Visual Impact Assessment in British Oil and Gas Developments[1]

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Abstract: Development of oil and gas resource in the North Sea has led to the application of visual impact assessment techniques to onshore oil and gas developments in the United Kingdom. Formal visual impact assessment methods are needed to supplement landscape evaluations and site selection studies. Three major orientations of British visual impact assessments are: the delineation and mapping of the zone of visual influence, or viewshed; the preparation of accurate graphic representations of the proposed facility; and, the collaboration of engineering and design professionals in all phases of facility planning and design. Visual impact assessments have been successfully applied in case studies throughout the United Kingdom. Formal methods and techniques for visual impact assessment will continue to evolve and their application will extend beyond oil and gas developments to include major energy and other industrial facilities.

INTRODUCTION

Visual resource management has a long established tradition in the United Kingdom. Since the Town and Country Planning Act of 1947 and the National Parks and Access to the Countryside Act of 1949, landscape management for amenity has been a statutory requirement (Hall 1975).

More recently, the Countryside (Scotland) Act 1967 and the Countryside Act 1968 require every, "Minister, government department and public body to have regard to the desirability of conserving the natural beauty and amenity of the countryside in all their functions related to land" (Cullingworth 1976). Consequently, the preservation of amenity is a basic objective of all planning policy. However, nowhere in the acts or their accompanying legislation is the term "environmental impact assessment" used, nor is there a statutory requirement for impact assessment as there is in the U.S.A., under the National Environmental Policy Act. Rather, local and regional planning authorities have considerable power to require, on a case by case basis, evidence that a proposed development will not injuriously affect the environment. With few exceptions, all development requires the prior approval of the local planning authority, and the authority has almost unlimited discretion as to what documentation will be required before planning approval will be granted. This is known as the "Development Control Process" and many planning professionals argue that it is sufficient, and a separate, formal environmental impact assessment process is not necessary. Others, including Thorburn

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(1978) argue that the development control process can only be improved by incorporation of some form of environmental impact assessment.

In the last few years increasing concern has been expressed about the effects of new large scale development on the quality of the environment and the ability of the planning and development control process to take these effects into account. Since 1970, the offshore discovery and development of oil and gas resources in the North Sea has placed tremendous pressures onshore, particularly in Scotland, for development sites for associated industrial facilities. This situation prompted the central government to examine the possibility of incorporating into the planning system formal methods and techniques of environmental impact assessment, including visual impact assessment.[4/]

Since October 1973 the Project Appraisal for Development Control (PADC) Research Unit at the University of Aberdeen has been studying the methods and techniques of impact assessment used in the United Kingdom and abroad, with particular emphasis to their application in appraisal of oil and gas related development. Drawing upon the PADC work, this paper presents a survey of techniques for visual impact assessment applied to onshore oil and gas developments in the United Kingdom. It discusses both general approaches used in visual impact assessment and techniques used in specific projects.

NEED FOR VISUAL IMPACT ASSESSMENT

Landscape Evaluation

Prior to the discovery of North Sea oil and gas the approach planning authorities used to protect and manage the visual resources of the countryside was the preparation of a county or regional landscape evaluation. The evaluation was intended to classify the study area into homogeneous tracts or zones according to its relative visual quality. The particular high quality tracts identified would then be designated for conservation purposes on the local development plan and any incompatible development proposals would be excluded.

Sometimes recognized experts were commissioned and asked for a landscape evaluation based on their professional opinion.[5/] Often planning officers and consultants developed formal methods of landscape evaluation and applied them in comprehensive county and regional studies. Among the best known work is that of Fines (1968), and of Land Use Consultants (1971), but numerous methods have been developed, applied and reviewed.[6/] While certain methods were criticized,[7/] most were generally accepted as legitimate and lands were subsequently designated for conservation.

