WIND TURBINES AND AVIATION INTERESTS
- EUROPEAN EXPERIENCE AND PRACTICE

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EXECUTIVE SUMMARY

Objectives

The aim of this report is to establish the European approach to the effects of wind turbines on civil and military aviation, and to determine the applicability of these experiences and practices to the concerns and needs of UK stakeholders. To this end, there were three objectives:

- To document the experiences and practices relating to wind turbines and civil and military aviation in Denmark, the Netherlands, Germany and Sweden;
- To consider relevant regulatory and institutional factors, influencing the consequences of any effects and how they are managed;
- To generate text suitable for incorporation in UK guidelines on Wind Energy, Defence and Civil Aviation Interests.

Background

A major constraint on the deployment of wind energy in the UK is the restriction on siting turbines due to the potentially hazardous effects they may have on aviation and related defence interests. Objections have arisen over the potential effects on radar systems for both air traffic control and air defence and the impact on military low flying.

The disturbance caused by wind turbines on various radar systems is not well understood and there is a lack of consensus on the severity of such effects. Nevertheless, major concerns have arisen within the aviation community regarding the potential for interference with radar systems and the subsequent effects on operations. The conflict between the two interests seems to be much less significant in other European countries despite their more extensive wind energy developments.

The Department of Trade and Industry (DTI) has set up a 'Wind Energy, Defence and Civil Aviation Interests Working Group' to investigate the issues of concern and improve understanding within both the aviation and wind energy industries. In parallel with this study, other work has been commissioned; specifically, scientific studies to improve understanding of the impacts of wind turbines on radar systems; and the creation of guidelines aimed primarily, but not exclusively, at wind energy developers, outlining the interactions between wind farms and aviation[1].

Main Results

The individual states surveyed have rather different methods of approaching the issues of wind farms and their affects on aviation. Denmark and Germany, Europe's leading exploiters of wind energy, have well-developed systems for dealing with planning, siting and approval

[1] 'Wind Energy and Aviation Interests – Interim Guidelines' (ETSU W/14/00626/REP), DTI, October 2002.

issues, whereas in Sweden and Norway, where wind farms are still in their infancy, the systems are still evolving.

The pre-planning consultation system used in the UK is one of the most developed and effective of those observed. Other nations have mandatory systems (Germany), more informal procedures (Sweden), or, in the case of the Netherlands, no consultation mechanism for developments away from airports. In comparison, the UK procedure, while non-statutory, is intended to cover all wind developments and to ensure that all relevant stakeholders have the opportunity to assess wind energy proposals.

All the countries studied safeguard their aerodromes against physical obstructions in accordance with ICAO guidelines and this applies to wind turbines just as it would to any other structure. However, turbines are treated as little more than physical obstructions, with little importance placed on the fact that they feature rotating blades. In addition, the approach to safeguarding technical sites and equipment for civil aviation in each country is different and less stringent than in the UK. Table 1 summarises the main findings of the report for each country.

The approach to safeguarding military technical sites, including radar, was also found to be very different outside the UK. Only the German military delineates an area within which it must assess all wind farm proposals and that range is much smaller than that of the UK. All other countries have a much more relaxed attitude to the potential impacts of wind turbines on radar-dependant operations and assess proposals on a case-by-case basis.

Another important issue in the UK is that of military low flying. As expected, this issue is not as significant in mainland Europe, purely due to the nature of flying training there. The UK is almost unique in allowing its military aircraft to fly as low as 250 feet above the ground in 'open country' and even lower in specified areas. Elsewhere in Europe low-flying limits are typically around 1000 feet. Only Sweden allows its pilots to fly as low (they may fly down to 50 metres) but in a country as sparsely populated as Sweden, this brings little conflict with any activities, not least wind farms.

Two issues arose that were not largely commented on in the UK but seemed to preoccupy many stakeholders in the other subject countries. The first was the issue of Search and Rescue operations (SAROps) in the vicinity of large wind farms, particularly offshore. It is quite feasible that, given the scale of planned offshore wind farms, SAROps will, at some point, be required perhaps within the bounds of such an installation. This would be an extremely hazardous operation and has prompted SAR personnel in more than one country to state that they would not be prepared to carry out such a task. The responsibility for SAR within wind farm boundaries is something that must be established.

The second issue was that of how best to mark and illuminate wind farms. This is particularly relevant for large-scale developments, especially those offshore. Night lighting is a very sensitive issue and has prompted many debates not just within aviation communities but also from the general public. Each country surveyed is establishing its own standards for day marking and night-time illumination of turbines.

TABLE 1 – SUMMARY OF MAIN FINDINGS

	Aerodrome safeguarding	Technical site safeguarding: Civil[2] – Airfield radar	Technical site safeguarding: Civil[2] – Other	Technical site safeguarding: Military	Planning, assessment and approval process	Low flying policy	Charting policy	SAR Ops policy	Marking and illuminating
UK	Assessed if within 17km (civil)	Assessed if within 30km	Assessed if within 34km (ILS); 30km (other systems)	Assessed if within 74km of AD radar; developer to prove no negative effects	Voluntary; widely used. Statutory via Local Planning Authority	Generally not below 250 feet	Charted if 300 feet	Nil stated	Policy being developed
Denmark	ICAO standards	ICAO standards	ICAO standards; VOR stations: not within 1km	Nil stated	Wind energy incorporated into regional plans; planning authorities inform aviation authorities	No objections to structures <100m	Charted if 100m or 'if deemed necessary'	Nil stated	National guidelines
Germany	ICAO standards	ICAO standards	ICAO standards	5km protected area; 20km 'area of interest'; Military to prove negative effects	Construction Committees inform aviation authorities; plans assessed within 2 months	Generally not below 1000 feet	Charted if 100m or 'if deemed necessary'	Statement of concern from SAR operators	National guidelines
Netherlands	ICAO standards	ICAO standards; not >150 metres within 30km	ICAO standards	Nil stated	No regulated process away from safeguarded aerodromes	Generally not below 1200 feet	Archive of all structures >300 feet	Nil stated	Follow ICAO regulations for tall structures
Sweden	ICAO standards	ICAO standards	ICAO standards	None aviation-specific	Voluntary	Not below 50 metres	'FIA' database (>50m in towns, > 20m, rural)	As Germany	As Netherlands
Norway	ICAO standards	ICAO standards, plus assessed if within 10nm and in LOS; (ILS: not within 20nm)		Not known	Energy authorities inform aviation authorities	Not known	Obstacles >15 metres registered	Nil stated	National guidelines

[2] For primary radar, ICAO standard is a protected surface slope of gradient 1:100; for Secondary Surveillance Radar a slope of 1:200; for navaids, 1:50.

Summary

The states investigated in this report have quite varying approaches and attitudes to wind power and this has shaped policies, procedures and developments. The reasons include politics, geography, economics and history and have resulted in wind industries at varying stages of evolution. Broadly speaking, the conflict of interest between wind energy and aviation is regarded as less significant in these other countries than in the UK, albeit to varying degrees.

The countries examined have wind farm application and assessment processes that are more relaxed than in the UK. Indeed, the authorities in Denmark and the Netherlands, in particular, had a notably *laissez-faire* attitude towards wind farm developments. However, in Germany, the European country with the largest installed wind energy capacity, military aviators are beginning to express some discomfort at the proliferation of wind farms and their subsequent effects on airspace structure.

Somewhat surprisingly, in the states surveyed with large installed wind energy capacities, few measures specifically to deal with their effects on aviation had been developed. Air traffic controllers were often happy to work around any clutter caused by wind turbines, just as they would work around clutter caused by any other obstacle. Kastrup airport in Copenhagen proved a useful case study and revealed some technical measures employed by radar and software technicians, but on the whole, the effects of wind turbines were not judged as being particularly significant.

CONTENTS

1 INTRODUCTION

1.1 The UK began to focus on the benefits of wind energy in the early 1990s as global concern about climate change influenced energy policy. Land-based wind energy has become the lead renewable technology during the last decade. However, after a promising start, industry argues that wind energy development has been slow over the last 5 years.

1.2 Government policy on windfarms follows a clear manifesto commitment to develop new and renewable energy sources. The ten-year strategy is to ensure, through rising targets, that 10% of UK electricity is generated from renewable sources by 2010. This includes many sources in addition to windpower, such as hydroelectric power and biomass. As two of the most cost-effective and mature renewables technologies, onshore and offshore wind energy are anticipated to supply a major proportion of this target.

1.3 2001 was a year of what the British Wind Energy Association (BWEA) calls 'solid growth'. 64.6 new megawatts (MW) of wind power were installed, taking the UK wind-generating capacity to 473.6MW, equivalent to the annual electricity needs of over 320,000 households and representing 0.37% of UK demand. However, this is still markedly less than several EU countries. Britain lags behind many of its EU neighbours in its wind exploitation, despite being the European state richest in wind resources. Table 2 illustrates the top 10 European states by their wind energy capacity plus, for information, Norway.

Wind Energy Capacity Installed in Europe, End December 2001	
Germany	8754MW
Spain	3337MW
Denmark	2417MW
Italy	697MW
Netherlands	493MW
United Kingdom	474MW
Sweden	290MW
Greece	272MW
Portugal	125MW
Ireland	125MW
Norway	17MW

Table 2 – Comparison of Wind Energy Capacity[3]

1.4 Clearly, Germany is the EU's leading wind-exploiter, by some margin, with Spain and Denmark deriving significant amounts of their power from the source. Britain lags behind as Europe's 6th-largest producer.

[3] Source: European Wind Energy Association.

1.5 However, the perception within the wind energy industry in the UK is that a significant proportion of wind farm applications are unsuccessful due to objections from the aviation community. Earlier concerns regarding noise have largely been overcome through technological developments and the principal cause for objection today is visual impact. Even so, there are difficult issues being raised by radar operators such as MOD and CAA that do not appear to constrain wind development in Germany, Denmark or Spain, for example.

1.6 <u>Aim</u>

1.6.1 The aim of the Wind Turbines And Aviation Interests - European Experience And Practice Study was to study, document and analyse the European approach to the effects of wind turbines on civil and military aviation, and to determine the applicability of these experiences and practices to the concerns and needs of UK stakeholders.

1.7 <u>Objectives</u>

1.7.1 The study had three primary objectives:

- To document the experiences and practices relating to wind turbines and civil and military aviation in Denmark, The Netherlands, Sweden and Germany;

- To consider relevant regulatory and institutional factors, influencing the consequences of any effects and how they are managed.

- To generate text suitable for incorporation in UK guidelines on Wind Energy, Defence and Civil Aviation Interests.

1.7.1.1 The four focus countries were chosen by the DTI, with each expected to have a different experience of wind energy development. Including the manufacture and export of wind turbines and their components, the Danish wind power industry was the largest in the world in 1999, controlling 70% of the world market. In that year, wind turbines produced approximately 8.8% of the country's total electricity consumption.

1.7.1.2 Through different initiatives, the Danish government has set the stage for increasing use of wind power. As a major supplier to the global world wind energy generating market, it was anticipated that Danish perspectives might be coloured by different considerations to importers of such equipment.

1.7.1.3 In 2001, Germany cemented its position as the world's leading exploiter of wind power by expanding its capacity by 44%. The industry has been encouraged by a law guaranteeing a minimum price for energy produced by wind power. Germany now has in excess of 11,000 wind turbines accounting for 3.5% of the country's energy consumption, and German companies are pioneering the development of large wind parks far out to sea.

1.7.1.4 These figures represent 18 times as much wind power-derived energy as the UK, in a country with much poorer winds; clearly, the planning process in Germany has been highly successful.

1.7.1.5 On a per capita basis, the wind energy production of the Netherlands is amongst the highest achieved. Furthermore, its population density is also extremely high. These two factors, coupled with Dutch concerns over flight safety which are the result of bitter experience of a number of devastating aircraft crashes (including a crash of an El Al Boeing 747 into a domestic tower block in the suburbs of Amsterdam), suggest that the Netherlands may have a unique set of concerns about public perceptions. This may be reflected throughout all government departments and may have had a major impact on siting decisions; thus, the Dutch perspective was anticipated as being particularly valuable.

1.7.1.6 Whilst Sweden is not one of Europe's leading producers of wind energy, the Swedes do appear to have studied the impacts of turbines on aviation and defence quite closely. For example, a Swedish defence logistics agency report in 1997 found no significant impact of wind turbines on two types of radar (a fixed ground-based radar for low-altitude surveillance and a mobile surface to air missile battery 'moveable' radar). The data showed no decrease in detection probability of targets or accuracy of detection, even when flying within the wind turbines. This experience may be of particular benefit in alleviating the concerns of the MOD and thus Sweden was included in the study.

1.8 Work Carried Out

1.8.1 In order to first establish the experience and practices in the UK, meetings and interviews with key UK stakeholders were carried out. These included representatives from the wind energy industry; government bodies; and defence and civil aviation authorities.

1.8.2 The primary aim of this phase of the work was to establish a baseline of stakeholders' concerns and responsibilities relating to the development of wind turbines and farms. The input from the full range of stakeholders then provided the basis for the data capture conducted with the European nations. In addition to the four named countries, written requests for information were made to other countries, but only Norway responded with sufficient information to warrant inclusion in the report.

1.8.3 Meetings were then organised with similar authorities and agencies in the four selected European nations and fact-finding visits occurred[4]. Individuals from relevant government ministries, civil aviation bodies, service providers, militaries and the wind energy industry were interviewed to identify processes, procedures, standards and practices in each nation, and to highlight differences and similarities between their practices and the UK experience. Site visits also took place to witness wind farms in operation at first hand and to see the effects on actual aviation systems.

[4] A complete list of all consultees is at Annex H.

1.8.4 The information thus provided, whether from face to face meetings, telephone interviews or written questionnaires, was then examined to determine any trends or patterns in the subject countries, or any distinct anomalies. The findings for each country were compared to each other and then specifically to the UK, in order to uncover any lessons that might be learnt.

1.9 Structure of Report

1.9.1 The report consists of 6 sections as follows:

1. Introduction.
2. The European Experience. This initially describes issues that are common across the nations surveyed, then details the experiences of each of the subject countries in turn.
3. The UK Experience.
4. Key Differences.
5. Summary.

The Annexes provide reference material and amplification.

2 THE EUROPEAN EXPERIENCE

2.1 Introduction

2.1.1 Throughout Europe, and the world, Civil Aviation Authorities in individual nations are responsible for the oversight and regulation of all activities carried out by civil aviators and airport operators. Much of this is harmonised by the International Civil Aviation Organisation (ICAO)[5]. To achieve their aims, individual authorities conduct a wide variety of activities, including the licensing of aerodromes and air traffic service providers, the planning and regulation of airspace, including the communications, navigation and surveillance (CNS) infrastructure, and consultation with the military on the topic of airspace usage.

2.1.2 The military in each country, predominantly (but not exclusively) in the form of air forces, needs access to airspace for primarily two purposes: training and national defence. This includes the surveillance of the airspace above and surrounding a country's territory, including over sea, the importance of which was highlighted by the events of 11 September 2001.

2.1.3 It is therefore essential that the safety of aerodromes, aircraft and airspace is guaranteed and as wind turbines increase in size and number, their potential impact on aviation operations increases correspondingly. Interactions between wind turbines and aviation activity are potentially complex. Further amplification on the impacts of wind turbines on aviation operations, with reference to the United Kingdom, is included at Annex A.

2.2 Common Issues

2.2.1 Offshore Wind Farms

2.2.1.1 In the countries surveyed, the impacts of offshore farms are assessed in the same way as onshore farms. Clearly, by their very nature, wind farms at sea are less likely to be in the vicinity of airfields than those on land, and thus avoid many of the impacts on aviation that onshore developments may cause. The main concerns tend to be held by the military, who may conduct training over sea, including using live ordnance; these issues are discussed in the relevant section for each country. The way offshore wind farms are being dealt with in the four countries is (as with oil and gas installations) by ensuring they are accurately denoted on aeronautical charts and sufficiently marked and illuminated (see sections on 'Marking, Illuminating and Charting').

[5] ICAO was formed in 1944, following the signing of the Chicago Convention, as a means to secure international co-operation and the highest possible degree of uniformity in regulations and standards, procedures and organisation regarding civil aviation matters. ICAO is a specialised agency of the United Nations.

2.2.2 Aerodrome Safeguarding

2.2.2.1 In order to protect aerodromes and the aircraft using them, ICAO restricts tall structures in the vicinity of aerodromes that may cause a hazard to safe flight operations (see Annex A for further information). This ensures the safety of aircraft departing and approaching the airfield and flying in the airfield circuit.

2.2.2.2 Although developed initially for application to the construction of tall buildings, masts and the like, it is a natural extension that the same restrictions be placed on wind turbines. However, it is feasible that, due to their nature, turbines may cause additional problems to technical equipment used at airfields, such as radar and communications equipment. Despite this, the countries studied are largely happy to simply apply traditional safeguarding criteria to wind farms in the immediate vicinity of airfields and do little more to restrict wind turbine development. The military apply the same or similar processes.

2.2.3 Technical Site Safeguarding

2.2.3.1 Just as ICAO seeks to protect aircraft in the vicinity of airfields, the flight safety-critical equipment that these aircraft rely on for their safe operation also needs to be protected. Hence, civil aviation organisations have criteria for safeguarding not only airfields, but also technical sites such as radar, navigation aids and communications equipment, to ensure their function is not impeded.

2.2.3.2 Again, the safeguarding system evolved to ensure that the construction of a tall building (for example) would not interfere with an airfield's approach radar. However, the movement of wind turbine blades has the potential to be more detrimental to such equipment than a simple stationary object. Therefore, in the UK and abroad, wind turbines are unique in the way they are treated for their effects on technical sites. However, the severity of their potential effects is viewed differently from country to country, and each nation has their own restrictions and limitations.

2.2.3.3 Airfield Radar

2.2.3.3.1 All the countries studied adhere to ICAO standards for safeguarding airfield radar and technical equipment and apply few further restrictions. These standards ensure that structures may not be constructed that infringe theoretical slopes around specific items of equipment, those being: for primary radar, a slope of 1:100; for secondary surveillance radar (SSR) a slope of 1:200; and for other navigation aids (navaids) and communications antennae, a slope of 1:50[6].

2.2.4 Search and Rescue (SAR) Operations (SAROps)

2.2.4.1 With the move of wind power offshore, issues are being uncovered in mainland Europe that have not arisen previously. One of the most pressing is

[6] For a brief explanation of primary and secondary surveillance radar (SSR), see Annex A.

the impact of wind farms on Search and Rescue (SAR) operations (SAROps). SAR pilots are frequently called upon to rescue personnel whose lives are in danger, either on land or at sea. Undertaking a rescue in the vicinity of, or even within, a large wind farm, particularly if it is at sea, in poor weather conditions, is a hazardous prospect and has prompted reaction from the SAR communities in several countries.

2.2.5 Marking and Illuminating

2.2.5.1 This is a topic that has sparked huge debate in all of the countries visited between manufacturers, civil aviation regulators, military aviators and the public, who may live in the vicinity of wind farms. The subject prompts fierce discussion and, unsurprisingly, different groups have different requirements that they would like to see implemented. So far, states are developing their own guidelines for regulating the lighting and marking of wind turbines.

2.2.5.2 As far as could be ascertained, ICAO has issued no specific guidance for the marking and illuminating of wind turbines, as distinguished from any other obstacle. Therefore, states are applying standard obstacle marking and illuminating standards, but often enhancing them to reflect the unique nature of wind turbines.

2.3 Denmark

2.3.1 Introduction

2.3.1.1 Denmark is well known throughout Europe and, indeed, the world, for the size of its wind energy industry and its positive attitude towards using the wind as a source of energy. Successive governments have, until very recently, used legislation and financial methods to encourage both individuals and power companies to invest in wind power (see Annex B for further information), resulting in a large installed wind capacity and the world's leading wind turbine manufacturing industry.

2.3.1.2 Wind farms are now spread throughout Denmark and have encountered little opposition from aviation organisations, whether civil or military. Consequently, Denmark is perhaps the best example of large-scale wind energy coexisting with aviation interests. The advanced state of wind power in Denmark is doubtless the result of a political will to derive a significant amount of electricity from renewable sources and aviation continues to function efficiently and safely in an environment where wind farms are commonplace.

2.3.2 The Planning, Assessment and Approval Process

2.3.2.1 The planning process in Denmark hinges upon the regional plans that each county publishes, which must address the issue of wind energy development. When these plans are initially drawn up, and subsequently updated, the Civil Aviation Authority (CAA), known as the Statens Luftfartsvæsen, or SLV, and NAVIAIR, Denmark's air traffic service provider, have input and may raise any concerns regarding aviation[7]. Therefore, when developers submit plans for specific developments, they are usually within areas already designated as suitable for wind turbines and will probably not be subject to objections.

2.3.2.2 Nevertheless, the SLV must approve construction of all structures taller than 8.5 metres (28 feet), which, of course, includes wind turbines. The SLV becomes aware of any proposed tall structures through regional planning offices, which, as part of the planning process, forward all such proposals to the SLV for assessment. The SLV, in turn, are required to inform NAVIAIR and the Royal Danish Air Force (RDAF), who will make their own assessments of any possible impacts.

2.3.2.3 As a rule of thumb, if a development is less than 100 metres (328 feet) tall, and is not within an aerodrome's safeguarded area (see Section 2.2.2 'Aerodrome Safeguarding'), then the SLV will have no objections and will usually approve construction. This height is used because the lowest level for VFR (Visual Flight Rules) flight for non-military aviation in Denmark is 150 metres (492 feet), and this ensures safe separation of 50 metres (164 feet) between a structure and low-flying aircraft.

