logs predominantly for wood burning stove or log fire enthusiasts. Tree surgeons also produce firewood and logs as a by-product of their activities but by and large this is also sold to the same market and the amounts involved are difficult to quantify.

**Figure 5-3** shows the woodland cover in Essex based on the woodland inventory carried out by the Forestry Commission.

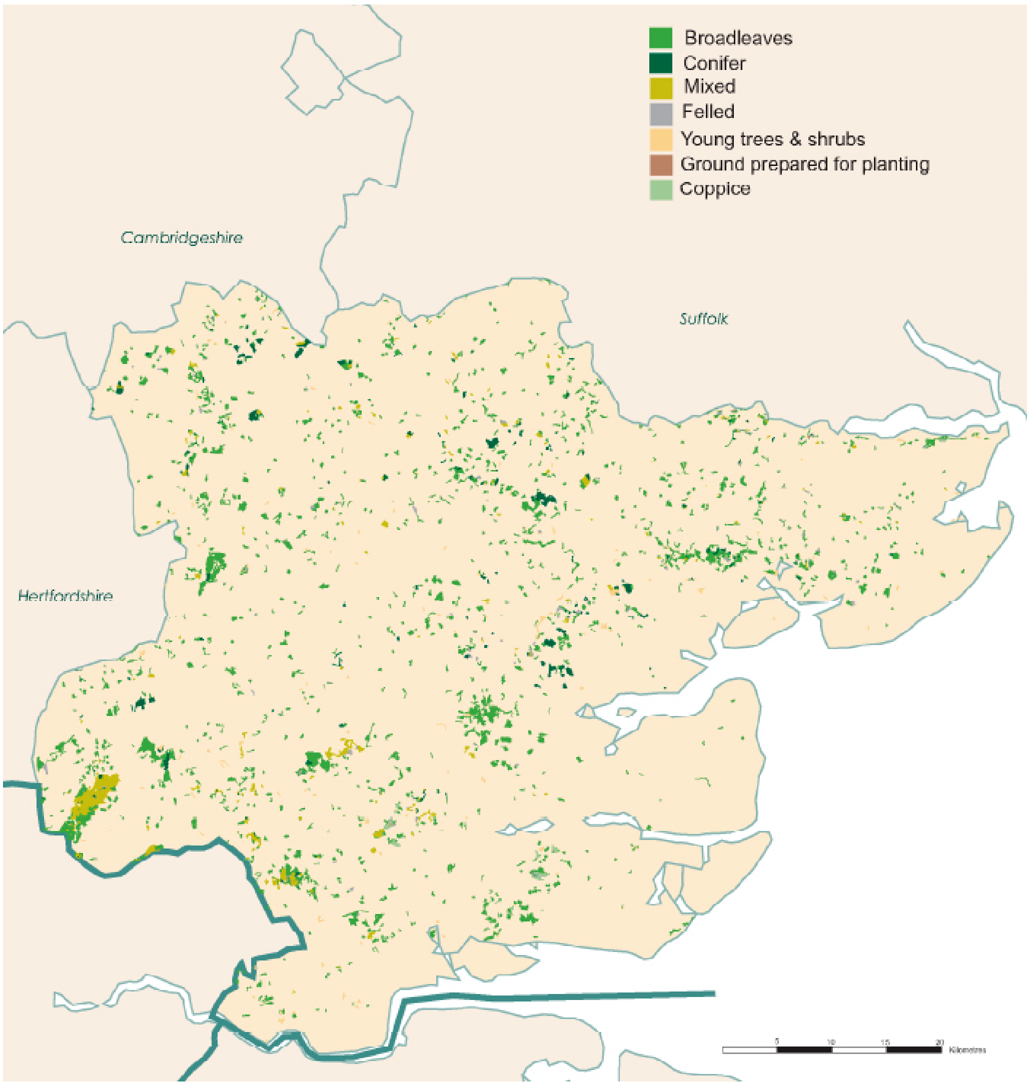


**Figure 5-3** Woodland Cover in Essex (Source Forestry Research)

**Figure 5-4** shows a close up view of the woodland cover of Essex showing the woodland cover in Uttlesford.

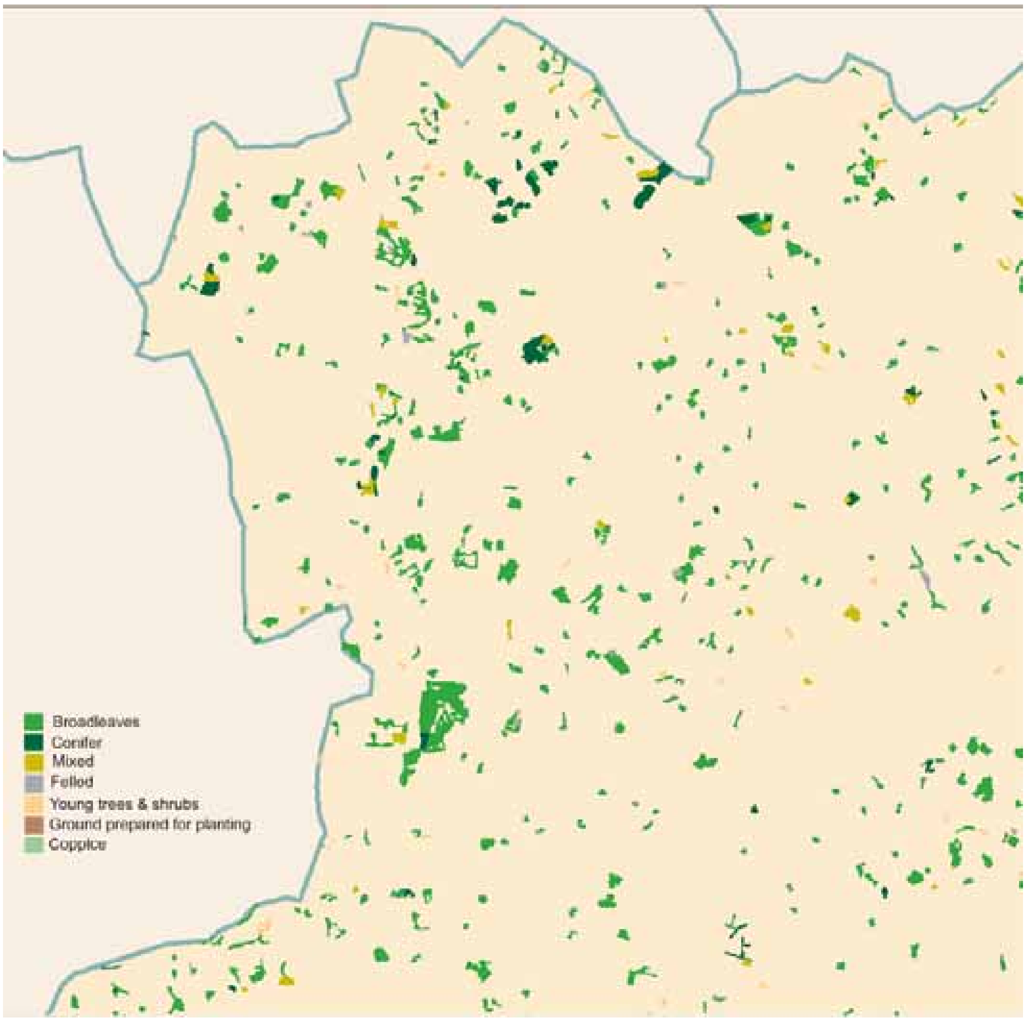


**Figure 5-4** Close Up View of Woodland Cover in Essex showing Woodland in Uttlesford (Source Forestry Research)

According to the Forestry Commission there is of the order of **280,000 oven dry tonnes/year** of wood fuels available from forest thinnings and a further **71,300 ODT/year** from arboricultural arisings through out the East of England. They also estimate that there are of the order of **24,500 tonnes/year** of wood by-products available annually in the East of England.

According to Anglia Wood Fuels Ltd, there are some 70,000 hectares of 'under managed woodlands' in East Anglia and they are developing supply chains to make and supply wood chips from this potential resource.

### 5.2.2 Short Rotation Coppice & other wood fuel growing methods

There has been considerable research and activity into the possibilities of producing wood fuels as energy crops (predominantly in Scandinavia) and another form of coppice has been promoted which is known as short rotation coppice or SRC, which is based predominantly on particular species of willow or poplar (**Figure 5-5**(a)). The crop is harvested every three to five years - usually in rotation. The wood is then usually chipped on site and transported to where it can be used as a combustion fuel - most commonly in wood fuel boilers or for co-firing in power stations able to utilise them.

The yields that are claimed in the literature are quite varied but the Biomass Energy Centre gives an annual yield of 8 oven dry tonnes (ODT) per hectare though yields as high as 18 ODT/ha are hoped for and considerable research Is underway to develop high yielding strains of willows and poplars.

**Figure 5-5:** (a) Short Rotation Coppice (left). (b) Miscanthus (right).

There have been a number of studies investigating the potential for growing SRC in the East of England, but the focus of activity has been elsewhere rather than Uttlesford as other parts of the region seemed to be more favourable particularly Suffolk. There is also some concern about the water/irrigation needs for SRC and the 'monoculture' nature of the crop.

The land owner and farmer has to be sure that there is a market for SRC grown wood chips in the future as they won't be able to sell any wood chips for the first few years. It also means that the land cannot also be used to grow food which could have other implications.

The current agricultural 'set-aside land area' in Uttlesford is around **5,600 hectares** so it may be possible to grow some SRC there but there are probably more lucrative crops and land uses.

A traditional land use is that of *Wood-Pasture* which can involve pollarding[7] trees. This has the advantage of combining wood production with farming. So another approach to producing wood fuel would be to plant more intensive Wood-Pasture with support from the English Woodland Grant Scheme (EWGS). This approach would also have a less dramatic effect on the landscape than SRC and while less productive in wood fuel could improve the overall production yield from the land from both agricultural produce and wood fuel.

Another approach that is more closely related to commercial forestry is planting of fast growing tree species as single stem trees (rather than coppice). Thinning the growth at different times produces the crop and it allows scope to permit some trees to grow to maturity. It might be possible to receive grants under the EWGS.

A flood prevention measure being tried in other parts of the UK is planting of flood plain catchment areas with coppice or trees to slow down the water run off and reduce the scale of flooding. This could be another approach to growing wood fuel energy crops in Uttlesford in appropriate risk areas.

[7] Pollarding is similar to coppicing except that the trees used are 'coppiced' above browsing height.

### 5.2.3 Wood Pellets

As well as wood chips the other main wood fuel that is becoming popular is wood pellets which have historically been mainly produced from sawdust as a by-product of timber and wood-working industries. Wood pellets are a much more 'user friendly' form of wood fuel and a range of domestic pellet stoves and boilers are now available(**Figure 5-6**). In some cases wood pellets can be burned in multi-fuel boilers and, because they are granular and can be piped like a fluid, can operate fairly automatically - much like an oil fuelled boiler arrangement.

Wood pellets can be obtained in consumer-friendly bags or sacks or delivered by a 'tanker'. However because they are available as a 'user-friendly commodity' they are also traded as such and many wood pellets used in the UK are imported from Scandinavia, the Baltic, North America and even from Brazil. There are therefore issues with regard to embodied energy/$CO_2$ from the transportation of wood pellets, so it is preferable to obtain them locally if possible.


