Warwickshire County Council

Warwickshire 10% Scenarios

A report commissioned by the Low Carbon Steering Group

January 2006

Encraft
46 Northumberland Road
Leamington Spa
Warwickshire
CV32 6HB
t: 01926 312159
f: 01926 772480
w: www.encraft.co.uk

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Executive summary

Just over 210 000 Warwickshire property owners and 20 000 businesses in the county spend between £400 and £500 million each year on energy and energy services. They are directly responsible for 2.4 million tonnes of carbon dioxide emissions (excluding transport).

The low carbon strategy is not about major direct investment by the county – it is rather about finding ways of influencing spending by others to optimise the county's infrastructure for the future – reducing carbon emissions at economic costs, and in a way that creates maximum long-term benefits for the local economy.

There are potentially many ways to optimise Warwickshire's energy system for the future. By modelling and comparing 14 hypothetical and distinctive scenarios in this report, each delivering 10% of either electrical or heat demand from renewable sources, we can identify major areas where energy and carbon strategy for the county should focus.

The scenarios reviewed range from large-scale wind farms through to solar systems and community combined heat and power schemes. We also model a base case option of simply allowing replacement of existing heating systems with modern condensing boilers, and a straightforward approach encouraging switching to green electricity tariffs.

The report concludes that the best ways to deliver an optimal energy system for Warwickshire in the 21st century include:

1. strengthening the role of the county and other local authorities in facilitating development of an appropriate and robust local energy system
2. using planning and selective support mechanisms to encourage economic wind, biomass and CHP schemes by preference, except where there are obvious local opportunities for other approaches (e.g., landfill gas, waste or hydro electric generation)

In the short-term, a valuable follow-up exercise for the Low Carbon Strategy Group to pursue would be to investigate in more detail a range of low cost financial and structural mechanisms that might be usefully implemented in the county. These mechanisms would provide ways for the council to influence how the £4-500 million of third party energy spend is directed locally, in line with their wider strategy.

1 INTRODUCTION

This is a brief report summarising a preliminary modelling exercise carried out for the Low Carbon Strategy Group. The purpose is to provide some objective data and scenarios to support strategy development. There is a specific focus on the comparative economics, carbon implications and supply chain consequences of pursuing alternative energy technology deployment routes across the county.

The report is accompanied by a spreadsheet model (WEMII) that is designed to be used for sensitivity analyses as necessary.

Section 2 of the report summarises the national and regional policy context within which Warwickshire's energy strategy must operate. Sections 3 to 5 review the model outputs for targets to source 10% electricity and heat from renewables, and to meet the county's share of the national target of 10GW of combined heat and power (CHP) by 2010. The model treats electricity, heat and combined heat and power separately for convenience. Section 6 discusses broad options for stimulating action, and section 7 sets out the overall conclusions from the study.

The report uses notional county targets for electricity, heat and CHP for modelling purposes only (and without target dates) although the starting point was the policy context described in section 2. For clarity, the targets used in this report are:

Electricity	10% of electricity consumed by households and industry in the county to be from renewable sources
Heat	10% of heat delivered to homeowners and industry in the county to be generated from renewable fuels
CHP	90MW of electricity to be generated in Warwickshire using CHP. The figure of 90MW is the county's share of the national 10GW target for CHP, given that Warwickshire consumes 0.9% of all UK electricity.

The assumptions and detailed outputs from the Warwickshire Energy Model (WEMII) are contained in the appendix to this report.

Important note
The economics of small-scale energy projects vary significantly around any averages generated by any modelling or statistical exercise. This is because local conditions can have a big impact on costs and performance. For example, some places are windier than others, some have more sunlight through the year, some are closer to sources of biomass or waste for fuel. Local community enthusiasm also makes a very big difference, and is worth a lot to project developers, as is the support of planning authorities. Government grants and fuel prices also change all the time.

For these reasons, this report is not intended to promote specific technologies, nor should its conclusions be taken as a blanket recommendation for Warwickshire to support any one technology at the expense of others. It is intended as a guide to strategy and policy debates, and to stimulate action to encourage implementation of a diverse and far-sighted energy strategy for the county.

Further information
If you require more detailed information about the assumptions or data used in the modelling work, or have any questions about the outcomes, please contact Matthew Rhodes at Encraft (email: matthew.rhodes@encraft.co.uk).