2.3.2.4 Until very recently, the majority of wind turbines proposed and constructed in Denmark have been less than 100 metres high, so the system has worked well and allowed large numbers of wind turbines to be constructed. However, more and more developments are now featuring turbines taller than 100 metres and the SLV is considering ways to deal with these.

2.3.2.5 Turbines between 100-150 metres are currently generally acceptable to the SLV, although they are marked and illuminated differently to smaller installations as they pose a greater hazard to aircraft (see Section 2.3.8 'Marking and Illuminating'). Accordingly, the SLV tends to accept developments of this scale as long as they are away from major airfields, in 'open country'.

2.3.2.6 Recently, the SLV has received an application for a test site in Jutland with a turbine that is 165 metres (541 feet) tall. This has prompted much thinking about how to deal with such a structure, but it appears that the plan will be approved, and that it will be charted as a hazard to aviation, as would other comparable structures. The lighting and marking of turbines greater than 150 metres tall is still being debated in Denmark.

2.3.2.7 Of course, all proposals are examined on a case-by-case basis and there may be examples of structures that are less than 100 metres high but which still could pose a hazard to aviation (such as when traffic is approaching an airfield). All such instances are studied and the SLV's response is passed back to the regional planning office. No scientific documentation is used by the

[7] NAVIAIR is an air navigation service provider in Denmark, providing services in the Copenhagen Flight Information Region (FIR) as well as services at some of the country's major airports. Denmark's ATM systems, including data links, radar, navaids and voice communications systems, are owned and maintained by NAVIAIR.

aviation authorities, civil or military, when assessing potential impacts; most assessments are based on 'staff workers' professional experience'[8].

2.3.2.8 Offshore Wind Farms

2.3.2.8.1 Denmark is a pioneer in the development of offshore wind farms, having constructed two demonstration plants that proved the viability of offshore technology. The success of these plants was followed by the construction of the Middelgrunden wind farm (described in Section 2.3.5.2) and Denmark's first two large-scale developments are currently under construction.

2.3.2.8.2 The country's offshore wind farm strategy document is 'Action Plan for Offshore Wind Farms in Danish Waters'[9], but this makes no reference at all to aviation matters. In this publication the government identified offshore areas suitable for wind energy development and companies will be invited to submit tenders to construct farms in these specified areas over the next few years. It is possible to build offshore wind farms in other areas, but applications must go through the same assessment process as for onshore developments.

2.3.3 Aerodrome Safeguarding

2.3.3.1 To safeguard civil airfields in Denmark the SLV applies nothing more than the standard ICAO protected surfaces, as outlined in Section 2.2.2. Military airfields in Denmark use a similar system but with different and simpler regulations for obstacle protection.

2.3.3.2 Around each military airfield is an 'obstacle-free sphere', i.e. a circle centred upon the runway(s) within which construction of tall structures is restricted. The restrictions are not as complex as those laid down by ICAO, however. Ranges differ for each airfield, but up to a distance of approximately 4km (2.5 miles), structures taller than 45 metres (148 feet) agl (above ground level) are restricted. Between 4km and 10km (6 miles) out from the airfield, the permissible height for developments increases to 100 metres. If proposed structures, including wind farms, would breach these limits, then they may still go ahead, subject to scrutiny by the RDAF, but must be suitably marked and illuminated.

2.3.4 Technical Site Safeguarding

2.3.4.1 Other than applying the ICAO standards for safeguarding technical equipment around an airfield (described in Section 2.2.3), the Danish authorities use no other formal process for assessing the impact of proposed wind farms. As a purely precautionary step, the SLV now does not allow wind farm developments within 1km (0.6 miles) of a VOR (VHF Omnidirectional Radio) station[10]. This is the only generic technical site safeguarding in effect in

[8] Quote from Major Per Coulet, Branch Chief, ATM, RDAF.

[9] Published by the Offshore Wind-Farm Working Group of the Electricity Companies and the Danish Energy Agency, June 1997.

[10] VOR is a radio navigational aid that provides suitably equipped aircraft with a continuous indication of bearing to and from the VOR station.

Denmark (see Section 2.3.7.2 for a brief description of a study on a VOR station).

2.3.5 Case Study: Kastrup Airport, Copenhagen

2.3.5.1 Kastrup Airport is located just outside Copenhagen, to the south-east of the city, and is well known in aviation circles for operating with a 20 turbine offshore wind farm, known as Middelgrunden, only 5km (3 miles) to the north. In addition, there is a small nine turbine wind farm even closer to the airfield, just outside the airfield perimeter, to the south. Several more small clusters of wind turbines can be seen from the air traffic control tower. This situation is an excellent opportunity to examine the operations of a civil airport in close proximity to multiple wind farms.

2.3.5.2 Middelgrunden Wind Farm

2.3.5.2.1 The Middelgrunden wind farm consists of 20 2MW turbines located to the east of Copenhagen city centre and north of Kastrup airport, in shallow (2-6 meter (7-20 feet) deep) water. The turbines are installed in a slight curve with 180 metres (591 feet) between each, giving the wind farm a total length of 3.4km (2 miles). The hub height of each turbine is 64 metres (210 feet) with a rotor diameter of 76 metres (249 feet), therefore the total height of each is 102 metres (335 feet). Three of the turbines went online at the end of 2000, but the entire wind farm was officially opened in May 2001.

2.3.5.2.2 When the Middelgrunden wind farm began operations, it immediately had an effect on both primary and SSR radar in use at Kastrup. Clutter was observed in the vicinity of the wind farm on the primary radar, which caused the initiation of tracks over the farm. This creates the appearance to controllers of one or more aircraft in that area when it is actually just the turbine blades showing up on the radar. However, the problem was not as bad as the clutter caused by road traffic using the bridge between Denmark and Sweden, the Øresundsbron (Øresund Bridge).

2.3.5.2.3 More problematic were the reflections of SSR returns that were found to occur under certain wind conditions. Due to the nature of SSR, it could be seen that radar returns from aircraft actually overhead Sturup airport in southern Sweden (some 30 miles east of Kastrup) were also being displayed to the north of Copenhagen by approximately 30 miles. If displayed to air traffic controllers, these false radar returns could have a significant impact on flight safety, as the controllers would be forced to avoid aircraft that were not, in reality, there.

2.3.5.2.4 When this problem first appeared, it was thought that, because it only occurred occasionally, under certain wind conditions, the small, nine turbine wind farm south of the airport may cause the reflections. However, use of SASS-C (Surveillance Analysis Support System for ATC Centre), a software tool produced by Eurocontrol, revealed that the reflections were, in fact, being caused by the wind turbines of Middelgrunden. What the software also revealed, however, was that the 20-turbine development was not as efficient a reflector as two chimneys, located around the same range from the airfield but slightly west of the wind farm. Figure 1 shows the ICAO Aeronautical Chart for Denmark, illustrating the airfield, Middelgrunden and the two chimneys.

Figure 1 – Section of ICAO 1 : 500,000 Aeronautical Chart of Denmark, depicting Kastrup airfield, Middelgrunden wind farm and other pertinent features

2.3.5.2.5 Fig. 2 shows a SASS-C image; marked are the original SSR return (overhead Sturup); the reflective surface representing Middelgrunden; the reflection from Middelgrunden; the reflective surface that is the two chimneys; and the reflection caused by the two chimneys. It can be seen that the reflection from the twin chimneys is much larger than that from the wind turbines of Middelgrunden. The SASS-C image has also been filtered to compare only the reflections from these two structures; there are many more reflective surfaces surrounding the airfield which all produce more serious reflection problems for the radar, one of which is the airport Marriott Hotel.

2.3.5.2.6 In contrast to Middelgrunden, the nine turbine wind farm just to the south of the airfield has absolutely no effect on the radar at all. The turbines are laid out in a 3-by-3 grid, and are only approximately 20-25 metres tall, but due to their proximity to the airport it would be expected that they would have some effect on the systems in use. No effects have ever been observed.

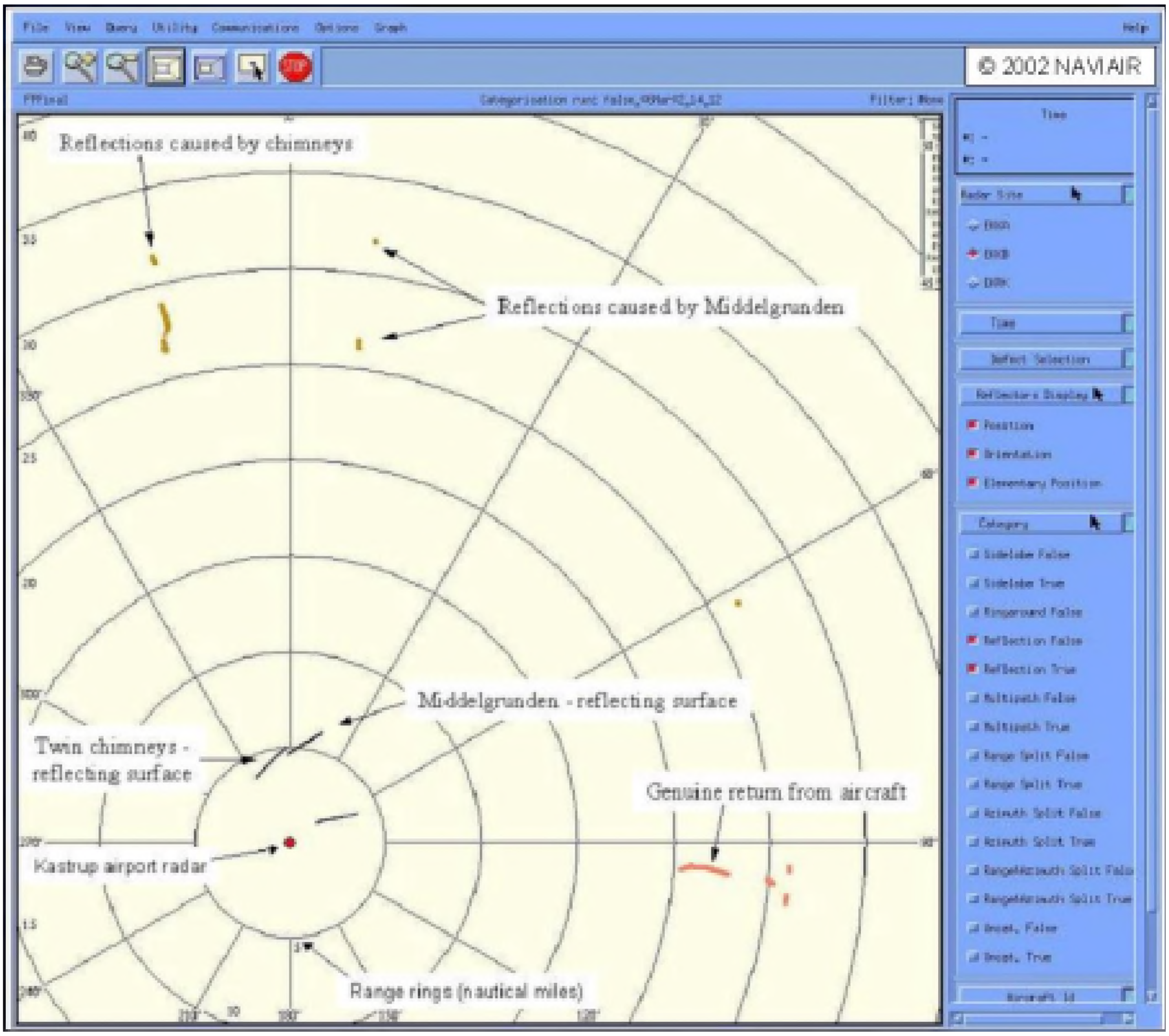

Figure 2 – SASS-C image illustrating radar reflections from Middelgrunden wind farm and a pair of nearby chimneys

2.3.5.3 <u>Mitigation Measures Employed At Kastrup Airport</u>

2.3.5.3.1 The effects described above could have significant impact on the air traffic control (ATC) operations at Kastrup, but the staff of NAVIAIR have employed simple techniques to solve the problems and present their air traffic controllers with a clean, accurate and workable radar picture.

2.3.5.3.2 To alleviate the problem caused by primary radar clutter initiating false tracks overhead Middelgrunden (just as false tracks are initiated by the traffic using Øresund Bridge), a track Non-Initiation Window (NIW) is inserted over the area in question. This simply prevents the radar system from automatically creating any tracks directly overhead Middelgrunden but allows existing tracks, i.e. existing aircraft, to continue to be tracked overhead the wind farm. A NIW was already being used successfully to filter out tracks initiated on the road traffic.

2.3.5.3.3 The problem of the SSR reflections is also easily resolved by using the radar processing software to filter out the reflections. In layman's terms, the software compares the track qualities of the SSR tracks, their track histories and positional information (i.e. where the track has come from) and a host of other information. It is then able to discern which is the genuine SSR return and which is reflected. The authentic plot is then presented on the air traffic controller's display and the reflection is not; all of this is transparent to the controller and no problems have ever been reported using these methods.

2.3.5.3.4 The only explanation for the lack of effects caused by the nine turbine development on any of Kastrup's systems is due to their size. However, a contributory factor is the fact that both of the SSR radars used at the airport are tilted upwards slightly to reduce ground reflections; this will also minimise reflections from structures such as the smaller wind turbines[11].

2.3.5.3.5 One other minor impact that the construction of Middelgrunden has had is that it is located directly below one of the airfield's holding points, where air traffic controllers hold aircraft in an orbit when the airport is busy and aircraft have to 'queue' before landing. Of course, the height of the turbines would not physically endanger the aircraft, which, even though they are flying relatively low, are well above the turbines' top height. Neither are clutter or false tracks a problem as these issues are resolved by the methods described above. The only step taken is that there is now an additional height restriction above the wind farm of not lower than 2000 feet. This is promulgated as a standing Notice to Airmen (NOTAM).

2.3.6 Low Flying

2.3.6.1 In Denmark, the lowest level for civil VFR flight is 150 metres (492ft), and the overall attitude of the SLV to wind farm developments has been described in Section 2.3.2. Similarly, the RDAF has no significant objections to wind turbines less than 100 metres tall. Even for turbines that are taller than 100 metres, the air force imposes no particular restrictions on developments due to effects on low flying, but just requires that they are marked and illuminated in line with SLV policy (described in Section 2.3.8).

2.3.7 Relevant Studies and Research

2.3.7.1 In Denmark, no-one interviewed was aware of any specific work done on the topic of the effects of wind turbines on aviation systems, nor of any that was pending or underway. It was generally accepted that wind turbines would have some sort of impact on many technical systems, for example, a small degree of shadowing of a radar picture, but that this was usually acceptable.

2.3.7.2 The SLV has conducted one study, into the effects that a wind farm in Jutland caused on a nearby VOR station. (It is interesting to note that the SLV had no specific restrictions in place other than the ICAO safeguarding slope of 1:50 and allowed the wind farm to be constructed, then used the situation as a case study). The wind farm in this case was constructed 4km (2.5 miles) from the station, but the turbines caused absolutely no discernible negative effects.

[11] SSR radar R1 is tilted up at an angle of 1.05°; SSR radar R2 is tilted up at an angle of 1.5°.

2.3.8 Marking and Illuminating

2.3.8.1 Anticipating that obstacle marking of wind turbines was an issue that needed to be addressed, the SLV approached the Danish wind turbine industry in 1999 in an attempt to prompt discussion and hopefully achieve an industry standard. However, nothing came of this and only recently have the Danish aviation authorities (the SLV in conjunction with the Danish Air Force) agreed on an obstacle marking policy.

2.3.8.2 Wind turbines with a height of less than 100 metres are not required to be marked or illuminated. Turbines between 100 and 150 metres are to be marked as follows:

- The outer 1/7th of the blades shall be red (day marking).
- The top of the tower shall be marked with two red flashing obstacle lights, on the side of the generator housing, so that they are visible in the horizontal plane (night marking).
- For turbines in large farms, all shall be marked. Turbines at the corners and outer edges of the wind farm shall have medium intensity lights; all others may be of low intensity[12].

2.3.8.3 Turbines greater than 150 metres tall are currently required to be marked with lights at the top of the tower (as above) and 'otherwise marked in accordance with guidelines stipulated by' the SLV. However, due to the hazard that such large turbines may cause, other options for turbines greater than 150 metres are being considered.

2.3.8.4 One of these is to install lights in the tip of each blade that illuminates as it passes the apogee. Of course, all the blades in a wind farm do not turn in a synchronised manner, so this could cause a large amount of irregular flashing as each blade reaches its highest point; in a 100 turbine wind farm this would be a most disorienting spectacle.

2.3.8.5 The SLV proposes that the blade lights only illuminate at the same time as the lights on the turbine tower; in other words, the tip of a blade would only be illuminated if it was at it's highest point *and* if this occurred at the same time as the other lights were illuminated. This would mean that only a proportion of the blades in any one farm would illuminate at any one time, but this would be easier on the eye than random flashing of hundreds of blades at irregular intervals. This has been put to industry, but as yet, there has been no co-ordinated response.

2.3.8.6 The issue of night-lighting wind farms has proved to be quite controversial with the public in Denmark. SEAS Distribution A.m.b.A is the company developing one of Denmark's two large offshore wind farms and has produced a document that contains many artist impressions of what the 72 turbine

[12] Source: 'Obstacle marking of wind turbines with a height from 100 to 150 m', SLV, 2000.

development will look like from a variety of aspects[13]. No attempt is made to address the crucial question of what the wind farm will look like when illuminated at night.

2.3.8.7 The SLV currently meets all costs involved in the marking of obstacles.

2.3.9 Charting

2.3.9.1 In Denmark, no special measures are taken to maintain a database specifically of wind turbines by the aviation authorities, but they are included on aviation charts if they are 100 metres tall or greater. Obstacles of a height less than 100 metres may be shown 'if deemed necessary'. Fig. 3 shows the Horns Rev offshore wind farm (currently under construction) as depicted on the ICAO 1 : 500,000 Aeronautical Chart for Denmark.

[13] 'Vindmøller syd for Rødsand ved Lolland – vurderinger af de visuelle påvirkninger', SEAS, July 2000.

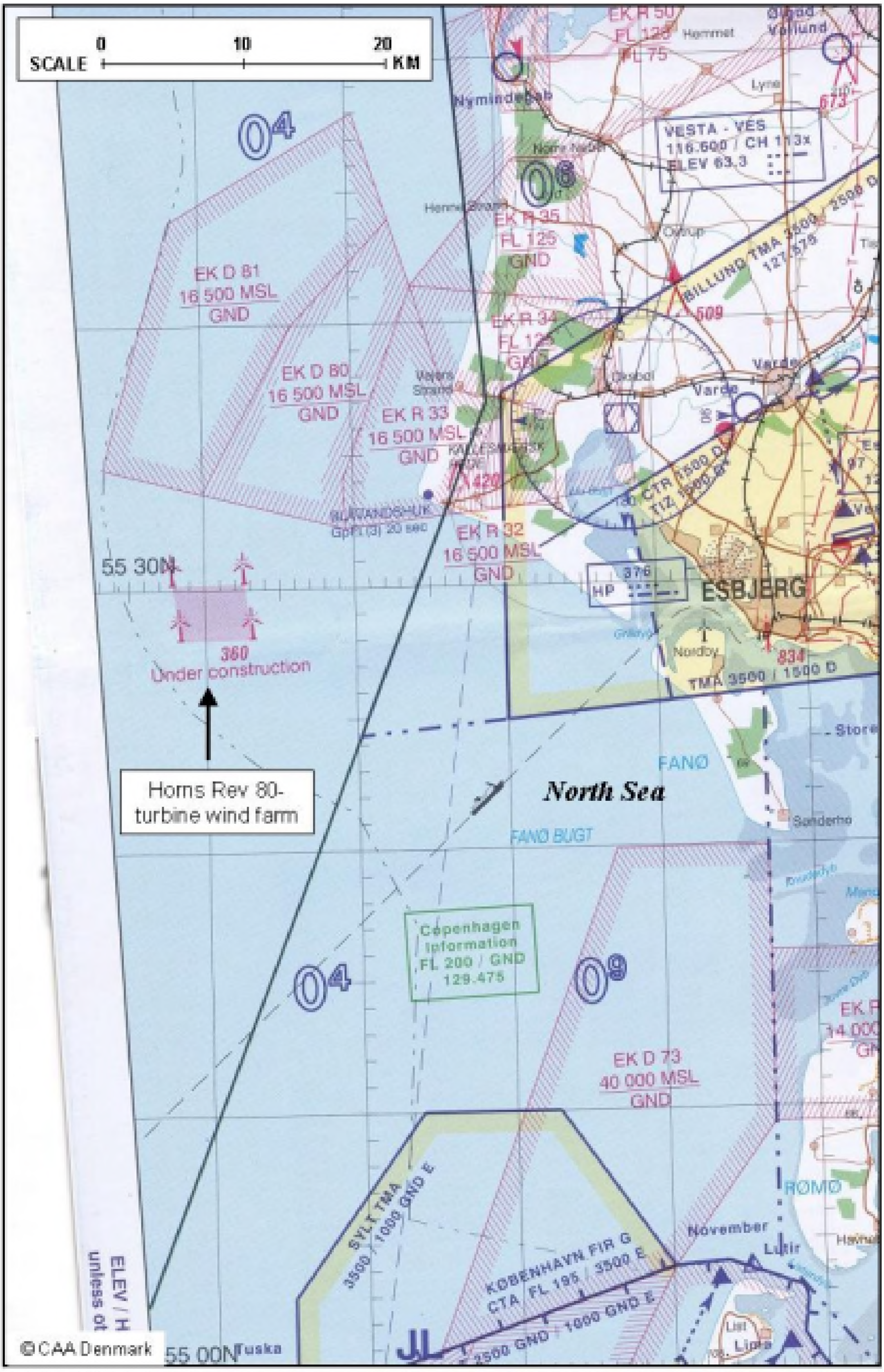

Figure 3 – Depiction of the Horns Rev offshore wind farm on the ICAO 1 : 500,000 Aeronautical Chart for Denmark

2.4 Germany

2.4.1 Introduction

2.4.1.1 Although Denmark is often the first European state to be mentioned when discussing countries with advanced wind energy programmes, it is actually Germany that has the greatest installed capacity in Europe, by some margin (8754MW by the end of 2001). By far the most populous country in this study, Germany has seen its installed capacity rise significantly in recent years, partly due to the influence of the Green Party in parliament.