Site Selection

Landscape evaluations are successful in rural environments where development pressure is low, several alternate development areas are available and the type of development is small scale land uses, already present in the area. With the increase in pressure for large scale industrial developments in the rural countryside and along the coastline, the traditional landscape evaluation begins to lose its effectiveness as a method of restricting development. Industrial site selection choices often extend well beyond county or regional boundaries. For certain facilities there may be literally only a handful of sites within a large region that can accommodate the installation for engineering or safety considerations. Site selection may also be influenced by government policy restricting certain developments from vast areas and encouraging there location in others. The Scottish Development Department (1971) identified certain segments of the Scottish coastline where oil and gas related industries are to be discouraged. The identification of the coastal segments to be conserved was based mainly on their "scenic quality" as judged through a series of landscape evaluations.

In other cases, a political decision may be made to locate within a certain region for employment and other social and economic considerations, or, the argument may be made that a particular facility site is the only suitable location and is necessary in the national interest, regardless of the immediate impacts on local amenity. Such an argument was advanced when planning approval was requested to develop a concrete offshore production platform fabrication yard at Drumbuie, near the mouth of Loch Carron on

[4/]Two major central government funded research reports resulted, see Catlow and Thirlwall (19771, and Clark _et al_. (1976a).

[5/] See for example Murray (1962).

[6/] See for example Robinson, _et al_. (1976), Dunn (1974), and Clark _et al_. (1976h).

[7/] See for example Brancher (1969).

the west coast of Scotland (Baldwin and Baldwin 1975). The application was finally denied, but only after the Secretary of State for Scotland conducted one of the most extensive public inquiries on a development issue to that date.

In situations such as these, the role of the landscape evaluation is to guide forward planning by identifying suitable sites based on amenity concerns. To be effective, they must inevitably precede site selection. Once a site has been chosen, comprehensive visual impact assessments during detailed project appraisal become a significant factor in deciding whether development should proceed.

VISUAL IMPACT ASESSMENT

Visual impact assessment to date in Britain has exhibited three major orientations. The first is the delineation of the "Zone of Visual Influence," or what is commonly referred to in the United States as the "viewshed." That is, a zone of adjacent land from which the proposed facility will be visible is mapped.

Second, it has been the concern for preparing an accurate graphic representation of what the facility will look like from certain sensitive viewpoints. While the emphasis is placed on the form of the facility and its general outline within the scene, certain studies have emphasized alterations in both the architectural design of the structures and the overall site layout.

The third, and perhaps most significant, orientation has been the active incorporation of architectural and landscape architectural designers into the initial facility layout and structural design stages of project development. Fortunately, a situation has resulted where impact assessment can easily stimulate design changes and mitigation measures that will ameliorate much of the negative visual impact.

Zone of Visual Influence

Several methods for determining the attendant zone of visual influence of a facility have been employed. They vary from rather simple techniques for study of small scale topographic maps, to computer simulations and to actual empirical data collection. In common with all is the desire to map the actual lands from which the facility will be visible.

The PADC Research Unit at the University of Aberdeen has suggested a simple technique for determining the zone of visual influence directly from topographic maps (Clark et. al. 1976b). First developed by Hebblethwaite (1973) for use by the Central Electricity Generating Board, the technique considers two factors, topography and horizontal distance from the installation. It does not easily allow for consideration of existing vegetation or structures although the technique can be adapted to include them.

Two inexpensive pieces of equipment are required, a transparent ruled "height plate," corresponding to elevation, and a transparent "sight line," (Clark 1976b). The technique involves laying the sight line over a large scale topographic map projecting away from the facility in any desired viewing direction. The height plate is superimposed over the sight line corresponding to the maximum height of the facility. Proceeding outward from the facility, visible and invisible points along the sight line can be identified. If the visibility of only one viewpoint along each sight line is important, it can quickly be determined.

This technique can provide a rapid and accurate method of determining if a proposed installation will he visible from a few specified sensitive viewpoints without the necessity of drawing elevation profiles. If the technique is used with successive sight lines established at constant intervals in all directions, an isopleth can be drawn around the installation defining the aerial extent of the zone of visual influence. The technique is of particular value to local planning authorities without professional staff skilled in either the drafting of elevation profiles or conducting computer-aided analyses.