2 NATIONAL AND REGIONAL POLICY CONTEXT

The development of a low carbon strategy for Warwickshire takes place in the context of a major national debate on energy and climate change, including a formal consultation and review of government energy policy, due to conclude during 2006.

This makes it difficult to make definitive statements about national government policy, although the broad direction has been increasingly clear for some years. The 2003 Energy White Paper set our four goals for energy policy:

1. to put the UK on a path to cut carbon dioxide emissions by 60% by 2050.
2. to maintain reliable and secure energy supplies
3. to promote competition in energy markets
4. to ensure that every home is affordably and adequately heated.

The current review seems unlikely to change these goals, and is more concerned with the specifics of how to deliver them, probably with greater urgency and focus.

There are already firm short term national and regional targets in place as follows:

Nationally:

- for 10% of all electricity generated to come from renewable sources by 2010 (in fact this has now been subsumed into a target of 15.4% by 2015).
- for there to be 10GW of installed combined heat and power (CHP) capacity by 2010

Regionally:

- for 5% of all electricity consumed in the region to come from renewable sources by 2010 (West Midlands Energy Strategy).

The regional target reflects the reality that there are currently few large scale power stations in the region: we are a net importer of useful energy and depend on others for our supplies.

A number of UK regions have taken up quite strong strategic positions on energy, with a view to securing longer-term advantage for their businesses and local economies. For example, London (which is a net importer like the West Midlands) has established a Climate Change Agency and is altering planning laws and seeking its own building regulations to encourage small-scale local generation and business development. The North East and North West have both invested strategically in low carbon energy technologies, and Scotland has a strong emphasis on wind power development.

3 OPTIONS FOR WARWICKSHIRE ELECTRICITY SUPPLY

There are many ways to generate electricity, from the large scale (nuclear, coal, offshore wind) through very location-specific schemes, like hydroelectric turbines, landfill gas and wave power, to the very small scale (microgeneration) such as roof-mounted wind turbines and solar photovoltaic systems. The large scale and hydro/wave systems have specific resource needs which are scarce or non-existent in Warwickshire, so evaluating these was excluded for this preliminary study.

Warwickshire already generates 3% of its electricity demand from renewables. 99.9% of this is from landfill gas schemes. This contribution is expected to fall in future as landfill resource is increasingly constrained both by site capacity and legislative controls.

For this preliminary report we have concentrated on seven potential options that are immediately accessible to the county and have a long-term future. Cogeneration or combined heat and power systems are considered separately in section 5. It is straightforward to add further technical options to the model in future if required.

Summary of model outputs
The table below shows selected results from the model; there are more details in the appendix. The table ranks technologies using total cost per tonne of carbon saved. The third column shows how many permanent jobs might be created in Warwickshire were 10% of the county's electricity demand to be sourced from this technology locally, and the fourth column shows how many installations would be required. (Installations in this context means standardised installations for modelling purposes as described in the appendix).

Table 1. Initial sample of 10% electricity supply options

Option	Cost per t CO_2	Total investment	Long-term local jobs	"Typical" Installations
Industrial-scale 1.5MW wind turbines on sites > 6.5m/s	£33	£83 million	8	83
Community 600kW wind turbines on sites > 6.5 m/s	£36	£93 million	9	208
Farm-scale 6kW wind turbines on sites > 5 m/s	£142	£347 million	52	24 800
2MW community-scale biomass generating stations	£152	£108 million	97	22
Rooftop micro-wind turbines 1.5kW on sites >4 m/s	£153	£317 million	106	211 309*
Households switching to green electricity	£201	0	0	50 119**
78 sqm 10kWp solar photovoltaic (PV) electrical installations	£672	£1723 million	173	36 815

* There are only 210 000 households in Warwickshire (plus 20 000 businesses).
** One green electricity installation is 5443 kWh – the equivalent of an average Warwickshire household.

Cost per tonne of CO_2 includes running costs and capital costs apportioned over a standard lifetime for the installation. Investment is initial project costs only, and long term jobs excludes jobs created to build the installations (typically between 400 and 4000 FTE years per technology – see appendix). The jobs figure is employment within Warwickshire only.

The small-scale biomass generation option has the added advantage of requiring fuel to be sourced locally. This creates and economic opportunity for farmers, and a demand for between £5 and £6 million of biomass fuel per year, needing around 15000 hectares of land.