2.4.1.2 Political imperatives have been instrumental in promoting renewable energy sources in Germany and whilst wind energy has largely developed with little impact on civil aviation, the German Air Force (GAF)[14] has found itself increasingly in conflict with wind farm developers. On more than one occasion, objections from military aviation have been over-ruled in order to promote the development of wind energy in Germany. However, conflicts with military low flying, for example, are not as common as in the UK due to restrictions placed on such activities.

2.4.2 The Planning, Assessment and Approval Process

2.4.2.1 Proposals to build wind farms in Germany must be submitted to Community Construction Committees (CCC), who decide, in consultation with other agencies, whether or not a proposal will go ahead. Under German law, development proposals must be replied to, and any objections raised, by all concerned parties, within two months of submission, or it is assumed there are no objections.

2.4.2.2 With respect to a development's impact on aviation, the height of the structure is the key factor, and this applies to wind turbines just as to any other construction. If a vertical obstruction is planned that is taller than 100 metres, then the approval process is defined under Section 14 of the German Aviation Act (Luftverkehrsgesetz, LuftVG). If the proposal is less than 100 metres tall, then only the German Air Force will assess the development; the civil aviation authorities have no interest in such developments (unless they are in close proximity to an airfield, in which case standard ICAO aerodrome safeguarding procedures apply, as described in Section 2.2.2).

2.4.2.3 For developments taller than 100m, the application is dealt with initially by the German CAA (the Deutsche Flugsicherung GmbH, DFS), who will, in turn, consult the air force; the process is illustrated in Figure 4. First, the proximity of the development to, and the impact on, civil airfields is assessed, including any impacts on protected surfaces. Also, the impact on all other aspects of civil aviation operations is considered, including the technical infrastructure and traffic using German airspace.

[14] In German, *Luftwaffe*.

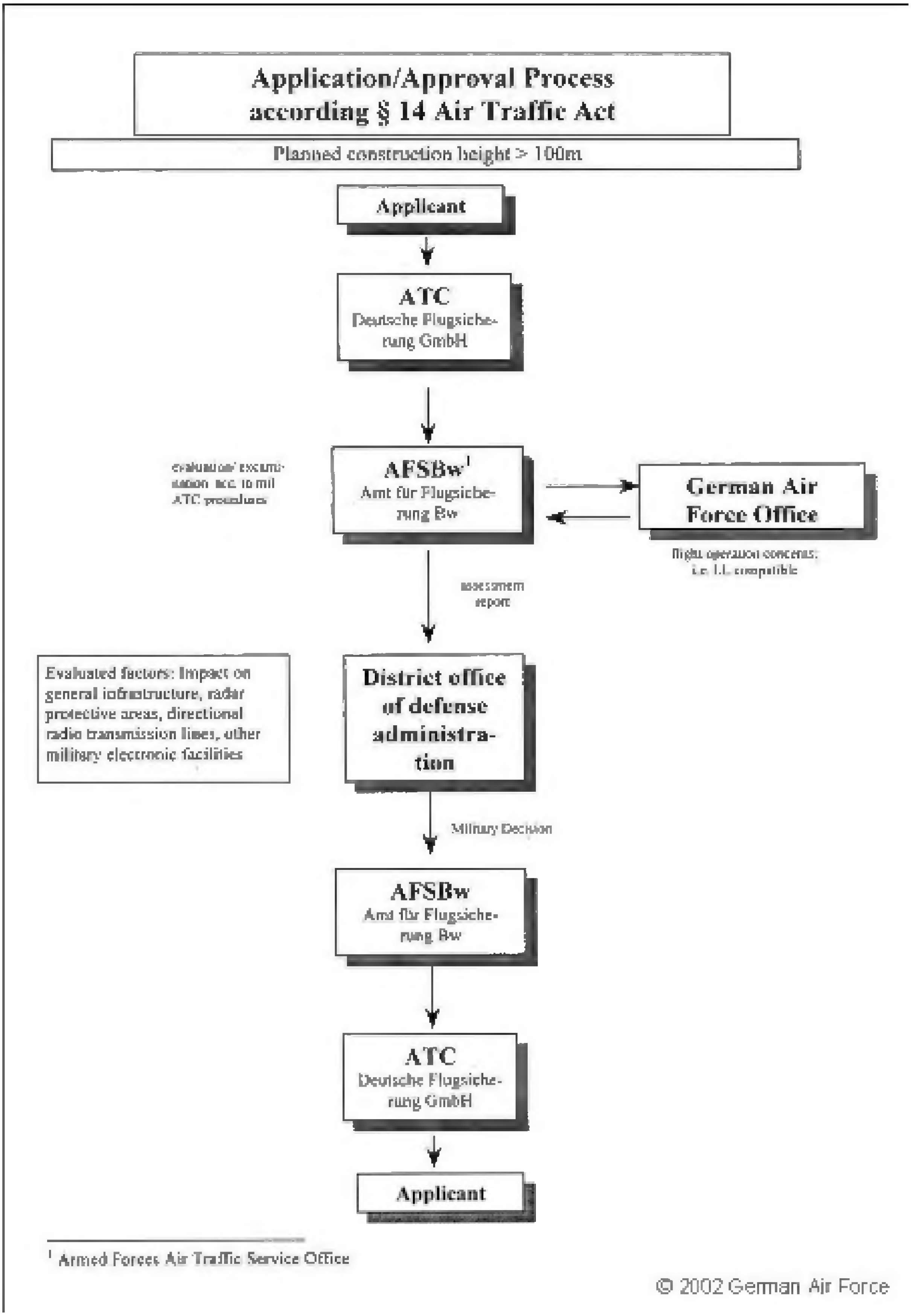

Figure 4 – The application and approval process for structures taller than 100 metres, in accordance with the German Air Traffic Act.

2.4.2.4 Following this procedure, the application is forwarded to the Armed Forces Air Traffic Service Office (Amt für Flugsicherung Bw) for evaluation of the impact on military ATC services. Simultaneously, the German Air Force Office will evaluate the impact of the development on military flight operations, for example, low-level operations.

2.4.2.5 The relevant District Office of Defence Administration deals with the next stage; there are four of these within Germany, responsible for military administration in the north, south, east and west. This office will evaluate any other potential impacts the proposed wind farm may have on the rest of the military infrastructure, including, but not limited to, radar systems, radio transmissions, other electronic facilities, etc. (for more detail, see Sections 2.4.5-8). When this is complete, a decision is reached from the military, which is then passed back to the applicant via the Armed Forces ATC Office and the DFS.

2.4.2.6 As mentioned above, the DFS has no interest in structures less than 100m tall (that are not in the immediate vicinity of airfields) as they are not deemed to have an impact on civil aviation operations. However, the Luftwaffe still has an interest in such developments and will receive notification of them through the CCC. The air force will assess the proposal in exactly the same way as for those over 100m tall.

2.4.2.7 The German process seems to work well, but, as with all such systems, is not perfect. One anecdote came to light of a single wind turbine that was built which encroached the lower levels of the night low level flying system by 16 metres (52 feet)[15]. Somehow, this turbine slipped through the net; it is assumed that an objection was not received within the two month period allowed by law and therefore construction went ahead. The turbine is currently highlighted to aviators by a permanent NOTAM (Notice to Airmen), but at the time of writing the German courts are deciding whether there is a case for the turbine to be dismantled.

2.4.2.8 Offshore Wind Farms

2.4.2.8.1 In January 2002 the German government published 'Strategy of the German Government on the use of off-shore wind energy'[16]. However, this makes only a fleeting mention of the impacts on 'military uses' of the ocean and does not mention aviation specifically, concentrating on the effects on, inter alia, wildlife, visual impact and mineral exploitation.

2.4.2.8.2 The first stop for planning applications for offshore wind farms in German waters is the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH), an agency of the Federal Ministry for Transport (BMVBW). Plans must be accompanied by Environmental Impact Assessments, and the BSH consults with all relevant government departments,

[15] The German Night Low Level System is a 'Spidernet' system spread over Germany. It is made up of controlled airspace (Class E) within which military aircraft may generally only fly as low as 1000 feet agl; however, in a very small area under tightly controlled circumstances, aircraft may on occasion fly down to 250 feet and it was in this area that the encroachment occurred.

[16] German Federal Government, January 2002.

including the DFS and the Air Force Office, who assess the proposal's impact on their area of interest.

2.4.3 Aerodrome and Technical Site Safeguarding

2.4.4 In Germany, the German Air Traffic Act establishes safeguarding criteria for both civil and military airfields[17]. This implements ICAO safeguarding standards into German law but, beyond this, there are no other restrictions on wind turbine developments in the vicinity of aerodromes. The only other method of assessment used is the professional experience of CAA and GAF personnel when looking at a development plan, but this is, of course, subjective.

2.4.5 Technical Site Safeguarding – Military

2.4.5.1 The GAF approach to the protection of their technical sites, including air defence radar, is quite straightforward. A 'protected area' of 5km (3 miles) radius, within which no significant developments are allowed, surrounds all technical sites. Outside this is an 'area of interest' of 20km (12 miles) radius, within which any proposals must be approved by the military following an assessment of the development's potential impact on the technical site in question[18].

2.4.5.2 The air force has no right to object to, or prevent, any developments outside these areas, unless they can explicitly prove that the development will have a detrimental and unacceptable effect on the operation of the technical site in question. This is significant, as the burden of proof is on the air force; the burden of proof is not on the developer to prove that there will *not* be a negative effect, as it may be argued is the case in the UK.

2.4.5.3 A wind turbine in the vicinity of the Control and Reporting Centre (CRC) at Auenhausen had to be dismantled due to the amount of interference it caused to the air defence radar. It is assumed that the development was outside the 'area of interest' specified and the German Air Force could not prove the effects the turbine would have on their system prior to its construction. However, when the wind turbine was built, its effect on the capability on the radar proved too damaging and the air force made a successful case for the turbine to be dismantled, at the developer's expense.

2.4.6 Low Flying

2.4.6.1.1 The low flying issue in Germany is less quantifiable. Whilst Germany does not have a low flying system (LFS) comparable to the UK, as wind turbines grow in size they are having a more significant impact on military aviation. Current regulations allow military aircraft no lower then 1000 feet ordinarily, but very occasionally down to 250 feet, in Germany.

2.4.6.2 The concern the GAF has is with the proliferation of onshore wind turbines. Although turbines, as yet, have not directly impinged the low flying activities

[17] German Air Traffic Act, Para. 12

[18] 'Protected area' and 'area of interest' are not formal definitions but are widely used and accepted.

of the German military[19], pilots are more frequently planning routes that will avoid existing wind farms. This is understandable, but it is creating false traffic flows at low levels, forcing military jets into smaller areas of airspace than normally might be the case and thus increasing the risk to flight safety. In addition, it is causing aircraft to fly nearer to centres of population, leading to an increase in low-flying complaints. As turbines grow in size, so will the problem. The German Air Force Office has recently received a submission detailing a plan to construct a turbine with a total height of 220 metres (722 feet), which would have a significant impact on flying operations.

2.4.7 Danger Areas

2.4.7.1 The GAF has experienced some conflict with the proposed development of wind farms in the vicinity of military Danger Areas. Consequently, wind farms are not permitted close to areas where air-to-ground weapons training occurs, due to the nature of the ordnance being dropped and also because aircraft may well be approaching such ranges at high speeds and low altitudes. Again, proposals are assessed on a case-by-case basis, and reference is made, on an *ad hoc* basis, to safety distance prerequisites used when safeguarding airports from tall structures. This is not formalised anywhere, however.

2.4.7.2 One unforeseen situation arose recently when it was realised that a proposed offshore wind farm in German waters lay below a military danger area that is occasionally used for live air-to-air gunnery practice[20]. The initial position of the GAF was that, as the danger area had been in existence for a long time, the developers could build their wind farm, but at their own risk. However, the air force's lawyers have since decided that, in the unlikely occurrence of wind turbines suffering any damage from live firing conducted by the GAF, i.e. rounds falling to earth and striking a turbine, then the air force would be liable and would have to pay compensation. It is thought that the development will go ahead with the GAF accepting the risk of damaging the turbines.

2.4.8 SAROps

2.4.8.1 German military SAR pilots have stated that it is likely that they will not be able to conduct SAR operations within, or in the vicinity of, large-scale offshore wind farms. Indeed, the Principle Advisor on Flying Operations at the German Federal Ministry of Defence has gone on record at a conference, stating that 'SAROps within large offshore wind farms will not be possible' due to the associated hazards. Thus far, there is an unofficial statement by the German Navy that SAROps will be made difficult or impossible by the presence of offshore wind farms; of course, the distance between individual turbines is the key factor.

2.4.9 Relevant Studies and Research

2.4.9.1 Germany has been somewhat proactive in the area of wind turbine research, undertaking some work into the effects on aviation-related and other technical systems, although it has not been possible to obtain English language copies of

[19] With the exception of the single turbine described earlier.
[20] The Danger Areas in question are ED-D 41 and ED-D 46, located over the North Sea off the German coast.

such reports. Principally, EADS, the European Aeronautic Defence and Space Company, has financed some studies examining the impact of proposed wind farms on military radar. These did reveal some shadowing of the radar behind the turbines and a degree of clutter. This is accepted by the German military, but the severity of the effect and the degree to which it compromises operations is assessed on a case-by-case basis.

2.4.10 Marking and Illuminating

2.4.10.1 Current procedure for marking and illuminating turbines in Germany varies considerably from the other nations visited. Currently, German regulations require that the tips of all turbine blades be marked with a 6 metre (20 feet) wide red band. If a turbine is within 5km (3 miles) of an airfield, then an additional band is added. This is illustrated in Figure 5.

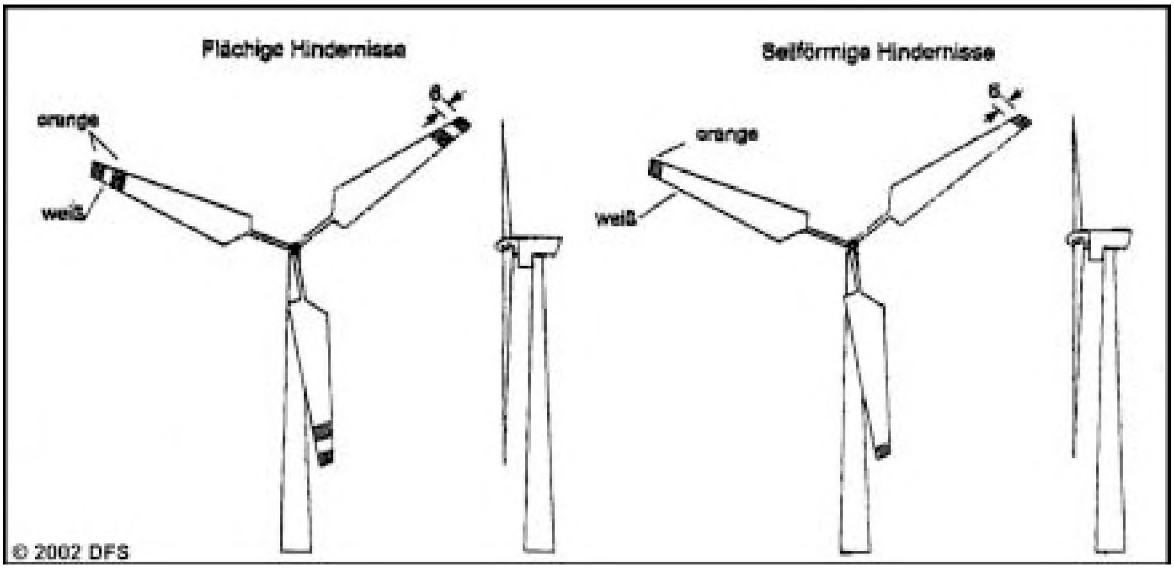

Figure 5 – German day marking requirements for wind turbines.

2.4.10.2 Alternatively, a turbine may not have red bands on its blades but, instead, may have a flashing white light at the top of the turbine tower. The German military prefers the use of red bands to lights at the top of towers, mainly to aid helicopter crews. There is anecdotal evidence of a helicopter crew, flying in poor weather and visibility, who found themselves in the vicinity of a wind farm. The first they knew of this was when the tip of a blade descended out of the cloud towards them. The turbines all had lights on top of the towers, but these were shrouded by the low cloud, and the white, unmarked blades were very difficult to see.

2.4.10.3 Night lighting standards in Germany call for turbines taller than 100 metres to have a red, low intensity flashing light on the top of the turbine tower. Of course, this does not give an indication of the maximum height of the structure including the turbine blade. To give some warning of this, if the blade length is greater than 15 metres (49 feet), the intensity and frequency of the light is higher. This is illustrated in Figure 6.

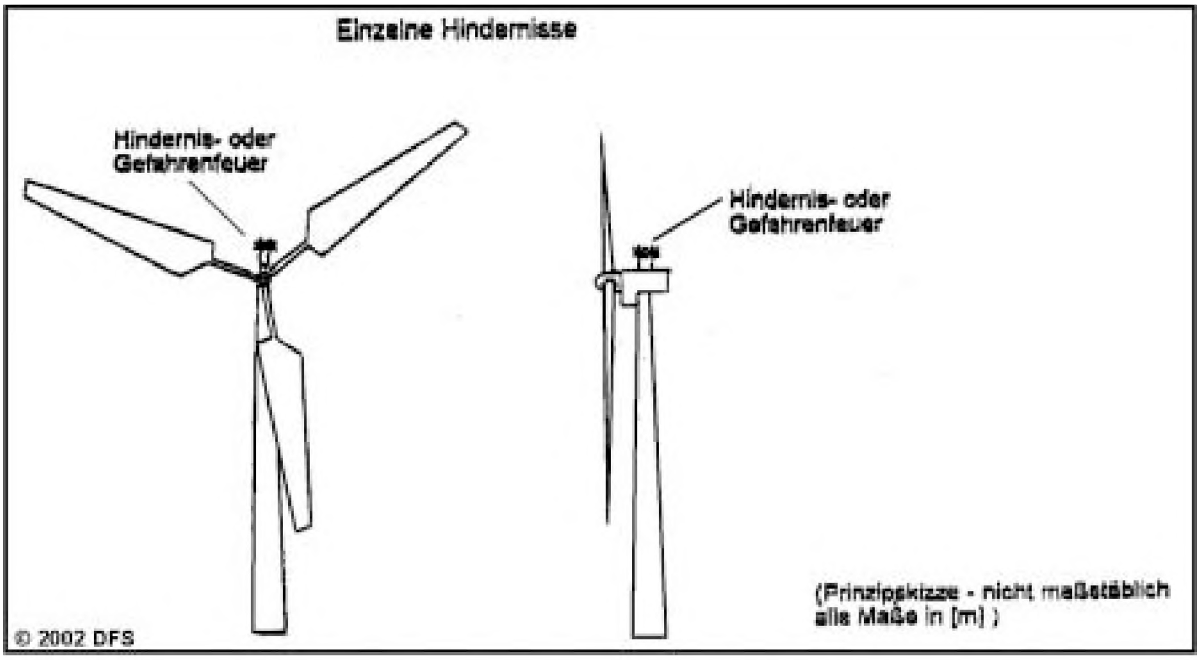

Figure 6 – German lighting requirements for wind turbines.

2.4.10.4 The GAF pays for the marking of all turbines that are smaller than 100 metres tall as only they regard them as a hazard.

2.4.11 Charting

2.4.12 Germany follows the same guidelines as Denmark, in that obstacles greater than 100 metres tall are charted for aviation purposes. Structures that are smaller than 100 metres may be charted if it is deemed necessary; this is usually if they are in the vicinity of an airfield or another area where they may prove a hazard to aircraft.

2.5 The Netherlands

2.5.1 Introduction

2.5.1.1 The smallest country in the study, with an area of approximately 41,500km^2, the Netherlands still has more installed wind energy capacity than the UK (493MW at the end of 2001, compared to 474MW in the UK). The study found that aviation-imposed restrictions were few and far between, with a somewhat relaxed and informal approach to wind turbine construction.

2.5.1.2 This is not to say that safety considerations in the Netherlands are any less stringent than in any other state, but that, as in Denmark, aviation and wind energy appear to coexist with little conflict. As Annex D describes, the challenge now facing the wind energy industry in the Netherlands is that of finding suitable space in a country so small and densely-populated. For this reason, the Dutch government is beginning to look to offshore locations to meet its wind energy targets.

2.5.2 The Planning, Assessment and Approval Process

2.5.2.1 The system in the Netherlands appears to be the least regulated of the countries studied. As far as could be ascertained, no regulated process, either formal or informal, exists for developers to submit forms to aviation authorities for approval. Currently, the aviation authorities (the Dutch CAA and the Royal Netherlands Air Force, RNlAF) rely on the goodwill of developers to inform them of their plans and it was stated that no clear mechanism exists for any sort of mandatory notification. It is possible that a wind energy development could be constructed without any dialogue occurring between developer and aviation bodies.

2.5.2.2 The government has passed legislation that allows local and regional authorities to designate areas suitable for wind energy development. As in Denmark, areas are assessed for their suitability and impact on all other land users, including aviators, and, in theory, wind farms can be built in these areas relatively quickly. However, due to the topography of the Netherlands, designating such areas has proved problematic and it has not accelerated the development of onshore wind noticeably.

