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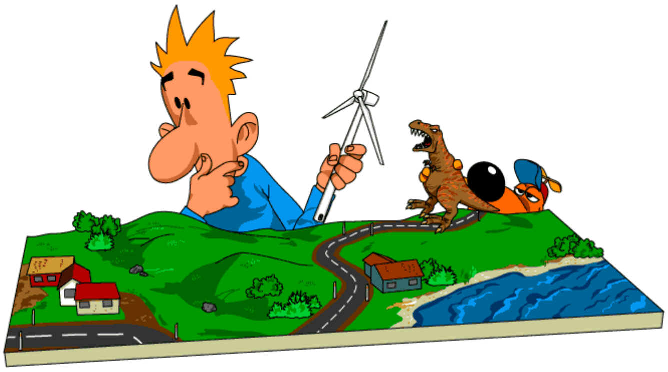
WePWEP:

Web-based Participatory Wind Energy Planning



BACKGROUND INFORMATION ON
WIND ENERGY AND WIND FARM SITING

Ana Simao
April, 19th, 2006

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ABBREVIATIONS

AONB	Areas of Outstanding National Beauty
BWEA	British Wind Energy Association
CAA	Civil Aviation Authority
CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
CO_2	Carbon dioxide
dB	Decibel, unit of measurement of voltage or other type of intensity
dB(A)	Decibel Adjusted, unit of noise power calculated in dB (decibel)
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EWEA	European Wind Energy Association
GWh	Giga Watt hour, unit or energy [10^9 W of electricity spent over 1 hour]
IGCC	Integration Gasification Combined Cycle
LDF	Local Development Framework
km	kilometre, unit of length
kWh	Kilo Watt hour, unit of energy [10^3 W of electricity spent over 1 hour]
LPA	Local Planning Authority
m	Meter, the International System's unit for length
m/s	Meter per second, the International System's unit for speed
MoD	Ministry of Defence
mph	Mile per hour, unit of speed
MW	Mega Watt, unit of power [1 MW = 10^6 W]
NO_x	Nitrogen oxides
PPS 22	Planning Policy Statement 22 – Renewable Energy
RSS	Regional Spatial Strategy
SAC	Spatial Areas for Conservation
SDC	Sustainable Development Commission
SO_2	Sulphur dioxide

SPA	Spatial Protection Areas
SRO3	Scottish Renewable Obligation 3
U.K.	United Kingdom
W	Watt, the International System's unit for power

INTRODUCTION

This document has been prepared in the frame of a PhD research project, which aim is to develop and test a learning-enhancing website design to involve the public in spatial planning. The application focused is the strategic planning of wind farms location. The website developed is named WePWEP – Web-based Participatory Wind Energy Planning and is available at hppt://ernie.ge.ucl.ac.uk:8080/WePWEP/.

Being the purpose of the website to contribute to learning and engage the public in the strategic planning of wind farms, it provides some background information on wind energy and wind farm siting. This document compiles the information that is available in the website.

With regard to wind energy, the section dedicated to the debate surrounding wind energy should be of particular relevance for those interested in an overview of the arguments pro and against wind energy development.

Under the wind farm siting topic, the factors that need consideration during the site selection process are introduced, and subsequently the involvement of the public in wind farms planning is reviewed and discussed.

The document concludes with the author supporting a more participative role of the public in the wind energy planning process and suggesting that the WePWEP website is a means that can contribute to this achievement.

WIND ENERGY

1 Facts and figures

Did you know that...?

- ... worldwide there are 55,500 MW of installed capacity to generate wind energy, both on- and offshore, 70.2 % of which in Europe[1] - 1 MW (mega Watt) corresponds to 1 million Watt (W), with the Watt being the International System's unit for power - a normal kettle uses around 2,000 W;
- ... Germany (17,743 MW), Spain (9,653 MW) and the US (8,500 MW) are the world leaders in wind energy production; the U.K. occupies the seventh position in this world ranking (1,337 MW), followed by Holland (1,219 MW)[1];
- ... the U.K. has the best wind resource in Europe: 40% of the total European wind resource[2];
- ... throughout the U.K. there are 117 operational wind farms, four of which offshore; in addition, 24 wind farms are currently under construction (one offshore); 70 projects have obtained planning consent (nine offshore); and 165 other projects are in planning stage (six offshore)[3];
- ... throughout the U.K. there are 1,445 wind turbines - when operating at full output (i.e. maximum rated power) they produce enough electricity to supply 747,666 houses and

[1] Statistics World Wide by Wind Service Holland, last updated in 19 January 2006 – available at: http://home.wxs.nl/~windsh/stats.html

[2] "Beaufort Scale" for wind energy, by BWEA, last updated in 23 August 2004 – available at: http://www.bwea.com/ref/bweabeaufort.html

[3] "UK Wind Energy Database", by BWEA, available at: http://www.bwea.com/ukwed/

save 3.02 million tonnes of CO_2, 35.1 thousands of SO_2 and 10.5 thousands of NO_x from being released to the atmosphere annually;