Conclusions from table 1
Large scale wind power provides an economically-attractive way to reduce carbon dioxide emissions in Warwickshire, to an extent limited by wind resource and planning constraints (see below). Farm-scale wind, community-scale biomass schemes and rooftop wind turbines are all comparable in cost-effectiveness to many of the heat technologies discussed in subsequent sections, and should have a role to play in suitable locations and circumstances. Rooftop turbines have probably been somewhat over-sold (see comment below) but nevertheless may have a useful role to play in public engagement.

Note on resource constraints and fit to previous work
The county commissioned an evaluation of wind resources locally in 2002. This work identified land areas within the county suitable for larger wind turbines where there are sufficient wind speeds and further qualified these to sites where there are no planning constraints. This deliverable resource amounts to an area suitable for up to 178 1.5MW turbines or 445 600kW turbines. This means the target numbers of installations at each of these turbine sizes to achieve 10% renewable supply (83 and 208 turbines respectively) are both in principle deliverable for Warwickshire and well within resource capacity.

Comment on rooftop wind turbines
The relative availability of wind resource for the larger turbines is not true for the rooftop machines, which the model suggests are unlikely to contribute more than 10% of county electricity even if installed on all homes. This is because the wind speeds in urban areas and near buildings in Warwickshire are rarely likely to exceed 5 m/s on average over the year. Our view is that the model assumption of 4 m/s for these machines on average, while slightly conservative, is also realistic.

Benefits of smaller systems
The great advantage of these smaller systems, though, is one that should not be understated from a public policy perspective. Their advantage is that they are relatively attractive and accessible to individual homeowners, who are thus often willing to finance their installation and operation to a far greater extent than the bigger machines. Small rooftop systems thus potentially provide a good starting point for any strategy; they are an effective way to engage homeowners; and they may ultimately contribute perhaps 1 or 2% overall to county targets.

4 OPTIONS FOR WARWICKSHIRE HEAT SUPPLY

Heat does not feature as much in the energy debate as it should, since it accounts for well over half of the typical domestic energy bill, and also for the largest share of national non-transport energy use. Lack of affordable warmth in the winter is what can kill people and drives the fuel poverty agenda.

Electricity can be used for heating but is an expensive and (usually) environmentally inefficient way to heat buildings. It is in common use because the capital costs of electrical heating are often much lower than gas systems, although the running costs are 3-4 times higher. These costs fall on residents rather than developers, however.

For the purposes of the preliminary model, therefore, we have concentrated on the more efficient gas, solar and biomass heating options (with combined heat and power community systems considered in section 5). It is also important to note that the target is expressed as 10% of delivered heat, not fuel input. This aloows the benefits of improving system efficiencies to be modelled. (For example, if a house currently uses 10000 kWh of gas a year to deliver 6000kWh of actual heat (because it has an old boiler operating at 60% efficiency) the target is to supply 600kWh of this heat from renewables – i.e., 10% of 6000kWh, not 10% of 10000kWh).

Heating is more complex to model than electricity because traditional gas boiler efficiencies have improved significantly in recent years. This means that simply replacing old boilers with modern condensing boilers (which is now mandated through building regulations) will reduce fossil fuel demand from Warwickshire homes without any further local action. We show this option in table 2, alongside the two renewable heating options. In fact the model shows that this approach would require more condensing boiler installations than homes: it is not efficient or effective if carbon reduction is the main goal.

Table 2. Initial sample of 10% heat supply options from renewables or efficiency

Option	Cost per t CO_2	Total investment	Long-term local jobs	"Typical" installations
Domestic woodchip-fuelled boilers (15kW)	£101	£136 million	26	28 953
Rooftop 4.2 sqm solar water heating systems	£155	£469 million	45	223 220**
Domestic condensing boilers (8kW, A-rated) – same CO_2 emission reductions through efficiencies alone.	£649	£322 million	198	247 892**

** this is more than the number of households in the county (210 000).

Table 2 does not include more complex heating options, such as ground or air source heat pumps, heat recovery ventilation, or insulation measures. This was purely due to the need to focus the scope of this preliminary exercise, and these could be modelled in a future exercise if required.

We also modelled a base case (table 3) to show what investment would be required to deliver 10% of Warwickshire heat simply using modern condensing boilers. This base case still reduces carbon emissions, but only by around a fifth compared to all three options shown in table 2.

