Designing a web-based public participatory decision support system: the problem of wind farms location

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ABSTRACT

Since the Rio de Janeiro Summit in 1992, there has been a strong political will to integrate renewable energy carriers in electricity generation and supply. Demand for wind energy in particular has been mounting. However, difficulties in securing planning permission have been reported by many authors. Through evidence in the literature we contend that more progressive and predictable planning consent can be achieved if the actual decision-making process is reformulated. First, comprehensive and accurate information should be provided to the public, as public attitudes in general are coloured by misunderstandings or biased information. Secondly, the public should be engaged in the decision-making process from the earliest phase of the planning procedure. Internet-based technologies have proved to be an efficient vehicle to disseminate information and have been argued to have the potential to widen participation in planning systems.

This paper presents the design of a web-based spatial decision support system conceived bearing in mind the following aspects: 1) the need to frame the wind energy context to the public; 2) the need to clarify wind turbines' and wind farms' impacts for the public, which can be achieved through the use of multimedia technologies (hotlinks to on-line movies, sounds, pictures, etc.); 3) the need to provide a virtual space where decision-makers (system users) can learn about their preferences concerning wind farm locations by exploring the consequences of stated preferences and have the opportunity to modify them in response until completely satisfied; and 4) the requirement for a framework in which arguments about the siting of wind farms can be explored, both by system users being given the opportunity to argue in favour of their learned positions and gaining knowledge about arguments supporting distinct positions.

This system will represent a contribution to three main domains. In the first instance, the collaborative planning stream concerned with participatory decision-making in spatial problems. In the literature, only a few collaborative spatial decision support systems give non-expert users the opportunity to explore and crystallize their preferences before stating their final judgement. Secondly, a contribution will be made to the field of wind farm planning, where the literature contains no reference to collaborative spatial decision support systems involving public participation. Finally, the web-based public participation arena where, in spite of the interesting examples already available, some aspects still represent major challenges and are worth further development: the use of the Internet as a bi-directional channel of communication between the public and policy authorities; and web-mapping technologies as a way to transmit spatial information at different scales seamlessly.

1 INTRODUCTION

The increasing emphasis on renewable energy and, in particular, the interest in wind energy developments frame the topic of this paper. A perceived sense of discontentment with the current wind farm licensing process motivated research on this topic. Several factors were identified that justify this discontentment: fundamentally, planning authorities have been making decisions without any strategic support and stakeholders have not been involved in the planning procedure until the late stages of public inquiry into project evaluation.

We favour a more positive, "plan-led" approach taking place at the regional level. Thus, decisions can be better tied to strategic needs. Further, we argue that public participation is fundamental to legitimating such decisions. Hence, we propose a collaborative framework that aims to enable stakeholders to participate effectively in defining the balance between local amenities and national policy in relation to wind farms, until now restricted to the licensing authorities. The proposed system explores the Internet as a vehicle to widen public participation and will use an argumentative framework to make reasoning public and trigger critical thoughts. This paper describes the structure of the system and systematises the questions that need to be answered before full implementation of such a system. After completion, we believe the proposed system will represent a valuable instrument for democratic participation.

The present paper is organised in nine sections. The following two sections set down the context of renewable energy and wind energy developments, respectively. Section four tackles the problems arising from current wind farm planning and licensing systems. The fifth and sixth sections depict the framework that supports our research and reveal our proposed way of proceeding. Section seven presents a brief discussion of the literature on public participation, which constitutes the basis of the proposed system, presented in section eight. Finally, the paper ends with some concluding remarks and sets out future work.

2 SETTING RENEWABLE ENERGY INTO CONTEXT

From heating and lighting to transport, industry and communications, energy is fundamental to almost everything we do. Most of the energy comes from fossil fuels, which has a negative impact in the environment due to the carbon dioxide (CO_2) released during its combustion. Annually, millions of metric tons of CO_2 are released to the atmosphere. During the year 2001, the Energy Information Administration estimated a worldwide emission of 24,082 million metric tons of CO_2 from the consumption and flaring of fossil fuels, 1.5% more than the previous year (EIA, 2003). Amongst the 6 main gases responsible for the greenhouse effect, CO_2 is the main contributor to the problem of global warming and climate change, the most serious environmental threats facing the world today.

The alteration of global climate became such a serious question that in 1992, a specific global convention was held in Rio de Janeiro, Brazil, to address this problem. The aim of the Convention was to get countries to agree to stabilise greenhouse gas (GHG) concentrations. Five years later, the subject was again at the centre of international debate during the Third Conference of the Parties to the United Nations Framework Convention on Climate Change held in Kyoto, Japan. A Protocol was signed as an attempt to limit CO_2 emissions levels in the atmosphere. Industrialised nations who signed up to the treaty are legally bound to reduce their collective emissions of the six GHG by at least 5% below their 1990 levels by the period 2008-2012. The European Union (EU) agreed a cut of 8% on its GHG emissions, making internal agreements to meet this target by distributing different rates to its member states.