2.5.2.3 When proposals *are* submitted to the CAA, they are initially handled by the Certification and Surveillance Division, which is the official point of contact for developers. As well as assessing the proposal themselves (if necessary, in consultation with the other sections in CAA: Aerodrome Standards and Flight Procedures and ATM), they forward copies to the Netherlands Air Traffic Control Agency (Luchtverkeersleiding Nederland, LVNL), and the RNlAF Environment Office (the military's interests are detailed in Sections 2.5.5-7). The only veto that the CAA and LVNL may exercise occurs if a development will impinge upon an airfield's safeguarded surfaces as defined by ICAO; other than that, they have no remit to object to a proposed wind farm. The CAA usually is able to reply to requests within one month.

2.5.2.4 If there is any doubt over the effects that a development may have on a technical system used by aviators, be it civil or military, then technical questions (for example, predicting the effect of a system on a radar) are handled by the Netherlands Organisation for Applied Scientific Research, known by its Dutch acronym of TNO, on a case-by-case basis. Specifically, questions regarding the effects of wind turbines on systems are referred to TNO-FEL, the Organisation's Physics and Electronics Laboratory[21]. TNO-FEL has conducted at least one study pertinent to this topic; see Section 2.5.7 for more information

2.5.2.5 When the RNlAF Environment Office receives a development proposal, it is forwarded to the Air Staff Operational Support Unit, which contains personnel from all specialisations within the air force (air traffic controllers, radar technicians, meteorologists, etc.). These individuals use their expertise to assess a proposal, but the RNlAF states no key ranges, rules of thumb or hard figures for the location of wind farms in proximity to military installations. Each proposal is examined individually and, should there be any uncertainty, then, again, the TNO is called upon.

[21] TNO-FEL is a corporate laboratory for the Dutch Ministry of Defence and Armed Forces.

2.5.3 Aerodrome Safeguarding

2.5.3.1 In the Netherlands in the summer of 2002 the law changed to make aerodrome safeguarding more robust. The new law required the production of new aerodrome safeguarding maps (derived from ICAO safeguarding criteria) and, for the first time, integrated them into regional development plans, thereby minimising potential conflict between wind energy developments and aviation. However, at the time of writing, only Amsterdam Schiphol airport's new map had been produced and made effective; for other airports in the country, it is intended to extend the law in the near future. A section of the new Amsterdam Schiphol safeguarding map is at Figure 7.

2.5.3.2 What this means in real terms is that wind turbines, like any other tall structure, in the vicinity of Schiphol Airport will receive approval only if they do not penetrate any of the protected surfaces delineated on the airport's safeguarding map. However, unlike the system in the UK, if a wind farm is developed just outside (or below) the protected surfaces, the CAA Netherlands has no remit to object to the proposal and the development will likely go ahead. Some states have criteria in addition to safeguarding maps, which place more stringent restrictions on wind turbine developments due to their effects on technical systems. The Netherlands has one additional restriction (which applies to any tall structure, not just wind turbines) and this is described below.

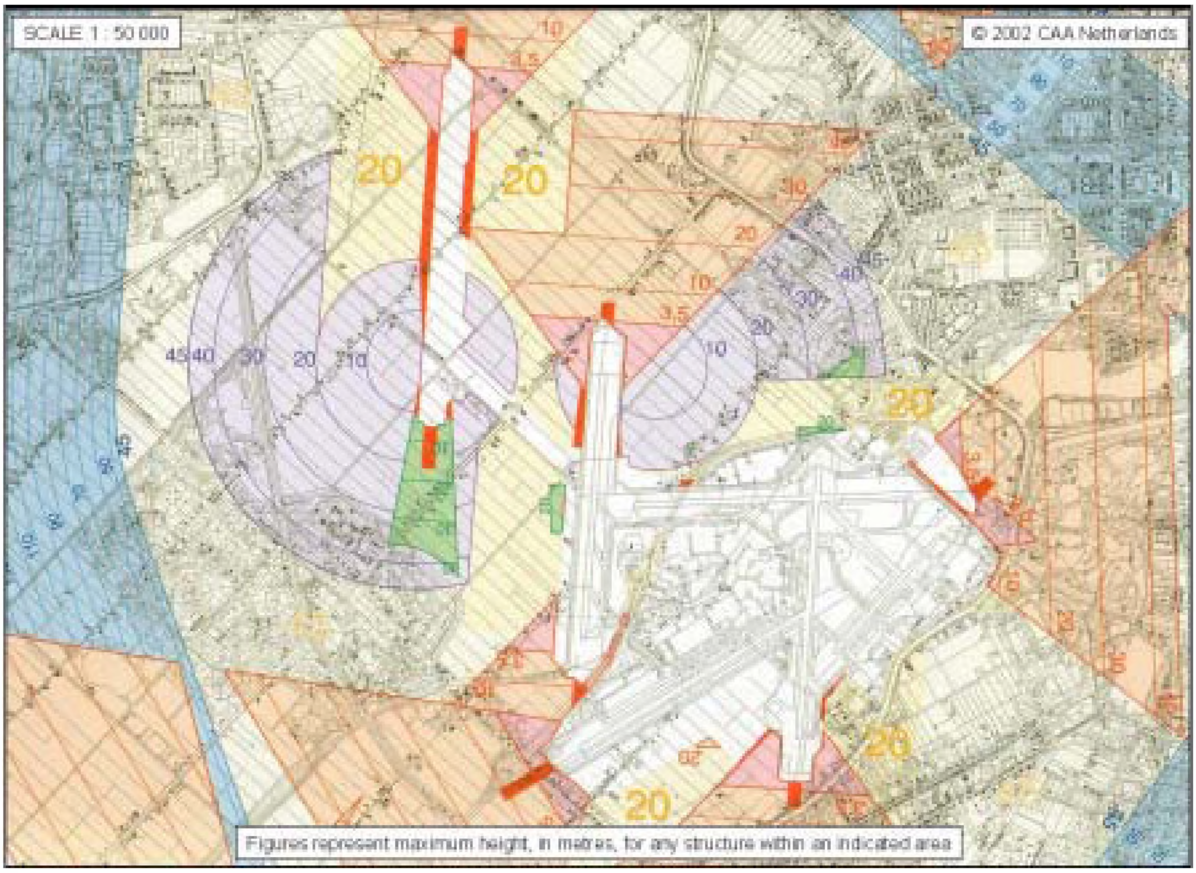

Figure 7 – Section of the new safeguarding map for Amsterdam Schiphol airport.

2.5.4 Technical Site Safeguarding – Civil

2.5.4.1 Authorities in the Netherlands place additional restrictions on developments in the vicinity of airfield radar but this is not specifically aimed at wind turbines but any tall structure. The restriction in question is a ban on developments taller than 150 metres within 30km (19 miles) of civil airfield radar sites. To date, it is not thought that this has had any effect on wind farm developments, as turbines are very rarely this tall; of course, turbines will get larger as technology progresses.

2.5.5 Technical Site Safeguarding – Military

2.5.5.1 The RNlAF places no set restrictions on wind turbine developments adjacent to technical sites of any description, but will assess any proposal on a case-by-case basis. The Netherlands has two air defence sites, one at Nieuw Milligen and one at Wier. Wier actually has a wind farm within 5km (3 miles) and experiences no significant negative effects.

2.5.6 Low Flying

2.5.6.1 Low flying is the main concern for the RNlAF, but is still not a major obstacle to wind farm development. Fast jets used to be able to fly down to 1000 feet in Holland, but this was raised to 1200 feet in 2001. This restriction applies across the whole country, except two low-level link routes. Dutch airspace is illustrated in Fig. 8. Within these link routes, aircraft may fly as low as 250 feet, so the area directly below these routes, and for 2 miles to either side, is specifically protected from tall structures.

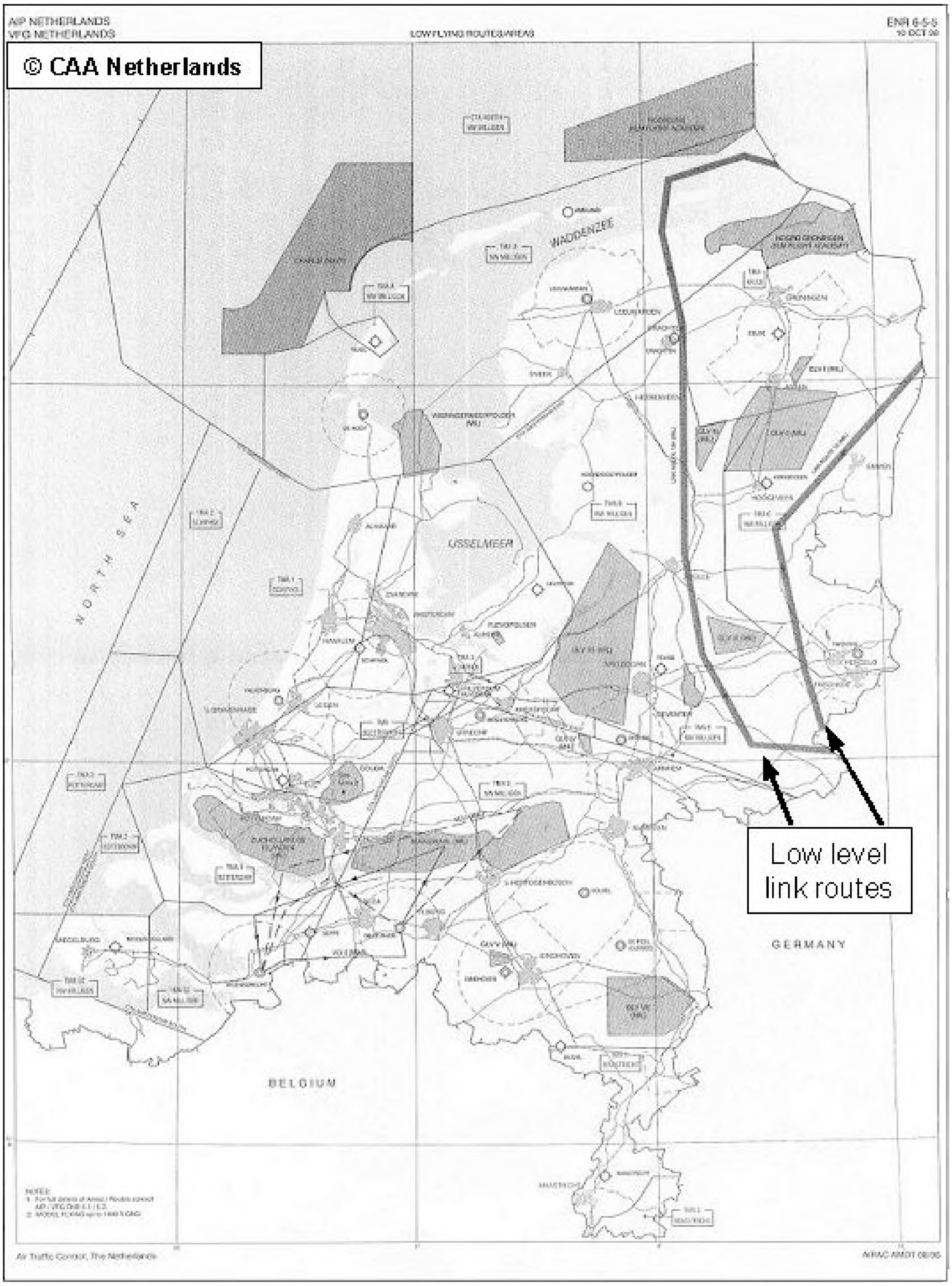

Figure 8 – Low Flying Routes and Areas in the Netherlands (taken from AIP (Air Information Publication) Netherlands) (No scale available).

2.5.6.2 Helicopters in the Netherlands may fly as low as 500 feet in routine airspace, but, due to their slower speeds and manoeuvrability, wind farms do not present such a hazard. Thus helicopters try to navigate around all tall structures on a 'see and avoid' basis when flying at low level.

2.5.6.3 In certain specified low-flying areas, helicopters and light training aircraft used by the RNlAF may fly down to 500 feet also. However, there are no restrictions on the construction of tall structures in these areas, they are simply recorded on aeronautical charts and aircrew must avoid them.

2.5.7 Relevant Studies and Research

2.5.7.1 In the Netherlands, TNO-FEL undertook a study in 1995 to measure the influence of large wind turbines on the performance of a long-range radar (no English language copies are available, but see the report summary page at Annex I). The study concluded that the performance of the radar would deteriorate if large obstacles such as wind turbines were placed in the proximity of the radar antenna. TNO-FEL has done further work, more recently, to ascertain the effects of a wind farm in the north of the Netherlands on the airfield radar of Leeuwarden Air Base. The study proved that there was some reduction in the detection performance of the airfield's terminal approach radar but that the extent was minimal and acceptable.

2.5.8 Marking and Illuminating

2.5.8.1 In the Netherlands, marking and lighting of wind turbines follows ICAO regulations for tall structures. In general, if a turbine is less than 300 feet tall and not in the vicinity of an airfield or military low-flying area then there is no requirement to mark or light it. This explains one famous wind farm in the Netherlands, in which the turbines are laid out in a long line, that has each turbine painted a different colour to create a rainbow effect.

2.5.8.2 Structures between 300 and 750 feet tall must be permanently lit with steady, low-intensity obstruction lights if within 120 metres (393 feet) of a highway. This is because Emergency Medical Service and police helicopters frequently operate in the vicinity of highways. Otherwise, wind turbines between 300 and 750 feet tall must be suitably marked and lit only at night.

2.5.8.3 In military low flying areas, structures smaller than 750 feet do not require day marking but must have low intensity night lighting. CAA Netherlands also states requirements for the illuminating of obstacles that are taller than 750 feet (229 metres), but due to the current and anticipated size of wind turbines they do not currently affect wind farm developments.

2.5.9 Charting

2.5.9.1 The CAA in the Netherlands goes somewhat further than the other states visited and maintains an archive of all obstacles taller than 300 feet agl (above ground level) called the Obstakel Archief (Obstacle Archive), which is maintained by the Certification and Surveillance Section of the CAA. Developers are required to fill out a form (the 'Obstakelformulier Aanmelding', Obstacle Reporting Form) at the early stages of planning, and then a new form (the 'Obstakelformulier-verwerking') is submitted when construction is complete, to ensure any changes have been recorded. Copies of these forms are included at Annex J, with partial translations. The forms are kept in the Obstacle Archive and updated every two years.

2.6 Sweden

2.6.1 Introduction

2.6.1.1 Sweden is the most sparsely populated country in the study and also has a relatively small wind energy capacity. Consequently, aviation has placed few restrictions on the development of wind energy in Sweden and many of the issues seen elsewhere have yet to materialise. Nevertheless, the Swedish military has displayed interest in the effects of wind turbines on its various systems and carried out several studies on the topic. Due to its military stance (i.e. not being a member of NATO) Sweden places great priority on its military capability and it is with military interests that wind energy has the greatest potential to conflict in the future.

2.6.2 The Planning, Assessment and Approval Process

2.6.2.1 In Sweden, again, there is no compulsory process for wind farm developers to consult with aviation bodies, but despite this, virtually all developers do inform both the Swedish CAA (Luftfartsverket, LFV) and Swedish Air Force (SwAF) of their intentions. This is facilitated by a form that can be downloaded from the LFV website that provides information on the proposed structure (similar to the form developed in the UK, shown in Annex K)[22].

2.6.2.2 As described in Annex E, Comprehensive Plans drawn up by municipalities should identify areas suitable for wind energy development, although in reality many do not. If a proposal is submitted that falls within one of these areas, then it will be assumed, to a certain extent, that there are no conflicts with aviation in the area, but the LFV and SwAF will still wish to see new proposals to verify this. In addition, many Comprehensive Plans fail to address the issue of wind energy, meaning that most proposals still need to be examined to ensure they do not impinge on aviation activities.

2.6.2.3 Once a form has been submitted, there is no set time frame within which it must be dealt with. The department within the LFV which assesses proposals, the Environment and Spatial Planning Department, deals with applications for all tall structures and is currently dealing with large numbers of applications for Third Generation (3G) mobile telephone masts. One estimate, for the two month period of May-June 2002, was that around 1900 applications for 3G masts were received and processed, compared with around 100-200 wind farm applications *per year*.

2.6.2.4 There are no set rules, ranges or figures used by the LFV for assessing proposed wind farms. Each proposal is assessed on a case-by-case basis and, provided the farm will not impinge on an aerodrome's protected surfaces, the judgement of the LFV staff is used. In order to veto a proposal, the LFV must prove that it would have unacceptable impacts on safe operations, or the military may use Sweden's Environmental Code to veto a development (see Section 2.6.7)

[22] The Swedish form can be found at www.lfv.se/site/pilot_info/air_traffic_society/hinderremiss_forms.asp.

2.6.2.5 Offshore Wind Farms

2.6.2.5.1 Exploitation of offshore wind energy in Sweden is still very much in its infancy, but Sweden does now have three offshore installations and will construct more. The Ministry for Agriculture, Food and Fisheries deals with all applications for offshore farms, and refers to the LFV and SwAF for advice.

2.6.3 Aerodrome and Technical Site Safeguarding

2.6.3.1 Other than applying ICAO safeguarding standards for the protection of aerodromes, the authorities in Sweden apply no other specific measures to restrict the development of wind farms. In short, this means that wind turbines are treated exactly as any other tall structure. The military does have some other concerns, as described in the following sections.

2.6.4 Low Flying

2.6.4.1 In Sweden, the lower limit for low flying is 50 metres. Wind farms present no real obstacle to low flying training in Sweden, however, due to the relatively small numbers of turbines and the size of the country. Most low flying occurs in the north, away from centres of population, where there are no wind farms of note. Sweden's military helicopter pilots have, however, written a paper addressing the issue of wind turbine (and 3G mast) construction and discussing areas that they would like to see remain free of such developments.

2.6.5 Danger Areas

2.6.5.1 Conflicts over military training areas and proposed wind farms have not arisen in Sweden as the country's geography allows live firing and the use of danger areas in places well away from centres of population and wind farms.

2.6.6 SAROps

2.6.6.1 As in Germany, SAR operators in Sweden are not willing to undertake search and rescue operations in the vicinity of wind farms and the SAR pilots of the Swedish military have signed a letter to this effect. The situation has still not yet been fully resolved, but it is assumed that once any large offshore wind farms are operational, search and rescue in their vicinity will be the responsibility of the farm operator.

2.6.7 Other Military Concerns

2.6.7.1 The biggest concern of the Swedish military is one that is unique to the country. Not being a member of NATO, Sweden has a quite different defence posture to the other nations in this study and puts national defence high on its list of priorities. In addition, the country's location on the Baltic Sea, opposite the Russian enclave of Kaliningrad, presents military planners with unique challenges.

2.6.7.2 Quite simply, Chapter 3, Section 9 of Sweden's Environmental Code[23] states:

- "Land and water areas that are important for total defence purposes shall, to the extent possible, be protected against measures that may be detrimental to the interests of the total defence.

- "Areas that are of national interest because they are needed for total defence installations shall be protected against measures that may be prejudicial to the establishment or use of such sites."

This legislation can be, and is, successfully used by the Swedish military to veto wind farm developments that it is thought would prejudice the national defence.

2.6.7.3 The primary concern of the Swedish military, unlike the Royal Air Force, is not the impact of wind farms on air defence installations, but on a system of what are best termed 'listening posts' that is employed by the Swedish armed forces. These posts are movable units that are positioned in selected locations on Sweden's east coast and monitor the electro-magnetic spectrum for intelligence. Their activities and locations are highly classified.

2.6.7.4 Although the units may move between sites, all possible locations are safeguarded against wind farm development under the Environmental Code for the sake of the 'total defence'. The restrictions on nearby developments are not a simple radius, however, but, bearing in mind the coastal location of the listening posts, wind farm developments are not permitted within 50km (31 miles) to either side of the unit location, or at any range out to sea. Restrictions inland of the listening post were not stated; it is assumed there are no restrictions as the area of interest is offshore. This is illustrated in Fig. 9.

[23] The Environmental Code came into force in Sweden on 1 January 1999, representing an amalgamation of several existing environmental acts in one piece of legislation. The Code modernised, broadened and tightened Sweden's environmental law.

Figure 9 – Illustration of restrictions on developments in the vicinity of listening posts employed by the Swedish military.

2.6.8 Relevant Studies and Research

2.6.9 Sweden has conducted a significant amount of work on the topic of interference from wind turbines, dating back to a study by the Defence Materiel Administration (FMV) in 1994. In 1999, the Swedish National Defence Research Establishment (Forsvarets Forskningsanstalt, FOA) conducted a study by setting up a transportable air defence radar adjacent to an existing wind farm, then measuring the radar's capability to track a fast jet flying at low levels behind and above the turbines.

2.6.10 The report discovered two problems:

- When the aircraft flew above the wind farm, multiple returns from the single target were observed, the result of the blades reflecting the electromagnetic energy. This made accurate tracking of the target very difficult.

- When the target flew at low level behind the wind farm, scattering of EM energy was observed.

2.6.11 The result concluded that these results occurred whether the blades were rotating or not. The study therefore proved that there were significant impacts on the radar in question, but it is thought that the results are very system- and location-dependent and may not necessarily read across to other similar situations, with different wind farm layouts and different radars.

2.6.11.1 Also in Sweden, Ericsson, the electronics manufacturer, carried out a study into the effects of wind turbines on radio communications links. Anecdotal evidence suggests that the study found that the turbines interrupted the radio link and caused delays between transmission and receipt of up to three and a half hours.