Table 3. Base case – how much would it cost to supply 10% of Warwickshire's heat using standard condensing boilers (and fossil fuels)

Option	Cost per t CO_2	Total investment	Long-term local jobs	"Typical" installations
BASE CASE Domestic condensing boilers (8kW, A-rated) – to deliver 10% of Warwickshire heat	£649	£75 million	46	57 906

Conclusions from tables 2 and 3

Domestic biomass boilers are theoretically-attractive (and will also create economic opportunity for local farmers). However, they will be limited in application because they involve continuous input of labour by property owners (which doesn't show in the economic analysis) and they are also not widely available as yet in sizes small enough to supply modern homes.

Like rooftop wind turbines, rooftop solar systems have a contribution to make (and are reasonably economic in saving carbon). However, to make a significant contribution to county heat demand would require more systems than there are homes, which places a physical constraint on widespread deployment. Nevertheless, there is a role to play in engaging homeowners, and the technology is so simple that any significant volume demand could quickly bring prices down.

We estimate between 15-20 000 home heating systems will be replaced in Warwickshire each year, in the course of normal maintenance and replacement. This means that if the county does nothing beyond enforce current building regulations, it will take around 10-15 years to hit the 10% heating target (table 2 line 3).

Overall, therefore, the initial conclusion is that straightforward installation of good quality condensing boilers is only a limited first step towards a more carbon-efficient heating infrastructure. Traditional heating systems alone are not enough, and will need to be supplemented by the more attractive solar and biomass technologies to make a significant impact on carbon emissions, quickly (or indeed by other technologies not analysed here). Renewable options will also be more attractive sooner for larger properties or those with high water heating demands (for example, solar is particularly efficient providing supplementary heating for swimming pools).

This analysis also needs to be qualified by the conclusions of the next section, which discusses combined heat and power. As we will see, in many circumstances CHP presents a more efficient and attractive option for heating both communities and households.

5 OPTIONS FOR USE OF COMBINED HEAT AND POWER IN WARWICKSHIRE

Combined heat and power (CHP) schemes can be very attractive where appropriate load conditions exist, For example, a continuous heat demand from an industrial process or swimming pool or waste heat from an incinerator can be coupled to an electrical generator to provide low cost electrical power for nearby homes. This is often more efficient than sourcing heat and electricity separately.

Warwickshire's share of the national target of 10GW (electrical) of CHP by 2010 would be 90MWe, as the county is responsible for 0.9% of national electricity consumption. According to Warwickshire Energy Statistics (a report by ECOTEC for WCC in 2005) there are currently 2MWe of operational capacity in the county. Much of this will be retired within the next 10 years, however. A potential 115MWe scheme in Rugby was registered with Ofgem 3-4 years ago, but we understand it has been abandoned (from Rugby Borough Council).

Table 4 shows three CHP options. In developing this analysis, we have assumed that small-scale CHP installations will be heat-driven, because this is usually the case for installations below 2MW, and is not an option for domestic scale CHP, where electrical output is fixed.

Table 4. Initial sample of 90MWe CHP options for Warwickshire

Option	Cost per t CO_2	Total investment	Long-term local jobs	"Typical" installations
Community biomass-fired 2MWt CHP with district heating	£150	£951 million	856	180
Domestic micro-CHP (8kWt/1.1kWe units)	£433	£245 million	98	81 818
Community gas-fired 2MWt CHP with district heating	£585	£634 million	190	180

The biomass-fired CHP option has the additional benefit of creating a demand for £18 million of energy crops each year from local farms (around 50 000 hectares of land). This £18 million spent is instead of £74 million per year flowing out of the county (and sometimes country) to buy gas supplies for the gas-fired CHP option.

Conclusions from table 4

All three CHP options shown are more economic at reducing carbon than A-rated condensing boilers. Community-scale biomass (which might also be built around a school heating system, or based in a large office building or industrial site) is particularly attractive. For example, the 180 biomass installations shown in the table would reduce county carbon dioxide emissions by almost 725 000 tonnes, and they offer additional economic benefits for farmers as discussed.

The main challenge with CHP, however, is matching installations to heat demand. The 180 2MWt installations indicated here, operating at industry benchmark utilisations would between them deliver 1800GWh of heat each year to the county. This represents 36% of total county heat demand. This is probably achievable, but will require careful siting of schemes, co-operation of industry, community acceptance, and optimisation of project development processes.