- ... within the U.K., England has the greatest number of operational wind farms but Scotland generates more wind energy;
- ... a commercial onshore wind turbine ranges in capacity between 0.7 MW and 2.5 MW; the typical turbine installed in the U.K. today is "rated" at 1.8 MW; the trend is towards larger machines as they can produce electricity at a lower price;
- ... the total height of a commercial wind turbine, from the base to the blade tip, can be 140 m; in the U.K. wind turbines of about 120 m are quite common - the height of a 40-store building;
- ... the ideal turbine has 3 blades, and the greater the blades' length, the greater the energy output - today a common blade length is 40 m, just a bit less than four London buses in a line;
- ... a wind turbine has an average working life of 20-25 years, after which the turbines can be either replaced with new ones, taking advantages of the existing foundations, or decommissioned[4];
- … most of the costs of a wind farm are paid "up front", when the wind farm is built: approximately 75% of the total power generation costs are related to capital costs, i.e., costs for the wind turbines, foundation, electrical equipment and grid-connection[5].
- ... the cost of producing 1,000 units of wind energy (1 kWh) of electricity using wind energy in the U.K. varies between 3.5 pence and 2.9 pence, depending on the wind speed and the formula used to calculate the cost[6];

[4] "Wind Turbine Technology", BWEA briefing sheet, Sept. 2005 – available at: http://www.bwea.com/energy/briefing-sheets.html

[5] "Wind Energy - The facts: Cost & Prices" published by the European Wind Energy Association and the European Commission's Directorate General for Transport and Energy, volume 2, 2003.

[6] Refer to "The economics of wind energy" section in this document for details.

- ... the average wind farm will pay back the energy used in its manufacture within 3-5 months of operation[7];
- ... a 10 MW wind farm can be constructed within 2 months[8];
- ... a wind turbine generates electricity for 70-85% of the time, although the electrical output depends on the wind speed (wind turbines work at their maximum “rated” capacity for wind speeds between approx. 15 m/s and 25 m/s)[9];
- ... over the course of a year, a wind turbine typically generates about 30% of the theoretical maximum output; his is known as its load factor (the load factor of conventional power stations is on average 50%);
- ... the European wind industry sector employs, directly and indirectly, more than 72,000 people; the EWEA estimates that this figure will reach almost 200,000 by 2020; and
- ... in the U.K., a 1995 survey suggests that there were about 1,300 full time equivalent jobs in the U.K. wind industry in 1994-5[10]; BWEA estimates that today the wind industry employs over 4,000 people[11].

2 Why wind energy?

An answer to this question has three parts:

- today’s society is highly dependant on energy;
- renewable energy is essential to tackle the environmental threat of global warming; and

[7] “Top Myths About Wind Energy” by BWEA – available at: http://www.bwea.com/energy/myths.html

[8] “Wind Energy - The facts, an Analysis of Wind Energy in the EU-25” by EWEA, Feb 2004 – available at: http://www.ewea.org/index.php?id=91

[9] “Can we rely on the wind?” by BWEA – available at: http://www.bwea.com/energy/rely.html

[10] “Employment in Wind Energy in the UK” by BWEA – available at: http://www.bwea.com/jobs/jobsurvey.html

[11] “Why wind?” by BWEA – available at: http://www.bwea.com/ref/whywind.html

- wind energy is arguably the most cost-effective renewable energy currently available.

Since the two first statements are fairly consensual, this section focuses on the third point.

Amongst the various forms of renewable energy available (solar, tidal, waves, hydro, wind, biomass, landfill gas ...), wind energy is the one that has seen the most development over the past 10-15 years. The technological progress that occurred over this period is simultaneously cause and effect of the relatively low prices of wind energy nowadays.

2.1. The economics of wind energy

In 2004, a study commissioned by the Royal Academy of Engineering estimated the average cost per generated unit of power (kWh) from onshore wind energy in the U.K. at 3.7 p/kWh[12]. A more recent study by Sustainable Development Commission (SDC), an independent government advisory body, estimated this figure around 3.2 p/kWh (+/-0.3 p/kWh)[13]. This represents a premium over the current price of gas-fired electricity (combined cycle gas turbine) of around 3.0 p/kWh.

The single most important factor influencing the cost of wind-generated electricity is the production power available at any location: turbines sited at good wind locations are likely to be more profitable than those at poor wind locations.

With respect to the supplying cost of wind energy, assuming the extreme scenario that the government's target for renewable energy by 2020 (i.e., 20% of electricity consumption being generated from renewable energy) is entirely fulfilled by wind energy, the SDC's study estimated that a net additional cost of around 0.17 p/kWh would be added to the electricity network when compared with the cost of conventional electricity generation scenario, i.e., coal/gas mix, with gas price at 30 p/thermo. This net additional cost is calculated by adding all estimated costs of wind power (i.e., increased need for balancing services, higher installed costs and network upgrades) and subtracting all estimated benefits (i.e., reduced conventional fuel use and the displaced costs of conventional plant). In these calculations the social cost of carbon dioxide emissions (CO_2) was not included; if it were, the

[12] "The Cost of Generating Electricity", by PB Power for the Royal Academy of Engineering, March 2004.

[13] "Wind Power in the UK", by Sustainable Development Commission, November 2005.

extra cost of supplying wind-generated electricity could be zero, depending on the price attributed to each tonne of CO_2.

2.2. Comparative costs of electricity

Having for reference prices bid into the third (and last) round of the Scottish Non-Fossil Fuel Obligation (SRO3), the British Wind Energy Association (BWEA) suggests that, in 2004, wind energy prices ranged between 2.2 and 3.2 p/kWh. At the same time, the cost of gas-fired electricity production (combined cycle gas turbine), the least expensive technology, ranged between 2.0 and 2.4 p/kWh, including an additional 0.3 p/kWh to account for the cost of carbon (2004 prices). New coal and nuclear power were more expensive than wind, even without the inclusion of the cost of carbon[14].

Differently, the study by the Royal Academy of Engineering[12] suggests that coal- and gas-fired technologies are cheaper than wind power, even when the costs of CO_2 emissions are accounted for. The nuclear power is identified as the cheapest technology for electricity production, however, it is noteworthy that the costs of dealing with nuclear waste are not internalised in the analysis.

