# Landscape, climate and renewable energy: envisioning future options

*In a project for the Countryside Agency, Ethos has been pioneering virtual reality models of landscape and future technology. These techniques of visualisation may provide a template for a more democratic and less conflict ridden process of development for renewable energy in the countryside.*

PETER TAYLOR[1] & RICHARD FRASER[2]

1) Consultant ecologist with Ethos and the Institute for Life-based Architecture, Furth-im-Wald, Germany; associate fellow of the Wildland Research Institute, Leeds University;
2) Formerly, Visionscape; now freelance at www.richardfraser.co.uk

The landscape of Western Europe will undergo radical changes on an unprecedented scale if current policies to replace fossil fuels with a substantial proportion of renewable energy supplies are realised. Almost all renewable resources are located in the countryside, and in the case of wind and hydro often in the wildest and most remote places. Landscape, whether familiar and local, with its sense of identity and continuity; or remote and beautiful and sought out for rest and recuperation, contributes an essential component to our sense of sustainable living – and it should have equal standing with other criteria of sustainability. However, the fear of climate change is driving a hard agenda of sacrifice. A conflict of interests is thus emerging, and this paper explores methods of visualising and presenting change that may have some potential for resolving this conflict such that important elements of sustainability are respected.

**Energy options and the land**

The UK, in common with many other industrialised countries, has a policy of reducing fossil fuel use by 80% over the next five decades, partly through increased efficiency to reduce demand and partly through supply options ranging from wind turbines, wave and tidal power, biofuels and photovoltaics. A replacement nuclear power programme is also under consideration.

Compared to readily accessible stores of fossil fuels, renewable energy resources are essentially diffuse and expensive to harness. A large 4 GWe coal-burning station such as Drax would require over 6000 turbines of 2 MW each (operating at 30% efficiency). When this project was first initiated in 2003, this was roughly equal to the government's 2010 target of 10% renewable-sourced electricity and at the present time, Drax imports via ship and special 'green' trains, about 10% of its fuel supplies from forests in the southern USA.

Following the development of onshore wind, another tranche – perhaps as high as another 10% is expected from offshore locations. The next most feasible option of biofuels – from woodchip power stations and biodiesel or ethanol crops for liquid fuels, is projected to supply 20% of overall energy demand by 2050, and would require a crop area estimated at 15% of agricultural land. In actuality, the UK now imports a substantial part of its legal requirement of 5% biofuel in forecourt diesel from palm-oil plantations in countries such as Colombia.

## Future scenarios

In 2000, the Royal Commission on Environmental Pollution in its report 'Energy: the Changing Climate' explored a number of scenarios where the mix of technologies, economic growth forecasts and scale of energy saving programmes were varied to the year 2050.[1] There were four major projections – from high future demand where all renewable and nuclear options were required to be fully developed; through intermediate mixes to a lower demand set (50% reduction) where nuclear was not necessary, but still with a highly developed renewables sector. All of these longer term scenarios assumed that the Severn Barrage (8Gwe) would be built, as well as several thousand 'small-scale hydro installations' and several hundred 'tidal stream' installations (submerged turbines without a barrage).

Thus, even where overall demand is reduced by 50%, there is still a perceived need for an extensive deployment of renewable energy technologies in the countryside.

## Techniques of visualisation

The *overall* environmental impact of so much industrial development in a countryside environment normally protected from industry, has not been appraised. Government has devolved responsibilities for siting to the regions – district councils approve planning on a case-by-case basis (except for installations over 50MW, which the DTI decides), and regional assemblies have been responsible for mapping the resource-base. However, little has been done on the visual and quality of life impacts. There are no detailed studies of the eventual visual and environmental implications of such large-scale developments, nor of the range of options and choices available.

Communities are faced with single choice applications in a 'developer-led' policy where alternative sites or technological choices are not provided. Responsible local authorities then have to weigh 'national need' as derived from government policy and the imperative to combat climate change, with both local impacts and other national needs, such as recreation and nature conservation. In this process, there is a need for more effective techniques of visualisation – not just of landscape change, but also of secondary impacts, such as numbers of lorries (e.g. woodchip), emissions, and noise.