**Figure 5-6** (a) Wood Chip Boiler, (b) Wood Pellet Boiler, (c) Wood Pellet Stove

Higher energy density of wood pellets compared to wood chips reduces this impact though they are not currently produced within or near Uttlesford and there are no major wood related industries from which to source. However if they could be obtained from within the East Anglian region, then the impact should be minimal particularly if the distributor uses biofuel for the transportation.

Wood pellets do seem to have a role to play as a low carbon means of producing space and water heating, so it seems probable that any wider scale uptake of wood fuels in the domestic sector is likely to be wood pellet based.

One of the challenges has been to be able to produce wood pellets from wood energy crops but this has proved to be difficult as it requires the drying and milling of wood chips as well as the pressing the pellets. There are a number of systems that claim to be able to achieve this including mobile units that offer the potential of insitu wood pelletting at the energy crop site.

### 5.2.4 Miscanthus

As well as wood based fuels based on trees or short rotation coppice, another perennial 'woody energy crop' that seems to have promise in the UK and which is also more akin to a conventional agricultural crop is based on Miscanthus commonly known as 'elephant grass' (**Figure 5-5 (b)**).

According to DEFRA, much of the Uttlesford agricultural land would be suitable for growing miscanthus and the potential yields would be of the order of 12 ODT/hectare per year. As an example if miscanthus was to be grown on 50% current Uttlesford Set-aside, it would potentially yield something of the order of **33,000 ODT/year**.

Miscanthus can be harvested in a similar way to conventional cereal crops and so may be more appealing to farmers. Miscanthus can be harvested in a relatively dry state and chopped or baled. It usually has a higher ash component than wood fuels and is less 'user friendly' than wood pellet fuels, so it is probably of limited appeal to domestic users except for farmhouses or other larger properties with automatic hoppers etc. Miscanthus does have potential for larger scale boilers used for group housing, neighbourhood scale schemes, district heating or community heating schemes, schools and appropriate combined heat and power schemes.

### 5.2.5 Using Wood or Woody Fuels for Space and Water Heating of Uttlesford Housing

Wood fuels seem unlikely to make much inroad into the gas heated housing stock - other than as wood pellet stoves used as design features or as a back up stove - at least initially. Therefore the potential requirements for the current oil and solid fuel heated housing stock was investigated.

Assuming the current levels of average space and water heating demand, the oil/solid fuel heated households in Uttlesford would require wood fuels of the order of **28,000 tonnes** of wood pellets or **38,000 tonnes** of wood chips or **28,000 tonnes** of miscanthus per year. **Figure 5-7** shows the proportions of these fuels for the oil heated and the solid fuel households.

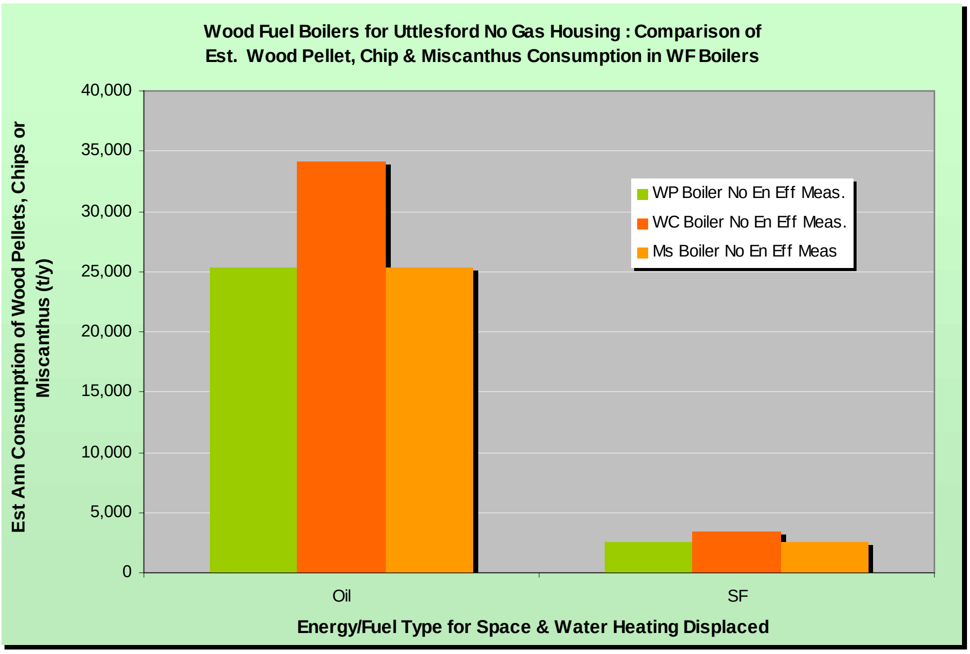


**Figure 5-7:** Estimated Aggregated Annual consumption of wood of wood pellets or wood chips or miscanthus fuel for Uttlesford oil and solid fuel housing stock.

Using the Building Regulations emission factor of 25 $gCO_2$/kWh for wood fuels and assuming boiler efficiency of 80% the estimated annual aggregated $CO_2$ emissions would be reduced to around 3,200 tonnes per year for space and water heating in the oil and solid fuel heated housing stock resulting in an estimated annual aggregated $CO_2$ abatement for these houses of the order of **38,500 tonnes $CO_2$ per year**. However if the wood fuels are used in dual fuel boilers the Building Regulations emission factor increases to 187g $CO_2$/kWh which would reduce the net $CO_2$ abatement to around 11,100 tonnes $CO_2$/year (i.e. around 3.5 times less compared to specific wood fuel boilers). **Figure 5-8** shows the range of $CO_2$ abatement from substituting wood fuels for 10% to 100% of Uttlesford oil and sold fuel heated housing stock.

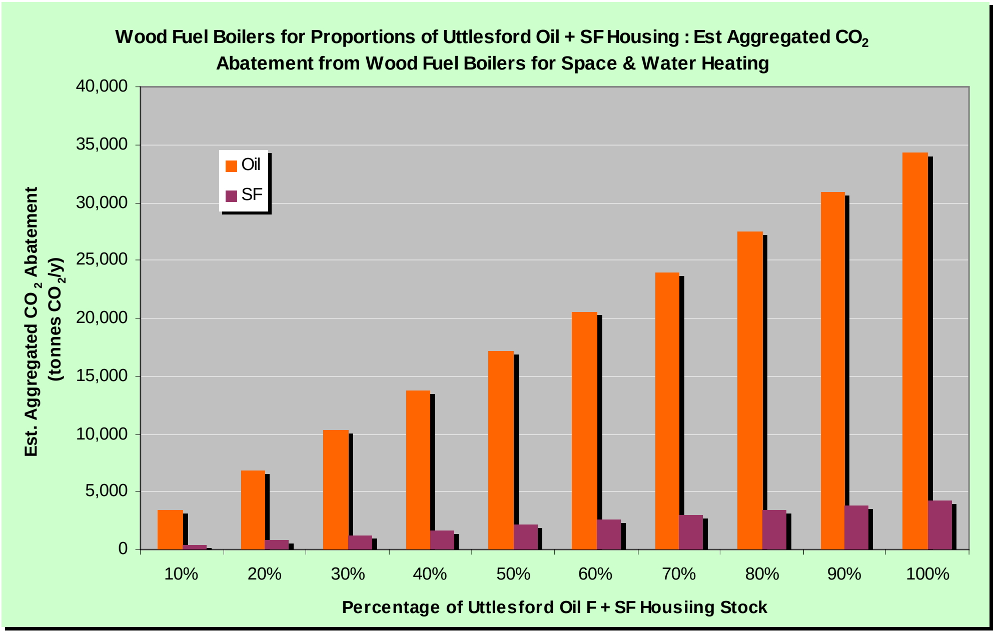


**Figure 5-8:** Range of estimated aggregated annual $CO_2$ abatement from substituting wood fuels for space and water heating needs for 10% to 100% of Uttlesford oil & solid fuel heated housing stock.

Wood pellets are the most probable method of using wood fuel, but they are unlikely to be produced in Uttlesford so would need to be sourced outside the district.

It may be possible to produce wood chips or miscanthus at least in part within Uttlesford. If the wood chips were derived from SRC, 38,000 tonnes of wood chips would require around **4,700 hectares** (equivalent to around **83%** of Uttlesford set-aside land). In the case of miscanthus, about **2,300 ha** would be required to produce **28,000 tonnes** per year or around **41**% of the Uttlesford set-aside.

### 5.2.6 Woody Fuels for Space & Water Heating with Reduced Demand

Uttlesford DC has made energy efficiency/conservation proposals that could reduce the Uttlesford household annual space and water heating consumption by around 30%.

If we assume that this was realised, the wood fuel required would be of the order of **19,600 wood pellets** or **26,300 tonnes** of wood chips or **19,600 tonnes** of miscanthus. **Figure 5-9** shows the proportions of these fuels for the oil heated and the solid fuel households and compares the fuel consumption to match the current space and water heating demand and the demand reduced by 30%.

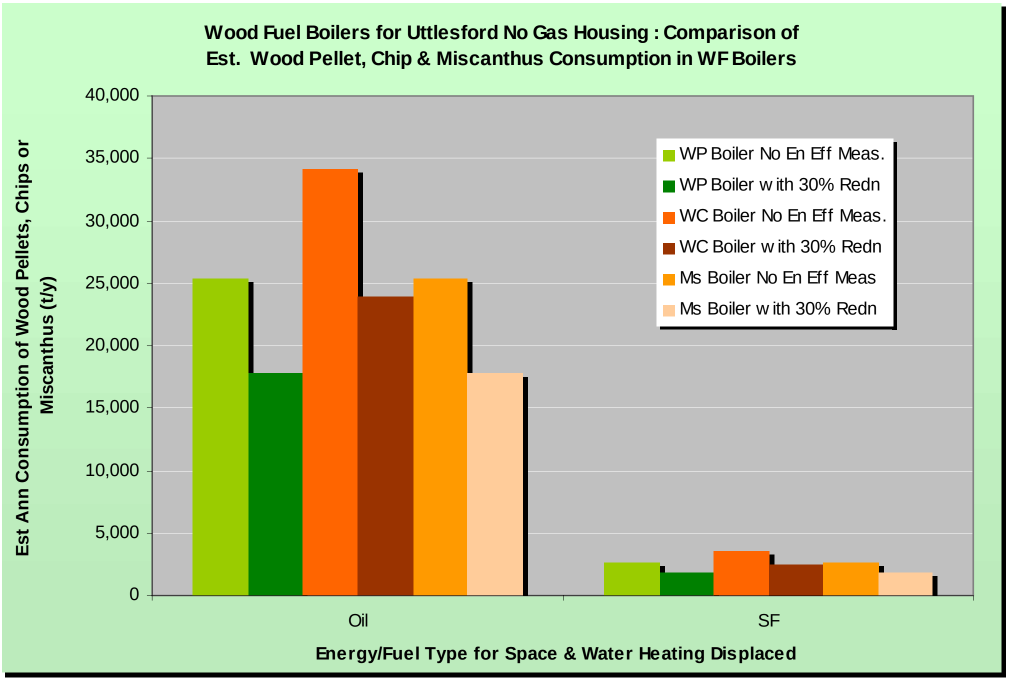


**Figure 5-9:** Estimated Aggregated Annual consumption of wood pellets or wood chips or miscanthus fuel for Uttlesford oil and solid fuel housing stock. For current space & water heating demand and demand reduced by 30% (from energy efficiency measures).