2.6.12 Marking and Illuminating

2.6.12.1 The Swedish authorities have no guidelines in place for the marking and illuminating of wind turbines specifically. At the moment, standard ICAO guidance for obstacle lighting is applied to turbines (as laid down in ICAO Annex 14 – Volume I, Chapter 6, 'Visual Aids for Denoting Obstacles').

2.6.13 Charting

2.6.13.1 The Swedish military is very keen to maintain an accurate database of obstacles and tall structures around Sweden. One reason for this is because Swedish defence posture dictates that the air force must be able to operate from dispersed locations, and regularly practices this. Therefore, every open stretch of road in the country is a potential operating strip for military aircraft, and this must be taken onto consideration when building any tall structure, including wind turbines.

2.6.14 To this end, the Swedish military maintains a common obstacle database called FIA. This uses a colour code system to denote existing and planned obstacles. It is a paper system, but is available to the military in digital format and can, for example, be downloaded into the computer system of a jet aircraft to inform the pilot of obstacles. A change is proposed to the current system that would ensure that structures taller than 50 metres in urban areas and 20 metres (66 feet) in rural areas are included in the database.

2.6.14.1 Independent of the use of FIA (which is also available to the LFV), the LFV, in 2000, decided to conduct a study to catalogue all the wind turbines in Sweden and chart them for aviation purposes. This was done by simply sending personnel out into the field to find wind turbines and record their positions using GPS. It was discovered that the LFV was not aware of 75% of Sweden's wind turbines, but it is now confident that it has a comprehensive record of all in existence.

2.7 Norway

2.7.1 Introduction

2.7.1.1 Although not included in the primary remit of this study, contact was made with CAA Norway to ascertain their stance on the issue of wind turbines through a written questionnaire. Similar to Sweden, wind energy is very much in its infancy in Norway as the country derives virtually all its electricity from hydropower. For this reason, there has been little interaction between aviation and wind energy, but the information from Norway provides an insight into a still evolving process.

2.7.2 The Planning, Assessment and Approval Process

2.7.2.1 As stated in Annex F, anyone wishing to build a wind farm in Norway must apply for permission to the Water Resource and Energy Directorate (NVE). Civil Aviation Authority Norway (Luftfartstilsynet), along with other interested parties, is on the NVE's mailing list of 'must-see' agencies for wind turbine developments and thus receives plans at an early stage, well before the start of construction.

2.7.2.2 CAA Norway normally asks Norwegian Air Traffic and Airport Management (NATAM) to assess any impacts on airfields or navigation equipment. However, NATAM states that they are informed of proposals at varying stages of development and by different groups: sometimes by the CAA, sometimes by the developer, or sometimes by other authorities. NATAM believes that a more co-ordinated process here would be an improvement.

2.7.2.3 NATAM is the provider of most air traffic management (ATM) and air navigation services (ANS) in Norway and operates most Norwegian airports. If an airport is not NATAM-operated, the CAA will contact the private airport operator and ask them if they foresee any possible impact from the development.

2.7.2.4 If NATAM, or an independent airport operator, does have an objection to a project they will pass their comments back through CAA Norway to the developer. The possibility of dialogue between developers and any objectors exists, but no examples of this could be recalled, nor could any cases where a wind farm development had been halted due to objections from the aviation community.

2.7.3 Technical Site Safeguarding

2.7.3.1 In Norway, NATAM first assess whether the turbine blades of the proposed development are visible from any navaid or radar equipment in use, or from any potential future site. If the wind farm will be out of sight of such equipment and further away than 10nm, then no impact is assumed and NATAM raise no objection. If a turbine is in the line of sight of any technical equipment, then the severity of any impact will be assessed, as described below.

2.7.3.2 If a wind turbine is proposed in the line of sight of an airfield radar then NATAM will assess its potential impact on operations. This is usually achieved by relying on the professional experience and judgement of NATAM staff. It is possible to filter out unwanted returns from turbines, but NATAM does not like the fact that this creates 'blind spots' in the radar coverage.

2.7.3.3 NATAM perceives the Instrument Landing System (ILS) to be the most sensitive of the navaids used and allows no wind turbines within an area $\pm 10°$ in azimuth from the runway centreline, up to a distance of 20nm, if the runway is equipped with an ILS. This is only if the development would be in the line of sight of the navaid, however; if it would be shielded by terrain then it is assumed there would be no impact. For VOR, due to its omnidirectional nature, the impact is assumed to be minimal but is still evaluated using computer simulations.

2.7.4 Marking and Illuminating

2.7.4.1 In Norway, Obstacles with a height of 60 metres (197 feet) or more agl must be marked and illuminated and the developer is responsible for all lighting and marking. (CAA Norway can also require that smaller obstacles be marked, depending upon their location).

2.7.4.2 For structures between 60-100 metres, the hub of the rotor should be marked with a red, low-intensity obstacle light. Structures between 100-150 metres tall should be marked with a low intensity light on top and one low intensity light on a lower level, with the distance between the lights not being more than 75 metres (246 feet). Structures taller than 150 metres should be marked with a high intensity light on top and low intensity lights on lower levels, with the distance between the lights not exceeding 75 metres.

2.7.5 Charting

2.7.5.1 In Norway, it is the responsibility of the developer to submit physical data on any tall structure to the Norwegian Mapping Authority (Statens Kartverk). Obstacles that are 15 metres (49 feet) (30 metres (98 feet) in built-up areas) or taller must be registered with this authority, the body responsible for maintaining the obstacle register.

3 THE UK EXPERIENCE[24]

3.1 The Planning, Assessment and Approval Process

3.1.1 In the UK, local planning authorities (LPAs) grant formal planning approval for most onshore wind farms[25]. However, if developers go straight to this stage of the planning process without first consulting with interested parties, including those in aviation, their application runs a higher risk of being formally objected to, which may cause extra cost to the developer. For this reason the Wind Energy, Defence and Civil Aviation Interests Working Group has developed a pre-planning consultation process. This establishes dialogue between developers and aviation stakeholders as early as possible in order to identify any conflicts and address them at the earliest opportunity.

3.1.2 The use of the pre-planning consultation is purely voluntary and developers are under no obligation to participate in it. However, if developers do not, they will likely be recommended to take that route by one or more stakeholders at some stage, and they may also be taking extra risk by not consulting with the aviation community prior to the formal planning application.

3.1.3 The process is initiated by the developer completing a preplanning consultation proforma as early as possible in the development process; a copy of the form is at Annex K. This form contains pertinent information regarding the proposed development, such as number of turbines, location, height, etc. This form is then submitted to Defence Estates (MOD) and the Civil Aviation Authority, who assess the proposal and pass it on to key stakeholders for them to make their assessments. To assist wind farm developers, the Working Group has also produced a set of guidelines on the siting of wind farms with regard to their impact on aviation interests[26].

3.1.4 Should any of the stakeholders have any concerns regarding the potential impact of a proposal that they cannot resolve, it is likely that they will, directly, via CAA or via Defence Estates, raise an objection. This does not represent the end of the process, but should mark the beginning of negotiations between the objector and the developer.

3.1.5 Once all stakeholders have been consulted, given the opportunity to examine a proposal and, if necessary, raise an objection, the proposal will eventually proceed to the formal planning permission stage. Ideally, all objections raised will have been resolved, but a proposal may still get to this stage with objections outstanding. In this case the objection would need to be taken into account by the competent authority in making a decision whether or not to grant planning approval.

[24] Background country data can be found at Annex G.
[25] Large wind farms need approval from the relevant government minister depending upon their generating capacity and whether they are in England, Scotland, Wales or Northern Ireland.
[26] 'Wind Energy and Aviation Interests – Interim Guidelines' (ETSU W/14/00626/REP), DTI, October 2002.

3.1.6 Offshore Wind Farms

3.1.6.1 A key aim of the UK government is to develop large-scale offshore wind farms in the near-term. Such developments will be subject to the same assessment criteria as onshore farms, plus other consents.

3.1.6.2 Offshore consent for developments in England and Wales is decided by the Secretary of State for Trade and Industry. In Scotland, depending upon the generating capacity of the development, either the LPA or the relevant Ministers of the Scottish Executive will consider proposals.

3.2 Civil Aviation Concerns

3.2.1 The Directorate of Airspace Policy (DAP) at the UK CAA is the focal point for assessment of wind energy proposals in the civil aviation sphere and ensures that all civil aviation interests are considered. To this end, DAP forwards all applications to the CAA Safety Regulation Group, National Air Traffic Services Ltd, the UK air traffic service (ATS) provider, and airport operators for their assessments of proposals.

3.2.2 Aerodrome Safeguarding

3.2.2.1 The Safety Regulation Group (SRG) of the CAA is responsible for ensuring that UK aerodromes are safe to use, therefore the construction of a wind energy development in the vicinity of a licensed aerodrome is of interest to the SRG. The Group uses a number of criteria to assess proposals.

3.2.2.2 If a development is within 17km of an officially safeguarded aerodrome, then its impact on the airfield's protected surfaces is assessed. This addresses the issue of the turbine(s) purely as physical obstructions.

3.2.3 Technical Site Safeguarding

3.2.3.1 The Air Traffic Services Standards Department (ATSSD) of SRG also assesses the impact of any proposals on an airfield's technical facilities: if the development is within 30km of an airfield from which ATS are provided (or 34km if an ILS may be affected) then the impact should be considered by the airfield(s) concerned. In some cases, NATS or another company is contracted to provide ATS; they will be asked to provide a technical safeguarding assessment.

3.2.3.2 NATS En-Route Limited (NERL) is the service provider for 'en route' air traffic flying in UK airspace and over the north-eastern Atlantic Ocean. NERL, therefore, has an interest in safeguarding CNS equipment at both aerodromes and stand-alone technical sites.

3.2.3.3 The criteria for consultation on a wind energy proposal is if it is within 30km of a facility and whether it is in the line of sight (LOS). If the development is *not* within LOS, regardless of range, then it is unlikely that NERL will object. If the development is within LOS, then UK Civil Air Publication (CAP) 670 provides guidance that can be applied to assess interference with various types of technical equipment[27]. It is unlikely that turbines that infringe these criteria will be acceptable.

3.3 Military Aviation Concerns

3.3.1 The assessment of proposals by military agencies is co-ordinated by the Defence Estates (Safeguarding) office at the Ministry of Defence. This office acts as the facilitator, forwarding all applications to relevant stakeholders to ensure that all MOD concerns are addressed.

3.3.2 Aerodrome Safeguarding

3.3.2.1 Safeguarding of military aerodromes is similar to that of civil aerodromes, but is less formalised. Just as civil airfield operators do, the Royal Air Force assesses the potential impact of all proposals upon not only RAF airfields but also relevant Army Air Corps bases, Royal Naval Air Stations and the airspace above and around military firing ranges. Turbines will be assessed for their impacts as physical obstructions and also for their effects upon airfield technical systems.

3.3.3 Low Flying

3.3.3.1 The issue of military low flying training in the UK is one that prompts fierce debate for a number of issues, one of which is the impact upon wind energy developments. The UK Low Flying System (UKLFS) is unique in that it covers the whole of the open airspace of the UK (up to 3 miles offshore), from the surface to 2000 feet above ground or sea level. Certain areas of the UK (airports, conurbations, certain industrial sites, etc.) are excluded from the LFS for safety reasons and flying over some conservation areas is also avoided[28].

3.3.3.2 The normal lower limit for low flying by fixed wing aircraft is 250 feet, which is lower than the top height of many current wind turbines. Some operational low flying (OLF) training is permitted between 100 and 250 feet in three designated areas, called Tactical Training Areas (TTAs)[29]. In addition, helicopters are defined as low flying when operating at less than 500 feet and may operate down to ground level.

3.3.3.3 In addition to the TTAs, the UK is also host to the Spadeadam Electronic Warfare Tactics Range (EWTR), a training facility offering EW training unique in Europe. Aircraft using the range fly at high speeds and low levels and are subject to simulated anti-aircraft missile firings, prompting sudden evasive manoeuvring.

3.3.3.4 All proposed wind farm developments are assessed on a case-by-case basis for their impact on the LFS, with particular attention paid to the impact upon low level traffic flows and any knock-on effects, for example on aircraft using

[27] CAP 670 uses the ICAO gradients for protecting SSR, primary radar and navaids, as described earlier.
[28] Further information on low flying can be found in General Aviation Safety Sense Leaflet 18A, "Military Low Flying" published by the CAA.
[29] These are located in northern Scotland, the borders area of northern England/southern Scotland, and central Wales.

nearby airfields. Most proposals in the 'open' UKLFS will not receive an objection.

3.3.3.5 There is no blanket ban on wind farm developments within TTAs (there are already developments in all three TTAs) but due to the height of OLF, proposals are subject to careful scrutiny. A proposal on the edge of a TTA has a greater chance of obtaining approval. Very large developments, the proliferation of developments, or developments at certain locations within the TTA may, for reasons of safety, result in a significant curtailment or displacement of training that would lead to the lodging of an objection by MOD.

3.3.3.6 Offshore Low Flying

3.3.3.6.1 The LFS *per se* extends only 3nm out to sea; however, both military and civilian aircraft routinely fly down to low levels over the sea, including military fast jets conducting training, surveillance aircraft engaged in fisheries protection, or helicopters conducting search and rescue operations or en route to oilfields. Nevertheless, there is currently no formal low flying system over the sea that is likely to be affected by wind turbine developments.

3.3.4 Technical Site Safeguarding

3.3.4.1 The safeguarding of technical sites associated with military airfields (i.e. aerodrome radar, navaids, relevant communications equipment, etc.) is dealt with by the RAF as part of the aerodrome safeguarding process detailed in Section 3.3.2. However, the British military has other equipment that it deems requires protection from the effects of wind turbines.

3.3.4.2 Most of this is communications equipment, such as microwave links, and the impact on such systems is assessed by a body called the Defence Communications Systems Agency (DCSA). DCSA also advise other defence interests of potential conflicts.

3.3.4.3 Air Defence Radar

3.3.4.3.1 In the last year, the impact of the terrorist attacks on the United States in September 2001 has caused changes in UK defence posture, one of which has been an increased emphasis on airspace surveillance. Consequently, the importance of the RAF's network of air defence radars has risen and safeguarding them against any developments that may reduce their effectiveness has been become more important.

3.3.4.3.2 To that end, current MOD policy is not to accept any application within 74km (46 miles) of an air defence radar site unless the developer can prove that it will have no impact on the radar concerned. Where turbines are not in the LOS of the radar due to topography, this will usually be straightforward to achieve.

3.3.4.4 Weather Radar

3.3.4.4.1 The UK Meteorological (Met) Office is a government agency that provides long and short-term weather forecasting to a variety of communities, including the general public, broadcasters, industry and, of course, aviation. To facilitate this, the Met Office maintains a network of weather radars around the UK. These look at a thin layer of the atmosphere, close to the surface of the earth, and, as such, are likely to suffer from interference if too close to a wind farm.

3.3.4.4.2 There are only 12 weather radar stations in the UK, so it is unlikely that a proposal will have a significant impact on the Met Office's capability. Nevertheless, the Met Office still needs to assess all plans to ensure the continued operations of the network. One of the most important effects for aircraft is "wind shear", where the winds at different altitudes may vary greatly in both direction and speed. Wind profiling radars are susceptible to spurious reflections and, for this reason, wind farms in close proximity (currently assessed as 10km or less) to Met Office wind-profiling radars are likely to be objected to.

3.4 Relevant Studies and Research

3.4.1 A significant issue in the UK in the debate regarding wind farms and their effects on aviation is the distinct lack of accepted scientific work on the topic. Several studies have been conducted in the past (see Annex L for a short list of relevant documentation) and work has recently been commissioned by the DTI, which is described below. Until some consensus is reached on the effects of wind turbines on various technical systems, then it will remain difficult to develop a consistent approach to wind farm siting and location.

3.4.2 The first study commissioned by the Wind Energy, Defence and Civil Aviation Interests Working Group is by QinetiQ and will produce a model that will be used for predicting the impact of wind turbines on radar systems. This tool will be used to predict the effect a proposed wind farm will have on a specific radar system, and will therefore be of use to both developers and radar users when assessing such issues. It is expected that the results of this study will be published in early 2003 as report ETSU W/14/00614/REP.

3.4.3 The second study is being carried out by AMS. This is investigating the different technical approaches that could reduce the effect of wind turbines on radar function. This will look at technical feasibility and the practical issues and will include a first look at the possible cost of implementing any feasible approaches. It is expected that the results of this study will be published in early 2003 as report ETSU W/14/00623/REP.

3.5 Marking and Illuminating

3.5.1 Marking and illuminating of turbines was not identified as a specific area of concern by the UK stakeholders, but the issue is currently being examined by the Directorate of Airspace Policy. The topic has been included in this report due to the differing approaches taken by the nations concerned. UK stakeholders may therefore find these variations of interest.

3.6 Charting

3.6.1 In the UK, there is no comprehensive database of operational wind turbines. The most accurate is probably that held by the British Wind Energy Association, but even that does not contain every single turbine. Additionally, individual stakeholders in the approval process in the UK maintain their own databases and records of applications, approved applications and existing turbines, but, again, none are recognised as complete.

3.6.2 UK regulations state that developments taller than 300 feet must be declared, usually through the planning authority, to the aviation authorities so that they may be charted and recorded as obstacles to aviation. Clearly, given the scale of wind turbines until recently, this has meant that most wind farms have not been recorded in this way. However, it is good practice for wind developers to ensure that ALL constructed wind turbines and associated tall equipment (such as anemometry masts) are included on aeronautical charts.[30]

[30] This may be done by notifying the Aeronautical Information Section at the Defence Geographic and Intelligence Agency of the an accurate latitude and longitude of the 'obstruction' via email sent to ais@milsvy.gov.uk marked FAO John Young.

4 KEY DIFFERENCES

4.1 As can be seen from the previous sections, each of the individual states surveyed has rather different ways of approaching the issue of wind farms and their effects on aviation. Unsurprisingly, in many areas, Denmark and Germany, two countries with large installed wind energy capacity, have well-developed and efficient systems for dealing with planning and approval issues. In contrast, Sweden and Norway, where wind energy is still in its infancy, have systems that are still evolving. Some of the key differences, and similarities, are highlighted here.

4.2 The Planning, Assessment and Approval Process

4.2.1 The voluntary pre-planning consultation system that is used in the UK is one of the more developed and effective of those observed. It is becoming widely used as awareness of the issues and the system itself grows. All relevant stakeholders should be involved in the consultation process, ensuring comprehensive assessment of proposals. The biggest drawback of the system is that most stakeholders are not suitably staffed to deal with the ever-increasing numbers of wind farm applications, with the potential for delays or inadequate assessment of proposals.

4.2.2 The German system is somewhat similar to that in the UK but is a legal requirement, as opposed to voluntary. When plans are initially submitted to Community Construction Committees, they are subsequently forwarded to relevant agencies, including aviation, for assessment. This ensures that proposals are assessed at an early stage and that consultees must raise any comments or objections within 2 months or it is assumed that they have no objection.

4.2.3 The mechanism in Denmark is somewhat different. Planning authorities at all levels in Denmark must set aside suitable land for wind energy development, meaning that when a proposal to build a wind farm is submitted, the suitability of the site has already been assessed. This is a reversal of the position in the UK, where sites are generally chosen for their potential for wind power and then assessed against other interests.

4.2.4 Norway and Sweden both use purely voluntary systems, which appear to work satisfactorily at current low levels of wind farm development. The most informal system is that of the Netherlands, where, unless a development is to be in close proximity to an airfield, the authorities rely on the goodwill of the developer to inform them of plans. It is quite feasible for a wind farm to be constructed in the Netherlands without any dialogue between developer and the CAA occurring.

4.3 Aerodrome Safeguarding

4.3.1 All the countries in the report apply safeguarding measures in the vicinity of airfields and this, of course, applies to wind turbines as it would any tall structure. This, however, only addresses turbines as a physical obstacle; as described in Section 3.3.4, the impact on technical facilities associated with airfields is also scrutinised in the UK, certainly more so than in other nations.

4.4 Technical Site Safeguarding – Civil Sites

4.4.1 None of the countries examined in this report are as restrictive in the siting of wind turbines relative to CNS equipment as the UK. Other than assessing wind turbines as a physical obstruction, Denmark, Germany and Sweden place no other restrictions on them relating to airfield technical equipment. The restrictions imposed by Norway (relating to ILS) and the Netherlands (no developments taller than 150 metres) are also relatively minor. In the UK, the authorities assess all developments within 30km of a technical site.

4.5 Technical Site Safeguarding – Military Sites

4.5.1 The approach to safeguarding of military technical sites in mainland Europe is also different to that in the UK. Only Sweden imposes restrictions that are similar to those of the UK MOD (see Section 2.6.7), but this is in relation to a technical system unique to Sweden. In the countries surveyed, the onus is, on the whole, on the military to prove negative effects, rather than on the developer to prove no effects.

4.5.2 Germany has the most 'restrictive' regulations for safeguarding it's technical sites, including air defence radar, this being the 'protected area' and 'area of interest' zones described in Section 2.4.5.1; these extend to 20km. All other states examine proposals on a case-by-case basis and have no key ranges within which proposals must be assessed or are/are not approved. Indeed, as mentioned in Section 2.5.5, one air defence site in the Netherlands has a wind farm within 5km, and suffers no ill effects.

4.6 Low Flying

4.6.1 The European experience of military low flying is different to that in the UK in that the UKLFS, as described in Section 3.3.3, is unlike any other in allowing aircraft to fly at such low levels with such freedom. Consequently, low flying interests have not had nearly as much impact on the construction of wind farms in mainland Europe as in the UK.

4.6.2 In Germany and the Netherlands, with (general) low flying limits of 1000 and 1200 feet respectively, wind turbines have minimal impact on low flying activities. Even so, the German Air Force is experiencing some disruption to low level air traffic patterns from the cumulative effects of wind turbines and individuals did express a desire for a reduction in the rate of wind turbine construction.