## The use of Virtual Reality models of future landscapes

With this problem in mind, in 2000 the Countryside Agency contracted Ethos to explore the use of virtual reality software as a means of visualising landscape change to the year 2050 under the different scenarios presented by the Royal Commission.[2] At that time, there were no other such 'virtual reality' studies in progress, although a unit at the University of East Anglia was exploring small-scale ecological change in coastal retreat scenarios using very simple software.

We developed a technique whereby realistic models of installations – ranging from large wind turbines to biomass power stations, could be placed in 'generic' English landscapes (the Agency was reluctant to use identifiable locations), varying the type of technology and scale of deployment according to the different scenarios. The overall aim was to present 'choices' for each of the landscapes, and for the visualisation tool to aid planners in seeing the consequences of different options.

Surprisingly, no organisation had constructed realistic 3-D images of generic English landscapes. VR software had been used extensively for architectural projects and was highly developed for this use. Likewise, fantasy landscape for gaming and film was also highly developed but used hugely expensive software and vast amounts of computing capacity and skilled programmers' time. Our first task was to find ways of using film-developed landscape and 3-D technology-drawing software to construct realistic 'eastern', 'western' and 'middle' England landscapes with towns, villages, river systems, hedgerows, woods and other features into which our models of the installations could be placed (and do it on a tight budget!).

This task required several very fast modern computers – and we collaborated with *Visionscape* a small Glastonbury-based company specialising in graphic design, marrying the cooperative endeavour of an ecologist with an expert designer who had little ecological sense of the structure of an English countryside. The endeavour required many hours of sitting at each others shoulders until a landscape emerged that bore resemblance, for example, to Shropshire rather than Bavaria (see Fig 1). Similarly, we tackled the fens of East Anglia and a composite Middle England.

***Figure 1 Western model landscape showing field patterns, open hills, river valley and small town with present day grid and infrastructure.***

The landscapes are constructed first as 'wire-frames' and then clothed in various ecological textures, with hedgerows, rivers, individual trees and woods added. The software at the time (and within our budget) was limited – and hedgerows were particularly difficult to get right, especially for close up views. Houses were constructed individually, aiming for local vernacular, and then cloned for streets. Churches were added, and country road patterns centred on villages and small towns. We had decided to restrict ourselves to small towns and villages – modelling cities would be another proposition. This gave us the opportunity to quantify a town's energy requirements – for present uses, and projected future 2050 demand (**S4**: 50% demand reduction, low growth; **S1**: no demand reduction and high growth). We then had the choice of presenting a local 'sustainability' option where energy technologies provide for the need of the town, or options where the local countryside is used maximally to supply the National Grid and the needs of distant cities.

**Technology choices**

In the example of a small market town of 10,000 people (our 'western' example looked a little like Oswestry nestled below the Berwyns) we presented visual scenarios that showed two directions for development:

Scenario 1

The local resources are maximally developed and with little regard for amenity, local vernacular, scale and landscape impact – but within basic planning guidance. Thus, the distant wild hills are covered by 100 large turbines; plantation forestry is expanded and exploited by a large 10-20MW woodchip and forest residue power station (using the ugly, grey and white vertical design as seen at Arbre in Yorkshire); the local hills are crested by large turbines; an industrial park is built that houses another large vertical-design woodchip station drawing lorry-loads of chipped Short-Rotation Coppice (SRC) from a 50km radius (the model taken from the unsuccessful Hay-on-Wye application) and requiring new infrastructure such as a by-pass, as well as fostering further industrial development using distributed heat (Fig.2).