6 STIMULATING ACTION

Energy involves big numbers. The important thing to remember is that most of these big numbers are other people's money, ***which is already being spent on energy***, and the trick as a public policy body is to apply limited resources to influence where this money flows in the long-term interests of the county, without necessarily having to make major investments on behalf of the council itself.

The best ways to achieve this are likely to be through developing partnerships, establishing suitable facilitating bodies where appropriate, and ensuring existing processes and structures are adapted and aligned to make achievement of the desired outcomes as straightforward as possible.

There are a number of specific and relatively low cost things the council can do to direct action and these major capital flows in the public interest. These include:

Financial mechanisms

- creating financial vehicles that make innovative energy projects easier, for example an energy services company, possibly in partnership with private sector organisations to secure broad expertise
- allowing re-investment of savings made through energy efficiency in renewables projects

Targeted funding

- providing limited funding for agencies that facilitate project inception and do the legwork around setting up supply chains (for example for biomass) that otherwise impose excessive costs on the first movers in the field. For example, London has established a Climate Change Agency with just this goal in mind
- selectively sponsoring demonstration projects, like EPIC, where a little county support can leverage significant external private and public funding and create an exemplar that can be used to engage others in similar developments

Communications

- encouraging homeowners and businesses to appreciate the benefits of investment in small-scale renewables, working with the local Energy Advice Centre and Agenda21 organisations
- providing simple networks and infrastructure to enable community projects to develop (and to draw external funding from national and European bodies into the county)
- using the trusted county "brand" to support specific initiatives to motivate homeowners and industry, like the CRED pledge scheme, for example

Planning

- using section 106 agreements and planning rules imaginatively on new developments, to kick start local energy schemes and create a secure long-term infrastructure for the county
- providing a clear and supportive planning regime to make it easier for the right kinds of energy project to be developed

Some or all of these should be worked up and costed in more detail as part of action plans to deliver the agreed low carbon strategy in due course.

7 CONCLUSIONS

Warwickshire faces a plethora of choices in developing a secure and efficient energy infrastructure into the future. It is unwise to try to make all these decisions centrally, because optimal energy solutions generally depend on very local considerations.

Nevertheless, the UK as a whole is going through a transition from a century where very few people had to worry about energy, to one where it will again be everyone's concern. In this context local government has a responsibility and opportunity to take a lead, and to help citizens and local stakeholders make the best decisions for everyone's future.

This report is intended to inform this process. The findings point to the following preliminary conclusions.

1. Where there are no specific local resources that are easily exploitable (e.g., hydro-electric schemes) Warwickshire low carbon strategy should concentrate particularly on (in no particular order):
   - biomass-fired community-scale CHP
   - small-scale technologies to encourage homeowner and small-business engagement (particularly in energy efficiency, which is outside the scope of this report but a very important and difficult part of the challenge)
   - larger scale wind developments in a small number of already-identified areas (around 30 sq km) plus attractive industrial sites, farms, and community locations where there is local support.
2. The council doesn't necessarily need to invest significantly in energy hardware itself (beyond what happens routinely as part of estate management). What the county should do is invest selectively to ensure that appropriate mechanisms are in place to direct private investment optimally for the county's benefit (i.e., a low carbon project development infrastructure). There are a number of examples of such mechanisms available, and detailed evaluation of these should be a priority area for further work by the Low Carbon Strategy Group.

Appendix

This appendix is a printout from the Warwickshire Energy Model (WEMII) developed by Encraft for this report.

The model is also available as a spreadsheet, either from Encraft or the Carbon Management Team. The electronic version enables users to explore alternative targets and the impact of fuel price changes, among other things.

Methodology and assumptions

General notes

All the analysis in this model uses the same base data and financial assumptions. This is to allow sensible comparisons. It means that as far as possible we avoid introducing assumptions about economies of scale, variable discount rates, population growth, changing patterns of energy use etc where these would potentially distort or confuse figures without materially altering the conclusions.

Data on energy demand and household numbers for Warwickshire is the latest available. Where different estimates exist, they have been cross-checked to ensure the figures used are broadly consistent. No attempt has been made to account for forward projections as this introduces an element of uncertainty into the analysis that is potentially spurious for the purposes of this model - such future changes are unlikely to alter the relative economics of alternative technology choices.