In spite of the conflicting prices put forward by the different studies, an important message seems to prevail when comparing wind energy to conventional technologies: although wind power generation costs are marginally higher, when external (social and environmental) costs are accounted for, wind energy become competitive with conventional technologies, specially at sites with good average wind speed (6.9 m/s and above).

When comparing the generation costs of renewable energy technologies, the studies draw a unanimous conclusion: wind energy is the cheapest renewable energy today. Significant in the U.K. context is also the conclusion of a recent study commissioned by the Department of Trade and Industry: excluding biomass/coal co-firing, onshore wind (at sites with wind speed above 9 m/s) is the lowest cost source of renewable energy with guaranteed availability in the U.K.[15]

[14] "The Economics of Wind Energy" by BWEA – available at: http://www.bwea.com/ref/econ.html

[15] "The Costs of Supplying Renewable Energy" by Enviros Consulting Ltd, commissioned by the Department of Trade and Industry, February 2005.

Looking forward, renewable energy prices are anticipated to decrease while conventional fossil-fuel technologies are projected to increase[16]. The table below shows the projected costs of various electricity fuel sources for 2020. It suggests that, in about 15 years' time, wind energy will be the lowest price renewable technology, and almost as cheap as large Combined Heat and Power (CHP).

Table 1: Electricity fuel source cost projection for 2020[17].

Technology	Cost in 2020 (p/kWh)	Confidence in estimation
Conventional fuels		
Coal (IGCC)	3.0 - 3.5	Moderate
Gas (CCGT)	2.0 - 2.3	High
Fossil generation with CO_2 capture & sequestration	3.0 - 4.5	Moderate
Large CHP (gas)	under 2.0	High
Micro CHP (gas)	2.5 - 3.5	Moderate
Nuclear	3.0 - 4.0	Moderate
Renewables		
Onshore wind	1.5 - 2.5	High
Offshore wind	2.0 - 3.0	Moderate
Energy crops	2.5 - 4.0	Moderate
Wave	3.0 - 6.0	Low

[16] "The True Price of Generating Electricity" by BWEA 2001, reporting on the results of the ExternE, a research project of the European Commission.

[17] "The Energy Review" by the Prime Minister's Strategy Unit, February 2002.

Solar photovoltaic	10.0 - 16.0	High
IGCC - Integration Gasification Combined Cycle CCGT - Combined Cycle Gas Turbine CHP - Combined Heat and Power		

3 Wind energy: the debate

This section provides an overview of the arguments for and against wind energy development in the U.K. The arguments are organised by topic:

- Resource and technology
- Environmental impacts
- Landscape impact and tourism
- Local amenities and house prices
- Jobs and the economy

3.1. Resource and technology

Arguments for

- wind resources are free, widely available and will never run out;
- the U.K. has the best wind resource in Europe, especially Scotland;
- wind is an inner resource, thus harnessing it reduces our dependency upon imports of (and the effects of fluctuation prices of) fossil fuel energy sources;
- wind energy is clean: it prevents the emission of several greenhouse gases, including carbon and sulphur dioxides;
- wind energy is benign: it produces no harmful pollutants or waste products, nor does it have

costs that are passed onto future generations;

- wind technology is safe: “in 25 years of wind generation, with 68,000 turbines now worldwide, there are no significant reports of health issues”[18];
- wind electricity can be generated and consumed locally, reducing energy losses in transmission - local electricity generation is particular valuable in remote areas;
- onshore wind is the most cost-effective renewable energy technology that can be deployed in the U.K. today[19]; and
- every unit of electricity produced by the wind displaces a unit of electricity which would otherwise have been produced by a power station burning fossil fuel.

Arguments against

- subsidies going into renewable energy (wind energy, in particular) should be diverted to energy conservation;
- there are other available technologies capable of producing electricity while cutting on CO_2 emissions;
- wind energy does not help to reduce carbon dioxide emissions significantly;
- wind energy is inefficient and unreliable, a direct consequence of the unpredictability and intermittent nature of the wind;
- wind energy requires extra investment in improving and reinforcing the grid to enable it to accommodate the fluctuations in supply;
- wind energy needs fuel-generated energy back-up for the times when the wind is calm; and

[18] “Wind power: 10 myths explained” by DTI, 2005 – available at: http://www.dti.gov.uk/renewables/renew_1.1.2.2.htm. See also the accident statistics compiled by Caithness Windfarm Information Forum – available at: http://www.caithnesswindfarms.co.uk/pages/accidentData.htm

[19] Refer to “The economics of wind energy” section in this document for details.

- wind energy raises security concerns: parts of broken blades and lumps of ice have been thrown hundreds of metres away.

3.2. Environmental impacts

Arguments against

- wind power plants are land-intensive: many wind turbines, spread out over a big area, are needed to produce small amounts of energy;

- wind energy can result in habitat loss and degradation: erosion after the soil surface has been disturbed to install wind turbines has been reported;

- wind energy is hazardous for birds: many have died in collision with wind turbines[20]. Evidence shows that wind energy's overall impact on birds is low compared with other human-related sources of avian mortality: in every 10,000 bird fatalities, less than one is due to wind turbines[21]; and

- the environmental costs of developing wind energy outweigh the savings in emissions: "the core of the problem is tiny output (...), the prominence of the sites (...) and the huge numbers required in consequence to generate even modest amounts of electricity"[22].