4.6.3 In Denmark, the military may fly down to 100 metres but much low flying is done over the sea and as long as wind turbines are charted, the RDAF is happy to avoid them. Only Sweden permits low flying as it is known in the UK, down to 50 metres (164 feet), but due to the small numbers of wind turbines and vast expanses of open country, the SwAF can conduct low level training without conflict.

4.7 Marking And Illuminating

4.7.1 Standards for marking and illuminating wind turbines vary considerably from nation to nation, despite efforts from many sides for standardisation. Current ICAO literature (Annex 14 – Volume I, Chapter 6) provides guidance for visual aids for denoting obstacles, but this was originally intended for structures such as tall buildings and masts. The nature of wind turbines, in that their highest point (the tip of the blade) is only at its apex temporarily, has caused some problems for regulators in deciding upon the best way to illuminate them.

4.8 Charting

4.8.1 In the UK, structures that will be taller than 300 feet agl should be notified to the aviation authorities by the planning authority when planning permission is granted. In this way, obstacles are notified for inclusion in aeronautical charts. Clearly, this has omitted many wind turbines in the past due to their size and as a result there is no comprehensive database in the UK of wind turbine locations. Many independent parties maintain their own databases, including the BWEA and various sections of the MOD. Denmark and Germany have similar standards, in that obstacles 100 metres or taller are charted for aviation purposes.

4.8.2 The other three nations in the study maintain more comprehensive databases. The Netherlands 'Obstacle Archive' is for structures 300 feet or taller, but as the forms at Annex J show, it is rather more than a simple record of position and height. The forms contain a wealth of information on each structure, including who owns, maintains and is responsible for it and a photograph. Entries are also reviewed every two years to ensure they are up to date.

4.8.3 Plans are afoot in Sweden to increase the remit of the FIA database to include all obstacles that are 20 metres (66 feet) tall (50 metres (164 feet) in urban areas). Norway has potentially the most comprehensive database, requiring all structures 15 metres (49 feet) or taller (30 metres (98 feet) in urban areas) to be registered with the State Mapping Authority.

5 SUMMARY

5.1 The states investigated in this report have quite varying approaches and attitudes to wind power and this has shaped policies, procedures and developments. The reasons include politics, geography, economics and history and have resulted in wind industries at varying stages of evolution.

5.2 Broadly speaking, the conflict of interest between wind energy and aviation is less significant in these other countries, albeit to varying degrees. In Denmark the two seem to coexist most easily. In the Netherlands, also, aviation interests do not appear to impinge on wind energy developments. In Germany, frictions have appeared in the past between the two interests and may well increase in the future, but this has not prevented the rapid growth of wind development. In Sweden has there been a similar amount of interest in the issue as the UK, particularly with reference to the effects of turbines on technical systems. However, the tightest restrictions in Sweden come not from aviation specifically, but from other military activities unique to Sweden (the 'listening posts').

5.3 Despite the greater number of wind farms in most of these countries, little research appears to have been done to establish the effects of wind turbines on aviation systems. Table 3 summarises the main findings for each country.

5.4 Consultation and Consents Procedures for Wind Turbines

5.4.1 The various states' wind farm application and assessment processes are less formal than in the UK. The authorities in Denmark and the Netherlands, in particular, had a somewhat *laissez-faire* attitude towards wind farm developments. That is not to say that their safety regimes are lacking or have any lower standards, but that the approach taken to the potential risk to aviation caused by wind farms has been different.

5.4.2 In Denmark, much of the work regarding site suitability is already done as part of regional planning; areas must be designated that are suitable for wind energy developments, therefore the potential impact on aviation has already been assessed, to a degree. In the Netherlands, unless a development lies within an aerodrome's safeguarded area, there is no requirement for consultation between the developer and the aviation authorities.

5.4.3 In Germany, it is a legal requirement for the aviation authorities to assess any proposed tall structure's impact upon aviation, and to effect this, Community Construction Committees pass all such plans to the CAA and/or air force. Similarly, in Norway, the energy authority that deals with all wind farm applications will inform the aviation authorities as a matter of routine. Sweden currently has a purely voluntary system that, given the current low levels of wind energy development, has thus far proved successful.

TABLE 3 – SUMMARY OF MAIN FINDINGS[31]

	Aero-drome safe-guarding	Technical site safeguarding			Planning, assessment and approval process	Low flying policy	Charting policy	SAR Ops policy	Marking and illuminating
		Civil[32]		Military					
		Airfield radar	Other						
UK	Assessed if within 17km (civil)	Assessed if within 30km	Assessed if within 34km (ILS); 30km (other systems)	Assessed if within 74km of AD radar; developer to prove no negative effects	Voluntary; widely used. Statutory via Local Planning Authority	Generally not below 250 feet	Charted if 300 feet	Nil stated	Policy being developed
Denmark	ICAO standards	ICAO standards	ICAO standards; VOR stations: not within 1km	Nil stated	Wind energy incorporated into regional plans; planning authorities inform aviation authorities	No objections to structures <100m	Charted if 100m or ‘if deemed necessary’	Nil stated	National guidelines
Germany	ICAO standards	ICAO standards	ICAO standards	5km protected area; 20km ‘area of interest’; Military to prove negative effects	Construction Committees inform aviation authorities; plans assessed within 2 months	Generally not below 1000 feet	Charted if 100m or ‘if deemed necessary’	Statement of concern from SAR operators	National guidelines
Nether-lands	ICAO standards	ICAO standards; not >150 metres within 30km	ICAO standards	Nil stated	No regulated process away from safeguarded aerodromes	Generally not below 1200 feet	Archive of all structures >300 feet	Nil stated	Follow ICAO regulations for tall structures
Sweden	ICAO standards	ICAO standards	ICAO standards	None aviation-specific	Voluntary	Not below 50 metres	‘FIA’ database (>50m in towns, > 20m, rural)	As Germany	As Netherlands
Norway	ICAO standards	ICAO standards, plus assessed if within 10nm and in LOS; (ILS: not within 20nm)		Not known	Energy authorities inform aviation authorities	Not known	Obstacles >15 metres registered	Nil stated	National guidelines

31 Table 3 is a repeat of Table 1, found in the Executive Summary.
32 For primary radar, ICAO standard is a protected surface slope of gradient 1:100; for Secondary Surveillance Radar a slope of 1:200; for navaids, 1:50.

5.4.4 All the countries looked at rely little on hard figures, 'exclusion ranges' for technical sites or black and white 'yes/no' areas suitable for developments in their assessment of the impact of wind farm proposals on aviation. The method in each appears to be more *ad hoc*, relying more on the expertise of specialists (air traffic controllers, engineers, and pilots) to assess proposals no matter where they are and to decide whether the impact on aviation operations is acceptable. Clearly, the systems are not infallible (as the case of the wind turbine in Germany that may have to be dismantled proves) but the essential difference in all the continental states is that the onus is on the aviators to prove negative effects, rather than on the developer to prove an absence of such effects.

5.5 Experience of Managing the Effects of Wind Turbines

5.5.1 In the countries surveyed with greater installed wind energy capacity (and therefore more wind turbines), it was expected that the aviation industries would have developed all manner of methods to deal with the effects wind turbines have on aviation systems, and ways to work around them. Surprisingly, few were uncovered. Most controllers, for example, if controlling aircraft in the vicinity of wind turbines, simply treated clutter caused by the turbines on their displays as they would any other clutter (such as may be caused by clouds, buildings, terrain, etc) and worked around it. As previously mentioned, the effects of wind turbines were simply not seen as particularly significant.

5.5.1.1 Technical Measures

5.5.1.1.1 The best examples of technical measures employed are those used at Kastrup airport (see Section 2.3.5.3). The problem of the Danish air traffic system initiating tracks on radar returns caused by the Middelgrunden wind farm is solved by placing a Non-Initiation Window (NIW) over the area in question. A similar window is used to stop the same happening from traffic using the Øresundsbron.

5.5.1.1.2 What this effectively means is that if an actual aircraft were to appear, for example from low level, within that NIW, then the system would not track it, and controllers would not see it. Once the aircraft had left the area covered by the NIW, then the system would begin to track it and it would then be visible to air traffic controllers. The Danish authorities are happy to accept this, assessing that the likelihood of an aircraft appearing with no notice in such a small area of sky is minimal.

5.5.1.1.3 The other problem caused by the Middelgrunden turbines is the reflection of SSR plots. This problem is not caused only by the wind farm, though, but by many reflective surfaces around the airfield, many of which are more effective reflectors than the wind turbines. This is a potentially very serious problem but is easily resolved by the software used in the Danish ATM system. Whether such measures could be used in the UK depends on the system employed and its software. Also, a safety case would probably have to be made to assess the effectiveness of such filtering.

5.5.1.1.4 In addition, the AMS study investigating technical approaches to reduce the effects of wind turbines on radar may go some way towards answering this question. This will look at technical feasibility and any practical issues and will include a first look at the possible costs of implementing any findings. It is expected that the results of this study will be published in early 2003 as report ETSU W/14/00623/REP.

5.5.1.1.5 The final technical measure employed at Kastrup is the simple step of having the SSR antennae tilted upwards slightly. This was initially to reduce reflections from the ground, but also has the benefit of reducing reflections from all nearby obstacles, including wind farms.

5.5.1.2 <u>Controller Management Measures</u>

5.5.1.2.1 Surprisingly few controller management measures were uncovered. If controllers were required to control aircraft in the vicinity of wind turbines then, depending upon the nature of the task and the classification of the airspace, radar clutter from turbines was treated as clutter from any other obstacle. Controllers would either vector their aircraft to avoid such clutter or merely inform them of the turbine's presence and let the pilots avoid it.

5.5.1.3 <u>Mitigation Measures</u>

5.5.1.3.1 A number of mitigation measures were found in Denmark and Germany. In Denmark, more by chance than by design, the Middelgrunden wind farm is laid out with the turbines roughly in a line heading away from the radar of Kastrup airport, thus minimising the amount of clutter and false tracks caused. Had the 20 turbines been arranged tangential to the radar heads, then the problem would have been much worse, but could still have been solved by a NIW, albeit a larger window.

5.5.1.3.2 The construction of Middelgrunden also caused a new height restriction in one of Kastrup's holding areas (described in Section 2.3.5.3.5), but this is transparent to pilots. A new restriction of no lower than 2000 feet is now promulgated above the wind farm, to ensure safe separation between the turbines and aircraft.

5.5.1.3.3 A similar measure employed in Germany is the raising of the airfield pattern at one German airfield. A wind farm proposal was rejected initially as it breached the protected surfaces of the airfield; however, political pressures meant that the installation was approved for construction. To ensure safe operations at the airfield, the height for aircraft using the circuit was raised by 200 feet. The aviation community was not happy that it was forced to take this measure, but the airfield continues to operate safely with the turbine nearby.

5.6 Other Issues

5.6.1 In effect, the nations surveyed treat wind turbines as little more than a physical obstruction; the fact that they also feature rotating blades has resulted in few additional measures. Consequently, the civil aviation authorities seldom place restrictions on wind energy developments unless in the vicinity of aerodromes and the militaries of only Germany and Sweden take specific steps to protect sites of interest.

5.6.2 As expected, the issue of conflict with military low flying was not significant in mainland Europe. With the exception of Sweden, all of the countries surveyed do not permit military aircraft to fly as low as the UK MOD does, except in specific areas. Only Sweden has comparable low flying limits, but the large areas of open country and relatively few wind energy installations result in no noticeable conflict of interests.

5.6.3 What is noteworthy is that two issues were raised in mainland Europe that were not broached by UK stakeholders. The first is the issue of SAROps in the vicinity of offshore wind farms and who should be responsible for such cover; SAR operators in both Germany and Sweden have expressed reluctance to undertake such missions. Secondly, the issue of marking and particularly illuminating turbines is an increasingly contentious one as it impacts on all sectors of society, not just aviators. Each state is devising its own set of guidelines on this issue and some efforts towards harmonisation would be desirable.

ANNEX A – PROTECTION OF AVIATION INTERESTS

1 Protection Of Aviation Interests

1.1 There are basically two ways in which the construction of a wind turbine or wind farm may impact upon aviation operations:

- The physical obstruction caused by a tall structure; and
- The effects that rotating turbine blades can have on a variety of navigational aids and other equipment (referred to herein as 'technical sites').

1.2 UK stakeholders in both civil and military aviation conduct a process aimed to ensure that their needs are not compromised that is termed 'safeguarding'[33]. Its objectives are threefold:

- To prevent the granting of planning permission for developments which would impact upon the safe use of aerodromes or navigation aids (including radar);
- To ensure that the cumulative effects of previous and continuing developments are taken into account; and
- To ensure that planning permission which might have this effect is granted subject to appropriate conditions.

1.3 Requirements for safeguarding aerodromes and technical sites are set out in Department for Transport (DfT) documentation[34]. The consultation requirements in the documentation apply to military as well as civil facilities. The process is based on safeguarding maps that are lodged with local planning authorities (LPAs).

1.4 To assist all interested parties in the siting and planning of wind farms, the Wind Farms, Defence and Civil Aviation Interests Working Group has produced a set of guidelines outlining the interactions between the wind energy and aviation domains and the possible effects that wind turbines can have on aviation operations.

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[33] The formal term 'Safeguarding' in association with wind turbines is only used for civil purposes in UK; military agencies do not have an equivalent formal term but follow effectively the same procedures. For simplicity, the term 'safeguarding' in this document is used to refer to both civil and military processes.

[34] 'Safeguarding Aerodromes, Technical Sites and Explosive Storage Areas: Town & Country Planning (Aerodromes and Technical Sites) Direction 1992' (England & Wales) and Scottish Development Department Circular 16/1982, 'Safeguarding Aerodromes, Technical Sites and Explosive Storage Areas'. These documents are scheduled to be replaced in September 2002 by the Department for Transport document 'Safeguarding Aerodromes, Technical Sites and Military Explosives Storage Areas: the Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2001'.

2 Safety Of Flight – Vertical Obstructions And Aerodromes

2.1 Due to their size, wind turbines are assessed as a vertical obstruction, as would be any other tall structure, such as a large building or mast. This is of particular relevance in the vicinity of aerodromes and within the UK Low Flying System, both of which are described here.

2.1.1 Safeguarding of Aerodromes

2.1.1.1 Clearly, tall structures can impinge upon aviation activities and nowhere is this more important than in the vicinity of an aerodrome. Here, aircraft fly at their lowest as they depart the airfield and also as they approach and fly in what is known as the airfield 'circuit'. For this reason, the safeguarding process protects many aerodromes in the UK.

2.1.1.2 Safeguarding Maps – Aerodromes. A safeguarding map is centred on a safeguarded aerodrome and is colour-coded to indicate varying restrictions on structures around the airfield, based predominantly on the structure's height above ground level. These coloured areas are derived from a series of protected 'surfaces' around an aerodrome (such as approach paths and aircraft routes)[35]. If a proposed structure would exceed the levels indicated on the safeguarding map, then the relevant planning authority is required to consult the aerodrome regarding the proposal.

3 Safety Of Flight – Vertical Obstructions and Low Flying

3.1 In addition to the hazard posed to aircraft in the approaches to or departing from an airfield, wind turbines can also pose a potential danger to aircraft flying at low level for any other reason. In the UK, this is largely (although not entirely) restricted to military aircraft conducting low flying training.

4 Safeguarding of Technical Sites (Including Radar)

4.1 Any tall structure can potentially interfere with certain electromagnetic transmissions; however, the nature of wind turbines makes the issue somewhat more complex than it is for static structures. The impact on technical sites is assessed when a wind turbine or farm is proposed near an aerodrome that has a co-located technical site (for example, airfield radar); a stand alone civil technical site (for example, a National Air Traffic Services (NATS) en route radar); or on a stand alone military technical site (for example, an air defence radar).

4.2 The technical sites requiring safeguarding fall into three basic categories:

- Sites conducting or supporting airspace and air traffic management (both civil and military), including radars and navigation aids.

- Sites conducting or supporting air defence of the UK, including radars.

[35] These are described and detailed in UK Civil Aviation Publication (CAP) 168 (Licensing of Aerodromes).

- Meteorological (Met) Office weather radars.

4.3 Safeguarding requirements for civil technical sites are expressed in site-specific maps, two for each site. The first is, similar to an airfield safeguarding map, a colour-coded map showing the extent of the safeguarded area; the second map shows a 30km radius centred on the technical site to indicate the area within which any proposed wind turbine development requires consultation[36]. This is to reflect the fact that turbines can have effects on the electromagnetic spectrum in addition to their mere physical presence

4.4 <u>Air Traffic Management</u>

4.4.1 The potential impacts of wind farms on air traffic management include the cumulative effects on the UK airspace management and surveillance infrastructure and affect the following systems:

- Primary Radar.
- Secondary Surveillance Radar (SSR).
- Microwave links associated with primary and SSR.
- Navigation Aids (Navaids).

4.4.2 However, many of the precise effects caused by wind turbines to the affected systems are not yet fully understood[37].

4.4.3 <u>Primary Radar</u>

4.4.3.1 There are two basic effects that can be caused to air traffic management radars: the presentation of false radar responses (known as returns), and the masking (shadowing) of genuine aircraft returns. Each causes different problems to the air traffic management systems (and air traffic controllers in particular) but both may be amenable to mitigation in similar ways.

4.4.3.2 Both the towers and the blades of wind turbines will be detected if they are in the line of sight of the radar[38]. This will cause the presentation of returns to the radar users that, in principle, are the same as the returns of actual aircraft. The towers can easily be differentiated from aircraft because they are stationary and, in this respect, they are no different from other objects that cause returns, such as buildings and radio masts.

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[36] It should be noted that this figure applies to civil sites only. Separate arrangements apply to military sites, including radars.

[37] Studies into both the effects of wind turbines and possible technical mitigating measures are currently being undertaken.

[38] The line of sight for radar is usually equal to or greater than the optical line of sight. The radar line of sight is a complex function of the radar, the terrain and local weather conditions. A good approximation is that the radar line of sight is 33% greater than the optical line of sight, however over the sea the difference can be much greater.

4.4.3.3 The movement of the blades, however, makes differentiation more difficult. Each blade will only be seen when it is in a particular range of positions (say, for example, when any part of it is more than 120 feet above the ground) and the blades of a single turbine will always appear in the same place. However, when a number of turbines are present in a farm, the combination of blades from different turbines can give the appearance of a moving object. This may cause air traffic controllers to perceive this as an unidentified aircraft and to take action to ensure that other aircraft avoid it (which may, in itself, cause other safety problems).

4.4.3.4 The masking of real aircraft can happen in two ways: by reflecting or deflecting the radar such that aircraft flying in the 'shadow' of the turbines are not detected, and by presenting such a large number of returns from the towers and the blades that the returns from actual aircraft are lost in the 'clutter'. Whilst shadowing will only affect returns from aircraft flying at low altitudes and will thus normally only have a small effect, the effects of radar clutter will have an impact on all aircraft flying at all altitudes over the area affected and is more critical. Clutter can also be caused to radar displays by a number of other reasons but its effects on flight safety are always potentially extremely serious.

4.4.4 <u>SSR</u>

4.4.4.1 SSR relies on co-operative transmissions from aircraft carrying equipment known as transponders. For this reason, confusion between returns from aircraft and from other objects is highly unlikely and many of the effects caused to normal radars will not occur. However, both reflection and deflection of transmissions could be caused by wind turbines in some circumstances. Both events could cause misidentification or mislocation of aircraft, which can have potential flight safety implications.

4.4.5 <u>Navaids</u>

4.4.5.1 Navaids could suffer from similar reflection and deflection effects as SSR, with similar flight safety implications. Such effects could have an effect on the safe operation of Navaids and it is not known of a minimum safe distance from such installations that wind turbines should be kept to ensure they would have no effect.

4.5 <u>Air Defence Considerations</u>

4.5.1 The main effects that wind turbines can have on air defence operations are upon the ability of the surveillance and command and control systems to detect and identify aircraft approaching, over-flying or leaving the UK and thence to produce a Recognised Air Picture (RAP). In the UK, the system for achieving this task is known as the Air Surveillance and Control System (ASACS).

4.5.2 Radar

4.5.3 The UK ASACS relies primarily for its information upon a network of ground-based air defence radars, augmented (under an agreement with NATS) by feeds from a number of civil air traffic control radars. The performance of ground-based radars is likely to be affected by any wind turbine sited in their field of view.

4.5.4 The air defence radars are typically more complex and capable than air traffic control radars and may be able to electronically process out some of the effects that might be caused by wind turbines. Research into this topic is underway but is not yet complete[39]. However, it is likely that both the impacts of the turbines and the results of mitigation techniques will vary depending on each individual radar and each individual wind farm location.

4.6 Meteorological Office Weather Radar

4.6.1 There are 12 weather radar stations in the UK (1 in Northern Ireland, 1 in Wales, 3 in Scotland and 7 in England) and they are used for monitoring weather conditions to assist in forecasting. In simple terms, two types of radar are used: weather radar and wind profiling radar.

4.6.2 Weather radar is designed to look at a thin layer of the atmosphere, as close to the ground as possible, for accurate forecasting. For this reason, they are situated on high ground and look out at a narrow band of airspace between 0 and 1° of elevation. Consequently, there is potential for interference from wind turbines. Wind profiling radar are used to measure wind characteristics at varying altitudes and can measure 'wind shear', one of the most important weather effects for aircraft.

[39] Early indications are that a variety of mitigation techniques may be of use either individually or in combination.