Several measures can be explored to reduce CO_2 emissions. The two major axes of combat are: promoting renewable forms of energy supply and energy efficiency. We are particularly interested in the former. Promoting renewable energy, other than address the problem of GHG emissions and environment protection, tackles the problem of dependence on energy imports, as renewable energies are indigenous sources of energy, protects exhaustible energetic resources and contributes to the socio-economic development of peripheral, isolated and insular regions. Recognizing the prominent role of renewable energy, in 1997, the European Commission set out the ambitious objective of doubling the renewables' share of the EU's total energy supply from 6% to 12% (and 22.1% of electricity), by 2010 (European Commission, 1997). All Member States are responsible for reaching this target. Thus, in September 2001, the European Parliament and the Council adopted the Directive 2001/77/EC on the promotion of electricity produced from renewables in the internal electricity market (European Commission, 2001). Member States adopted national targets for renewables; the UK, for instance, set the target of 10% of the internal consumption of electricity to come from renewable energy sources by 2010. More recently, the UK Government decided broadly to double renewables' contribution to the energy mix to 20% by 2020, grabbing a recommendation from the Performance Innovation Unit (The Stationery Office, 2003).

3 WIND ENERGY

Renewable energy is obtainable from different sources: hydro, wind, solar, tidal, waves, landfill gas wastes and biomass residues, energy crops, etc. Considerable technological progress has been achieved on some of these renewable energy technologies over recent years, in particular for wind energy. The cost of wind energy plant has fallen substantially during the last fifteen years and this trend is continuing. This conjugated to the fact that wind energy is indigenous, secure and freely available and, in addition, does not create any dangerous waste products has lead some authors to argue that wind energy is one of the most cost-effective energy options for reducing global warming.

Wind energy is generated by wind turbines, most often gathered in wind farms. Traditionally wind farms locate on land. However, as wind speeds are generally higher offshore than on land, major offshore developments started to appear. Prices for energy generated in such a way are more attractive and it opens up further opportunities for wind industry.

By June 2003, 24,904 MW of onshore wind energy capacity were installed in European countries, 24,626 MW of which are in the European Union (EWEA, 2003). As for offshore, BWEA (2003a) state that a total of 10 projects are currently operational worldwide, with a combined capacity of 260.75 MW (all of them in Europe). Recently (November this year), a new offshore project started generating energy: the 60 MW North Hoyle Offshore Wind Farm in the UK. Several other projects both onshore and offshore are planned.

Despite these impressive achievements, difficulties in securing planning permission have been reported and are acknowledged to be a grave hindrance to achieving the necessary growth of renewables. NWP (2000) reported that, in the UK, up to three years are required for wind farms to go through the planning and Public Inquiry process, with less than a one in five chance that planning permission will be granted at the end of it. This problem is further exacerbated by the increasing drive toward larger wind farms justified by gradually falling prices of progressively bigger wind turbines and other factors related to economies of scale.

4 CRITICISMS TO CURRENT WIND FARM LICENSING PROCEDURE

Despite results of surveys of public attitudes, that reveal strong and often overwhelming public support towards wind energy and wind farms (BWEA, 2003b; Braunholtz, 2003), obtaining planning permission has been a problem. Considering current licensing processes throughout Europe, and in particular in the UK, two main reasons may justify this fact. Firstly, although planning instruments provide for local plans to specify suitable sites for renewable energy (cf. PPG22), they rarely contain sufficiently detailed policies to be able to determine in advance of making a planning application whether a project will be successful in planning terms. As a result, strategic wind farm decisions must be taken at a local level without the benefit of a broader strategic approach supported by sound principles. Several consequences derive from this fact: 1) enlargement of the degree of uncertainty for prospective wind farm developers as they are unable accurately to predict public reactions to their proposal; 2) arbitrariness in judging planning applications as it is difficult to maintain consistency over time; and 3) delays in processing planning applications by the already grossly overworked planning departments. Second, current decision-making processes either exclude the public or involve them too late in site selection decisions. Fig. 1 depicts the planning procedure in the UK for both onshore and off-shore wind farm developments. The public is neglected in early phases of the procedure, most often with their voices only heard at the level of an individual planning application (if developers decide not to undertake the recommended scoping exercise prior to the EIA).

The onus of site selection is on the developer, who makes a choice using feasibility studies, develops the project proposal and submits it for planning consent to the licensing authority. In the UK, projects under 50 MW of generated wind power are considered by local authorities. For larger projects, the DTI is the licensing authority.