Arguments for

- turbines have a small footprint: a turbine's base only occupies a small area and the land around them can be used for other purposes;

[20] "Chilling Statistics - Birds/Windfarms - A Compilation Of Bird Mortality Reports" by Iberica 2000.org, 2006 – available at: http://www.iberica2000.org/Es/Articulo.asp?Id=1875

[21] "Summary of Anthropogenic Causes of Bird Mortality" by Erickson et al., 2002, quoted in the American Wind Energy Association's website, 2006 – available at: http://www.awea.org/faq/tutorial/wwt_environment.html#Visual%20impacts

[22] "The Case Against Wind 'Farms' ", by Country Guardian, 2000 – available at: http://www.countryguardian.net/case.htm

- negative environmental impacts from wind energy systems are minimal and local - conscientious site selection and adequate landscaping and engineering practices help to minimise them;

- bird collisions with wind farms is a site-specific issue: areas with the potential to threaten or endanger bird species should be regarded as unsuitable for wind development;

- wind energy creates important social and environmental benefits due to reduced CO_2 emissions: avoided illness, prevention of acid rain which has harmful effects on wildlife and crops; and
- the environmental benefits of wind energy far outweigh the negative impacts.

3.3. Landscape impact and tourism

Arguments for

- visual impact of wind turbines can be mitigated by careful site selection and wind farm design;

- wind farms are tourist attractions: wind farms' visitor centres continue to receive people; and
- wind energy endorses a region's positioning as a "green" and environmentally friendly place to visit: wind turbines are often featured on post cards, magazine covers, and web pages.

Arguments against

- wind turbines are visually intrusive, spoil the landscape and destroy the countryside;

- wind energy has an adverse impact on tourism: a consequence of the degradation of landscape quality and rural tranquillity induced by wind turbines - a 2002 survey of visitors to major beauty spots in Scotland found that 91% of respondents said the presence of wind farms in the area made no difference to whether they would return[23]; and

- once the novelty value of wind farms is lost, the number of visitors to received by wind farms will drop.

3.4. Local amenities and house prices

Arguments against

- wind turbines are noisy: some people have stated that a nearby wind turbine has detrimental effect on their health and quality of life (nuisance and sleep disruption being the most frequently stated reasons);

- wind turbines produce flickering shadows (when the sun shines through the rotating blades), which cause disturbance and nuisance to people, particularly for those suffering from epilepsy - scientists have shown that the maximum frequency of this flicker effect is too low to produce adverse reactions[24];

- the movement of, and light reflected from, turbine blades are potentially dangerous to drivers;

- wind turbines can disrupt radio and television reception, radar systems and other electromagnetic networks; and

- wind energy has an adverse impact on house prices, mostly due to the visibility of wind turbines - a study by the Royal Institution of Chartered Surveyors acknowledges this impact but suggests that house prices begin to recover once the wind farm has been up and running for two years[25].

Arguments for

[23] "Wind farms and tourism: the facts" by BWEA, 2002 – available at: http://www.bwea.com/media/news/tourism.html

[24] "Key issues: Shadow flicker" by DTI, 2005 – available at: http://www.dti.gov.uk/renewables/renew_3.5.1.4.htm

[25] "Wind farms hit house prices" by Royal Institution of Chartered Surveyors, 2004.

- current wind turbines are quieter than in the past and the trend is to become quieter still: the wind industry states that today it is possible for people to have a normal conversation while standing underneath an operating turbine without having to raise their voices.
- judicious site selection and wind farm design avoids or minimises potential problems from the flickering effect of blades and light reflected from them; and
- technical solutions exist to overcome potential electromagnetic interference from wind turbines

3.5. Jobs and the economy

Arguments for

- if the subsidies going into wind energy were diverted to other technology or energy conservation, jobs would also be created;
- the local jobs created by the wind industry are temporary, concentrated in the few months that the construction work takes, and there are examples of foreign construction site workers installing foreign-made turbines5;
- maintenance of wind turbines creates few local jobs: the number of full-time employees at a wind farm is minimal and maintenance is often by contracted external specialists; and
- wind energy threatens jobs in the tourism industry.

Arguments against

- wind energy helps the local economy by creating local jobs in construction and ongoing maintenance of wind energy projects and provides an extra source of income for land owners from site rental; and
- wind energy development creates jobs in manufacturing and other sectors indirectly involved in

it, such as environmental consultancy, electrical and civil engineering and financial and legal services

4 Public opinion on wind energy

"Visual intrusion" or the "loss of visual amenity" remains the primary cause of opposition and objection to wind energy in the U.K.. Despite this, surveys of public attitudes regularly show that a large majority of respondents are in favour of wind power, both in principle and in practice.

Data from 50 surveys carried out in the U.K. between 1991 and 2004 show that, on average, 77% of the public are in favour of wind energy, with 9% against[26]. A survey of people living close to Scotland's ten largest wind farms, carried out in 2003, shows that 82% of respondents were in favour of increasing the proportion of electricity generated from wind energy; 54% of respondents would support an expansion of their local wind project by half the number of existing turbines, while 9% were opposed to an increase in the number of wind turbines at their local wind projects. It additionally shows that most people think that the local wind project had had neither a positive nor negative impact on the area - 20% said the local wind project had a broadly positive impact and 7% said it had had a negative impact[27].

Interestingly, the surveys reveal that positive attitudes increase through time and with proximity to wind farms: people not convinced at planning and construction stages become supportive once the wind turbines enter operation; and the closer the proximity to the wind turbines, the higher level of support from residents.