British Gas Corporation prepares a viewshed analysis mapping all visible lands within a five-mile radius of most above ground facilities and for a larger radius from certain major installations.[8/] In the case of relatively small facilities, such as compressor stations along gas transmission pipelines, the viewshed may be determined from Ordinance Survey topographic maps using simple map study techniques such as those described above, or by preparing hand drawn elevation profiles at five degree intervals around the facility. For particularly

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[8/] Conversation with P.G. Parkinson, Environmental Planning Division of British Gas Corporation, 21 December 1978.

sensitive areas, hand drawn profiles are prepared at one degree intervals.[9/]

For large industrial installations such as the St. Fergus coastal gas terminal and for liquified natural gas (LNG) storage installations, computer programs have been developed to determine the viewshed zone. The programs employ radial searching algorithms incorporating gridded input data on topography, vegetation and distance from a specified location, and outputs line printer or pen plotter maps. The programs are similar in operation to viewshed mapping programs described by Elsner (1971) and by Steinitz (1976).

The computer programs have been beneficial during early facility design stages to test rapidly the effects of changing site layouts, structure heights and potential landscape mitigation measures. The same technique has also been used for locating sites for radio masts which have to he within sight of each other (Dean and Graham 1976).

In cases where the facility was expected to be visible from a large area and the issue of visibility was of major importance, a computer viewshed map study has been supplemented with a different type of simulation. British Gas has raised balloons in the exact location and to the same height as the proposed structure, and then traversed the roads of the study area recording where the balloon can and cannot he seen.[10/]

These techniques for determining the zone of visual influence yield information only on the extent to which proposed facilities will be visible. For a determination of how the facility will be perceived other analyses must be made.

Graphic Representations of Views

Almost all oil and gas project appraisals have included a graphic representation of what the installation will look like from one or more viewpoints. They usually represent a ground level view from a sensitive viewpoint several miles away in a nearby town or from a nearby public road. Typical of most such studies is that carried out for the Ross and Cromarty County Council in 1974 on a proposed oil refinery at Nigg Point at the mouth of the Cromarty Firth.

Cromarty Petroleum Co. Ltd. had applied for planning permission to use a 569-acre site on the southwest side of Nigg Point for construction of a very large crude carrier (VLCC) tanker berthing facility and a hydroskimming refinery with ultimate processing capacity of 200,000 barrels per day (Cromer and Warner 1974). If built, it would be the first refinery and among the largest industries in the Scottish Highlands.

The Architects Design Group (1974) was commissioned to analyze and comment on the visual impact of the proposal and the effects upon the amenity of the area. Nine sensitive viewpoints were identified and sight lines were constructed from the viewpoints, through the highest point of the proposed refinery facilities, to the hill serving as the backdrop to the site. The main emphasis of the analysis was to determine from which viewpoints the existing skyline of the hill would be broken by the refinery facilities. Sketches were presented showing the form of the facilities as they would be viewed from each viewpoint. An alternate site layout plan was proposed that would minimize skyline interruption from all nine viewpoints. The study did not indicate how the nine viewpoints were selected or how many people were likely to see the facilities from each viewpoint. The proposal was subsequently withdrawn for reasons other than the expected visual impact.

A similar analysis was carried out for a proposed natural gas liquids separation and storage facility near Peterhead, Scotland (Shell U.K. Exploration and Production 1976). In this case, the facility was proposed in an agricultural area of gently rolling topography with numerous hedgerows and woodland copses. Altering the site layout or onsite planting of vegetation screening would have little effect on the visibility of the higher structures from distant viewpoints. Instead, limited offsite planting of vegetation along the sight lines, between the viewpoints and the facilities, was proposed to act as a visual screen. Elevation profile drawings documenting the site line analyses and sketches of the view from each viewpoint with and without mitigative vegetation planting were presented.

With a large number of viewpoints from which a view of a facility must be represented, the preparation of hand-drawn elevation profiles and sketches can become an almost insuperable task. British Gas, working with the Computer Aided Design Centre of Cambridge, has developed a computer program for quickly and accurately simulating the addition of a structure or

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[9/] Conversation with Frank Dean, Chief Environmental Planning Officer, British Gas Corporation, 21 December 1978.

[10/] Conversation with P.G. Parkinson, Environmental Planning Division of British Gas Corporation, 21 December 1978.

group of structures into a photograph of the landscape (Dean and Graham 1976).