Again using the Building Regulations emission factor of 25 $gCO_2$/kWh for wood fuels and assuming boiler efficiency of 80% the estimated annual aggregated $CO_2$ emissions would be reduced to around 2,300 tonnes per year for space and water heating in the oil and solid fuel heated housing stock, resulting in an estimated annual aggregated $CO_2$ abatement for these houses of the order of **39,500 tonnes $CO_2$ per year** (or approximately **23%** of current $CO_2$ emissions from space and water heating of the aggregated Uttlesford total housing stock). **Figure 5-10** shows the range of $CO_2$ abatement from substituting wood fuels for 10% to 100% of Uttlesford oil and solid fuel heated housing stock with the demand reduced by 30%.

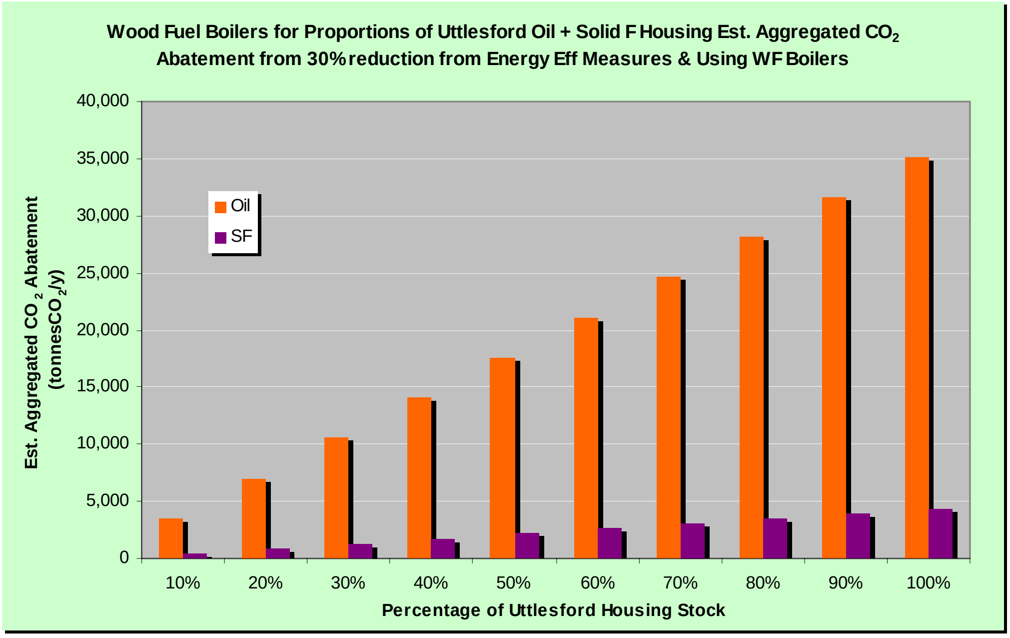


**Figure 5-11:** Range of estimated aggregated annual $CO_2$ abatement from substituting wood fuels for reduced space and water heating needs for 10% to 100% of Uttlesford oil and solid fuel heated housing stock. Demand reduced by 30% (from energy efficiency measures).

The land required to produce this amount of wood chips from SRC would be around 3,300 ha (or 58% of Uttlesford Set-aside). In the case of miscanthus this would require some 1,630 ha (or 29% of Uttlesford Set-aside).

Of the two types of energy crops that could be grown in Uttlesford on Set-aside or on other suitable agricultural land, miscanthus is the most feasible but it is not currently very well suited to smaller scale boilers.

### 5.2.7 Straw Fuels for Space & Water Heating

Another option is that of straw. The predominant form of agriculture and land use in Uttlesford is the growing of cereals and some **28,000 hectares** is allocated to growing cereals including **26,600 ha for wheat**.

Straw has been used in straw bale boilers for some time (Woburn Abbey in Bedfordshire has been heated by a straw bale boiler for over a decade), however apart from farms and certain other enterprises these are not very suitable for domestic uses.

The production of straw based pellets is now becoming a potentially promising pellet fuel, though like miscanthus it does result in more ash than wood pellets and requires appropriate boilers. Whilst not for fuel, straw-based pellets are produced in Cambridgeshire as animal feed.

If we assume the current levels of average space and water heating demand for the oil/solid fuel heated households in Uttlesford , this would require woody fuels of the order of **33,000 tonnes** of straw pellets and use straw from around 9,400 ha or around **38%** of the Uttlesford wheat crop land.

Assuming the 30% reduction in space and water heating from energy efficiency/conservation is achieved, the demand for straw pellet would be of the order of **23,000 tonnes** which would be around **6,600 ha** or around **27%** of the current Uttlesford wheat based area. **Figure 5-12** compares the consumption of straw pellets with wood pellets or wood chips or miscanthus fuel to provide the reduced space and water heating demands of 10% to 100% Uttlesford oil and solid fuel heated households. **Figure 5-13** compares the land area requirements.

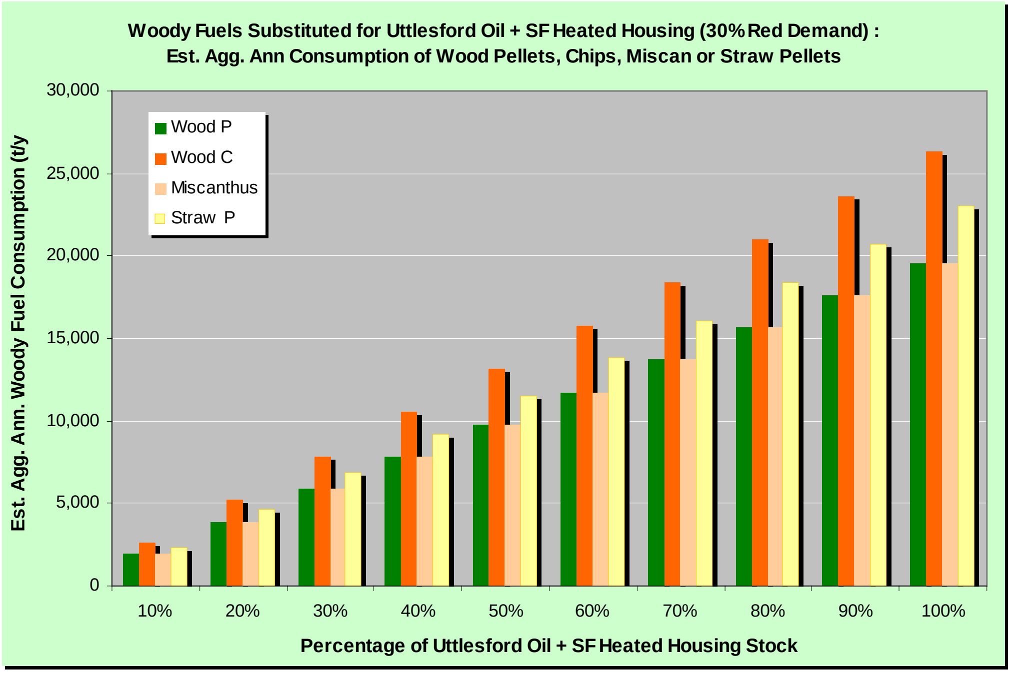


**Figure 5-12:** Estimated Aggregated Annual consumption of wood pellets or wood chips or miscanthus fuel or straw pellets for 10% to 100% of Uttlesford oil and solid fuel housing stock with space & water heating demand reduced by 30% by energy efficiency measures.

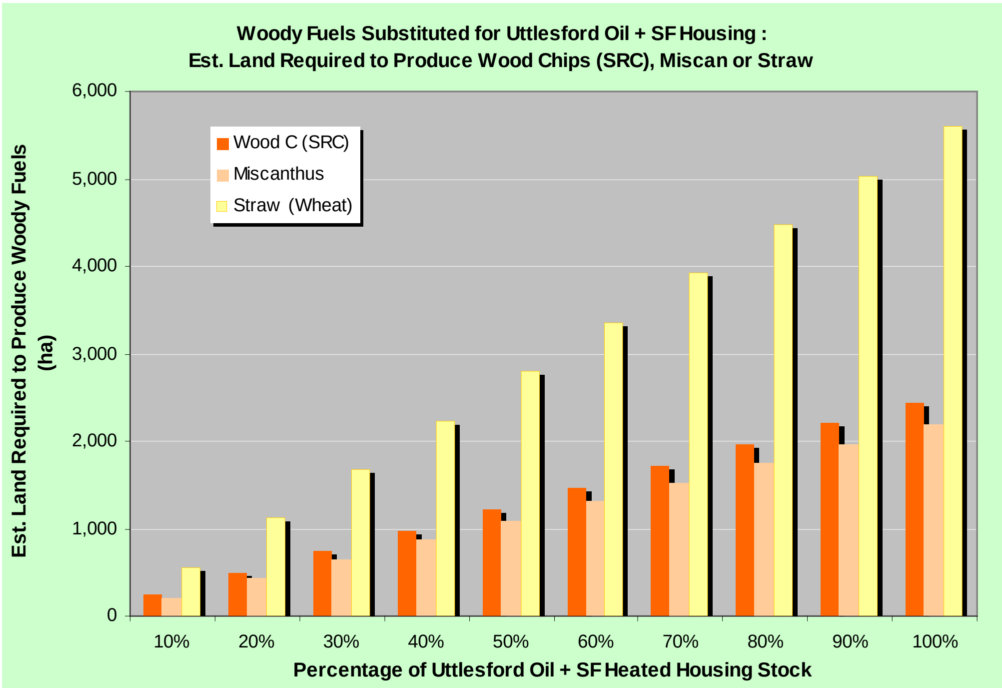


**Figure 5-13:** Comparison of land area required to grow SRC for wood chips or miscanthus fuel or straw (wheat) for supplying 10% to 100% Uttlesford oil and solid fuel housing stock with space & water heating demand reduced by 30% by energy efficiency measures.

**Figure 5-14** compares the land requirements above and shown as a proportion of Uttlesford Set-aside or Uttlesford wheat crop area. This shows that the use of straw fuel uses a much smaller proportion of the available land to provide for these needs.