Results from some surveys even contradict the idea that stronger opposition to wind turbines comes from those who can see them from their houses. This finding suggests that the typical NIMBY (Not In My Back Yard) syndrome does not fully apply to wind energy. Instead, it appears to be a case for

[26] "Public attitudes to wind energy in the UK", BWEA Briefing sheet, 2004 – available at: http://www.bwea.com/ref/surveys.html

[27] "Public Attitudes to Windfarms: A Survey of Local Residents in Scotland" by MORI Scotland, commissioned by the Scottish Executive, 2003.

NIABY (Not In Anyone's Backyard), as a blanket rejection of the very concept of wind energy is advocated by the technology's opponents.

Survey evidence also indicates that people's viewpoints are critically influenced by the nature of the planning and development process: the earlier and more open and participatory the process is, the greater the likelihood of public support. If local residents feel driven into a fury of activity by profit-driven developers, strong opposition may be generated.

Commenting on the results of surveys, opponents to wind energy often draw attention to the pro-wind pre-disposition of the authors when evaluating survey results or suggest that "opinion surveys are often snapshots of ill-informed opinion". Specifically, with reference to a survey that identifies the reasons behind people's support for the local wind farm, the Country Guardian states that "survey respondents generally expressed support of wind energy based on the belief that it was a solution for global warming. Given wind energy's limited effectiveness in reducing greenhouse gases based on today's studies, we question how survey participants might respond if contacted again"[28].

[28] "The Case Against Wind 'Farms' ", by Country Guardian, 2000 – available at: http://www.countryguardian.net/case.htm

WIND FARM SITING

1 A feasible site

Feasible sites for wind farms are selected by wind farm developers. In the process a number of factors are considered. These can be grouped in three categories:

- Developer's requirements;
- Planning considerations;
- Interests of other stakeholders.

1.1. Developer's requirements

The developers' requirements generally relate to the technical feasibility and economical profitability of the site. However, other aspects may also impinge on the decision. Below is a list of principal factors that developers take into account when appraising a prospective site:

- **wind speed** - The energy produced by a wind turbine depends on the strength of the wind to which it is exposed. Wind turbines start generating electricity at wind speeds of around 3-4 metres per second (m/s); generate maximum rated power at around 15 m/s; and shut down to prevent storm damage at 25 m/s or above. Usually developers consider sites with a minimum annual mean wind speed of 6.5 m/s (14.5 mph), at the hub height of the turbine, for potential wind farm development - other reasons, such as promotion of the technology or the image of the company may, however, lead to the consideration of lower wind speed sites. A site with wind speeds of around 8 m/s is considered a good site.

- **extent of the site -** Although a single turbine only requires enough space to accommodate the turbine's foundation, projects involving several wind turbines need to provide adequate separation between turbines to lessen energy loss through wind shadowing from upstream machines. Minimum distances between turbines are 5 rotor diameters in the prevailing wind direction (about 300 m for a current 1.3 MW wind turbine) and 3 rotor diameters (130 m) in the perpendicular direction.

- **access to the site -** Wind turbines are structures of large dimensions manufactured offsite. Access to a site must accommodate trailers carrying the longest loads (usually the blades) as well as the heaviest and widest loads (generally the cranes required in erection). Developers are frequently forced to consider upgrading existing roads to ensure adequate access.

- **gradient of the site -** Terrain with large gradient is unsuitable for wind farm installation. A 10% gradient appears in the literature as the acceptable upper threshold.

- **grid connection -** Like any other power station, wind farms need to be connected to the electricity network. The developer is responsible for collecting the output from each turbine in the farm at a single point where a small sub-station acts as an interface to the electricity distribution network. The routing of the electrical cabling onwards from this sub-station to the nearest suitable point of the local electricity distribution network is the responsibility of electricity distribution network operator, but paid for by the developer. The distance between the sub-station and the connection point is a critical determinant of the costs of the connection lines and the impact of such costs on the total site development costs. Moreover, shorter connection lines result in reduced losses and, thus, in increased energy output to sell.

- **prospect of obtaining planning permission –** The difficulties that developers are encountering in getting their projects approved, paired with the technological advances that enable reasonable outputs at lower wind speed than ever before, are making the prospect of obtaining planning permission a more dominant factor in site selection process and wind speed a less pivotal criterion.

- **willing landowner -** Since rent is paid to the site's land owner, finding a willing landowner is not generally difficult.

1.2. Planning considerations

Planning considerations aim to ensure that environmental interests and local amenities are adequately protected by new wind farm developments. The following aspects are commonly considered during the site selection process:

- **Proximity to dwellings -** Operating wind farms produce noise (mechanical and aerodynamic). The current practice to ensure that the ambient noise levels around noise-sensitive developments (e.g., dwellings) are kept to acceptable levels with relation to existing background noise is to consider sufficient distance between the turbines and these developments. At low wind speed, when the difference between the noise of the wind farm and the background noise is liable to be the greatest, the recommended lower fixed limit noise, outside the development, for night-time is 43 dB(A) [LA90,10min] and within the range of 35-40 dB(A) for day-time[3]. The indicative noise level of a wind farm at 350 m is within the range 35-45 dB(A). The minimum distance between a wind turbine and the nearest dwelling commonly accepted is 300 m; however, developers should assess the noise effects of their project and act in conformity. The minimum distance needed to tackle the noise issue is regarded greater than that necessary to meet safety requirements, in the unlikely event of fragments of ice or a damaged blade being thrown.

- **Landscape and nature conservation designated areas -** Landscape designated areas include World Heritage Sites, Areas of Outstanding National Beauty (AONB), National Parks and Gardens, etc. Nature conservation designated areas include Ramsar sites, Spatial Protection Areas (SPA), Spatial Areas for Conservation (SAC), etc. The national policy on renewable energy (Planning Policy Statement 22) says that designated areas, whether international, national or local designations, are not "no-go areas" per se. However, it puts the onus on the developer to demonstrate that the wider social, economic or environmental benefits coming out of the development outweigh any potential adverse effect on the integrity of those sites. In practice, developers seek to avoid such locations as they bring additional difficulties in getting their planning applications approved.