ANNEX B – COUNTRY INFORMATION – DENMARK

1 Country Information

1.1	Area:	43,094 sq km	
1.2	Coastline:	7314km (4545 miles)	
1.3	Terrain:	Low and flat to gently rolling plains	
1.4	Highest point:	173 metres (568 feet)	
1.5	Land use:	Arable land	60%
		Forests and woodland	10%
		Permanent pasture	5%
		Other	25%

1.6 Note: About one quarter of the population lives in greater Copenhagen.

1.7 Population: 5,352,815

1.7.1 Population density: 124 per sq km

1.8 Airports: 119[40]

1.9 Military aircraft: 137 (including 69 fast jet, 30 helicopters)[41]

2 Energy Policy

2.1 Energy policy[42] has been an area of broad consensus within the Danish parliament (Folketing) over the last 25 years and this has resulted in a very consistent policy over this time period. Recent wind-energy-friendly policies can be traced back to the oil crises of the 1970s, which prompted Danish policy-makers to address the security of their energy supply. In large part this was achieved through exploitation of North Sea oil and gas. However, by the 1980s, Denmark, like many other nations, had relatively high greenhouse gas emissions as a result of dependence on coal-fired power stations and environmental pressure grew to reduce these emissions.

2.2 Denmark therefore adopted very ambitious greenhouse gas abatement policies, in the form of 'Energy 21', its plan for the sustainable development of energy

[40] Source: CIA World Factbook 2001, www.odci.gov/cia/publications/factbook/index.html.
[41] Source: Flight International 2001.
[42] Source: 'Wind Energy Policy in Denmark, Status 2002', S. Krohn, Danish Wind Industry Association, 22 February 2002 (available at http://www.windpower.org/publ/index.htm).

that was published in April 1996. This stance was aided by the merging of the Energy and Environment Ministries (although the new government of 2001 has since moved energy policy to the Ministry of Economics and Industry, perhaps signalling a change in policy).

2.3 Wind energy in Denmark in 2002 accounts for 18% of electricity consumption, well above the 10% target that was set to be achieved by 2005. In view of this success, the target was adjusted to 16% by 2003. If current trends continue, by 2003 wind power will actually generate 21% of the country's electricity. Longer-term goals aim for 40-50% of electricity to be derived from the wind by 2030.

2.4 Over 2600MW of wind power is currently installed onshore in Denmark (the official target was 1500MW by 2005) and large developments are now being constructed offshore. Two experimental farms were initially constructed as test sites in Danish waters (Vindeby and Tunø Knob, both 5MW-capacity installations) and the Middelgrunden farm, next to Copenhagen, is the first large (40MW) operational offshore project.

2.5 Two further wind farms of 160MW each are currently being constructed, one in the North Sea (Horns Rev) and one in the Baltic Sea (Rødsand); these two developments are being built under executive order from the Danish government. As Denmark's wind energy programme is several years ahead of schedule, a similar executive order for power companies to build another three large offshore farms has since been recalled, and these developments will go out for public tender in the future.

3 Planning Legislation And Policy

3.1 Administratively, Denmark is divided into 14 counties, which are further divided into 275 municipalities. The spatial planning system is based upon the Planning Act, which was a part of planning reform that took place in the 1970s, and wind energy projects must be located in accordance with this Act.

3.2 Each of Denmark's counties must prepare a regional plan that contains guidelines for wind energy location. These regional plans, in combination with other guidelines on nature protection and land use in general, form the basis for the municipal plans written by the 275 municipal counties.

3.3 The municipal plan may go into some detail regarding overall targets for wind power, going so far as to specify locations and numbers of turbines and their height and appearance. Below municipal plans are local plans, which are detailed plans for small areas that create binding rights for property owners. A wind energy project that does not comply with a local plan is illegal and cannot be constructed.

3.4 If a developer wishes to build a farm with more than three turbines or that is taller than 80 metres, then an Environmental Impact Assessment must be carried out, at the investors' expense. This EIA will then be approved (or not) at county level. Otherwise, the size of the development will dictate whether it is approved at a local, municipal or county level.

3.5 A municipal council is obliged to prepare a local plan when 'major developments' are planned; based on previous experience, this is defined as 8 or more turbines. Nevertheless, specific circumstances may require the council to prepare a local plan if fewer turbines are planned.

3.6 The Folketing has subsequently amended the Planning Act to regulate the planning and administration of coastal areas. Naturally, this has an impact on the development of offshore wind farms. The aim is to keep Denmark's coast as free as possible from installations that do not need to be located near the coast. As a consequence, wind energy projects may only be located within the coastal zone (approximately 3km from the coast) if this does not contradict the overall objectives of coastal planning.

3.7 The source document on planning (onshore) wind farms in Denmark is 'Municipal Planning for Wind Energy in Denmark', but this contains only two paragraphs regarding possible impacts on aviation:

- "Wind energy projects that could disturb the radio link system of Telecom A/S and maritime installations are not allowed. About 200-350 metres on each side of the main beam of a radio link tower must normally be kept free of wind turbines to ensure adequate transmission.

- "The height of wind turbines near airports is extraordinarily restricted because of air traffic safety. The Civil Aviation Authority must therefore approve any wind energy projects within the altitude zones of the airports."[43]

[43] Source: 'Municipal planning for wind energy in Denmark', Ministry of Environment and Energy, Spatial Planning Department, 1995.

ANNEX C – COUNTRY INFORMATION – GERMANY

1 Country Information

1.1 Area: 357,021 sq km

1.2 Coastline: 2389km (1484 miles)

1.3 Terrain: Lowlands in north, uplands in centre, Bavarian alps in south

1.4 Highest Point: 2963 metres (9721 feet)

1.5 Land use:

Arable land	33%
Forests and woodland	31%
Permanent pasture	15%
Other	20%

1.6 Population: 83,029,536

1.6.1 Population density: 233 per sq km

1.7 Airports: 613[44]

1.8 Military aircraft: 1397 (including 445 fast jet, 757 helicopters)[45]

2 Energy Policy

2.1 Germany is a federal country comprising 16 'Länder'. Responsibility for most energy policy issues (for example, legislation)[46] is at the federal level, but Länder may also create their own measures.

2.2 Energy production from renewable sources is currently subsidised at Federal, Land and municipality levels. At the Federal level, the Renewable Energy Sources Act was introduced in 2000 and obliges electricity companies to buy electricity that is generated from renewables at a premium; this is supplemented by direct subsidies. Subsequently, electricity production from renewables in general and wind energy in particular is growing at a fast pace.

2.3 In 2000, the proportion of total electricity consumption derived from renewables in Germany was 6.25% and installed wind energy capacity totalled

[44] Source: CIA World Factbook 2001, www.odci.gov/cia/publications/factbook/index.html.
[45] Source: Flight International 2001.
[46] Sources: 'Energy Policies of International Energy Agency (IEA) Countries Germany 1998 Review', IEA, 1998; 'German Environmental Report 2002', German Federal Environment Ministry, 2002; 'Strategy of the German Government on the use of off-shore wind energy', German Federal Government publication, 2002; 'Speech of the Federal Minister for the Environment, Nature Protection and Nuclear Safety on the occasion of the World Wind Energy Conference and Exhibition', 2 July 2002.

6113MW. By spring 2002, this capacity had increased to 9211MW, making Germany the world's leading user of wind power.

2.4 The Federal Government has continued its emphasis on renewable energy sources and set a target for 12.5% of electricity consumption to be met from renewables in 2010. Much of this is expected to come from offshore wind farms.

2.5 However, for spatial reasons, the number of onshore wind farms being built per year is starting to decrease, necessitating the expansion of existing onshore farms and the development of offshore locations. The government has been proactive in promoting offshore wind development and as of January 2002, 29 wind farm applications have been submitted in the German Exclusive Economic Zone (22 in the North Sea and 7 in the Baltic Sea), comprising several hundred separate plants. The longer-term goal is for renewable energies to provide 20% of electricity (10% of overall energy) by 2020.

3 Planning Legislation And Policy

3.1 In Germany, the lowest level of planning authority is the Community Construction Committee (CCC). These are located in every town and deal with local planning issues; they are roughly analogous to Local Planning Authorities in the UK.

3.2 Above these committees are town planning authorities, which are located in larger towns that serve as administrative centres and have regional responsibilities. The next level up is the Länder, which each have their own authorities and legislation, characterising Germany as a decentralised state. Finally, the Ministry for Transport, Building and Housing is responsible for spatial planning at the highest level.

3.3 All plans for wind energy developments are submitted to CCCs, who will examine the plans in their own right and also promulgate them to interested parties. These include the civil and military aviation authorities and any others that may be interested. When all opinions and advice have been received, it is the CCC that will decide on whether the development goes ahead or not.

ANNEX D – COUNTRY INFORMATION – THE NETHERLANDS

1 Country Information

1.1 Area: 41,526 sq km

1.2 Coastline: 451km (280 miles)

1.3 Terrain: Mostly coastal lowland and reclaimed land; some hills in the southeast

1.4 Highest point: 321 metres (1053 feet)

1.5 Land use:

Arable land:	25%
Permanent pasture	25%
Forests and woodland	8%
Other:	39%

1.6 Population: 15,981,472

1.6.1 Population density: 385 per sq km

1.7 Airports: 28[47]

1.8 Military aircraft: 312 (including 128 fast jet, 146 helicopters)[48]

2 Energy Policy

2.1 Since the oil crises of the 1970s, the general objective of Dutch energy policy[49] has been to provide the Netherlands with adequate supplies of reliable, affordable and clean energy. In the last decade, it has also been motivated by a desire to reduce the country's dependence on energy from OPEC countries.

2.2 Given that climate change is believed to be caused by the use of fossil fuels, policy measures designed to combat climate change are formulated within Dutch energy policy, which plans increasing use of renewables. The Action Programme for Renewable Energy was launched in 1997 to address three topics: improve the price:performance ratio of renewable technologies;

[47] Source: CIA World Factbook 2001, www.odci.gov/cia/publications/factbook/index.html.
[48] Source: Flight International 2001.
[49] Sources: Dutch Ministry for Economic Affairs website, www.ez.nl; 'Annual Review of Progress in the Implementation of Wind Energy by the Member Countries of the IEA – National Report of the Netherlands 2001', J. 't Hooft, 2001; 'Dutch Government Designates Areas for Urbanisation and National Landscapes', Dutch Ministry for Spatial Planning press release, 2000; 'Energy Policies of IEA Countries – Netherlands 2000 Review', IEA, 2000; 'Energy R&D in the Netherlands', E. Luiten & K. Blok, 1999; '1999 Energy Report', Dutch Ministry for Economic Affairs, 1999; 'IEA R&D Wind Annual Report 1998', IEA, 1998.

stimulate market penetration of renewable energy technologies; and tackle administrative bottlenecks that frustrate the deployment of these technologies.

2.3 The government's target is that 5% of all energy consumed in the Netherlands in 2010 should be supplied by renewable sources, with this proportion rising to 10% by 2020. Estimates of the necessary installed capacity to meet targets for wind energy were 2000MW by 2007 and 7500MW by 2020 (of which 6000MW will be offshore). At the end of 2000, the country had 446MW installed.

2.4 Dutch electricity companies voluntarily committed themselves to supply 3.2% of electricity from renewable sources in the year 2000, around one-third of which was due to come from wind. Also, some companies started 'green pricing', offering customers the chance to buy all or a share of their electricity as 'green' electricity. This proved to be a success, proving that Dutch citizens are prepared to pay extra for clean and renewable energy.

2.5 The challenge the government must overcome to meet its admittedly ambitious renewables lies on the supply side: it must raise the acceptance of renewable installations in a small, densely populated country. A major problem hampering the growth of wind farms in the Netherlands is that locations are not being provided fast enough (see section below on planning).

2.6 Due to the size and geography of the country, it is not thought that more than 1500MW of capacity can be installed onshore in the Netherlands. Clearly, to meet the national target of 7500MW of wind power by 2020, offshore installations will have to provide the majority, and it is in this direction that the Dutch wind energy industry is now looking.

2.7 To this end, offshore wind energy development was accelerated in 1997, following a successful study by Novem of a demonstration project for a near-shore wind farm. The search for an appropriate offshore location to build a 100MW wind farm began in 1998 and an environmental impact assessment was completed in 2000, leading to the selection of a site at Egmond aan Zee. Currently, the procedure for obtaining a Key Planning Decision (pkb) has entered its final phase, requiring the government to reply to formal objections before the pkb can be finalised.

2.8 In a bid to further stimulate offshore developments, in October 2001 the Dutch government issued the final draft of the Spatial Core Decision, which designates an area on the Dutch continental shelf for 6000MW of wind capacity. By the end of 2003 a regime will be in place to allocate areas to developers to build offshore farms.

3 Planning Legislation And Policy

3.1 In 1994, the Dutch parliament implemented the Boers-Wijnberg plan, which encapsulated the idea of setting aside land for extensive wind energy developments. The underlying thinking was that if only small wind farms were built, the cumulative effect would give the landscape a fragmented appearance. Some provinces have included large locations reserved for wind farms in their regional plans (called 'mega-locations')[50].

3.2 Even so, newly installed wind energy capacity has dropped dramatically in the Netherlands since 1996, largely due to the difficulty in developing sufficient sites with building permits for wind turbines. In a country as small and densely populated as the Netherlands, finding suitable and, perhaps more importantly, widely acceptable, sites for wind farms is increasingly difficult.

3.3 In an effort to avoid large numbers of objections for wind farm plans, from local residents, nature and conservation organisations, etc., local authorities exercised great care in preparing local and regional zoning plans. However, such preparations, and the processing of objections, take a great deal of time and means that wind projects are often abandoned.

3.4 To address the problem, Novem, the Netherlands Agency for Energy and the Environment, started a national campaign called 'Space for Wind Energy', primarily aimed at local decision-makers and authorities. The backbone of the campaign was a series of products and services that could be of help to local authorities to create space for wind energy.

[50] Sources: 'Renewable energy in progress 1999: progress report', Dutch Ministry for Economic Affairs, 1999; 'IEA R&D Wind Annual Report 1998', IEA, 1998.

ANNEX E – COUNTRY INFORMATION - SWEDEN

1 Country Information

1.1 Area: 449,964 sq km

1.2 Coastline: 3218km (2000 miles)

1.3 Terrain: Mostly flat or gently rolling lowlands; mountains in west

1.4 Highest point: 2111 metres (6926 feet)

1.5 Land use: Forests and woodland 68%

Arable land: 7%

Other 24%

1.6 Population: 8,875,053

1.6.1 Population density: 20 per sq km

1.7 Airports: 255[51]

1.8 Military aircraft: 787 (including 448 fast jet, 148 helicopters)[52]

2 Energy Policy

2.1 Sweden is the fourth largest country in Europe (area 450,000 square km), extending from the southern Baltic to the Arctic Circle. Nearly 90% of the land area is forested or other woodland, bogs, fens and lakes, with only 3% consisting of built-up areas. Most of the population of 8.8m lives in the southern half of Sweden and 90% of this number live in urban areas.

2.2 The objectives of Sweden's energy policy[53] are to secure the short- and long-term electricity and other energy supplies, on competitive terms. In 1997, the Parliament (Riksdag) took a major energy policy decision concerning the future of nuclear power and the development of the energy system. In short, the government's phase-out of nuclear power was confirmed, but the target date of 2010 that was originally decided has since been abandoned due to fears that the impact on society and the environment be too severe.

2.3 Following Parliament's decision, an extensive and well-funded energy policy programme was implemented, one pillar of which was a long-term research, development and demonstration programme to develop renewable energy

[51] Source: CIA World Factbook 2001, www.odci.gov/cia/publications/factbook/index.html.
[52] Source: Flight International 2001.
[53] Source: 'Energy Policies of IEA Countries – Sweden – 2000 Review', IEA, 2000.

sources, including wind energy. The aim is to make renewables economically viable so as to be able to replace fossil and nuclear fuels.

2.4 Wind power is currently a negligible contributor to energy supply in Sweden (290MW installed capacity at end of 2001), but this is increasing as a result of investment subsidies. Wind power has been demonstrated offshore and will also be demonstrated in arctic and mountain locations.

2.5 The need for criteria for permission to establish wind power, both on- and offshore, and the need to reinforce local electricity grids to take into account wind power were identified as key issues to be addressed. Areas have been selected with excellent conditions for the generation of electricity from wind, and it has been suggested that they be denoted as areas where wind farm development would be in the national interest.

3 Planning Legislation And Policy

3.1 Sweden has a long tradition of planning and today the system is quite complex, with many players[54]. The main platforms of Swedish planning legislation are the Planning and Building Act (PBL, Plan–och bygglagen) and the Environment Code (Miljöbalken).

3.2 The planning system is principally designed for the municipalities, which are requested to develop and maintain a Comprehensive Plan, which covers the entire area of the municipality. Although not legally binding, the plan must be kept up to date. This plan should highlight areas suitable for wind energy developments, but in most cases, fail to do this. This is no doubt due to a lack of awareness regarding wind energy

3.3 At a lower level, the Detailed Development Plan *is* a binding planning instrument, a legal agreement between the municipality, public and land owners, which makes it possible to implement the intentions of the Comprehensive Plan. The final type of planning regulation is the Special Area Regulation, which is also legally binding, but these are used within limited areas to ensure specific demands of the Comprehensive Plan.

3.4 For planning issues that may be of interest to several municipalities, the government may appoint a regional planning body to oversee regional issues. They may also draw up a Regional Plan, which is a form of Comprehensive Plan that incorporates several municipalities. Thus far, several regional plans have been drawn up that address the issue of wind energy developments. These are in southern Gotland, northern Gotland and the county of Skane.

3.5 The Environment Code

3.5.1 The Environment Code serves as an umbrella for both the PBL and other special acts connected with the physical environment. It defines situations in which the government must make decisions on planning issues, including in connection with granting permits for power generation plants, which would

[54] Source: 'Planning in Sweden – Fundamentals outlined', B. Alfredsson & J. Wiman.

include large-scale wind farms. In these cases, where national interests weigh more heavily than local interests, a government permit is required.

3.5.2 In the environmental area, impact assessments are compulsory in certain cases, including the construction of wind turbines. The Environment Code also specifies certain quality standards that must be upheld. At the level of the Comprehensive Plan, these standards are intended as a level of ambition, but when it comes to Detailed Development Plans, the standards are absolute limits that may not be transgressed.

ANNEX F – COUNTRY INFORMATION – NORWAY

4 Country Information

4.1 Area: 324,220 sq km

4.2 Coastline: 21,925km (13,624 miles)

4.3 Terrain: Glaciated; mostly high plateaus and rugged mountains broken by fertile valleys; small, scattered plains; coastline deeply indented by fjords; arctic tundra in north

4.4 Highest point: 2469 metres (8100 feet)

4.5 Land use:

Forests and woodland	27%
Arable land	3%
Other	70%

4.6 Population: 4,503,440

4.6.1 Population density: 14 per sq km

4.7 Airports: 103[55]

4.8 Military aircraft: 138 (including 57 fast jet, 50 helicopters)[56]

5 Energy Policy

5.1 Norway has abundant resources of gas, oil and hydropower, and exports around eight times the amount of energy it consumes. 99% of electricity is generated from hydropower and until recently, the pursuit of 'new' renewables (i.e. excluding biomass and hydropower) was extremely limited. However, the environmental consequences of fossil fuel consumption, the need for greater energy flexibility and greenhouse gas commitments agreed to at Kyoto are seen by the government as important reasons to develop new alternative sources of energy (mainly wind electricity and biomass heat)[57].

5.2 A carbon tax, introduced in 1991, encourages renewables indirectly by discouraging fossil fuels. New renewables are also encouraged directly through economic incentives, R&D, education and information campaigns and voluntary agreements. The government recognises that in order to increase use

[55] Source: CIA World Factbook 2001, www.odci.gov/cia/publications/factbook/index.html.
[56] Source: Flight International 2001.
[57] Sources: 'Renewable Energy Policy in IEA Countries Vol. II: Country Reports', IEA, 1998; 'Enova – Spearheading Norway's Effort Towards an Energy Efficient and Renewable Future', Enova website, April 2002, www.enova.no.

of new renewable energy sources there is a need for additional political measures and more favourable conditions for renewables than in the past.

5.3 In April 1998 the government announced new incentives for new renewables to the Storting (parliament), such as exemptions from investment taxes for wind power, biomass systems and heat pumps. A financial support scheme for the production of wind power was also accepted.

5.4 Although hydropower generates almost all power in Norway at present, room for expansion is limited. The government's aim therefore provides an impetus for the development of electricity from other renewables, particularly wind and biomass. However, siting problems are judged an important barrier to increased use of wind.

5.5 Nevertheless, wind energy is seen in Norway as the most developed new renewable. Wind capacity was 17MW (installed predominantly at sites on the west coast) at the end of 2001, although the state-owned generator, Statkraft, has estimated that Norway has significant windpower potential.

5.6 On March 27, 2001 the Storting approved the establishment of a new agency for promoting energy savings, new renewable energy and environmentally friendly natural gas solutions, called Enova. The agency is owned by the Government of Norway, represented by the Ministry of Petroleum and Energy, and has been operational since January 1, 2002. Enova's main task is to achieve the objectives that were approved by the Norwegian parliament in the spring of 2000, including the installation of 3TWh/year of wind power capacity by the year 2010[58].

6 Planning Legislation And Policy

6.1 At local level, the Municipal Council is responsible for planning in the municipalities in Norway and is guided primarily by the Planning and Building Act, amongst other pieces of legislation. Municipal Master Plans are prepared in each municipality consisting of long-term and short-term components[59].

6.2 For a specific area within a municipality, a Local Development Plan (LDP) may be prepared, which regulates the use and protection of land in specific areas of a municipality. When a LDP is drawn up, an announcement is published in local newspapers describing the purpose of the planning and expected consequences for the area. Furthermore, any developer planning to build a wind farm must apply for permission from the Norwegian Water Resources and Energy Directorate (NVE, the Ministry of Petroleum and Energy's agency for, inter alia, resource management, power generation and distribution and new renewable energy sources).