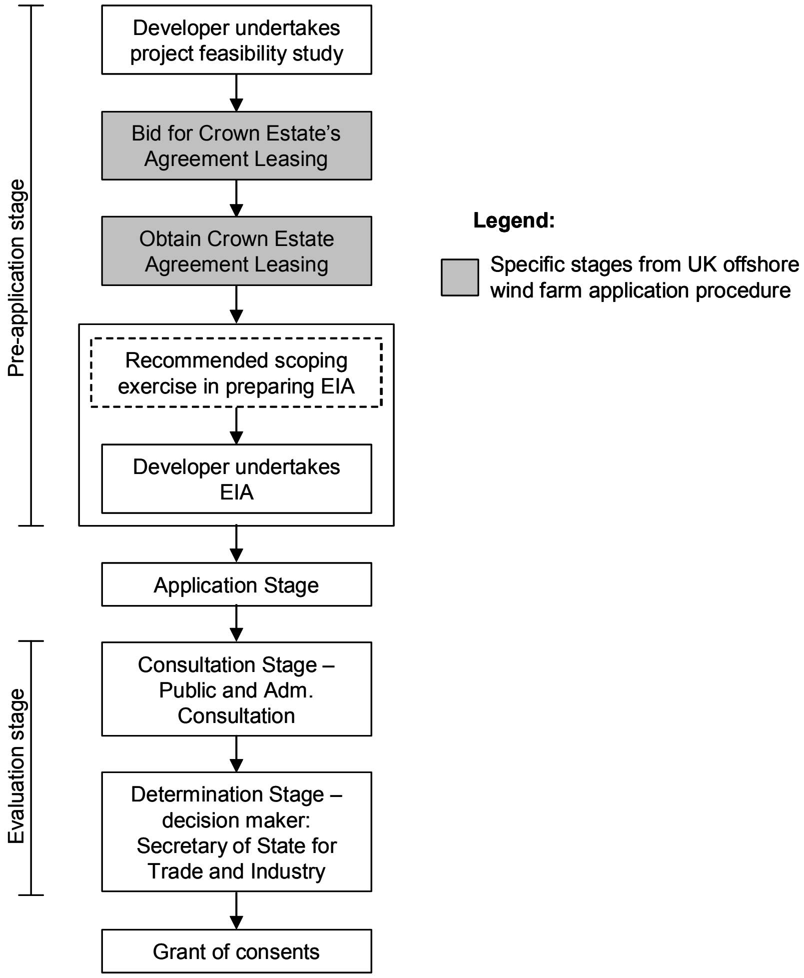

Figure 10 – Planning procedure in UK. Gray boxes enclose supplementary procedures associated to offshore wind farms planning permission.

By the time the public get involved, significant alterations to projects represent a big nuisance and only small changes are willingly accepted by developers. Therefore, whenever there are objections, the debate is predictable. Developers defend their project as they invested a considerable amount of money in its conception. The public, most likely guided by pressure groups, will find more and more arguments to "justify" why the chosen site is "unacceptable" and/or support their standpoint. Impasse is the result until The Secretary of State is called upon to review the application and make a final decision, which often is challenged in court.

5 SOME STEPS FORWARD

The UK Government acknowledges the need to "promote and encourage" wind energy. Moreover, there are huge inconsistencies over approval of onshore wind schemes (BWEA, 2003c) in England (at the local authority level Devon, Lancashire and Northumberland turned down all applications over the past five years, Yorkshire allowed 100% of applications and many counties passed between 50% and 80%) and in the UK (overall, in England the approval rate for the past five years is 50% while in Scotland is 94%). Thus, the UK Government undertook two important initiatives based on the concept of 'thinking globally, acting locally', long associated with sustainable development.

The first initiative aimed to implement a more proactive regional planning system. The Government established a "new" regional agenda which sets up the possibility for Regional Planning Bodies (RPB) to produce Regional Planning Guidance (RPG) (DTLR, 2000). RGP should be based on a sustainability appraisal (The Stationery Office, 1999) and will evolve into a specific integrated spatial strategy for the region, providing the framework for the range of public policies that will manage the future distribution and level of activities in the region. The appraisal process is intended to be continuous, iterative and take place throughout RPG preparation. Regional stakeholders and the community are welcome to participate in the RPG process, as the main idea is to test the performance of a plan, thereby providing the basis for its improvement. In 2001 this framework was enlarged to all EU Member States by Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment (European Commission, 2001).

The second initiative consisted of the Government's request to elaborate a regional approach to renewable energy (DETR, 2000a). This should include regional renewable energy generation targets flowing from the assessments of each region's capacity to generate electricity from renewable sources and a full consultation with local groups of what is realistically achievable in the region. RPG should assist in the delivery of these targets by 1) defining broad locations for renewable energy development; 2) setting criteria to help local planning authorities select suitable sites in their plans and 3) setting sub-regional targets – i.e., feeding into subsequent structure plans and unitary development plans, only "where sensible to do so" according to the Planning Minister Nick Raynsford[1] in 2000. The overall aim is that the strategies and targets should feed through into development plans, which are the starting point for planning decisions at a local level. These plans must be subject to public consultation during the Strategic Environmental Impact (SEI).