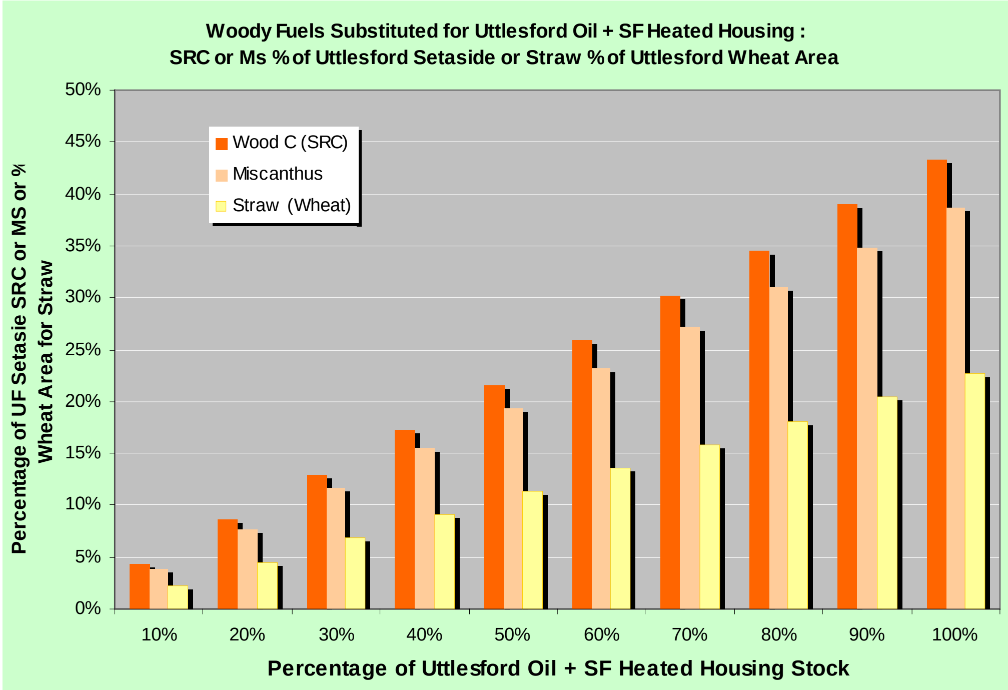


**Figure 5-14:** Proportions of Uttlesford Set-aside required to grow SRC for wood chips or miscanthus fuel & proportions of Uttlesford wheat crop land for straw for supplying 10% to 100% Uttlesford oil and solid fuel housing stock with space & water heating demand reduced by 30% by energy efficiency measures.

Whilst there are other competing uses for straw, the use as heating fuel within Uttlesford would seem to have potential once boilers suitable for using straw pellets become more widely available. Conventional wood pellet boilers are not appropriate for burning straw pellets, though boilers designed to use grain fuels such as corn etc (**Figure 5-15(b)**) are apparently able to cope with the special combustion characteristics of straw pellets such as increased ash or clinker.

**Figure 5-15 (a)** Prototype mobile straw & grass pellet mill (left) (Source BHS). **(b)** Grain boiler (right) (Baxi).

Boilers capable of burning corn are available in the UK so if local straw producers or merchants were to commence production of straw pellets, it would in principle be possible produce and use a local biofuel indigenous to Uttlesford to offset $CO_2$ emissions from the oil and solid fuel heated housing within Uttlesford.

Conversion options for converting from oil fuel or solid fuel based systems to wood (or straw) pellet fuels are more of a practical preposition as flues and chimneys are in place. The other potential housing sector that could potentially benefit is that using electric heating and if the electrically heated housing in Uttlesford was included, the non-gas housing stock at current space and water heating demand would use **50,000 tonnes wood pellets** or **66,000 tonnes of wood chips** (requiring **8,223 ha** or **1.5 tim**es Uttlesford Set-aside if from SRC) or **49,000 tonnes of miscanthus** fuel (requiring **4,100 ha** or **72%** of Uttlesford Set-aside) or **57,500 tonnes** of straw pellets (requiring 16,500 ha or 67% of Uttlesford wheat crop land area). The estimated annual aggregated $CO_2$ emissions abated for the non gas housing would be of the order of **70,000 tonnes $CO_2$ per year**.

Assuming that the space and water heating demands were reduced by 30%, the Uttlesford non gas housing would use some **34,300 tonnes** of wood pellets or **46,000 tonnes** of wood chips (requiring 5,800 ha or equivalent to around **100%** of Uttlesford Set-aside) or **34,300 tonnes** of miscanthus fuel (requiring **2,800 ha** or around **50%** of Uttlesford Set-aside) or **40,300** tonnes of straw pellets (requiring **11,500 ha** or **47%** of Uttlesford wheat crop land area). **Figure X** compares the consumption of straw pellets with wood pellets or wood chips or miscanthus fuel to provide the reduced space and water heating demands of 10% to 100% the Uttlesford non-gas households. **Figure 5-16** compares the land area requirements

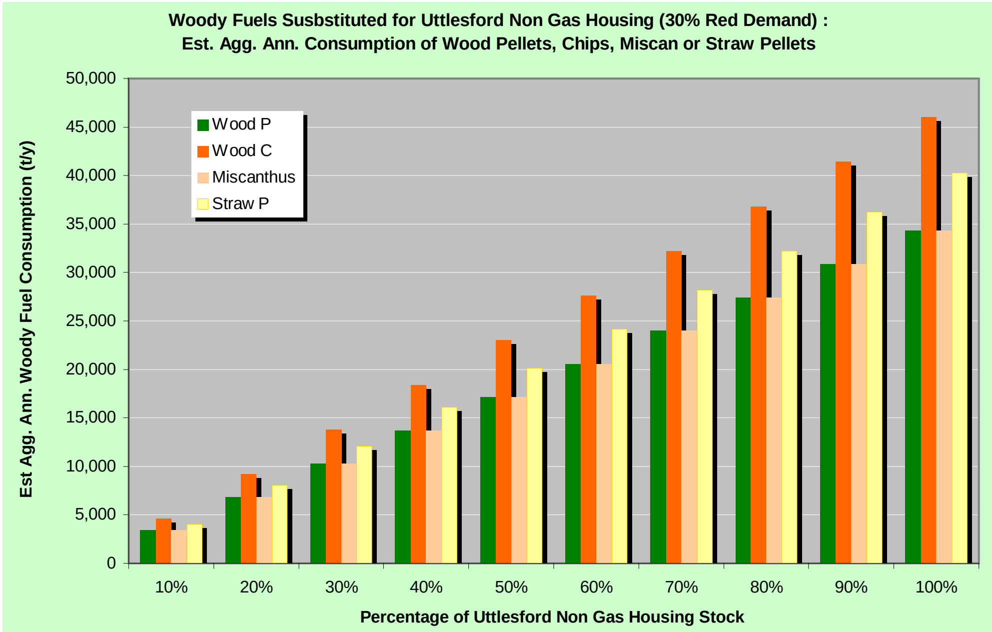


**Figure 5-16:** Estimated Aggregated Annual consumption of wood pellets or wood chips or miscanthus fuel or straw pellets for 10% to 100% of Uttlesford non-gas housing stock with space & water heating demand reduced by 30% by energy efficiency measures.

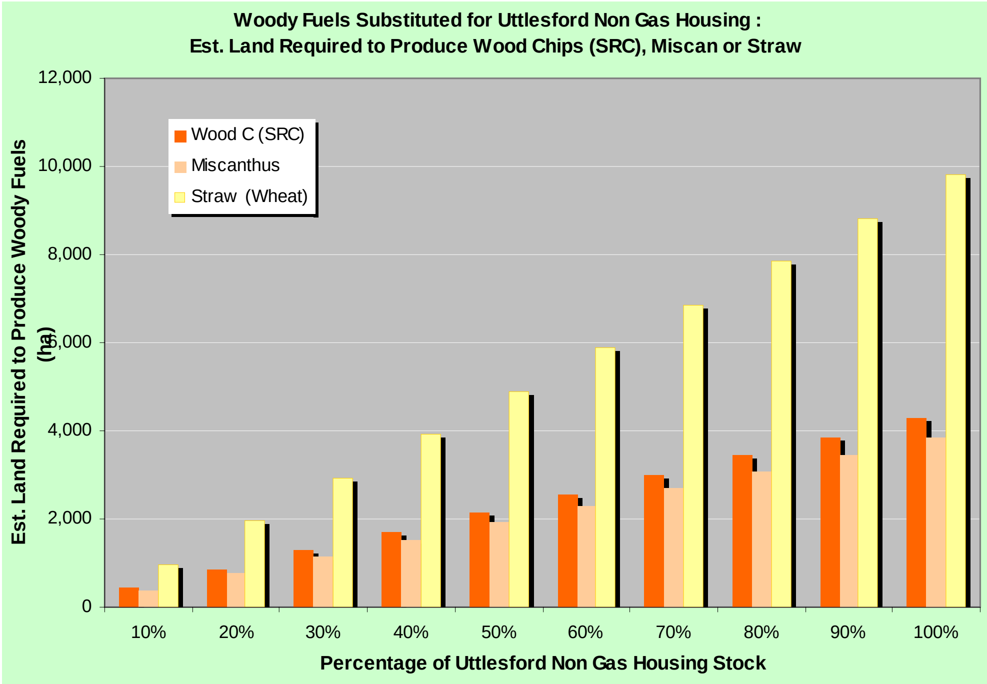


**Figure 5-17:** Comparison of land area required to grow SRC for wood chips or miscanthus fuel or straw (wheat) for supplying 10% to 100% Uttlesford non-gas housing stock with space & water heating demand reduced by 30% by energy efficiency measures.

**Figure 5-18** compares the land requirements above and shown as a proportion of Uttlesford Set-aside or Uttlesford wheat crop area.

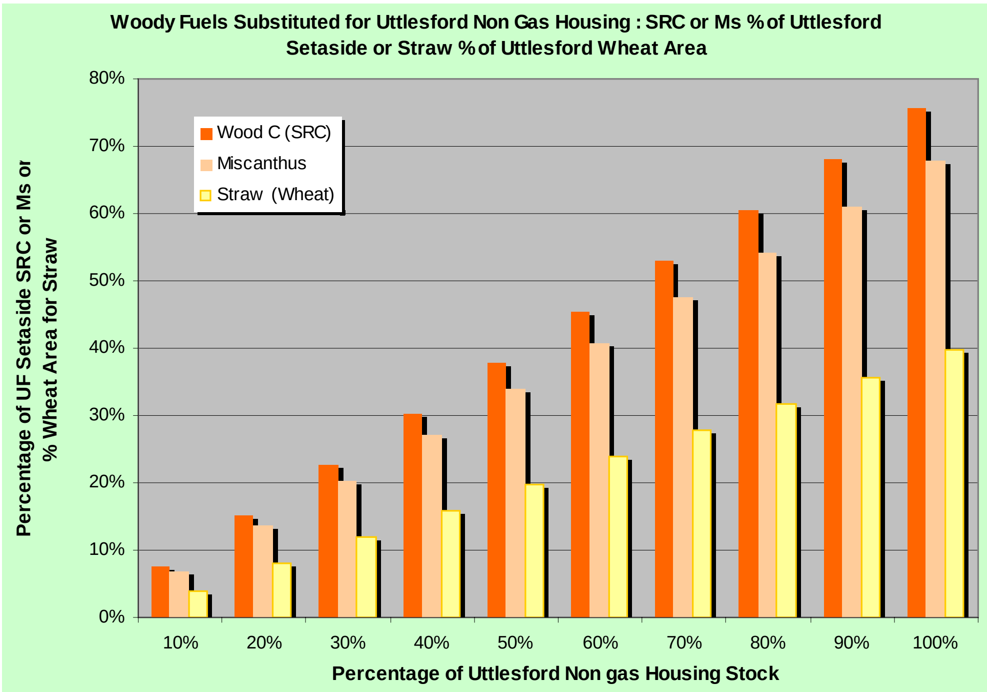


**Figure 5-18:** Proportions of Uttlesford Set-aside required to grow SRC for wood chips or miscanthus fuel & proportions of Uttlesford wheat crop land for straw for supplying 10% to 100% Uttlesford non-gas housing stock with space & water heating demand reduced by 30% by energy efficiency measures.