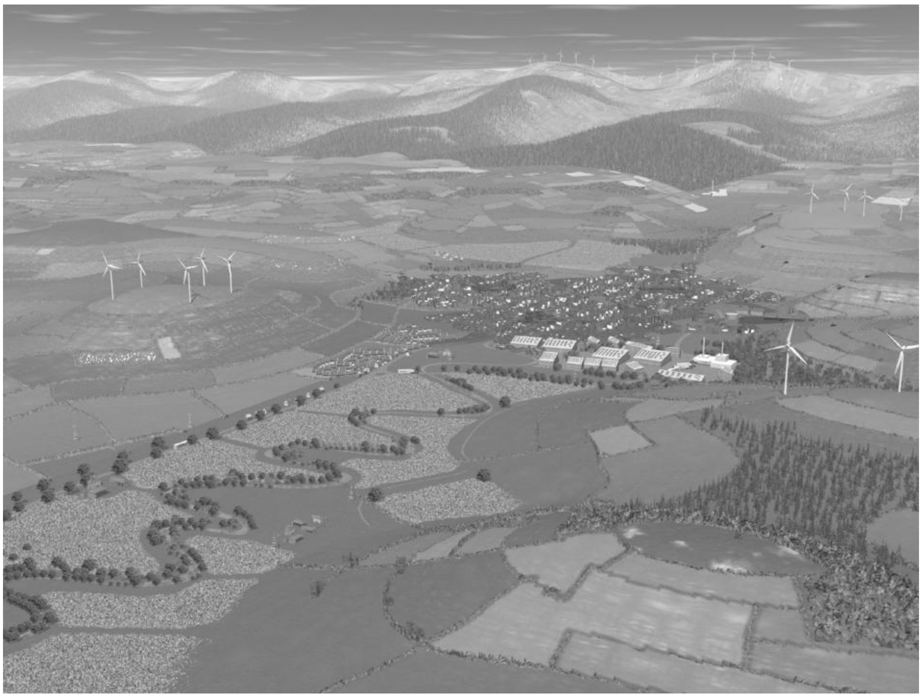

***Figure 2 Western model showing maximum development and minimal sensitivity to local landscapes and communities: note turbines on the hills, large scale forestry for woodchip, intensive SRC in river valleys, large 20 MW woodchip power station and distributed heat to industrial development, turbines sited on hill-crests and new road infra-structure to facilitate transport***

Scenario 4

Only local needs are met from the local environment (and assuming a 50% reduction of demand by 2050). There are no large wind-farms, nor forest-residue stations on the hills (in the ‘eastern’ landscape large windfarms are located out to sea, with various distances explored). Instead the degraded ecology is restored as a sink for carbon with regenerated oak woodland and a local market for wood-fuel in the ‘western’ landscape (Fig.3). In the Eastern landscape coastal retreat and regeneration of carr-woodland is compared to tidal barrages and heavy engineering solutions (Fig.8). The local biomass station of 1-2 MW (barn-sized, low profile construction) draws tractor-loads from carefully designed SRC that respects the river ecology. Smaller, less-obtrusive turbines are located away from the hill crests. The local creamery has a biogas installation running on the biological waste stream. In both scenarios, photovoltaic tiles replace a substantial proportion of the roofing.

***Figure 3 The western model showing development to meet local needs – note the hills are afforested with native species for conservation and carbon sequestration; the SRC development is less intensive and includes new nature conservation areas, with the woodchip moving by tractor to the smaller 2 MW ‘barn-sized’ and landscaped power station; wind turbines are smaller and sited off the crests of hills.***

**Altering the viewpoint**

The 3-D technology allows the observer to ‘fly-in’ to the landscape. This can be achieved by a short video journey – but this requires very large computing time to create, as each frame has to be taken like a photograph and then ‘rendered’ with the textures. The advanced software we used – *Lightwave,* actually bounces virtual rays of light off all surfaces to create shadows and reflections, just as light from the sun strikes objects and then the observer's retina. For normal presentations we used a series of 'snapshots' at different viewpoints (see Figs 2,3 & 4).

***Figure 4 Low-level 'snapshot' showing landscaped small power station and smaller turbines in the S4 scenario.***

**Scenarios are not projections**

The scenarios that we explored are not projections of what will happen – and in such a small project they could not be realistically related to *actual* countrywide demand – to do that effectively we would have to model cities and regions. What we explored were ways of visualising the options – and not just in terms of visual impact, but layout, infra-structural demands, and other consequences – for example, using simple 'click-on' techniques, closer-up views could be accessed as well as data-pages relating to lorry-loads, emissions, employment, etc..

In the 'eastern' landscape we sought to represent some of the more creative options – such as rewilding an estuary and river system with woodland and coastal retreat scenarios where the location of sea defences are altered (Fig.5,6, and 7). The offshore windfarms could be located at varying distances to explore visual impact under different weather conditions.