These two initiatives compose the scenario where our current work takes place, as described in the next section.

6 CONTEXT FOR PROPOSED WORK

We contend that the way to move forward is by fostering a more positive, "plan-led" licensing system at the regional level that can be cascaded down to lower tiers, i.e., local development plans and individual planning applications. Such a procedure would: 1) offer more predictable planning consents for developers; 2) contribute to greater public familiarity with, and acceptance of, prospective renewable energy developments; and 3) secure the achievement of national and regional targets in a more strategic and advantageous form.

RPG provides a realistic opportunity for wind energy to be integrated into strategic thinking at the regional level. Furthermore, sustainability appraisal as a continuous, iterative and participatory planning process sets the scenario for ongoing research work. Planning instruments, such as guidance, guidelines and plans are the responsibility of planning authorities that have democratic mandates for making planning decisions. Such decisions must take full account of national government policies but also of regional and local requirements. Decisions can not be made in isolation; there is potential benefit to all parties that interested stakeholders get involved in the elaboration of such instruments. In fact, some bodies, particularly nature conservation and landscape protection bodies, often have valuable advice to give and so has the public. On the other hand, democratic participation legitimates outputs and brings considerable weight to the determination of planning application and appeals.

Supported by these considerations, the proposed research aims to design, develop and test a framework for democratic participation by allowing the public to express their opinion and collaborate in the process of determining the "most appropriate" places for siting wind farms. The idea is that if access to relevant information, and the tools with which to use it, are available, then widespread public consultation and participation in the decision-making process surrounding problems of national or local importance could be expected. In return, decision makers (government ministers, local authority planners, etc.) get a greater insight into the views of the participating electorate. In consequence, we should all be better informed and have better informed decision-making.

Before describing the proposed framework, let us outline some general aspects of public participation in decision-making.

7 PUBLIC PARTICIPATION

The biggest impulse towards public participation comes from Local Agenda (LA) 21, the action plan proposed by the United Nations at the Rio de Janeiro Earth Summit in 1992. LA 21 aims to achieve sustainable development and a higher quality of life for all people. As many of the problems and solutions addressed by LA 21 have their roots in local activities, principle 10 of the document expressly states "At the national level, each individual shall have appropriate access to information concerning the environment … and the opportunity to participate in decision-making processes". In June 1998, this basic principle was further elaborated on in the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, which entered into force on 30 October, 2001 (DETR, 2000b).

7.1 Traditional methods of public participation

Traditional methods of public participation in the planning system range from neighbour notifications, exhibitions, public meetings and public enquiries through to high court hearings (Thomas, 1995). Over recent years, these methods of participation have been criticised by many (Healey, 1998). Council planning meetings, in particular, present several characteristics that discourage participation (Kingston *et al*., 2000): they often take place in an atmosphere of confrontation; sustaining a tone of "them and us", with the authoritative decision makers holding all the knowledge, expertise and information and, more often than not, positioned on a platform with the general public down below in a less favourable physical and psychological position. Such meetings can be dominated by a vocal minority (activists) and often the whole process involves highly technical and legal "jargon" that is barely understandable for laypersons. Finally, meetings are nearly always held in a fixed place or location and at a fixed time, restricting the number and types of people who are able to attend.

7.2 Alternative approaches to public participation

To overcome these difficulties, alternative methods of public participation have been investigated by making use of Information and Communication Technologies (ICT) (Shiffer, 1995; Howard, 1999; Kingston *et al.* 2000; Carver, 2001; Al-Kodmany, 1999; Hudson-Smith *et al.*, 2002). Web-based approaches, in particular, have been argued to have the potential to widen participation in planning system (Kingston, 1998, quoted in Al-Kodmany, 1999).

An immediate advantage of this web-based approach is greatly increased levels of public access. Public meetings available over the web are no longer restricted to geographical location or specific times. The concept of "24/7" (i.e., 24 hours a day, 7 days a week) opens up opportunities for more people to participate in public consultation. Furthermore, the Internet has the potential to break

[1] As quoted in *DETR's strategic planning for renewables* [Online], extract from the July-Aug 2000 edition of Renew On Line (UK) 27. Available from: http://www-tec.open.ac.uk/eeru/natta/renewonline/rol27/6.htm.

down some key barriers to participation by taking away certain physiological elements that the public face when expressing their points of view at a public meeting. In reality, as participants are at the end of a telephone line, they are free to make comments and express their views in a relatively anonymous and non-confrontational manner when compared with making a point verbally in front of a group of relative strangers. Thus web-based systems can provide a more comfortable environment and any person can argue in favour of his/her opinions more confidently. The richness of information readily accessible at a mouse click is another relevant issue. Although some problems may arise from unproductive distractions and even "getting lost" (Shiffer, 1995), the immense sphere of information available on issues being discussed is beneficial as participants can "hunt and gather" a multitude of resources to support individual arguments.