- **Bird areas -** The most common concern regarding birds is the risk of "bird strike", i.e., birds flying through the area swept by the blades and being hit, causing injury or death. To avoid such occurrences, wind farms should not be erected in migration paths, or areas of high concentrations of particular species (breeding areas).

- **Proximity to historical and cultural monuments -** There is no rule on how close a wind turbine can go to a listed building or conservation areas. On a case by case basis, developers should ensure that the landscape and visual effects of the project are acceptable in its setting.

- **Proximity to roads, railways and power lines -** Well erected wind turbines are stable structures. However, to achieve maximum safety, it is recommended that wind turbines are set back from roads, railways and power lines of at least fall over distance (i.e., the height of the turbine plus that to the tip of the blade).

- **Proximity to public rights of way -** There is no statutory separation between wind turbines and public rights of way. It is often taken that a wind turbine's blades should not oversail the public; and fall over distance is considered an acceptable separation. Nonetheless, following internal consultations, some bodies have suggested set-back distances: the British Horse Society has suggested a 200 m exclusion zone around bridle paths to avoid wind turbines frightening horses; and the Countryside Agency has called for a distance of three times the height (to blade tip) of the turbines from bridleways and four times the height of the turbines near National Trails.

1.3. Interests of other stakeholders

Wind farms may interfere with other stakeholders' activities or interests. A feasible site should respect these interests to obviate objections to a proposal.

- **Shadow flicker and reflected light -** Rotating wind turbine blades can cast moving shadows that affect residents living nearby. This effect is called shadow flicker and has been proven to occur only within 10 rotor diameters of a wind turbine: if a turbine has 80 m diameter blades, the potential shadow flicker effect would be felt up to 800 m from the turbine. As a corrective measure, for this impact the developers are often asked to consider shutting down the turbine during critical periods. Flashes of reflected light from the turbines can be reduced by careful choice of the blade colour and surface finish: light grey, semi-matt finishes are often used.

- **Electromagnetic interference -** Wind turbines can interfere with electromagnetic transmissions in two ways: by emitting an electromagnetic signal itself, and by interfering with other electromagnetic signals. The first type of interference is rarely a problem; the second type may affect TV and radio reception and, therefore, is of concern to the general public. These effects can be alleviated either by installing signal booster equipment on or around the wind farm site, or by ensuring a clearance distance on either side of a line-of-sight link from the swept area of the turbines' blades, typically of 100 metres.

- **Air traffic safeguarding -** Wind turbines may have an adverse affect on two aspects of air traffic movement and safety: 1) they may represent a risk of collision with low flying aircraft; 2) they may interfere with the proper operation of radar, by limiting the capacity to handle air traffic and aircraft instrument landing systems. With respect to the risk of collisions, developments within a specific radius of major airports and aerodromes are subject to mandatory consultation with the Civil Aviation Authority (CAA) and/or Ministry of Defence (MoD). With respect to radar interference, the same need of consultation applies, mandatory within a 15 km radius, and advisable up to 30 km and 32 km around civilian and military air traffic radar respectively.

2 Planning application process

Onshore wind energy developments result from the initiative of developers. It is up to the developer to select potential sites, undertake feasibility studies, develop the final project, conduct the necessary environmental assessment, prepare the planning application and finally submit it to the planning authority for determination.

The determining authority for onshore wind farms is either:

- the Local Planning Authority (LPA), if the development is smaller than 50 MW - the final decision is taken by a committee of elected councillors;