***Figure 5 The 'eastern' landscape of 2000***
*Note: the nuclear station on the promontory*

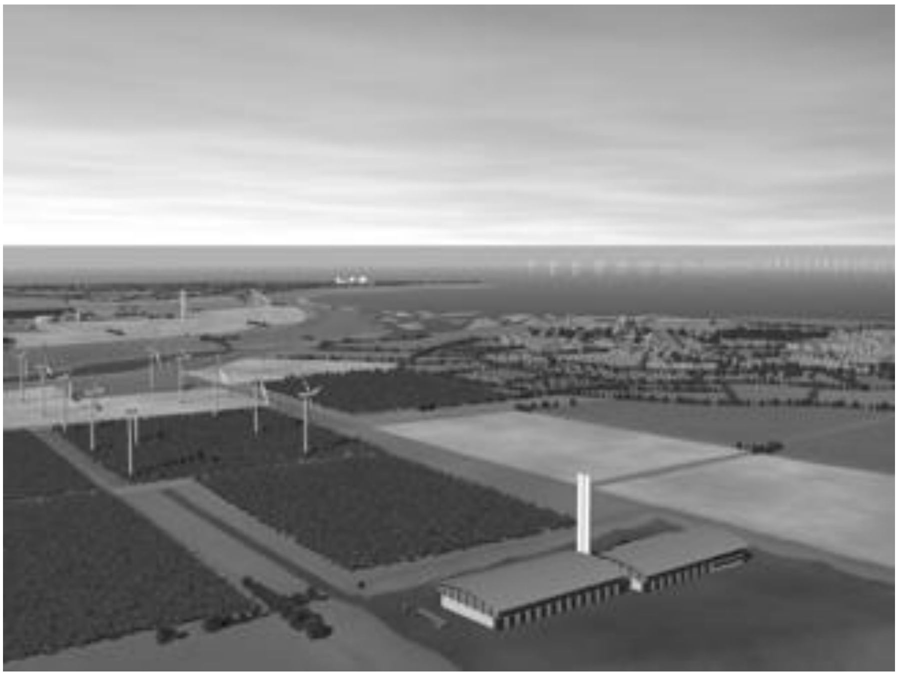

***Figure 6 The 'eastern' landscape fully developed under Scenario 1***

*Note: The nuclear station is replaced, large windfarms are developed offshore and onshore, an SRC biomass plant is in the foreground and biofuel plant across the estuary.*

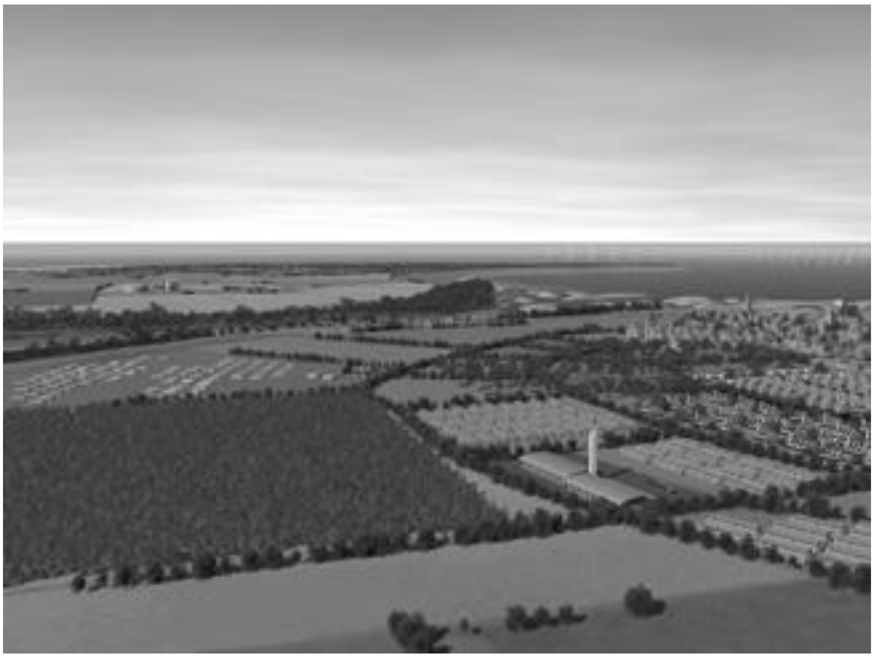

***Figure 7 The 'eastern' landscape under Scenario 4***

*Note: the SRC plant is located closer to the town, surrounded by greenhouses and housing-estates using the distributed heat, the local biofuel plant operates on the headland. The nuclear station is not replaced and all wind turbines are sited offshore; the estuary and river corridor is re-wilded for carbon sequestration*

## Climate change and landscape

In part of the project we also looked at the potential of the VR techniques to model climate change and its concomitant effect not only on renewable energy supplies but on the countryside itself. In the eastern model we altered sea defences to reflect coastal retreat options and to visualise flooding (Fig.8). The general feel of landscapes would be altered by different crop types and forestry regimes adapted to drier conditions,, and we used simple techniques of texture and colour to represent these.