Although they offer noteworthy advantages, web-based participatory systems are not without critics. The principal criticism focuses on the public's ability to understand maps that are essentially "birds-eye" views. In the past, several researchers claimed that many people do not instantly recognize locations when presented as an aerial view (Keetes, 1996; Monmonier, 1996). Currently, other authors rebut this argument stating that "Dynamic maps", which are interactive and provide information about their features, help people to understand the information presented (Kingston *et al.*, 2000). Moreover, multimedia (text, graphics, still images, synthetic animations, video and audio) can be explored to improve people's understanding of maps and contextualize issues in debate (Shiffer, 1995).

Other criticisms concern the technology itself: access to it; the eventual creation of the so called "Digital Divide" (an information underclass); the lack of familiarity with the technology and individual skills in using it (overload of information and how to find his/her way); data and copyright issues and also public trust in the technology (response legitimacy). However, these criticisms are not insurmountable. The future widespread use of the Internet (or whatever succeeds it), its long term availability to all (as with television and telephones now) and increasing experience in using computers and the web are just some of the arguments that balance the debate.

Web-based systems can inform and engage the public in decision-making. They allow individuals to make representations directly to the decision-makers themselves (democratic participation) and thus circumscribe the prevalent system of representative participation, i.e., the public is represented through a series of elected representatives over which individual members of the electorate have little direct control. Techno-optimists believe that the Internet and wireless communications will generate a new public sphere supporting interaction, debate and new forms of democracy that will result in a renaissance of stronger public involvement in the politic/policy arena.

7.3 Examples of web-based systems in planning applications

One of the first experiences using the Internet in collaborative planning is described by Shiffer (1995). Other developments have since come to light. In 1996, a group of researchers from Leeds University made available to the general public across the Internet a Geographic Information System (GIS)-based Decision Support System (DSS) for finding a suitable site for a radioactive waste disposal facility in Britain. The system was developed in collaboration with UK Nirex Ltd, the organization entrusted with the responsibility of managing and disposing of Britain's radioactive wastes. The system allows users to access background information relevant to the problem, GIS datasets and information about these data (source, relevance, etc.), to identify suitable sites according to the user's own ideas about what factors are important in the siting process. The site identification process involves the user choosing site constraints and weighting each of the given factor maps. The original system was later overhauled to bring it up to date with new, web-based technologies and to update the information about the nuclear waste disposal issue (link: http://www.ccg.leeds.ac.uk/teaching/nuclearwaste/).

Based on this same idea and presenting similar displays, two other on-line spatial DSS were subsequently developed. One aimed to stimulate public involvement in locating areas for regeneration of native woodland in the Yorkshire Dales National Park, an area of 1,790 km^2 lying astride the Pennines in the counties of North Yorkshire and Cumbria (Kingston, 2002). The link is available at http://www.ccg.leeds.ac.uk/dales/start.html. The second system (Carver *et al.*, 2002) lets participants decide where the wildest places in Britain are using interactive mapping tools. The link is available at http://www.ccg.leeds.ac.uk/wild/.

In June 1998, a different system was launched by the same group of researchers. The "Virtual Slaithwaite" project mirrors a Planning for Real® (PFR) exercise taking place in the small village of Slaithwaite, located in the Colne Valley in the West Yorkshire District of Kirklees (Kingston *et al.*, 2000). Through a web-based virtual PFR model, the local community could interact with the 2-km^2 area digital map and input their comments, which were stored in web access log files. Thus, a community database was created to represent a range of views and feelings about planning issues in the village, which can be used for future analysis and feedback into the planning process.

Another notable example of Internet use for community participation is described by Al-Kodmany (1999). The web-based GIS application was developed to discover the community's shared evaluative image of Pilsen, a neighbourhood of Chicago with a large Mexican-American and Mexican immigrant community. First, participants' inputs are stored in web access logs, permitting the creation of a database containing a range of views about areas liked and disliked and the associated reasons. Afterwards, web technologies were explored to create visual "tours" of the areas most often selected by residents and to publish the neighbourhood's collective image of the city. The author concludes that the visual clarity provided by web-based technologies results in a highly interactive public participation process. Although asynchronously, this project explores the Internet as a two-way canal of communication: the public communicate with the Planning Team in the first part of the project and the Team publish its findings in an animated and accessible format in the second part.

More recently, framed by the concept of e-Government, which aims to transform government by making it more accessible and accountable to citizens, a number of central government departments and local authorities throughout the UK and worldwide have been actively involved in providing electronic access to their public services, including planning services. An interesting concretization of this concept is The Planning Portal (http://www.planningportal.gov.uk/wps/portal) launched by the UK Government as a gateway to planning information throughout the UK. Although valuable initiatives, most web-sites only give people the "right to know" and the "right to object" but not the ability to "participate in actual decision-making" (Kingston, 2002). Some exceptions are nonetheless in development providing hope that in the short term the full potential of the Internet as a two-way channel of communication might be at democracy's service.