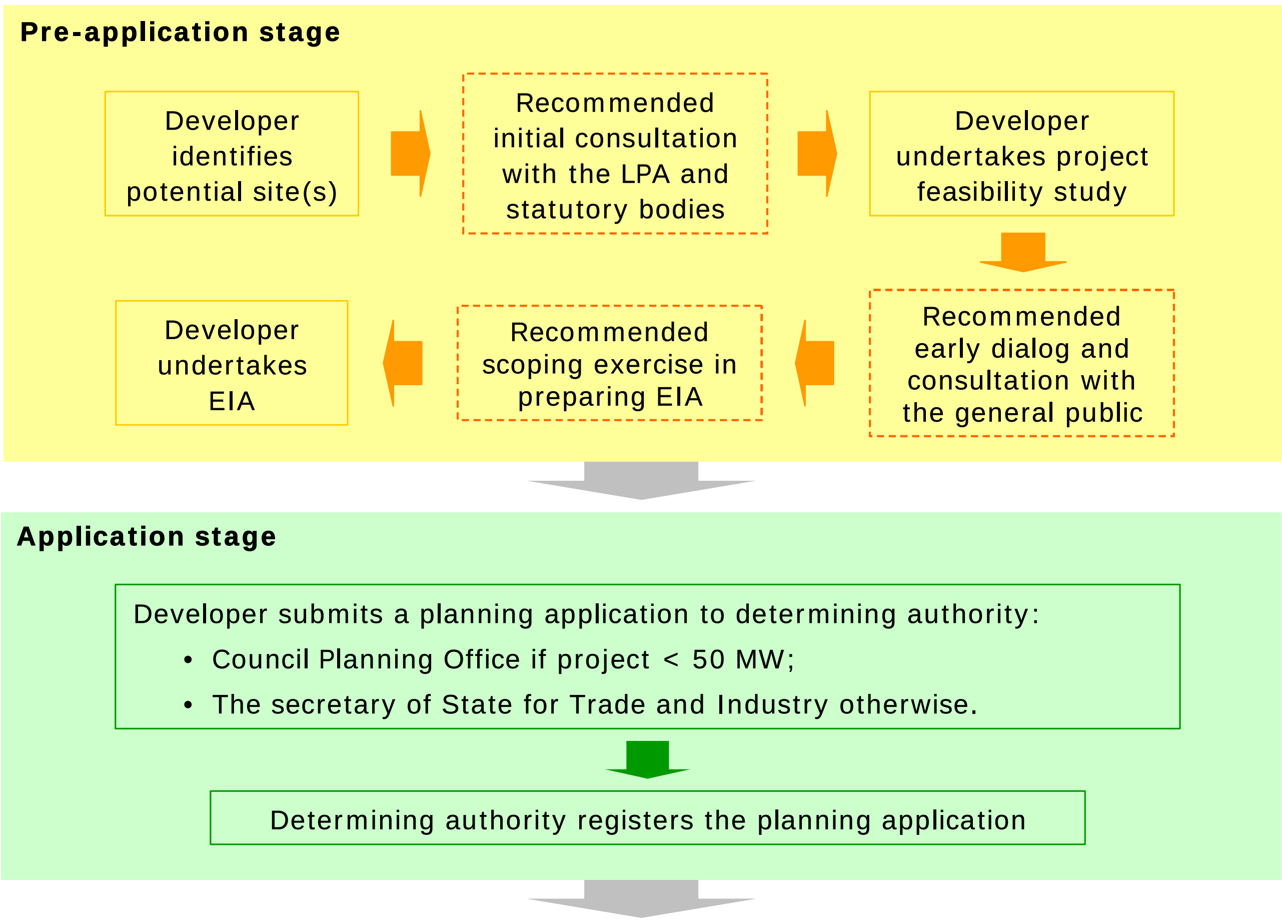
- or by the national or devolved government (The Secretary of State for Trade and Industry in England)- in this case, the LPA is a statutory consultee in the process.

The determination process consists of balancing the benefits arising out of development against the induced (local) environmental impact.

Wind farm projects are listed under Schedule 2 Developments of the Environmental Impact Assessment (EIA) Regulation[29], thus requiring EIA in case they are likely to have significant effects on the environment by virtue of factors such as its size, nature or location. Developers are encouraged formally to request from the LPA an opinion on whether or not the proposed development requires an EIA (screening) and which issues should be addressed in the Environmental Report/Statement to accompany the planning application (scoping opinion).

Figure 1 outlines the planning application process. Two real-world illustrations of this process are available at the WePWEP website and Simao (2006).

Figure 1 – Wind farm planning application process.



[29] "Environmental Impact Assessment (EIA) Regulation" - Circular 02/99: Environmental Impact Assessment, published by the Office of the Deputy Prime Minister.

Consultation stage

Public consultation:
- LPA advertises the application;
- Public lobbying.

Administrative consultation:
- Other district council departments;
- Government departments;
- Conservation groups ;...

Determination stage [target: within 8 weeks or 4 months if application has EIA]

Planning officer elaborates a recommendation based on the outputs from consultation stage.

Decision maker:
- Planning Committee, if project = 50 MW;
- The Secretary for State for Energy, if project > 50MW or if planning issues of more than local importance are involved ('call-in').

Post-determination stage

Permission granted

LPA can grant planning permission with or without planning obligations.

Permission refused

Developer can:
- Accept the decision;
- Appeal the decision; or
- Improve project and resubmit.

3 Public involvement in wind farm siting

National guidance on renewable energy (PPS 22[30]), best-practice recommendations[31] and multiple reports on wind energy encourage wind farm developers to engage in early dialogue with stakeholders and local communities, highlighting that wind farm projects have greater chance of being accepted if they are involved in decision-making regarding the site or/and project design. However, this comes down to a decision of the developer and the reality is that this is not common practice.

[30] "Planning Policy Statement 22": Renewable Energy, August 2004.

[31] For instance, "Best Practice Guidelines for Wind Energy Development" by the British Wind Energy Association, 1994.

When developers do approach local communities, their purpose is often to inform of their intention and proposal rather than to seek collaboration or constructive comments to incorporate in the project design. At this time, legitimate concerns or valuable opinions expressed by the communities are hardly welcome by the developer - amendments to the project at this stage represent extra delay, extra costs, and possibly technical difficulties.

The UK planning system determines two moments when the public can get involved in the wind farm siting:

- **During the consultation stage of a submitted planning application**[32] – members of the public can put forward their views on the submitted proposal by writing a representation to the local planning officer or local councillor; these letters shall be considered during the determination of the application.
- **During the planning appeal**[33], in case the developer appeals the decision of the determining authority – members of the public that have written representations during the consultation stage are contacted and invited to comment;

It is easily understandable that these moments imply a reactive behaviour by members of the public. Indeed, there is no formal timing for local communities to contribute to, and collaborate in, the development of a wind farm proposal, nor to wind farm planning in the wider context of their district or county.

It is our view that **the public, and local communities in particular, should be afforded a more participative role in the wind energy planning process**. We propose a strategic sub-regional approach to wind energy planning, and support the involvement of the public in this process since early stages. This approach is not a utopia and has already been implemented by several countries.

WePWEP website has been developed as a proof-of-concept tool to serve the purpose of involving interested citizens in the strategic planning of wind energy. Citizens are asked to state the importance they attribute to impacts associated to wind farm, and based on this information feasible sites to accommodate a wind farm are classified in classes of suitability for this purpose. Subsequently, citizens are invited to consider the feasible sites in their spatial context, and write any comment if they whish.