The program uses as input: three-dimensional coordinate location information for existing objects within the photograph; information as to the viewpoint, height, lens focal length and enlargement factor of the camera used; and three-dimensional descriptive and locational information on the structures to be inserted into the photographic scene. The program calculates the position of the structure within the scene and plots, to scale, the structure outline on a transparent overlay as it would appear in the photograph. The technique is of value to British Gas because they are continually conducting such analyses and because the majority of their facilities are of standard design. Thus, the facility unit descriptions in computer readable form can be stored for continual use. The program allows for rapid evaluation of the effects of design alterations, site layout changes and topographic or vegetation changes. When the final site layout and facility design is selected, a photomontage can be prepared for public presentation.

The technique has been successfully used in a number of studies, especia1ly for gas pipeline compressor stations.[11/] The computer aided photomontage technique can be expected to play an increasing role in the visual impact analyses prepared by British Gas.[12/]

Design Collaboration

When it is not possible to site a major facility out of view, emphasis has been placed on incorporating architects and landscape architects into the project engineering design team. Rather than bring designers into the process only to assess or attempt to mitigate visual impact, they have been incorporated from the initial stages of project design so that many potential impacts have been avoided in the first instance. Two of the earliest gas terminals to receive comprehensive design treatment were the Bacton terminal in Norfolk, and the Theddlethorpe terminal in Lincolnshire. In addition, the most recent attempts at professional collaboration have dealt with the main oil and gas receiving, storage and distribution terminals in Scotland. They are the St. Fergus gas terminal on the northeast coast near the town of Peterhead, and the Flotta crude oil terminal in the Orkney Islands. The Sullom Voe oil terminal in the Shetland Islands is the largest oil handling terminal in Britain and is operated by British Petroleum for a consortium of companies. Several studies including limited environmental impact assessments preceded construction (The Sullom Voe Environmental Advisory Group 1976). However, no comprehensive visual impact assessment or mitigation studies were prepared, apparently because of its isolation.

St. Fergus Gas Terminal-- From the time a site near Peterhead, on the northeast coast of Scotland, was selected for the major receiving and distribution system of gas from the Frigg offshore field, the Architects Design Group collaborated with British Gas engineers in all phases of the site layout and facility design.[13/] The component buildings, compressor stations, piping units, gas storage tanks, pressure release stacks and all ancillary facilities received design treatment by the architects. The offshore pipeline landfall required excavation through and restoration of a frontal dune. Recently completed, the result is a sensitive, orderly, visually coherent example of an industrial facility that is usually perceived negatively.

Flotta Oil Terminal-- The major oil handling terminal in Scotland to receive detailed visual assessment is currently under construction on the island of Flotta, in the Orkney Islands off the northern coast of the Scottish mainland. Occidental Petroleum Corporation of Britain, in association with other companies, selected the Flotta site after evaluation of seven possible locations in Scotland (Thielhelm 1973). The comparative evaluation was made based solely on technical suitability for construction and operation of the terminal facilities with no consideration of visual or other social and environmental concerns. Occidental subsequently retained W.J. Cairns and Partners, an Edinburgh planning and design firm, to conduct detailed environmental analyses of the project, including a comprehensive visual impact analysis (Cairns and Associates 1974).

The Flotta study was concerned with the site layout and color treatment of the seven oil storage tanks, to minimize their visibility as viewed from adjacent islands and from the air, and to "achieve maximum integration of the development and the landscape..." (Cairns and Associates 1974). Because Flotta was directly under a heavily travelled commercial airline flight path, the form of the terminal layout as perceived from a nearly plan view took on added significance.

[11/] See for example Architects Design Group (1978).

[12/] Conversation with Frank Dean, Chief Environmental Planning Officer, British Gas Corp., 21 December 1978.

[13/] Conversation with Frank Dean, Chief Environmental Planning Officer, British Gas Corp., 21 December 1978.