There is no allowance for economies of scale in any of the capital costs. They are all at current quoted market prices. This means that in many cases there may be significant scope for cost reduction with volumes of this magnitude. We have not allowed for this in the analysis so there is a clear and common baseline for evaluation purposes.

The technology performance figures are based on market averages and historical project outcomes. Local circumstances mean individual project economics may be better or worse than indicated and every project must be locally optimised.

Individual business cases will need to adjust individual project costs for: market valuation of social and carbon benefits (e.g., renewable obligation certificates - from 4-6p per kWh) plus billing, network and service costs, risk cost of capital etc. Many of these costs typically vary by site, with time, and with local political judgements. They can make a significant difference to project economics.

Definition of terms used in the model

Base cost per kWh — This is the undiscounted cost per kWh (heat or electrical energy) including capital, operating and maintenance and fuel costs over the lifetime of the installation. It includes empirically-supported capacity factors for each technology in normal operating environments.

Table of fuel parameters

Fuel	t CO2/kWh	£/kWh	£/tonne	kWh/tonne	Notes
Gas	0.000194	0.025	-	-	
Electricity	0.000422	0.081	-	-	Grid average emissions, allowing for existing renewables
Green electricity	0	0.085	-	-	
Biomass	0	0.006	30	5278	19GJ per tonne (JL) is 5278 kWh per tonne
Solar	0	0	-	-	
Wind	0	0	-	-	

Sources — *SAP 2005*
Consumer and industrial prices for electricity and gas Jan 2006, sample online quotations.

Other model parameters

Total cost of employment	50000	£ p.a.	includes all overheads, admin and management costs etc for one individual
Average efficiency of existing installed heating	70	%	Source: BRE 2003
Price of Renewable Obligation Certificates	4.2	p/kWh	Source: Platts 2005
Recoverable value of ROCs after admin	88	%	Source: Carbon Trust (industry-reported average)
Duration of ROC market	10	years	Model variable
Discount rate	6	%	Not used yet.
Biomass crop intensity	12	odt (tonnes) per hectare	
Average farm size	81	hectares	

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Warwickshire County Energy Needs

The model uses the following base data, from sources as indicated.

Base data point		units	average per user		source	comment
Domestic sector						
Number of domestic households	210898	households			Census 2001.	
Total domestic energy demand per year	4973	GWh	23580	kWh	WES 2003	This is prorated by ECOTEC from national statistics
Total domestic electricity demand per year	1148	GWh	5443	kWh	DTI 2003	
Total domestic heat demand per year	4227	GWh	20043	kWh	BRE 2003	85% of domestic energy is used for heating (incl hot water)
Actual delivered heat energy per year	2959	GWh	14030	kWh	BRE 2003	Domestic heating systems are 70% efficient on average
Industrial and commercial (I&C) sector						
Number of I&C gas users per year	4000	sites			DTI 2003	
Number of I&C electricity users per year	20000	meter points			DTI 2003	
Total I&C energy demand per year	5149	GWh	257450	kWh	WES 2003	Derived from national statistics
Total I&C electricity demand per year	1580	GWh	79000	kWh	DTI 2003	Excludes very large users with direct connection to the transmission grid
Total I&C heat demand per year	2454	GWh	122700	kWh	WES 2003	Use gas demand as proxy.
Actual delivered heat energy per year	1963	GWh	98150	kWh		I&C heating systems assumed to be 80% efficient on average

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Warwickshire model results - electricity

% supplied by renewables 10 % by changing the figure to the left, you can see the budget costs and benefits of meeting different targets

The technical challenge is:
to supply 273 GWh per year of electrical energy (the above target, using 2003 estimated consumption as the base)
to 210898 households
and 20000 industrial and commercial meter points

The table below shows how many standardised mini or micro-renewables installations this would require, assuming for clarity the entire target were met from a single technology in a standardised configuration.
The columns show the relative economic, environmental and social benefits of each hypothetical case, using common assumptions.