[32] Refer to "Planning applications process" section in this document for details.

[33] "Planning Appeals Regulation" - Circular 05/00: Planning Appeals Procedures, published by the Office of the Deputy Prime Minister.

Comments can reflect concerns regarding a specific site; aspects that they would like to be dealt by a potential developer of this site, etc. The whole process takes place without reference to specific wind farm proposals.

3.1. Our proposal: strategic wind energy planning at County level

PPS22 determines that the Regional Spatial Strategy (RSS) - the document that sets out the broad spatial planning strategy for the development of the region - should include a target for renewable energy capacity in the region, derived from an assessment of the region's renewable energy potential. These targets should be assimilated by the lower-hierarchy plans, namely County Council plans and District Council and Unitary Council plans.

Until the reform of the planning system, in April 2004, County Councils were responsible for the strategic sub-regional planning. The new planning system abolishes this planning level and District Councils and Unitary Councils (Local Planning Authorities) became responsible for outlining the spatial planning strategy for their local area in a Local Development Framework (LDF).

We agree that wind energy strategic development should be planned at a higher level than the local level. County Councils, having an integrated view over their county, which Local Planning Authorities lack, are at an appropriate level: they are well positioned to lead/coordinate a sub-regional wind energy development strategy, capable of making the bridge between the regional targets set in the RSS and the local policies set out in the LDF. Therefore, we suggest that planning for renewable energy in general, and wind energy in particular, should become a responsibility of the County Councils alongside that of planning for waste and minerals.

Strategic plans for wind energy development should be prepared very much in line with the action plans for housing and employment prepared by the Local Planning Authorities, i.e., by allocating preferential areas for wind farm developments. In contrast to the Business Planning Zones, put forward by the Planning Green Paper[34], where no planning consents are necessary for developments if they accord

[34] "Planning: Delivering a Fundamental Change", by Secretary of State for Transport, Local Government and the Regions, December 2001.

with some defined parameters, we suggest maintaining the need for planning consent even in defined, preferential areas.

The main advantages emerging from the proposed strategic wind energy planning approach would be the creation of opportunities for:

1. developers, planning authorities and multiple stakeholders (e.g., English Nature, Ministry of Defence, etc...) to work in partnership to design a strategy for the wind energy development in the area; and

2. the public to get involved and participate at the early stages of wind energy planning and wind farm siting processes.

The strategic locational plan for wind farms, resulting from a collaborative process, would guide wind farm developers towards areas where they could have greater confidence in having their project approved. Many battles on wind farm projects would be avoided and determination times for wind farm planning applications speed up. These aspects would favourably contribute towards the achievement of national renewable energy targets and protect the image of the wind energy technology from overstatements by its opponents.

An important point is that, without a strategic approach to wind farm planning, it is impossible to carry out any Strategic Environmental Assessment to ensure the sustainability of wind energy development, and thus fulfil the requirements of national and international legislation on this matter[35]. Likewise, it becomes difficult to evaluate and properly address cumulative impacts arising from adjacent wind energy developments.

3.2. Strategic wind energy planning: it is not utopia!

It is worth noting that a strategic approach to planning for wind energy has already been adopted by some countries. The National Assembly for Wales, acknowledging that the all-Wales level is the most appropriate scale at which to identify areas for onshore wind energy development, has defined in the

[35] "Strategic Environmental Assessment: Legislation & Guidance", Strategic Environmental Assessment Information Service website.

Technical Advice Note 8 - Planning for Renewable Energy (TAN 8) seven Strategic Search Areas (SSA) where large scale (over 25 MW) onshore wind energy developments should be concentrated[36].

In Scotland, the National Planning Policy Guideline NPPG6: Renewable Energy Developments (NPPG 6) states that the former Structure and Local Plans "should define broad areas of search suitable for wind and other renewable energy developments or, where appropriate, specific sites in local plans"[37]. Despite this policy the Scottish Executive has offered no locational guidance nor prepared an overall strategy to guide on-shore wind farm development. This initiative has been taken by the Scottish Natural Heritage (SNH) in preparing its own policy statement *Strategic Locational Guidance for Onshore Wind Farms in Respect of the Natural Heritage*[38]. This document classifies the suitability of areas for accommodating wind turbines into a hierarchy of three zones: lowest natural heritage sensitivity (Zone 1); medium natural heritage sensitivity (Zone 2); and high natural heritage sensitivity (Zone 3); and was intended to inform Local Planning Authorities when preparing development plans and help wind farm developers undertaking site searches.

The concept of strategic planning for wind energy has also been applied in Denmark. Since 1992, the Danish government requires local governments to provide space for wind turbines. Regional plans set the framework for the municipalities' plans, and municipalities are only allowed to initiate planning for wind turbines in areas which were designated for such use in the regional plan. At the bottom line of the process, developers do still need to get planning consent (or building permits) from the municipality to develop their project in those pre-planned areas for wind turbine use[39].

[36] "Technical Advice Note 8: Renewable Energy" by Welsh Assembly Government, July 2005.

[37] "National Planning Policy Guideline NPPG6: Renewable Energy Developments", by Scottish Executive, revised November 2000.

[38] "Strategic Locational Guidance for Onshore Wind farms in respect of the natural Heritage Policy Statement 02/02", June 2002, updated July 2004.

[39] "Community Benefits from Wind Power" by the Centre for Sustainable Energy and Garrad Hassan, on behalf of the DTI, 2005.