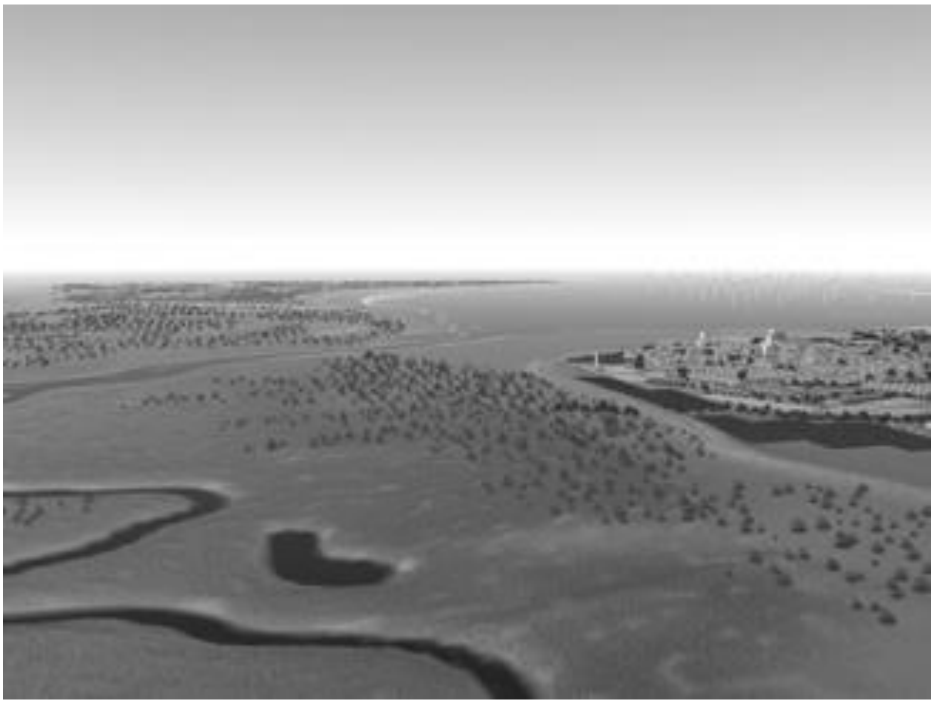

***Figure 8 The headland and river floodplain are rewilded for carbon sequestration and managed as 'coastal retreat' to accommodate rising sea-levels; a local biomass plant provides for the town.***

The models would provide an insightful teaching device rather than a planning tool in this regard, although flood defences and coastal retreat options can also be accurately modelled in site-specific projects.

## Prospective uses and development of the techniques

The current package (available from the Countryside Agency has found extensive use as a tool for presenting the overall nature of the problems of siting and visual impact in relation to countryside character, as well as all the various associated environmental implications relating to transport, emissions, etc. It has been made available to Local Support Teams working on the Community Renewables Initiatives, and to local authority planners.

## Site-specific – locality and region

There is a further potential to model specific localities – from district council scale, to region. This would require more manpower to construct landscapes using local data sets – but many 'fudges' can be used – most small towns have a similar structure and the vernacular can be approximated with different rendering for the fabric of buildings, types of churches, etc. Likewise, hedgerow structure and woodlands can be approximated using visual cues from photographs of typical parts of the countryside (the CA's volumes on the 'countryside character' areas are an ideal source). Where cities and large towns are concerned it is not so easy to model the 'sustainable local supply' option – and we have only given this passing thought, but a 'hinterland' approach could be used looking at integrated transport, food, biofuels, wind etc. The key to sustainable cities is the reductions in demand, the conversion to usable energy of concentrated waste streams, and the large-scale deployment of small-scale CHP, micro-CHP, heat-pumps, and photovoltaic surfaces.