					What are the supply chain implications?								
							Annual fuel costs						
Technology option	**What does each (notional) installation look like**	**How many would we need**	**What is the base cost per kWh of this solution**	**By how much do we reduce CO2 emissions**	**Capital investment £**	**Annual operating and maintenance (O&M) costs £ p.a.**	**Flowing ex-county**	**Spent in county**	**Capital jobs supported (person years)**	**Permanent jobs created to operate and maintain**	**Farms needed to grow 10% Biomass**	**Income per farm per year**
Solar PV (electrical) installations	78 sqm of solar modules on a community or commercial building - 10kWp systems	36,815	28.4p	115231 t.p.a	£ 1723 million	£ 8.6 million	0	0	4,134	173		
Community biomass electrical generation	2MW combustion/gas-fired generating plants in small industrial units.	22	6.4p	115122 t.p.a	£ 108 million	£ 4.9 million	0	£ 5.5 million	433	97	1871	£2,916
Micro-wind turbines	Rooftop mounted 1.5kW turbines (Swift or Windsave) with rotor diameters 1-2m	211,309	6.4p	114107 t.p.a	£ 317 million	£ 4.8 million	0	0	2155	106		
Farmyard wind turbines	6kW small turbines (4-6m diameter) on 11m masts (similar to telegraph poles).	24,800	6p	115072 t.p.a	£ 347 million	£ 2.6 million	0	0	1944	52		
Community wind turbines	Small industrial scale turbines (600kW) on 50m tall masts, with rotor diameters 45m	208	1.5p	115122 t.p.a	£ 93 million	£ 0.5 million	0	0	635	9		
Industrial wind turbines	1.5MW wind turbines, on 100m tall masts	83	1.4p	115122 t.p.a	£ 83 million	£ 0.4 million	0	0	565	8		
Purchase of green electricity	Individual homes switching to green suppliers	50,119	8.5p	115274 t.p.a	£ 0 million	£ 0 million	£ 23.2 million	0	0	0		

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Warwickshire model results - heat

% supplied by renewables 10 % by changing the figure to the left, you can see the budget costs and benefits of meeting different targets

The technical challenge is:
to deliver 492 GWh per year of heating energy
to 210898 households
and 20000 industrial and commercial sites

The table below shows how many standardised mini or micro-renewables installations this would require, assuming for clarity the entire target were met from a single technology in a standardised configuration.
The columns show the relative economic, environmental and social benefits of each hypothetical case, using common assumptions.

					What are the supply chain implications?								
Technology option	**What does each (notional) installation look like**	**How many would we need**	**What is the base cost per kWh of this solution**	**By how much do we reduce CO2 emissions**	**Capital investment £**	**Annual operating and maintenance (O&M) costs £ p.a.**	**Fuel costs £ p.a. Flowing ex-county**	**Fuel costs £ p.a. Spent in county**	**Capital jobs supported (person years)**	**O&M jobs created or retained**	**Farms needing to grow 10% biomass**	**Income per farm per year**
Boilers meeting current Building Regulations - **non-renewable** base case	8kW wall or floor-mounted modern gas condensing boiler, A-rated and 91% efficient.	57,906	4.2p	31848 t.p.a	£ 75 million	£ 2.3 million	£ 13.5 million	0	903	46		
Rooftop solar hot water systems	4.2 sqm flat plate solar water heating systems on individual family homes with 4 occupants	223220	4.3p	136164 t.p.a	£ 469 million	£ 2.3 million	0	0	1496	45		
Domestic wood-fuelled boilers	15kW wood chip boilers providing heating and hot water to family homes	28953	2.8p	136368 t.p.a	£ 136 million	£ 1.4 million	0	£ 3.3 million	1170	26	1122	£2,916
Allow boiler efficiency improvements to reduce carbon by the same amount	8kW wall or floor-mounted modern gas condensing boiler, A-rated and 91% efficient.	247892	4.2p	136341 t.p.a	£ 322 million	£ 9.7 million	£ 58 million	0	3867	198		

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Warwickshire model results - combined heat and power

Warwickshire CHP target 90 MWe by changing the figure to the left, you can see the budget costs and benefits of meeting different targets

The technical challenge is:
to supply 90 MWe power capability from CHP units
to 210898 households
and 20000 industrial and commercial sites

The table below shows how many standardised mini or micro-renewables installations this would require, assuming for clarity the entire target were met from a single technology in a standardised configuration.
The columns show the relative economic, environmental and social benefits of each hypothetical case, using common assumptions.