[58] TWh is Terawatt hour(s); one TWh is the quantity of energy supplied when one trillion watts of electrical power is generated continuously for one hour.

[59] Sources: 'Conservation in Norway – who does what?', Norwegian Ministry of the Environment website, www.odin.dep.no; 'The Planning and Building Act', Norwegian Ministry of Environment, 1990.

6.3 Those affected are given a reasonable time to respond and express an opinion before the Building Council considers the proposal. The Building Council will seek the advice of relevant organisations, which, in the case of wind farm developments, will include the aviation authorities.

6.4 When the Building Council has considered a proposal, it is submitted to the Municipal Council for a decision, if necessary with alternatives. If there are objections from expert authorities, e.g. the Civil Aviation Authority, then the Local Development Plan must be sent to the Ministry of Environment, who will decide if the plan shall go ahead. In addition, if it is believed that a project will have a significant impact on the environment, then the Ministry may also require that an Environmental Impact Assessment be carried out, funded by the developers.

6.5 The next level above the Municipal Council is the County Council, who draw up County Plans, which are, in effect, regional plans encompassing more than one municipality. The county planning process is a management tool with a regional scope, facilitating co-ordination between administrative bodies at national and local levels. County Plans consist of objectives and long-term guidelines, and may include the development of wind power.

6.6 The state, in the form of the Ministry of Environment, sets the overarching framework for regional policy and stresses the need for a co-ordinated land-use policy. At all levels of planning (national, county and municipal), authorities are to make an active effort at an early stage of planning work to inform individuals and groups about developments, usually by making plans available for public scrutiny and by having a public hearing.

ANNEX G – COUNTRY INFORMATION – UNITED KINGDOM

1 COUNTRY INFORMATION

1.1 Area: 244,820 sq km

1.2 Coastline: 12,429km (7723 miles)

1.3 Terrain: Mostly rugged hills and low mountains; level to rolling plains in east and southeast.

1.4 Highest point: 1343 metres (4406 feet)

1.5 Land use: Arable land 26%

Other 74%

1.6 Population: 59,778,002

1.6.1 Population density: 244 per sq km

1.7 Airports: 470[60]

1.8 Military aircraft: 1470 (including 482 fast jet, 593 helicopters)[61]

[60] Source: CIA World Factbook 2001, www.odci.gov/cia/publications/factbook/index.html.
[61] Source: Flight International 2001.

ANNEX H – METHODOLOGY

1 The work was carried out in two distinct phases, the first being the identification of and meeting with all UK stakeholders. This occurred over the period 14 May – 2 July 2002. This was to catalogue the interests, practices and concerns of all those involved in the interactions between wind energy and aviation.

2 The UK phase was followed by the European data gathering phase, in which personnel visited similar establishments in the four European countries in question. Simultaneously, telephone interviews and written questionnaires were employed to obtain information from individuals who were unable to meet on a face-to-face basis, but also to parties outside the direct scope of the study but who, it was felt, could still contribute.

3 UK Contacts

3.1.1 Airport Operators' Association

3.1.2 British Wind Energy Association

3.1.3 Civil Aviation Authority, Directorate of Airspace Policy, Off-Route Airspace

3.1.4 Civil Aviation Authority, Directorate of Airspace Policy, Surveillance and Spectrum Management

3.1.5 Civil Aviation Authority, Safety Regulation Group

3.1.6 Department of Trade and Industry, Energy Group, Licensing and Consents Unit

3.1.7 Maritime and Coastguard Agency

3.1.8 Meteorological Office

3.1.9 Ministry of Defence, Defence Estates, Safeguarding

3.1.10 National Air Traffic Services Ltd, Directorate of Infrastructure

3.1.11 National Air Traffic Services Ltd, Surveillance

3.1.12 National Assembly for Wales, Planning Division

3.1.13 Northern Ireland Office, Department of Enterprise, Trade and Investment, Energy Division

3.1.14 Northern Ireland Planning Service Agency

3.1.15 Royal Air Force, Directorate of Air Operations

3.1.16 Royal Air Force, Headquarters Strike Command Detachment, London Terminal Control Centre (Military)

3.1.17 Royal Air Force Strike Command, Headquarters 2 Group, ASACS

3.1.18 Royal Air Force Strike Command, Operations Support (Air Traffic Control)

3.1.19 Scottish Executive – Planning and Consents

3.2 Denmark Contacts

3.2.1 Civil Aviation Administration Denmark (Statens Luftfartsvæsen, SLV), 2nd Safety Inspection Department

3.2.2 Danish Energy Agency, Ministry of Economic and Business Affairs

3.2.3 NAVIAR Operations

3.2.4 Royal Danish Air Force, Tactical Air Command, Air Traffic Management Branch

3.2.5 SEAS Wind Energy Centre

3.3 Germany Contacts

3.3.1 Federal Ministry of Defence, German Armed Forces

3.3.2 Federal Ministry of Transport, Building and Housing, Airport Policies

3.3.3 German Civil Aviation Authority (Deutsche Flugsicherung GmbH, DFS)

3.4 **Netherlands Contacts**

3.4.1 Air Traffic Control Netherlands, Surveillance

3.4.2 CAA Netherlands, Aerodromes and Airspace Division, Aerodrome Standards Section

3.4.3 Royal Netherlands Air Force, Operational Policy and Requirements Branch, Air Traffic Management

3.5 Sweden Contacts

3.5.1 Swedish Armed Forces Headquarters, Environmental Department

3.5.2 Swedish CAA (Luftfartsverket, LFV), Aviation and Public Sector Department, Environment and Spatial Planning

3.5.3 Swedish Energy Agency

3.6 Other

3.6.1 CAA Norway (Luftfartstilsynet), Aerodrome Section

3.6.2 Norwegian Air Traffic and Airport Management (NATAM), Air Traffic Management (ATM) Department.

3.6.3 NATAM, Airport Management Department.

3.6.4 NATAM, Communications and Navigation Systems/ATM Systems Department.

ANNEX I – MOD NETHERLANDS REPORT DOCUMENTATION

ONGERUBRICEERD

REPORT DOCUMENTATION PAGE
(MOD-NL)

1. DEFENCE REPORT NO. (MOD-NL)	2. RECIPIENT'S ACCESSION NO.	3. PERFORMING ORGANIZATION REPORT NO.
TD95-1472		FEL-95-A222
4. PROJECT/TASK/WORK UNIT NO.	5. CONTRACT NO.	6. REPORT DATE
6025264	-	October 1995
7. NUMBER OF PAGES	8. NUMBER OF REFERENCES	9. TYPE OF REPORT AND DATES COVERED
42 (incl. 4 appendices, excl. RDP & distribution list)	4	

10. TITLE AND SUBTITLE

De invloed van grote windturbines op het functioneren van een lange-afstandsradar
(The influence of large wind turbines on the performance of a long range radar)

11. AUTHOR(S)

L.J. van Ewijk
G.A. van der Spek

12. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

TNO Physics and Electronics Laboratory, P.O. Box 96864, 2509 JG The Hague, The Netherlands
Oude Waalsdorperweg 63, The Hague, The Netherlands

13. SPONSORING AGENCY NAME(S) AND ADDRESS(ES)

Netherlands Ministry of Defence

14. SUPPLEMENTARY NOTES

The classification designation Ongerubriceerd is equivalent to Unclassified, Stg. Confidentieel is equivalent to Confidential and Stg. Geheim is equivalent to Secret.

15. ABSTRACT (MAXIMUM 200 WORDS (1044 BYTE))

The performance of ground based radar systems for long range surveillance will deteriorate if large obstacles are placed in the proximity of the radar antenna.
A number of the wind turbines which are or will be placed in the province of Friesland in the north of the Netherlands under a program to increase the contribution of wind energy to the overal energy provision, are of such a size and location that an investigation to their effects on radar was necessary.
The report (in Dutch) treats the shadow effect caused by a windturbine and analyses the reduction in radar range as a function of the distance between radar and turbine using a simple model for the wind turbine. Also the creation of double radar ghosts and a remedy against it are treated.

16. DESCRIPTORS	IDENTIFIERS
Surveillance radar	Radar obstacles
Performance	*Wind turbines*
Shadow zones	

17a. SECURITY CLASSIFICATION (OF REPORT)	17b. SECURITY CLASSIFICATION (OF PAGE)	17c. SECURITY CLASSIFICATION (OF ABSTRACT)
Ongerubriceerd	Ongerubriceerd	Ongerubriceerd

18. DISTRIBUTION AVAILABILITY STATEMENT	17d. SECURITY CLASSIFICATION (OF TITLES)
	Ongerubriceerd

ONGERUBRICEERD

ANNEX J – CAA NETHERLANDS ‘OBSTACLE FORMS’

‘Obstakelformulier Aanmelding’ – Obstruction Reporting Form

Obstakelformulier A (Aanmelding)
(Reporting)

Inspectie Verkeer en Waterstaat
Divisie Luchtvaart
Unit Infrastructuur
Postbus 575
2130 AN Hoofddorp
Telefax: 023-566 30 09

1. Object: Schoorsteen **(Chimney)** / zendmast **(antenna)** / hoogspanningsmast **(transmission tower)** / windturbine / gebouw **(building)** / anders **(other)***: …………..........

2. Adres: ……...
Gemeente **(Municipality)**: ……...

3. Materiaal ijzer **(iron)**/ steen **(stone)** / beton **(concrete)** / anders*: ……….................................

4. Coördinaten : ____ ° ____ ’ ____ ” N ____ ° ____ ’ ____ ” E

X (rd) : ………................. Y (rd) : ………................

Bij meerdere objecten: van elk object de coördinaten apart vermelden.

5. Hoogte object **(Object height)** : ……….................... m
NAP hoogte maaiveld **(Ground height AMSL)** : ……….................... m NAP
________________________ +
NAP hoogte object t.o.v. maaiveld **(Total height AMSL)** : ……….................... m NAP

6. Naam bedrijf **(Company Name)** :
……...
Adres :
……...
Telefoon :
……...
Fax :
……...

7. Naam opdrachtgever **(Name of initiator)** :
……..……………….........
Adres :
……...
Telefoon
:………………………………………………………………………………
Fax
:…………...

8. Bijvoegen **(Attachments)**:- Tekening zijaanzicht **(Drawing – side view)**

9. Overzichtstekening **(Map of overall layout)**

10. Topografische kaart **(Topographical chart)**

11. Defensie ingelicht **(MoD informed?)**: ja / nee*
LVNL ingelicht **(ATC informed?)**: ja / nee*

12. Opmerkingen **(Remarks)** : ……..

<u>‘Obstakelformulier-verwerking’ – Completed obstruction form</u>

Inspectie Verkeer en Waterstaat
Divisie Luchtvaart
Unit Infrastructuur

…[*Plaats object (provincie)*]…
…[*naam object*]…

<u>ATTACH FOTO</u>

1. Object: Schoorsteen / zendmast / hoogspanningsmast / windturbine / gebouw / anders* : ……...

Naam object: ………………………………………………………………………………………

Constructie: ………..……………………………………………………………………………

Materiaal: ..………………..……………………………………………………………………

2. Adres: ………..

Gemeente: ………..

Provincie: ……………………………………………………………………………………….

3. Coördinaten: ____ ° ____ ’ ____ ” N ____ ° ____ ’ ____ ” E (WGS)

X (rd): ……….................. Y (rd): ………................

4. Hoogte object : ……….......................... m
NAP hoogte maaiveld : ……….......................... m NAP
\+

NAP hoogte object t.o.v. maaiveld : ……….......................... m NAP

Vlam **(Flame)**/ gaswolk aanwezig **(gas cloud present)?** : Ja Nee N.v.t.

Hoogte t.o.v. top **(Height relative to top)**:……….....m extreme omstandigheden **(extreme conditions)** : ……........m normale omstandigheden **(normal conditions)**

5. Markering aanwezig **(Marking present)?** : Ja Nee
Patroon **(Pattern)**: ……………………………………………………………………………………
Kleur **(Colour)**: ………………………………………………………………………………………

6. Obstakellichten aanwezig **(Obstacle lights present)?** : Ja Nee
Aantal lichtkransen **(No. of light levels)** : ………..................
Kransen op **(Lights at)**: ………m ………. m ……….... m ……….... m ……….... m boven maaiveld
Aantal armaturen *(aangeven per niveau)* **(No. of fixtures per level)** :………………………… ……….
……………………………………………………………………………………………………

7. Eigenaar **(Owner)** : ………..
Adres : ……….. ………
Telefoon / fax : ………... ………
e-mail : ……………………………………………………………………………………….
contactpersoon : ……………………………………………………………………………………….

8. Beheerder **(Keeper/Maintainer)** : ………………………………………………………………...........
Adres : ………………………………………………………………………………………
Telefoon / fax : ……………………………………………………………………………..............
e-mail : ……………………………………………………………………………..............
contactpersoon : ……………………………………………………………………………..............

functionaris onderhoud **(Maintenance personnel)** :………..………
Telefoon / fax : ………...………… ………

10. Type obstakellichten *(indien meerdere typen op één object, dan aangeven per niveau)*
(Type of obstacle light)

Fabrikaat **(Manufacturer)**: ……………………………
Intensiteit **(Intensity)** : ……………………………cd
continu/onderbroken **(continuous/flashing)**: continu ………. Fl/min
Kleur **(Colour)** : rood wit
Dag en nacht **(Day/night)** /sensor: dag en nacht sensor, schakelt aan bij ……….cd/m2
Backup aanwezig : nee ja, nl. …………………..
Storingsmelding **(Failure indication?)**: nee ja
Installatiedatum **(Installation date)**: ………………………….

10. Bijlagen (**Attachments**): : kaart *[beschrijving +datum]* **(map [description + date])**
foto …*[beschrijving + datum]*… **(photograph)**
schets/tekening …*[beschrijving + datum]*… **(sketch/drawing)**

11. Opmerkingen (**Remarks**):

	Naam	Datum	Paraaf **(Signature)**
Opgesteld **(Posted)**			
Geverifieerd **(Verified)**			
Revisie A **(Revised)**			
Revisie B			
Revisie C			
Revisie D			

ANNEX K – BRITISH PRE-PLANNING CONSULTATION PROFORMA

(BWEA email #1692)WIND FARM DEVELOPERS APPLICATION PROFORMA:

Civil Aviation & Ministry of Defence Safeguarding

NOTICE TO WIND FARM DEVELOPERS

Please submit a completed application form for all new or revised onshore and offshore wind farm plans. This form has been compiled in consultation with the British Wind Energy Association. Its purpose is to standardise the information provided and to expedite the assessment of your proposed wind farm development. Assessment is made against air safety and defence interests, through evaluation of the possible effects on air traffic systems, defence systems and low flying needs.

NOTICE TO PLANNING AUTHORITIES

This form has been compiled with the assistance of the Civil Aviation Authority (CAA), the Ministry of Defence (MOD), the National Air Traffic Service (NATS) and the British Wind Energy Association (BWEA), to assist in the processing and assessment of wind farm applications. It is important that copies of this form are forwarded within the planning consultation process. This will help these organisations trace their records of any earlier consultations, as well as provide them with the relevant information for their assessments.

WHAT TO DO WITH THIS FORM

Please provide as much detail as possible by **filling in the shaded areas.** If the specific turbine and/or exact positions have yet to be established then fill in the likely turbine size (hub height, rotor diameter) and boundary points as a minimum. On completion send copies to both the following addresses.

Safeguarding
Defence Estates
Blakemore Drive
Sutton Coldfield
B75 7RL

Directorate of Airspace Policy
K6 Gate 3
CAA House
45-49 Kingsway
London, WC2B 6TE

It is important that a copy of this form is retained for inclusion with subsequent planning applications at the same site. If no application has been made prior to a planning application, please include a completed form in your planning application.

Wind Farm Name

Developers reference	
Application identification No.	

Related/previous applications (at or near this site): Provide reference names or numbers	

Developer Information

Company name:	
Address:	
Contact:	
Telephone:	
Facsimile:	
e-mail:	

Relevant Wind Turbine Details

Wind turbine manufacturer:			
Wind turbine model:			
Wind farm generation capacity (MW)		**Number of turbines**	

Blade manufacturer		
Number of blades		
Rotor diameter		Meters
Rotation speed (or range)		Rpm
Blade material including lightning conductors		
Wind turbine hub height		Metres
Tower design (* delete as required)	* Tubular	* Lattice

Tower base diameter/dimensions		Metres
Tower top diameter/dimensions		Metres

Comments
Are there any details or uncertainties that may be helpful to add?

Turbine Locations

Please provide as much information as you can. The position and height above sea level of every machine if available, the site boundary if not. The height above sea level is the above ordinance datum (AOD) used to specify all heights on OS maps

An Ordinance Survey (OS) map, or maritime chart, should be submitted with this pro-forma, showing locations of proposed turbine/turbines or scheme boundaries. Please number the turbines or boundary points on the map, to correlate with the information provided below.

Copy this page as necessary to account for all turbines or boundary points

Wind farm **Name & Address:**	

Turbine no.			**Height** AOD (m) of tower base					
Grid Reference				100 km square letter(s) identifier				
Easting (10 m)				Northing (10 m)				
	Degrees		Minutes		Seconds			
Latitude								
Longitude								
Turbine no.			**Height** AOD (m) of tower base					
Grid Reference				100 km square letter(s) identifier				
Easting (10 m)				Northing (10 m)				
	Degrees		Minutes		Seconds			
Latitude								
Longitude								
Turbine no.			**Height** AOD (m) of tower base					
Grid Reference				100 km square letter(s) identifier				

Easting (10 m)					Northing (10 m)					
	Degrees				Minutes		Seconds			
Latitude										
Longitude										
Turbine no.			**Height** AOD (m) of tower base							
Grid Reference					100 km square letter(s) identifier					
Easting (10 m)					Northing (10 m)					
	Degrees				Minutes		Seconds			
Latitude										
Longitude										

ANNEX L – RELATED RESEARCH AND WRITINGS

1 ‘Potential Effects of Wind Turbines on Navigational Systems’, A. Knill (CAA), July 2002, available from BWEA website, www.britishwindenergy.co.uk..

2 ‘Wind Turbines and Radar: Operational Experience and Mitigation Measures’, BWEA, December 2001, available from BWEA website.

3 ‘Information Paper – Radar Mitigations’, R. Lewis (CAA), March 2001, available from CAA SRG[62].

4 ‘The Operational Effects of Windfarm Developments on ATC Procedures for Glasgow Prestwick International Airport’, E. Summers, January 2001, available from BWEA website.

5 ‘The Provision Of Guidelines For The Installation Of Wind Turbines Near Aeronautical Radio Stations’, Dr H. Dabis, Dr R. Chignell (for CAA), April 1999, available from CAA SRG.

[62] Civil Aviation Authority, Safety Regulation Group, Aviation House, Gatwick Airport South, West Sussex, RH6 0YR, www.caa.co.uk/srg.

ANNEX M – LIST OF ACRONYMS

3G	Third Generation
AD	Air defence
agl	Above ground level
AIP	Air Information Publication
amsl	Above mean sea level
ANS	Air Navigation Services
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service(s)
ATSSD	ATS Standards Department (UK)
BMVBW	Bundesministerium für Verkehr, Bau- und Wohnungswesen, German Federal Ministry for Transport, Building and Housing
BSH	Bundesamt für Seeschifffahrt und Hydrographie, German Federal Office for Shipping and Hydrography
BWEA	British Wind Energy Association
CAA	Civil Aviation Authority
CAP	Civil Air Publication
CCC	Community Construction Committees (Germany)
CNS	Communications, navigation and surveillance
CRC	Control and Reporting Centre
DAP	Directorate of Airspace Policy (UK)
DCSA	Defence Communications Systems Agency (UK)
DFS	Deutsche Flugsicherung, German ATC organisation

DTI	Department of Trade and Industry (UK)
EWTR	Electronic Warfare Tactics Range
FIR	Flight Information Region
FMV	Försvarets materielverk, Swedish Defence Materiel Administration
FOA	Försvarets Forskningsanstalt, Swedish National Defence Research Establishment
GAF	German Air Force
GPS	Global Positioning System
Iaw	In accordance with
ICAO	International Civil Aviation Organisation
IEA	International Energy Agency
ILS	Instrument Landing System
LDP	Local Development Plan (Norway)
LFS	Low Flying System
LFV	Luftfartsverket, Swedish CAA
LOS	Line of sight
LPA	Local Planning Authority (UK)
LuftVG	Luftverkehrsgesetz, German Aviation Act
LVNL	Luchtverkeersleiding Nederland, Netherlands ATC Agency
MOD	Ministry of Defence
MW	Megawatts
NATAM	Norwegian Air Traffic and Airport Management
NATS	National Air Traffic Services (UK)
NERL	NATS En Route Limited

NIW	Non-Initiation Window
nm	Nautical miles
NOTAM	Notice to Airmen
NVE	Norges vassdrags - og energidirektorat, Norwegian Water Resource and Energy Directorate
OLF	Operational Low Flying
PBL	Plan–och bygglagen, Swedish Planning and Building Act
pkb	Key Planning Decision (Netherlands)
RAF	Royal Air Force (UK)
RDAF	Royal Danish Air Force
RNlAF	Royal Netherlands Air Force
SAROps	Search and Rescue Operations
SASS-C	Surveillance Analysis Support System for ATC Centre
SLV	Statens Luftfartsvæsen, Danish CAA
SRG	Safety Regulation Group (UK)
SSR	Secondary Surveillance Radar
SwAF	Swedish Air Force
TTA	Tactical Training Area
TWh	Terawatt hour(s)
VFR	Visual Flight Rules
VOR	VHF Omnidirectional Radio