The estimated annual aggregated $CO_2$ emissions abated for the non gas housing would be of the order of **71,700 tonnes $CO_2$ per year** (or approximately **43%** of current $CO_2$ emissions from space and water heating of the aggregated Uttlesford total housing stock).

Incorporating wood or straw fuels is more involved in the case of electrically heated buildings as it involves not only a change in the type of central heating system but also the introduction of boiler, flue/chimney fuel store etc. It is difficult to predict what proportion of the above would be realisable and it may be that such properties would be more likely to opt for ground source or air source heat pumps as the preferred renewable heat option (unless group-heat or district heating systems are feasible).

### 5.2.8 Wood or Straw Heat Contracting

Elsewhere in the UK there are a number of schemes that propose to sell heat rather than wood fuel. This has become possible with the advent of reliable heat metering and electronic controls. In this model the heat supplier installs a wood fuel boiler at the customer's site and the heat supplier manages and maintains the boiler and delivers the wood fuel (often in enclosed skip-like cassettes). The customer then receives $CO_2$ neutral heating and avoids having to make the capital investment in the boiler or find fuel suppliers. It is also in the interest of the heat supplier to make sure that the fuel quality is satisfactory.

Worcestershire County Council recently embarked on such a scheme for the heating of Worcestershire County Hall.

## 5.3 Biofuel Micro-CHP

The concept of Micro-CHP (combined heat and power) was first researched in detail in the UK as a joint Open University/British Gas project in the 1980s and conceptually the idea remains tantalising. In essence a Micro-CHP unit is much like a domestic boiler that produces both heat and electricity needs (**Figure 5-19**).

The main effort in Micro-CHP has been with gas as the fuel used and this appears to make sense when so much of the UK housing stock is heated by gas, however if biofuels could also be used for Micro-CHP then the $CO_2$ emissions abated per kilogram of biofuel would be greatly increased and should also potentially increase the value of the energy savings achieved from using biofuels. It also offers the potential to use Micro-CHP for the non gas housing stock and achieve even greater decreases in $CO_2$ emissions.

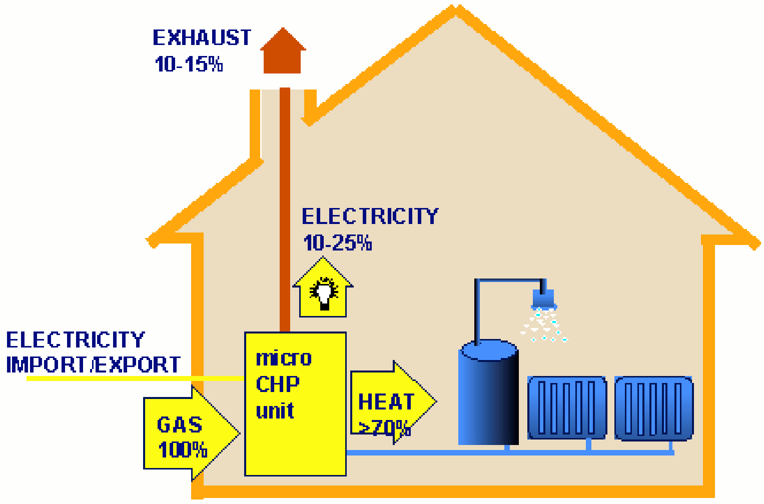


**Figure 5-19**: Schematic energy flows in a Micro CHP system (source EA Technology)


**Figure 5-20**: (a) Whispergen Stirling Engine (Whispergen) (b) Honda Micro CHP system (Honda)

If Biofuel Micro-CHP units are able to be installed in sufficient numbers and are also based on responsive prime movers and if they are also linked to smart meter based dynamic controls (and with buffer heat stores) then they can also be used to alleviate the variable outputs from wind power and facilitate a higher proportion of grid connected wind generated electricity.

Achieving viable small and Micro-CHP systems operating on biofuels has been problematic however - particularly those using wood or woody type fuels. One of the main limitations is that the electricity to heat ratios tend to be high so they tend to produce large amounts of heat (in many case 5 or 6 times more). Nonetheless in properties with large relatively continuous heat demand biofuel Micro-CHP units may be appropriate.

Biofuel Micro-CHP units are not widely available at the present time but there is considerable research taking place in Denmark, Austria, Japan and North America as well as in the UK.

These Biofuel Micro-CHP units are using a range of prime movers usually based on Stirling engines or Rankine engines and Fuel Cell based units (**Figure 5-20**). The appeal of the Stirling and Rankine engines is that they are external combustion engines and as such can in principle work with a range of different sources of heat including heat from a biofuel boiler or burner.

The Stirling engine is probably the most practical to consider for domestic purposes (until fuel cell based Micro-CHP units became cost effective). A number of Stirling engine based Micro-CHP units are being developed that are intended to operate on wood pellets. Some are also being configured to operate on biodiesel and straight vegetable oils (SVO).

As well as the external combustion engines, more conventional internal combustion engines can be used when liquid or gaseous biofuels are available. Some of the diesel-engine based systems are able to operate on biodiesel and a number of small and Micro-CHP units are being developed which can operate with straight vegetable oils.

Using SVO in conventional diesel engines can be problematic because of the glycerine content and is not recommended by most diesel engine manufacturers. A number of engines are available though few 'turnkey' systems are available as yet, however, given the ease of using straight vegetable oils, it seems probable that such systems will become more accessible - particularly with the growing interest in Biodiesel and even in SVO for vehicles.

**Figure 5-21:** Field of oil seed rape. (Altechnica)

The main source of indigenously produced vegetable oil is produced from oil seed rape (OSR) (**Figure 5-21**) and currently some 5,100 hectares of OSR is grown in Uttlesford. At current yield rates this represents around 6.5 million litres of rape seed oil[8]. This is mainly destined for food uses or as animal feed supplements and the health benefits of cold pressed rape seed oil are becoming more recognised as it is very high in omega 3 oils. Nonetheless a proportion could be used as a liquid fuel either as biodiesel or with much less processing as SVO and there are small scale oil seed presses available that can facilitate local production and the residue can be used as an animal feed - which helps to balance food versus fuel aspect of crops used for fuel. There is also scope to use OSR straw as a fuel either in baled form or as straw pellets (or briquettes).

In addition there could also potentially be production of OSR on a proportion of Uttlesford Set-aside. If 50% of Uttlesford Set-aside land was used for OSR, this would potentially yield around **3.5 million litres of oil/year** with an energy content of around **35,000 MWh/y**.

To research the potential for vegetable oil based Micro-CHP the numbers of households that could potentially be provided with electricity and heat (or a proportion of each) was explored.

If we assume an electrical efficiency of 25%, this would provide for around **1,900 households** (assuming UK average household electricity consumption of 4.7 MWh/y) and around **1600** on the basis of heat provision (assuming the 30% reduction in space and water heating demand measures proposed by Uttlesford DC). Taking energy efficiency measures a stage further and reducing average electricity demand to 3 MWh/y would increase the numbers of households supplied to around **3,100** and if the space and water heating demand were reduced by 50% the number of households provided with OSR Micro-CHP heat would be a around **2,300**.

If 50% of the current annual production of approximately 6.5 million litres was also used for this purpose, then the total number of houses that could be supplied would be increased to around **5,900 households** on the basis of electricity provision or around **4,500** on the basis of heat provision (assuming a 50% space and water heating demand reduction from energy efficiency/conservation measures) or around **2,200 households** at current levels of average space and water heating.

This level of OSR based Micro-CHP would abate of the order of **10,000 tonnes of $CO_2$/year**[9] offsetting electricity (assuming Building Regulations emission factor of 0.422 kg/$CO_2$[10]) and of the order of **9,560 tonnes of $CO_2$/year** from the Micro-CHP heat provision (assuming Building Regulations emission factor of 0.018 kg$CO_2$/kWh) assumed to be offsetting gas fired boilers at 90% efficiency).

[8] Biodiesel can be used in place of certain heating oils and so could be used in certain oil fuelled boilers and whilst this would be a straightforward conversion process, there are concerns about the use of liquid biofuels for heating when they may have more benefit when offsetting electricity generation (CHP) or vehicle fuels.

[9] There is some concern about the greenhouse gas implications of using rape seed biodiesel (and wheat based bioethanol) due to higher nitrogen dioxide emissions (derived from the nitrogen fertilisers used to grow the crop) which may have a larger greenhouse gas impact. It may be that this effect can be negated if catalytic converters are employed. It may also possibly be negated if the OSR can be grown organically though this is unclear.

[10] This emission factor was assumed (rather than 0.568 kg/kWh recommended for displaced electricity) to take account in part of the emissions involved in producing the OSR oil, though the $CO_2$ savings may be lower if they are able to be more accurately accounted for. The impacts may be minimised if it is possible to produce reasonable yields of OSR with an organic low input approach. One would also need to factor in transport emissions.

Additional $CO_2$ abatement could also be achieved if a proportion of the OSR straw is also used as a fuel either in baled form or as OSR straw pellets or briquettes.

Assuming typical yields of 1.5 ODT/hectare would give an annual aggregated yield of the order of **4,200** oven dry tonnes (ODT) per year if 50% of Uttlesford Set-aside was used for growing OSR. At an energy density of 13.5 GJ/tonne yields a fuel with an energy content of the order of around **15,800 MWh/y**. If this amount of OSR straw was converted to straw pellets and used in appropriate boilers, they could be used to provide space and water heating for around **750 houses** at current space and water heating demand or around **1100 houses** if demand reduced by 30% by means of energy efficiency/conservation measures. Similarly if the space and water heating demand was reduced by 50% then this would supply around **1500 houses**.

If OSR straw from 50% of estimated current production of OSR was also converted into straw pellets, this would provide space and water heating for around **700 houses** at current space and water heating demand, **1,000 houses** (assuming 30% reduction in space and water heating demand) or around **1,400 houses** (assuming 50% reduction in space and water heating demand was achieved).

Using OSR straw pellets from 50% Set-aside and 50% of current OSR production would together abate around **9,200 tonnes of $CO_2$/year** assuming that 80% efficient oil fired boilers were offset by the OSR straw pellets.

Therefore, on these assumptions using 50% of current OSR crop and OSR grown on 50% Uttlesford set aside land would be likely to achieve a combined abatement of the order of **28,000 tonnes of $CO_2$/year** or equivalent to around **17% of $CO_2$ emissions due to Uttlesford household space and water heating**.

If OSR Micro-CHP becomes a more widely available technology, then it could potentially provide a useful contribution to renewable electricity generation and heat provision from a locally produced biofuel resource and also make a contribution to reducing $CO_2$ emissions within Uttlesford.