8 THE PROPOSED SYSTEM

As stated earlier, a more predictable and progressive planning permission process can be attained if 1) planning decisions are "plan-led" and 2) democratic input legitimates development plans. Since ideas, values and attitudes over wind farms issues vary among the stakeholders (from national landscape bodies down to local residents), we propose a transparent and open environment where people can learn, crystallize their opinions and contribute to the decision-making process of wind farm siting during early phases of plan development. The Internet is used as a means to engage the public in the democratized decision-making process.

Contextualized by the scenario introduced in section 6, research focuses on strategic planning. Hence, a regional scale will be adopted for work development. Fig 2 depicts the structure for the proposed system.

1st tier

Welcome and introduction to the web site.

Framing of wind energy context; benefits and costs of wind farms; the siting problem.

User identification.

2nd tier

<u>Multi-Criteria Spatial Decision Support System</u>

Technically and economically feasible sites for wind energy developments are presented. Users are asked to sort these feasible sites by choosing site constraints and weighting a set of pre-defined set of criteria depicted by factor maps.

3rd tier

<u>Argumentative Framework</u>

Feedback to users by means of a "composite map" and a "controversial map". Users are given the opportunity to argue in favour of their learnt positions and explore arguments supporting distinct positions.

4th tier

Comments on the system and system usability.

Thanks and goodbye.

Figure 11 – Structure of the proposed system to improve public participation in wind farm siting.

The four-tier web system was designed bearing in mind the following overwhelming requirements:

1. Information is one of the most important aspects in decision-making. Public attitudes have been argued to be coloured by misunderstandings or biased information and a gap exists between the public's generalised appreciation of wind energy and a detailed understanding of the issues behind it. Consequently, there is a need to provide accurate and comprehensive information to the public.
2. Most citizens have not ever tried to articulate their preferences concerning the wind farm siting problem. Therefore, they need space and freedom to explore the decision problem and create personal constructs that represent their own outlook;
3. People feel more rewarded when they receive immediate feedback. Accordingly, updated information about the consultation process's evolution and previous participants' comments should be provided.
4. Consensual decisions result from interaction and constructive dialogue among interest groups. Hence, it seems appropriate to provide an "open-door" space where participants have the opportunity to express their concerns and discuss hot topics and arguments against or in favour of other participants' opinions, using a natural language.

Although the structure of the system is relatively established, each component (tier) is still being completed. Hereafter, we review each component in more detail, highlighting the questions to be answered.

8.1 The first tier

The purpose of the system's first tier is to welcome participants, present the objective of the initiative and introduce the web site by stating the stages users are required to progress through and how the system works. As information and public awareness are important issues in participatory decision-making, yet in the first tier the substantive problem of siting wind farms will be explained, as well as the relationship with geography and how GIS can be used to help solve the complex problem of finding suitable sites for them. Background information relevant to the problem will be presented.

This module concludes with a request for user identification. This information will be used to test out some basic assumptions, such as whether or not a user's qualifications affect acceptability of wind farms or that NIMBY symptoms lay underneath the user's response.

8.2 The second tier

If the decision-making process is to be participative, the preferences of a variety of people, representing many interest groups, must be elicited and validated. This system's second tier intends to "dress users with the decision-maker's skin" and hear from them an opinion about where to site wind farms.

Thus, this second tier consists of an Internet-based public participatory Spatial Decision Support System (SDSS), a framework that enables users to explore the decision problem, experiment alternative choices, crystallize their preferences and, finally, express an opinion about the factors they feel are important in addressing the problem of wind farm siting. Opinions are elicited by asking the users to specify their preferences (weights) for a pre-defined set of decision criteria, giving them the opportunity to re-access their decisions and interactively refine them by inspecting an output map displayed on the same screen. This output is obtainable by means of a cached-running Multi-Criteria Evaluation (MCE) technique. MCE techniques consist of numerical algorithms that derive outputs on the basis of input criteria and their relative importance (weights) together with some mathematical or logical means of determining trade-offs when conflicts arise (Keeney and Raiffa, 1976).

To a certain extent, the purpose of this tier is similar to some of the Leeds group's systems (cf. section 7.3, paragraphs 1 and 2). Thus, some of their strengths can be explored in approaching our problem. These are:

- Easiness to understand and use;
- Spatial materialization of users' preferences, via maps;
- "Real-time" maps that update after a user's re-assessment of preferences (criteria' weights);
- Integration of the control buttons (checkboxes for turning on or off important constraints and slide bars for weighting mapped factors) and the map in the same screen.

However, some other aspects can be refined. They are:

- User's input interface;
- Spatial MCE's output display.