					What are the supply chain implications?								
Technology option	**What does each (notional) installation look like**	**How many installations required**	**What is the base cost per kWh of this solution**	**By how much are CO2 emissions reduced**	**Capital investment £**	**Annual operating and maintenance (O&M) costs £ p.a.**	**Fuel costs £ p.a. Flowing ex-county**	**Fuel costs £ p.a. Spent in county**	**Capital jobs supported (person years)**	**O&M jobs created or retained**	**Farms needing to grow 10% biomass**	**Income per farm per year**
Domestic (micro) CHP	8kWt/1.1kWe wall or floor-mounted micro-chp units in individual family homes.	81,818	5.4p	100636 t.p.a	£ 245 million	£ 4.9 million	£ 22.4 million	0	2455	98		
Community biomass CHP (district heating)	2MWt biomass-fired CHP plant in small industrial unit delivering heat and power to around 500 homes	180	4.6p	724019 t.p.a	£ 951 million	£ 42.8 million	0	£ 17.7 million	3806	856	6083	£2,916
Community gas-fired CHP (district heating)	2MWt gas-fired CHP plant in small industrial unit delivering heat and power to around 500 homes	180	5.3p	214187 t.p.a	£ 634 million	£ 9.5 million	£ 73.9 million	0	2537	190		

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WES 2003	Warwickshire Energy Statistics, ECOTEC, 2003
DTI 2003	DTI Regional Energy Statistics, 2003
BRE 2003	Domestic Energy fact File, BRE, 2003
DTI 2002	Energy White Paper 2003
EST CE102	New and renewable energy technologies for existing housing, EST Sept 2005
Carbon Trust	Biomass Sector Review, October 2005

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Performance and technical data by technology option

			Parameters per installation														
Technology	**Size**	**Units**	**Power rating (kWe)**	**Power rating (kWt)**	**Price installed (£)**	**O&M costs per year (£)**	**Fuel costs per year (£)**	**ROC income available (£ p.a.)**	**Annual average output (kWh)**	**Annual average output (kWhe)**	**Annual average output (kWht)**	**Operating life (years)**	**Capital ratio (capital as % of installed cost)**	**Fuel displaced**	**CO_2 emissions (t p.a)**	**CO_2 emissions displaced (t p.a.)**	**Preliminary cost per kWh excl ROCs (p)**
column ref	2	3	13	14	15	16	17	18	19	20	21	22	23	26	27	28	29
Solar PV (electrical) installations	78	sqm	10	0	46800	234	0	274	7410	7410	0	25	88	Electricity	0	3.13	28.4
Micro-wind turbines	1	2m turbine	1.5	0	1500	22.5	0	48	1291	1291	0	25	66	Electricity	0	0.54	6.4
Farmyard wind turbines	1	11m turbine	6	0	14000	105	0	407	11000	11000	0	25	72	Electricity	0	4.64	6
Community wind turbines	1	45m turbine	600	0	450000	2250	0	48565	1314000	1314000	0	25	66	Electricity	0	554.51	1.5
Industrial wind turbines	1	100m turbine	1500	0	1000000	5000	0	121414	3285000	3285000	0	25	66	Electricity	0	1386.27	1.4
Community biomass electrical generation	1	Generator	2000	0	4862000	218790	245280	453277	12264000	12264000	0	15	80	Electricity	0	5175.41	6.4
Rooftop solar hot water systems	4.2	sqm	0	2	2100	10.5	0	0	2205	0	2205	25	84	Gas	0	0.61	4.3
Domestic wood-fuelled boilers	1	boiler	0	15	4700	47	113	0	17000	0	17000	15	57	Gas	0	4.71	2.8
Community biomass CHP (district heating)	1	system	500	2000	5286000	237870	98550	97131	13140000	2628000	10512000	20	80	Gas	0	4022.33	4.6
Domestic (micro) CHP	1	unit	1.1	8	3000	60	274	50	9860	1360	8500	15	50	Gas	2.13	3.36	5.4
Community gas-fired CHP (district heating)	1	system	500	2000	3524000	52860	410625	97131	13140000	2628000	10512000	15	80	Gas	2832.4	4022.33	5.3
Boilers meeting current Building Regulations -	1	unit	0	8	1300	39	234	0	8500	0	8500	15	40	Gas	1.81	2.36	4.2
Purchase of green electricity	5443	kWh	1	0	0	0	462.655	0	5443	5443	0	25	0	Electricity	0	2.3	8.5
Allow boiler efficiency improvements to reduce	1	unit	0	8	1300	39	234	0	8500	0	8500	15	40	Gas	1.81	2.36	4.2

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