Another factor that would need to be taken account of however is competition for biodiesel for road vehicles. It is unlikely to be major competition for the use of SVO in road vehicles however because even with use of conversion kits it is a complicated process to run a vehicle on SVO as it has to be started and stopped when running diesel/biodiesel.

An important factor that is causing concern with biodiesel for vehicles is that if its use expands significantly then much of it may be provided by oil from palm oil plantations that have displaced tropical rain forests. This would clearly be contrary to what was advocated by the use of vegetable oil as fuel but it is a factor that would need to be considered if vegetable oil based Micro-CHP technologies become popular.

## 5.4 Crop Residues

### 5.4.1 Straw Derived Briquettes

The energy density of straw bales is relatively low and bales are bulky and difficult to handle away from farms. The possibilities for converting straw into pellets was discussed in an earlier section but there may also be some scope for briquetting[11] of straw[12] and other crop residues for use as a local heating fuel. This is a successful approach in various overseas countries, but has not been widely applied in the UK in recent years - though briquetting of sawdust and other waste materials became widespread in Europe and the USA during World War II.

Small scale briquetting equipment is available in the UK so it is possible to envisage localised seasonal on-farm briquette production of straw briquettes (or briquettes made from other crop residues or wood wastes) using briquette presses leased from equipment hire companies or co-operatively owned by a group of farmers. Alternatively the processing could also be carried out by briquetting contractors.

### 5.4.2 Straw Fuelled District CHP

As was mentioned previously, some **28,000 hectares** is allocated to growing cereals including **26,600 ha for wheat** in Uttlesford.

Whilst there is the possibility to utilise this as a fuel by pelletting or briquetting, another approach is to use straw in baled form in small district scale combined heat and power stations.

The accepted wisdom for community scale/district scale combined heat and power is that it is only feasible in city centre sites because of the cost of the heat mains, however Denmark has been successfully demonstrating smaller scale district CHP plan fuelled by locally supplied straw.


**Figure 5-22**: Straw bale loading at Eilean Straw Power Station
Source Open University/EPR Ely

[11] It is also a technique employed in certain forms of charcoal production.
[12] Gains in bulk densities of 2 to 10 times can be achieved by briquetting - which of course considerably increases the energy density and the energy content per unit of bulk volume of the material.

The world's largest straw-fired power station is the 36 MW Eilean power station located at Sutton near Ely in Cambridgeshire (**Figure 5-22**). This is fed by around 200,000 tonnes of straw per year in the form of 550kg Hesston straw bales from large farms within a radius of 80 km of the power station. This is not a CHP based station though there are plans to use the waste heat in the future.

The Eilean power station has demonstrated the viability of straw fired electricity in the East Anglian context and has developed a system of collection, delivery and storage of straw for energy purposes. However it is a much large scale than would be needed for the Uttlesford situation.

Denmark has established a large number of district heating and combined heat and power systems and all of the cities have such networks, but more recently networks have been established in towns and are also being developed for villages and neighbourhoods.

The district heating and CHP plant use a variety of fuels, but since the 1980s the Danes have been researching, and demonstrating various biomass based technologies including straw. There are 58 straw fired district heating stations and six straw fired CHP stations currently operating in Denmark with a seventh under construction (**Figure 5-23**). Four of the CHP stations have rated electrical outputs under 10MW, ranging from 2.3 MW to 9.3 MW with straw consumption for these four CHP stations being around 12,500 to 40,000 tonnes per year.

**Figure 5-23:** Danish Straw fired district heating plant.

This being the case the potential scope for utilising straw fuel in this way in Uttlesford was explored in a preliminary analysis.

Whilst it may not be feasible to consider utilising all of the potential straw production (there are competing uses and some may be being used at the straw fired power station at Ely), it is useful to evaluate the totals.

At current yield rates 26,600 hectares of wheat would yield some 86,000 ODT of straw per year. Assuming a nominal energy content of around 13.48 GJ/tonne this yields an energy content of around **323,400 MWh/y**. If we assume an electrical efficiency of around 20%, this would yield some **64,700 MWh/y** of electrical output. This would provide for around **13,700 households** assuming the UK average electricity consumption of 4.7 MWh/y. If we were to add in the OSR straw from 50% of the OSR crop and OSR grown on 50% Uttlesford Set-aside, this would increase the electrical output to around **70,700 MWh/y** or enough to provide for around **15,000 households** at 4.7 MWh/y average household consumption. This amount of straw-CHP derived electricity (**70,700 MWh/y**) would offset around **29,800 tonnes of $CO_2$/yr**. If the average household electricity demand was reduced to around 3 MWh/y (by switching to more efficient devices and switching off appliances etc.) then some **23,500 households** could be supplied.

In terms of heat output, **86,000 ODT** of straw per year would yield around **161,700 MWh/y** of CHP derived heat (assuming 50% efficiency for the heat component) and would provide heat for around **7,350 households** at current average space and water heating demand. Again, if we were to add in the OSR straw from 50% of the OSR crop and OSR grown on 50% Uttlesford Set-aside, this would increase the heat output to around **176,900 MWh/y** or enough to provide for around **8,000 households** at current average household space and water heating consumption. This amount of straw-CHP derived heat (176,900 MWh/y) would offset around **34,100 tonnes of $CO_2$/yr** (assuming 90% efficient gas boilers were offset). If we assumed that space and water heating demand was reduced by 30% as proposed by Uttlesford DC, this would then provide for around **11,700 households** or around 46% of the Uttlesford housing stock. If the space and water heating demand was reduced by 50% below current consumption, then this level of heat could in principle provide for around **16,000 households** or around 60% of the Uttlesford housing stock.

The combined $CO_2$ abatement resulting from both the electricity and heat from the straw-CHP would be of the order of **64,000 tonnes $CO_2$/year**.

It seems improbable that all of the straw would be used, so if we assume that only 50% of the wheat straw is used for fuelling straw fired CHP units, this would result in around 32,300 MWh/y of electrical output and around 80,800 MWh/y of heat output. Adding in the OSR straw from 50% of the OSR crop and from OSR grown on 50% Uttlesford Set-aside, would increase the electrical output to around **38,400 MWh/y** and heat output **to 96,100 MWh/y**. This amount of annual electrical output would supply around **8,170 households** (at 4.7 MWh/y) or **12,800 households** (around **46%** of Uttlesford households) at 3 MWh/y average consumption. This amount of heat output would supply around **4,360** households at current average space and water heating demand, **6,400 households** (assuming 30% reduction from energy efficiency measures) or **8,700 households** (around **32% of Uttlesford households**) if average space and water heating was reduced by 50%. These amounts of straw CHP derived electricity and heat are estimated to abate around **16,200 tonnes $CO_2$/y** and **18,500 tonnes $CO_2$/y** respectively.

According to these estimates there would appear to be merit in giving consideration to establishing straw fired CHP stations in the larger settlements in Uttlesford, taking into account transport and delivery implications. These latter factors may mean that a Straw-CHP unit is located on the periphery of the settlement rather than in a more central location that would be more likely with conventional gas district scale CHP units.

As with any biofuel, its viability depends on the fuel being available into the future, but given the current strong prices for wheat, it would seem probable that cereal farmers will continue to grow wheat and the area allocated to wheat production may well increase. There may also be more of a switch to growing oil seed rape which can also provide straw.

However there may be competitive uses for the straw and there is interest in using the straw for paper making, straw based board, straw based insulation and fibre based products so these would need to be taken into account.

There may be issues about sustainability with regards to monocultural farming; soil degradation; dependence on chemical fertilisers, pesticide and other inputs; degraded biodiversity - unless farmers revert to mixed farms and organic farming techniques though this may result in lower yields.

One advantage of using straw as a fuel is that it does not involve substituting a food crop with a fuel crop though that does mean more land is required for a given amount of energy. The main disadvantages of straw as a fuel are its relatively low energy density in the form of bales; its potential corrosiveness when burnt - requiring appropriate materials and filters in furnaces.

Straw combustion does result in higher levels of ash and clinker compared to wood fuels though it is high in phosphates and other nutrients making it a useful fertiliser. Components of the ash/clinker may also have further economic value and climate change benefit as they may potentially be useable in the manufacture of low $CO_2$ 'eco-cement' or 'eco-concrete' products.

A number of factors will influence viability and these include the numbers of houses to be heated and willing to be connected) and ease of laying the heat mains. Transport and delivery access will be especially important because of the low energy density of straw, but Anglia Straw Ltd has managed to handle large quantities of straw from various parts of East Anglia to deliver to the straw based power station in Ely. This is very much larger than the types of relatively small scale Straw CHP stations of the kind developed in Denmark which would probably be the most likely types of Straw CHP stations for Uttlesford, rated at a few MW - depending on appropriate load factors.

In the Danish experience the maximum distance that hot water from a District Scale CHP station can be transmitted is around 24 km (15 miles) which means that such systems would be feasible in terms of geography for the towns and larger villages of Uttlesford. What is uncertain is how many houses would be needed to be viable, however if there are activities or enterprises that can make use of large quantities of hot water such as swimming pools or heated horticultural activities then the viability increases.

It would also improve the viability of such schemes if large scale heat stores (or accumulators) were also included as this allows the CHP station to be decoupled from the need to follow the heat demand pattern and to generate electricity at times when the price of electricity is highest and thus earn more revenue.

Such Straw-CHP (and conventional gas CHP) and heat mains together with heat stores could also form the basis of a distributed energy network which can facilitate the introduction and addition of other renewable energy technologies, as well as facilitate the establishment of 'Private Wire' networks on the lines of that implemented at Woking in Surrey.

Straw-CHP could provide a possible means of low carbon electricity for non gas communities or they could operate in tandem with gas-CHP stations in a distributed network in the settlements with gas available.

# 5.5 Food & Green Wastes

## 5.5.1 Food wastes and Green Wastes

Food wastes in the UK represents another potential biofuel resource. There are a number of techniques for recovering the energy from food wastes depending in part on the component parts of the food wastes in question.

### 5.5.2 Fermentation/Distillation

If the food waste is regularly made up of waste potatoes or other starch or sugar rich food wastes, the fermentation and distillation into ethanol may be worth considering.

### 5.5.3 Abrasive Drying of Food Wastes

Another option is that of heat treatment combined with 'abrasive drying' under controlled conditions in a batch process over a 24 hour period to yield a dry powder biomass fuel product which can be burned in boilers or furnaces. This technology has the ability to process food and non-recyclable packaging waste without segregation, but if the fuel is to be classed as a renewable biofuel, then it is preferable to separate the food waste at source or collect food wastes separately. As well as the dry powder biofuel, the process generates a wet effluent stream that has to be disposed of or treated appropriately.

## 5.5.4 Anaerobic Digestion of Food Wastes & Green Wastes

The other main method that can environmentally treat food wastes and at the same time produce a high value biofuel (biogas) is known as Anaerobic Digestion (AD). In fact the Anaerobic Digester (also sometime called bioreactors or fermenters or biogesters or biodigesters or biogas digesters) could be considered an analogue of a cow's stomach in which the bacteria break down the food wastes without the present of oxygen and this make the process different from conventional 'composting' techniques which utilise aerobic bacteria that require the presence of oxygen to function effectively.