Although interesting from a usability point of view, slider bars that roll freely and without any supplemental procedure warning users about the trade-offs being made can result in "incorrect" inputs or, at least, non generalizable for distinct contexts. Maps depicting users' preferences are interesting in "quasi-real" contexts, but can they be understood as a validation method of a user's input; or, when used in isolation by users lacking the required comprehensiveness of the whole procedure, do they lead to "unfelt preferences"?

The University of Leeds' SDSS are based on raster analysis. Datasets used are either graded maps showing the (un)suitability of a criterion to the analysis process or binary maps representing areas that may be considered suitable or unsuitable. Through a MCE technique these datasets are combined and the final result is also displayed in raster format: a graded map representing different levels of suitability. The user is then given the opportunity to "top slice" a percentage of the derived most suitable areas. Again, as the procedure enabling the identification of the most suitable areas is based on the direct analysis of a particular map, the validity (or generalization) of the user's parameter input can be questioned.

Alternatively, we propose an MCE technique that implicitly classifies feasible sites for wind farm development in three classes: recommended, acceptable and non-acceptable. The use of a sorting MCE technique (Zopounidis and Duompos, 2002) will help users to assess and re-assess proposals as it enables better control over the outcome when compared to graded maps. Furthermore, imposing the same class thresholds on all users brings additional consistency to the classification procedure and simplifies the overall aggregation of proposals. To improve the output map's legibility, only three different colours will be displayed (green, yellow and red).

The above observations raise the following questions:

- Can the spatial representation of a user's preferences in a map used to control experimental policy alternatives be considered a validation method? If not, how should these preferences be validated in a simple, Internet-compatible environment?
- Which sorting MCE technique should be selected from those in the literature? Should the user's capability to grasp the method determine the selection or can might theoretical considerations be more important?

Two other issues may be worth exploring:

1. uncertainty (or confidence) associated with individual preferences, i.e., subjects expressing preferences may not feel comfortable expressing precise trade-offs; there may be a range of values over which they would be indifferent;
2. fuzziness of original and generated datasets.

Whether or not these two topics will be considered in this research and, if so, to what extent, are questions to be answered.

Current work has been directed to the development of a comprehensive set of criteria to be used when considering the problem of wind farm siting. A number of technical guidelines for siting wind farms exist (BWEA, 1994; Sparkes and Kidner, 1996; Baban and Parry, 2000; amongst others) and so does a significant range of specific studies addressing individual issues related to wind farm impacts (Hill, 2001 for public opinion; Kidner *et al.*, 2000 and Miller *et al.*, 1999 for visibility analysis and visualization of the cumulative environmental impact; Percival *et al*., 1999 for effects on birds, etc.) However, this literature have not yet been synthesised in a truly democratic decision-making environment. In addition to inventorying meaningful decision criteria and collating data from a variety of sources, decisions have to be made concerning dataset manipulations that generate significant spatial representations of these criteria.

Data manipulation often implies that data are reclassified into categories, each one having a different value (or performing differently) with respect to the evaluation criterion. This raises two pertinent questions about class definition and class valuation. Ideally, every individual should be afforded the possibility of defining his/her own classes and evaluating them, as those tasks reflect personal values and ways of thinking. For some users, however, these tasks would represent an overload, both of time required and mental involvement, because they demand experimenting with different alternatives and an input validation procedure. Hence, the way forward seems to be the presentation of pre-defined classes and pre-defined valuations for these classes to users. Such resolution bestows consistency when individual inputs are aggregated. However, this might be seen as a simplistic and highly constraining solution. Some users might be motivated to complete such tasks or, at least, to define classes and evaluate them against criteria from his/her domain of expertise. Considering that such information could contribute to a further refinement of the system, it may be interesting to elicit such information on a voluntary basis. Is it legitimate to assume that submitted inputs from such tasks are reliable and can be used without validation? In other words, because such tasks are performed voluntarily, can it be assumed that users have invested enough time and effort that submitted inputs can be treated as accurate and reliable? If not, how can this information be validated in a simple and effective way? Furthermore, is there a structure for such information that enables us to integrate it into the ongoing appraisal (current system) without undermining the consistency of the individual data aggregation?

A final design for this tier depends on answers to all these questions and will only be possible after comprehensive responses are developed.

8.3 The third tier

The system's third tier has a twofold objective. First provide feedback and, second, allow the public to review and comment on other people's ideas about wind farm impacts and wind farm siting proposals. Al-Kodmany's (1999) Pilsen application (cf. section 7.3, paragraph 4) gives a valuable example of feeding participants with the results of public participation. However, the feedback is not immediate. This system's third tier should offer immediate feedback, consisting of a "composite map" of all participants' inputs (Kingston, 2002; Al-Kodmany, 1999) and a "controversial map" showing the variability of classifications attributed to each feasible site (Kardos *et al.*, 2003). Both maps will continuously evolve by assembling submitted weighting inputs (refer to section 8.1 paragraph 3).