With combined data for towns, cities and countryside the total regional resource could be realistically mapped, sites explored, options compared, and impacts assessed such that a regional plan could unfold – a plan that could then be presented and debated democratically at both district and regional level.

**The importance of process in decision making**

One of the biggest issues facing renewable energy developments is the growing opposition of local communities (from the Hebrides and Highlands, to the Cambrian Mountains and Dorset vales) to large scale technology developed solely to plug into the national grid. Much of the large-scale technology is shipped and manufactured by major international conglomerates. Communities are forced to respond to developer-led projects where location and scale are dictated by the commercial considerations of these manufacturers and the economies of scale demanded by regional utilities (themselves often owned by foreign companies and shareholders). In such cases, visualisation of impacts has limited usefulness.

We can imagine, however, some point in the future – it need only be a couple of years hence, where each local authority is given the responsibility not only to produce a sustainable energy plan but to action that plan in cooperative ventures with supply companies, and that they have ready access to the appropriate technical advice and funding to carry out this remit. This would operate at district level such that the community not only chose among options, but also had the opportunity to own the units of local production. The latter is not necessarily onerous, as ‘turn-key’ companies can design, manufacture and run power stations on behalf of client communities.

This reverses the current ‘developer-led’ and subsidy-fuelled feeding frenzy relating to wind turbines based upon purely financial motives and having minimal regard to local distinctiveness or local needs. Communities would have to face their responsibilities – but any divisions would be worked out democratically. One consequence, as witnessed in other areas of pollution control, is that where audits of use are combined with ownership of the problem in a localised ‘club’ there is an acceleration of awareness combined with effective action. At present, a community can either accept or reject a development coming from outside, and the Secretary of State can overrule them.

In the model we present here, towns and villages would be able to seek local solutions. Owner-communities could also be subscriber communities – they may have to pay higher prices when eschewing economies of scale, or choosing biomass, heat distribution networks and solar tiles, rather than wind turbines – but any profits could be recycled in dividends. There is a clear potential not only for conflict resolution, but also more appropriate technology and siting options. Government funds could be made available for communities that chose more expensive options in order to safeguard national landscape assets, wildlife, etc.

Cities would necessarily have to develop a relationship to their immediate hinterland (the commuter belts) and weigh options that might compromise other needs, such as greenbelt land. However, because there would be tough decisions on land-use, at least the denizens would come to appreciate their ecological footprint and perhaps be more strongly motivated toward reduced car-use, heating, and other demands. Industries might also be better motivated to seek joint ventures with local communities to develop energy-from-waste options.

**Education**

At the end of our project we all felt there was a tremendous potential to develop the Information Technology side of the visualisation techniques for use in schools. We could imagine each 6$^{th}$ Form (it might be possible to adapt the material for younger ages) being given the task of developing a local data-set (say, at district council level, and in cooperation with other schools), which would also be pooled to make a county and regional set, which would include a model of energy demand and supply, basic agricultural and forestry resource, water, transport, industry and housing.

The basis of all data sets would be the virtually real model of the local and regional landscapes. Data sets could be accessed by clicking on locations within the model. Each subsequent 6$^{th}$ form year could update the data sets and landscape, as well as develop their own projects using the data – for example, modelling choices, keeping abreast of latest technological developments, factoring in climate changes, agricultural economics, and creative nature conservation such as wildland corridors and river restoration.

We are not in a position to assess the feasibility of such a project – but our experience of 'short-cuts' that worked in the Countryside Agency project leads us to believe it could be done – although the initial budget to set up the software and training schemes for advanced students to use 3-D graphic packages would be relatively high. The challenge would be to provide templates and protocols that did not demand professional expertise.

Such a project would offer a large range of benefits – IT training and competence in graphic design techniques, cross-disciplinary experience, involvement in local issues, as well as raised educational awareness of local distinctiveness, Agenda 21 and sustainability. These students will be the voters or councillors, as well as the industrialists and planners of the not-too-distant future.

1. Royal Commission on Environmental Pollution (2000) *Energy: the changing climate* HMSO, London. See also Peter Taylor '*No regrets energy options – choices in a changing climate'* ECOS 21(2) p79-84 for a review of this report.

2. Countryside Agency (2002) Renewable Energy in the Landscape of 2050. Cheltenham.