Anaerobic Digestion has been known about for many years and is the biological process that makes a 'septic tank' function and also is employed in sewage treatment works. When the biogas is captured it is known as sewage gas, however gas production has tended not to be optimised as it is a secondary by-product of the process - which is to biologically treat sewage. AD has also been successfully employed to biologically treat animal manure on farms and in centralised or community digesters - particularly in Denmark and Germany.

Biogas is largely methane (with some carbon dioxide) which is the same gas as natural gas so it can be used for the same purposes as natural gas and use the same types of burners etc. It can be used in boilers for heating purposes or used in internal combustion engines employed in combined heat and power plant so it can be used to produce renewable electricity and heat. When compressed, biogas can also be used to power vehicles using the same type of equipment used in CNG (compressed natural gas) vehicles so it might be possible to use it to fuel the waste/recycling collection vehicles to improve or neutralise the energy/$CO_2$ balance of the waste/recycling system.

> There are two types of anaerobic digestion processes employed and these involve either mesophillic or thermophillic digestion. The main difference is the temperature at which the process operates.
>
> *Mesophillic digestion.* The digester is heated to 30 – 35 °C and the feedstock remains in the digester for 15 to 30 days. Gas production is less than that produced by the thermophillic digestion process and larger tanks are required, but it is a more robust process compared to thermophillic digestion.
>
> *Thermophillic digestion.* With this method, the temperature is maintained at 55 °C and takes typically 12 to 14 days. Gas production is greater and the process is much faster than mesophillic digestion. It achieves a more effect elimination of pathogens and viruses. Traditionally the thermophillic digestion process has required a greater energy input (but this could be reduced with better use of insulation) and involves more expensive technology and greater control.

Food wastes and other biological wastes sent to landfill are also digested by anaerobic bacteria and produce a form of biogas known as landfill gas. However this is taking place in less than ideal conditions so if the same process can be carried out in a properly designed and managed Anaerobic Digester, useful renewable energy can be utilised. In addition the residues can be used for fertiliser, soil conditioners and as an environmentally benign substitute for gardening peat - all of which can add value and secondary environmental benefits.

Food wastes has a much higher energy content compared to sewage or animal manure so utilising AD to treat food wastes generates much more biogas compared to the digesters used for those purposes. AD can also be used to digest other biological wastes such as garden wastes (although this has to be used in appropriate amounts relative to the food wastes components for the digester bacteria to function optimally), and un-recyclable paper, and may even be able to handle certain wood wastes.

Food waste based anaerobic digesters have been used widely in Denmark and Germany and there are examples in operation in the UK, particularly in Ludlow, Holsworthy and Bedfordshire and several others are planned.

To work effectively the food wastes need to be separated at source and fortunately Uttlesford have implemented a separated food waste collection scheme, so this offers the possibility to consider anaerobic digestion of this waste stream.

The South Shropshire Biowaste Digester in Ludlow (**Figure 5-24**), developed by Greenfinch Ltd and South Shropshire District Council is designed to process source separated kitchen and garden waste and is capable of handling 5,000 tonnes/year of this type of waste. The council has developed a plan to cover 60% of the households in the area.

**Figure 5-24:** South Shropshire Biowaste Digester - food waste anaerobic digester CHP plant. Source: Greenfinch & South Shropshire District Council

### 5.5.5 Food Wastes AD Based CHP Unit for Uttlesford

If we use the South Shropshire Biowaste Digester project as a guide we can evaluate the potential scope for utilising Food Waste Anaerobic Digestion in Uttlesford.

According to figures supplied by Uttlesford District Council, there were some 1,843 tonnes of Kitchen Waste and 1,011 tonnes of Green Waste separately collected between April 2006 and March 2007.

If we use these figures as a guide, we can estimate the likely biogas yield together with the potential electricity and heat output that might be feasible if the biogas was consumed in a combined heat and power plant, and if we assume that 50% of the Kitchen Waste and 50% of the Green Waste was used in the AD, this would be anticipated to yield around 250 tonnes of biogas with a fuel value of around 5,070 GJ/year. Assuming similar conversion efficiencies as at the South Shropshire digester, this would generate around **390,320 kWh/y** of net electricity (allowing for some electricity to be used at the plant) and around **574,420 kWh/y** of net heat output (allowing for some heat to be used at the plant). As mentioned previously, it would also make sense to include some form of thermal store (or accumulator) to permit the electricity generation to take place independently of the heat demand pattern so as to maximise the value of electricity exported and the biogas can also be stored for use at particular times of day.

This level of electricity (390,320 kWh) would abate approximately **220 tonnes $CO_2$/year** (assuming an emission factor of 568 g/kWh for displaced electricity or assuming a similar emission factor to wind farm generated electricity (e.g. 860 g $CO_2$/kWh) then the $CO_2$ emissions abated would be of the order of **330 tonnes $CO_2$/year**) and supply electricity for around **80 households** at current UK average household rate (4.7 MWh/y) of electricity demand and around **130 households** if average electricity consumption was reduced to 3 MWh/y.

This level of heat output (574,420 kWh) would abate approximately **1,210 tonnes $CO_2$/year** (assuming 90% efficient gas boilers with an emission factor of 190g/kWh) and supply approximately **26 households** at the average household space and water heating demand, or **37 households** if space and water heating demand was reduced by **30%** by adoption of the energy efficiency/conservation measures recommended by Uttlesford DC. If household average space and water heating demand was cut by **50%** by further measures the number of households supplied would then be around **50**.

Of course if all of the kitchen waste and green wastes were utilised then that would more or less double the above estimates.

It would also be potentially possible to increase the renewable energy outputs by also digesting carbohydrate-rich crops specifically grown to be digested. These could be grown on Set-aside land or as a catch crop between growing seasons. It is also possible to grow grass (or silage) or use grass mowings as an energy crop for this purpose (as an AD mimics a cow's stomach).

The Uttlesford kitchen waste and green waste is currently composted in a so called 'in-vessel' composting system, so whether this could be terminated in favour of substituting with an AD system or operated in parallel would need to be clarified, but there would appear to be useful benefit from the point of renewable energy provision, $CO_2$ abatement and energy saving to give some consideration to such a setup.

Also depending on the proximity of the plant to hard to heat houses and listed buildings, such a scheme would assist in reducing the $CO_2$ emissions from this difficult housing stock group.

Such a Food Waste AD based CHP unit could also form part of a distributed heat and electricity network in combination with the Straw fired CHP discussed earlier, or more conventional CHP and link up with other renewable energies such as car port solar, solar streets, neighbourhood/community wind power and group scale ground coupled energy/ground coupled inter-seasonal storage or solar/ground coupled roads.

## 5.6 Conclusions

Clearly there are opportunities for exploiting biofuels in Uttlesford and the resource has substantial possibilities, however the barriers and difficulties involved in realising these opportunities are not trivial but not insurmountable.

Apart from traditional uses of firewood, biofuels have to be considered as a new range of fuels and as such suffer from the usual problems experienced by new and unusual products and commodities; e.g. consumer resistance and a reluctance from the point of view of fuel suppliers to commit to production until there are enough consumers.

The main benefit of biofuels compared to the majority of other renewable energy sources (which deliver their useful energy according to the variations in the weather) is that they are storable fuels containing stores of chemical energy which with the appropriate equipment can be released more or less on demand[13]. As such biofuel derived electricity may be more valuable.

This benefit of biofuels is also one of its disadvantages, which is that it is a fuel and it has to be harvested, stored, possibly dried, processed, transported and burned. As such it incurs extra costs which undermine its economic viability when competing with conventional fuels whose prices generally do not reflect their external costs. Therefore if biofuels are to be used on a much more significant scale then they will often need to be supported in some way. This is beginning to be recognised and there are grants available periodically for growing short rotation coppice and miscanthus energy crops.

One of the barriers to wider uptake of wood chips for heating is the perceived extra effort involved in purchasing, storing and loading the fuel and ash removal. This is less of a problem with medium and large scale boilers for community heating or large projects where its management can be planned.

Wood pellets are a much more accessible and manageable fuel and wood pellet boilers can be incorporated into domestic properties. If small scale wood pelletisation can be established in Uttlesford, then there the use of wood pellet fuel may be expected to expand as it can be competitive with oil fuelled boilers. There are also pellet burners that can be fitted into certain existing insitu oil boilers, so it could potentially be utilised without having to replace an existing boiler.

The $CO_2$ abatement benefits of biofuel boilers are now in the building regulations, since 2002 so it is likely that more wood fuel boilers will be specified for new buildings.

Capital cost of wood fuel boilers may also be eligible for capital tax allowances for organisations subject to the Climate Change Levy, so this may also encourage more wood fuel boilers to be installed.

Current wood pellet suppliers comply with a code of practice to ensure quality of fuel, but wood chips can be highly variable. It is therefore important for those specifying or contracting the purchase of wood chips, to specify the fuel quality, maximum acceptable moisture contents and fuel storage requirements very

[13] Though this is not so feasible for traditional CHP units as electricity generation usually follows heat demand.

carefully. Accreditation of wood fuel suppliers would help to avoid potential fuel quality problems.

Apart from growing woody energy crops, if wood fuels are to be exploited in Uttlesford in any significant way it may mean extracting wood fuels from some of the existing Uttlesford woodlands. This would need to start off at the small to medium scale which will be based on marketing fuel wood chips or via ESCO[14] schemes which involve the selling of biofuel derived heat.

Wood chips will need to be subject to quality standards and will need the development of marketing channels. There are a number of organisations such as Anglia Wood Fuels who are working to improve the supply chain and overcome the chicken and egg problem of wood fuels. In addition there are a number of wood product networks that could potentially provide the basis of this service, but there may also need to be additional support from local authorities.

Wood-fuel heat service contracts have a number of advantages for medium and large scale heat projects as the consumer(s) do not have to fund the capital investment needed to purchase a wood fuel boiler or carry out the maintenance and loading or managing the boiler and heating system. Community Heating projects may also be eligible for grant support.

The ESCO approach may be also an approach that can facilitate the development of wood fuel CHP. There have been difficulties in the development of wood fired CHP systems but there are a few technologies that appear to be promising depending on scale. These include steam engine based technologies, a number of which are available and the Danes are developing systems in the 1 MW range. There are also a number of systems that employ hot gases from a wood fuel furnace to drive a modified gas turbine based system including a 1 Mw system being developed in the UK. One technology that has appealed to biomass CHP technologists for some time is the gasifier which employs a similar approach to that used to make town gas from coal until the discovery of natural gas in the North Sea. The solid fuel to be used is heated in appropriate conditions to yield a gas rich in hydrogen and carbon monoxide which is then burned in an engine or burners. Whilst several million were used in World War II, it has been difficult to operate the technology reliably at a small to medium scale. However Danish research appears to have solved the problems of wood gasification so it may become more a feasible option.

There could be scope for neighbourhood or village scale local heat networks in parts of Uttlesford as in Holsworthy in Devon or in Woking but the cost of laying heat mains would have to be viable or supported.

Similarly there may be scope for such schemes on some farms or large country estates that have their own wood supplies.

If such schemes include heat stores, it would, at least in theory, offer the possibility of earning higher revenues from the sale of electricity to meet peak demand, when electricity companies may be prepared to pay higher prices for electricity generated. A heat store would be needed to reverse the usual mode of CHP operation that follows heat demand.