The system will enable users to attach comments to composite map features explaining and supporting their decision as well as review and comment on other people's arguments. In contrast with the previous approach, which aims to identify suitable/optimal locations based on aggregations of multiple criteria (SDSS), this complementary approaches focus on the participatory process for identifying the problem(s) itself(themselves), rather than how to solve it. It creates a valuable environment for people to integrate local knowledge in the decision-making process by means of qualitative reasoning using natural language.

Today, most web-based discussions forums are text-based (i.e., discourses are not spatially referenced). Moreover, "a high tendency to incoherence, drift and dissolution can be observed" (Voss, 2002). Addressing this latter point, several authors assert that the use of suitable frameworks, which are able to capture, structure and present argumentation from interaction between collaborative individuals, greatly contribute to 1) widening participation in the decision-making process (by making reasoning public); 2) trigger critical thought; and, consequently, 3) create a useful public resource for future decision making. Such frameworks are called argumentative frameworks. Several instances of such frameworks exist: gIBIS (Begeman and Conklin, 1988), SIBYL (Lee, 1990), ZENO (Voss, 2002), HERMES (Karacapilidis and Papadias, 2001), etc.

Pilot applications in urban planning and design of such frameworks, generically identified as argumentative systems, have also been reported in the literature: GeoMed (Karacapilidis *et al.*, 1997), CrossDoc (Tweed, 1997), KogiPlan (Voss *et al*., 2002) amongst others. As Tweed (1998) expressed, due to an increasing demand for transparency, openness and accountability in decision making processes, these systems appear to have something to offer in assisting public participation in this domain. In addition, by allowing access to decision histories, these systems may play a fundamental role in avoiding previous planning deficiencies.

Another interesting pilot application in urban design is described in Horita (2000). The argumentative dimension in the computer-assisted communication tool, CRANES, proposed by Horita is structured through a simple tree mechanism, i.e., arguments (associated to strategic objects) are listed in threads, but arguments made as responses to existing ones are listed below their parent arguments with an indentation. In addition, a "folded" image of arguments is offered, based on an extended version of Analysis of Options developed by the author.

In order fully to develop the proposed third tier, a detailed analysis of these earlier systems is required, evaluating their strengths and drawbacks in approaching the wind farm siting problem. It is extremely important to consider the final system's simplicity as argumentation schemes have proved difficult for non-specialists to understand. Finally we must consider how multimedia technologies can be used and explored to create a more engaging participatory environment and to provide non-local users with a picture of the area in appraisal. Attractive results from associating the World Wide Web to multimedia are depicted in Shiffer (1995) and Ak-Kodmany (1999).

8.4 The fourth tier

The fourth and last tier of the system basically aims to receive users' feedback on both the issues presented and the system itself and to thank the user for their participation.

8.5 System workflow

The basic system workflow is depicted in Fig. 2. However, the system will enable users to skip the second tier if they have already accessed it. This avoids the introduction of "whatever" input in the second tier from already registered users interested in gaining a quick entrance to subsequent modules and facilitates access to the third module for those interested in following the problem's evolution and learning more it.

A technical aspect to explore is the possibility of enabling pre-registered users to change their initial contribution (criteria weights) in the second tier, either because their preferences may have changed as a result of the continuous learning process or because the user had suddenly to abandon this stage. Password-dependent systems certainly make this possible.

9 CONCLUDING NOTES

This paper describes the structure of a web-based, public participatory spatial decision support system to foster public participation in local and supra-local policies. It aims to draw out public preferences on the problem of wind farm siting. Although addressing that specific problem, the participatory tool described is intended to be generic and easily adaptable to any problem. In whatever context the system is applied, there will always be the unavoidable work of data collection, data collation, structuring of the spatial database, and derivation of the evaluation criteria.

Presently, the system is under construction. Current work focuses on the technical aspects of the system's implementation: selection of the Internet technology to apply (client-server architecture); choice of software for project development, concretely whether or not to opt for open source technologies such as GeoTools instead of commercial map servers; choice of database technology; and defining the second tier's layout (i.e., the SDSS) and implicit MCE technique to implement. Forthcoming work will concentrate on finding comprehensive answers to the formalised questions, in particular those datasets to be assembled to create a meaningful framework for site assessment.

In short, a lot of work still needs to be done to accomplish this challenging proposal. However, the motivation is strong as we expect that, after completion, this system will contribute to three main domains. In the first instance, the collaborative planning stream concerned with participatory decision-making in spatial problems. In the literature, only a few collaborative spatial decision support systems give non-expert users the opportunity to explore and crystallize their preferences before stating their final judgement. Secondly, a contribution will be made to the field of wind farm planning, where the literature contains no reference to collaborative spatial decision support systems involving public participation. Finally, the web-based public participation arena where, in spite of the interesting examples already available, some aspects still represent major challenges and are worth further development: the use of the Internet as a bi-directional channel of communication between the public and policy authorities; and web-mapping technologies as a way to transmit spatial information seamlessly at different scales.

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