If such schemes are combined with solar thermal collectors and PV modules, the CHP can be shut down in the summer months to make better use of the fuel supplies.

[14] Energy Services Company (ESCO).

There is growing interest in the use of wood fuels and if this can be exploited successfully to build enough exemplar projects in Uttlesford, then it has a chance of becoming established.

Apart from the short rotation coppice, miscanthus may be easier to introduce as an agricultural crop. Both these types of energy crop mean that the land is no longer producing food and could change the appearance of the landscape if introduced on a large scale. In the Uttlesford environment there may be some scope for expanding intensive wood pasture which could (subject to current livestock farming issues) provide income from both agriculture and wood fuels. Planting may be able to be supported by the English Woodland Grant Scheme (EWGS) and possibly via Biodiversity Action Plans. Likewise the planting of woodlands as an ‘energy forest’ with a mixture of fast growing species could be another model which may be supported by the EWGS.

Assuming cereal farming continues at current levels (and depending on competing uses), the use of straw seems to be the most important form of biofuel within Uttlesford. The conversion of straw into a pellet fuel (or briquetting for a 'log type fuel') may be a way to improve the energy density of straw fuel and, provided this is also accompanied by clear advice about its appropriate use together with suitable straw pellet capable (stoker) boilers being made available, this method of heating may be able to substitute for oil and solid fuel heated households in Uttlesford.

The straw fuelled power station near Ely has demonstrated the viability of using straw for this purpose in the East Anglian context. The Danish experience with 58 straw fired district heat stations and six straw fired CHP units has shown that district scale straw fired CHP is a viable technology for utilising straw to produce electricity and heat at scales that may be appropriate for the Uttlesford context.

Preliminary analysis of the potential for straw-fuelled CHP in Uttlesford indicates that such an approach using an indigenous biofuel would possibly appear to make a substantial contribution to the household electricity needs and a significant contribution to the space heating needs in at least the urban parts of the settlements in Uttlesford. If 50% of estimated current straw yield was able to be used in this way, then this could provide over 8,000 households in Uttlesford (assuming UK average household electricity consumption) and provide space and water heating needs for over 4,000 households (at current space and water heating demand rates). Such an approach can achieve major reductions in $CO_2$ emissions from offsetting electricity from substituting for household electricity, space and water heating needs including hard to heat/insulate houses and listed buildings.

Vegetable oil extracted from oil seed rape (OSR) is a biofuel that has potential for use in types of Micro-CHP units either in the form of biodiesel (which requires some processing) or so called straight vegetable oil (SVO) (minimal processing). Using locally produced biodiesel or SVO in Micro-CHP units improves the $CO_2$ abatement characteristics of these technologies and in addition also increases the amount of $CO_2$ abated per kilogram of biofuel. Micro CHP technologies are mainly at the demonstration and field trial stage of development but, assuming they become available, OSR oils grown in Uttlesford could potentially reduce $CO_2$ emissions for household electricity and heat needs. Unlike SRC or miscanthus, which preclude the production of food from the land, the oil seed residues can be used as an animal feed.

Food wastes and garden wastes represents another useful potential biofuel resource, the anaerobic digestion of which provides environmentally beneficial biological treatment whilst converting it into a valuable methane rich biogas. Food waste in Uttlesford is collected separately and according to the data provided, 50% of the annual amounts of food and garden wastes can provide biogas to operate a district scale CHP plant and potentially generate around 390 MWh/y of net electricity and 570 MWh/y of heat and abate 550 tonnes $CO_2$/y.

Both the Straw-CHP and the Food Waste AD based CHP units could form part of a distributed heat and electricity network in combination with the more conventional CHP and link up with other renewable energies such as car port solar, solar streets, neighbourhood/community wind power and group scale ground coupled energy/ground coupled inter-seasonal storage or solar/ground coupled roads.

Such combinations together with heat mains and heat stores could also form the basis of a distributed energy network that facilitates the establishment of 'Private Wire' networks on the lines of that implemented at Woking in Surrey. These types of arrangements can also provide funding mechanisms to expand the use of renewable energy technologies but also to help fund some of the more difficult energy saving measures and infrastructure.

Straw-CHP (and the Food Waste AD based CHP) could provide a possible means of low carbon electricity for non gas communities or they could operate in tandem with gas-CHP stations in a distributed network in the settlements with gas available.

Also, depending on the proximity of the plant to hard to heat houses and listed buildings, such schemes would assist in reducing the $CO_2$ emissions from this difficult housing stock group.

## 5.7 Recommendations

1. In order to break though the 'vicious circle' that inhibits the development of woody fuels a support network should be established to promote the use of good quality wood fuels and wood fuel boilers.

2. Establish a number of demonstration projects to trial the substitution of oil-fired boiler with a wood fired boiler.

3. Establish a number of demonstration projects to trial and monitor the operation of straw pellet boilers.

4. Uttlesford DC could consider a similar scheme as Worcester County Council (which has signed a wood heat ESCO[15] contract) to utilise local Uttlesford wood/miscanthus/straw fuels. Uttlesford DC could perhaps also consider wood-fuel CHP or Bio-Micro CHP schemes at some of its sites. Electricity generated could be exported for revenue and that which was to be consumed by Uttlesford DC would be exempt from the Climate Change Levy. If also used as part of Community Heating or Community CHP schemes, they may also be able to receive grant support.

5. Uttlesford parishes with large wood/straw resources should be encourage to consider introducing wood/straw fuel heating and wood/straw fuelled CHP within their boundaries, either managing them themselves or via ESCO contracts.

6. Housing Associations within Uttlesford should be made aware of the opportunities for wood fuels/straw fuels; particularly ESCO based heat (and or CHP) contracts and Community Heat or Community CHP schemes that may be eligible for support.

7. Similarly, building developers builders should be encouraged to consider provision of wood fuel/miscanthus/straw fuel boilers where appropriate.

8. Quality standards of wood fuels should be encouraged and assistance given to the development of marketing channels of wood fuels. There are a number of wood product networks which could potentially provide the basis of this service, but it may also need additional support from local authorities who could help to promote the use of local wood fuels for existing buildings but also to promote the specification of wood fuel boilers in new buildings.

9. Consider a detailed study into the potential for straw-fuelled CHP in Uttlesford and study visits to straw powered CHP and district heating schemes in Denmark.

10. The environmental benefits of processing food wastes and the like into Biogas should be promoted. Perhaps a detailed survey/census of additional potential feed stocks (e.g. carbohydrate crop wastes, supermarket/food shop/restaurant food wastes), which could form the nucleus of additional Community or Centralised Anaerobic Digestion plant, should be undertaken and study visits to such schemes in Denmark and the schemes at Ludlow,

[15] Wood Heat Energy Services Company - also know as wood heat contracting schemes.

Bedfordshire and Holsworthy could be organised. If such a demonstration scheme could be encouraged in Uttlesford, it would be important to bring on board potential retailers interested in selling the compost products and perhaps a garden centre could share the site and could utilise some of the fertiliser by-products. It would be worth looking in more detail at the South Shropshire model approach and to see if that can be replicated. The design of such a scheme should be such that it is able to receive visitors, as it would have an important educational role.

11. Consider the establishment of distributed energy networks including heat store, heat mains and private wire networks[16]. Funding for such could potentially be obtained from a variety of sources including planning levies such as the *Milton Keynes Tariff*[17] and *Milton Keynes Carbon Offset Fund*[18] and (extend the parameters of the Uttlesford DC SPD[19]) or consider one of the interest free loans schemes or grants available to support community scale renewable energy projects and CHP projects. Such distributed energy networks could also potentially be funded by establishing a public/private partnership on the lines of that established in Woking. If feasible it may be possible to consider the practicality of linking part of the Council Tax rates to $CO_2$ emissions[20] to establish an *Uttlesford Climate Change Offset Fund* which could be used to fund local insulation/$CO_2$ abatement grants and assist in funding distributed energy heat main private wire networks and heat store.

12. It is worth monitoring the developments in overseas countries of the various technologies for producing liquid fuels, as there may be potential opportunities within Uttlesford. Perhaps a survey of oil seed growers could form the nucleus of a community Biodiesel plant which can also process waste cooking oils and waste animal fats. Consider the feasibility of safe systems for separately collecting used cooking oil as part of the food collection scheme.

13. The viability of a small-scale holistic plant for producing Bioethanol from starch-rich or sugar rich food energy crops or wastes should be investigated. The by-products possible from the process include waste heat, fibre and a protein rich animal feed.

14. The development of biofuels is important from the point of view of reducing conventional fossil fuel consumption and consequent $CO_2$ emissions, but also of importance are opportunities that some of the biofuel technologies bring to ameliorating other environmental impacts and reducing material sent to land fill. These advantages should also be promoted.

15. Consideration should be given the setting up of Uttlesford *Renewable Fuel Stations* which could process a variety of biofuels (e.g. wood chips and pellets, straw pellets and briquettes, miscanthus fuel, SVO, charcoal, biogas, Biodiesel, Bioethanol, Bio-Producer Gas plus others) and allow feedstock exchange or mutual support for the different technologies. As well as generating and selling

[16] Once established such networks generate a revenue stream that can fund insulation/energy efficiency/$CO_2$ saving measures & fund the expansion of renewable energy schemes connected to the network or installed locally.

[17] An additional 'planning gain' Section 106 type of levy on developers and used to fund infrastructure developments.

[18] This consists of financial contributions to a Carbon Offset Fund to enable carbon emissions to be offset elsewhere (within Milton Keynes) under the *Milton Keynes Sustainable Construction Policy D4* which imposes carbon neutrality, renewable energy and energy efficiency targets on new developments exceeding 5 dwellings or of a gross floor area in excess of 1000 $m^2$.

[19] Consider extending the Uttlesford DC SPD (Supplementary Planning Document) to include new developments on the lines of the Milton Keynes Policy D4 above.

[20] Such that those households/properties that exceed certain levels have a higher Council Tax subject to premium rates (and those below certain lower levels receive a Council Tax Climate Change Rebate).

electricity and vehicle fuels, such a station could also provide a means of marketing some of the potential value added by-products such as animal feeds, soil conditioners, compost, liquid fertiliser, glycerine etc. If it was also integrated with a horticultural installation, some of the waste heat could be utilised with the fertiliser products. Produce from the horticulture installation could also be marketed through the station. Such stations should be allowed to evolve organically, but it would be sensible if they had a master plan to bring on stream the various facilities as and when needed or available. If designed to be suitable to attract visitors and students, such a station could help to educate and spread the word about what biofuels can offer.

There could be a variety of grants available for establishing such *Renewable Fuel Stations*, but they could ultimately become self-funding once established and could promote wider take up of biofuels. The local community could be favoured members with preferential and loyalty benefits and potentially receive discounts on fuel, energy and other related products purchased.

Such stations could generate local employment (based on a variety of jobs and skills) and stimulate other economic activity.


Altechnica
Designing for Sustainability
complete architecture + renewables design service
wind turbine design
zero energy design
building integrated renewable energy solutions
feasibility studies
renewable energy audits
85 Waterside Peartree Bridge Milton Keynes MK6 3DE
tel / fax 01908 668797
email: info1.altechnica@virgin.net