The study identified seven "cones of site visibility" within which the terminal would be visible to boaters in surrounding Scappa Flow and to motorists on public roads on the adjacent islands. Panoramic photographs were taken from representative viewpoints within each cone of visibility and from the air. Working with project engineers, alternative tank sizes, heights and layouts were sketched as they would he viewed from each viewpoint. Site models at the scales of 1:5000 and 1:1000 were also prepared. Each alternative model layout was photographed from sea level foreground, middleground and background positions. The three criteria against which each proposed layout was measured were, to minimize "edge definition," diminish "depth of field recognition," and maximize "visual overlap." Neither the alternative layout schemes nor assigned ratings based on the criteria are presented. Through successive iterations a final "solution" was agreed upon.

In attempting to design to meet the above criteria, the selection of tank color became an important factor in the Flotta study. The tanks would been seen against a backdrop of low rolling topography barren of trees and covered in various heathers, grasses and low shrubs, all changing color with the seasons and with atmospheric light conditions. Two alternative approaches to color treatment of the facilities were examined. The first was that of using bold primary colors in "image making." It is argued that in monotonous landscapes brightly colored structures can provide a sense of place and location, a landmark for orientation and a stimulus for visual excitement (Cairns and Associates 1974). The designers recognized that while such an approach has been successful when used in the nondescript urban industrial scene, the approach is not likely to be totally accepted in this location of comparatively undisturbed countryside. Thus, they adopted a strategy of using color to camouflage the tanks to the extent possible not to try to make the installation invisible, but to attempt to breakup the solid mass of the tanks and integrate them with landscape. The use of bold colors was not abandoned entirely, however. Working on the hypothesis that a single bright object in a field of homogenous dull objects will be visually isolated and will focus attention on itself and away from the remaining objects in the field, the designers proposed using hold, bright colors on the associated control, storage and maintenance complex.

In order to test the camouflaging effect of various colors, a technique described by Hardy (1971) was used to simulate the introduction of colored structures into a photographic landscape scene. Eleven colors from the British Standard 4800 range were selected for testing. Six landscape scenes representing the variation in vegetative landcover and background color were photographed and printed on high quality color enlargements. A rectangular strip of each of the eleven colors was then superimposed onto each of the six photographs, resulting in 66 superimposed photographs. Each composite photo was then rephotographed onto transparent color slides. Each of the six sets of eleven colors were then evaluated on a scoring system applied independently by four trained observers in two groups. Potential colors were narrowed to two and submitted to onsite testing by erecting large color panels in the location of the tanks, photographing them on transparent color slides and repeating the rating process. Finally, a single color for each tank as viewed from each viewpoint was selected.

No justification is given as to why or how the original range of eleven colors were identified, nor what the evaluation criteria were or how they were applied in the rating. It also seems that the design team felt they must eventually narrow color selection to one or at most two colors for ease of application and maintenance.[14/] With the exception of these possible shortcomings, the Flotta study represents a significant attempt at collaborating with petroleum industry engineers in assessing, and more importantly mitigating, visual impact of the proposed project.

British Gas has incorporated many of the same color and pattern concepts explored in the Flotta study into their treatment of gas transport and storage facilities, particularly gas pipeline compressor stations and liquified natural gas (LNG) storage facilities.

The national gas transmission system in Britain comprises over 3000 miles of onshore pipelines up to 36 inches in diameter (British Gas Corporation 1977a). Compressor stations are required approximately every 40 miles on a major truck line in order to maintain required pressures. A station may occupy from 20 to 40 total acres with from 5 to 10 acres of above ground structures. The compressor cab enclosures are the largest and most visible structures on any site. Recognizing that the compressor cabs should be visually pleasing as well as acoustically suitable, British Gas undertook a program beginning in 1969 where engineers, architects and compressor manufactures collaborated on the architectural design of compressor

[14/]Conversation with W.J. Cairns, Senior Partner, W.J. Cairns and Associates, 20 November 1978.

cabs (Dean and Graham 1977). Two standard designs resulted. Working with these standard units, site planners develop individual layout plans for each station.[15/]

LNG storage installations represent greater visual intrusions in the landscape than do compressor stations. They are much larger in size and scale than compressor stations, and are often associated with other existing industry. Thus, opportunities for architectural modifications of the facilities are much more limited than in the case of compressor stations. British Gas has instead relied on color treatment as the primary visual impact mitigation technique for LNG storage installations.

LNG storage tanks are the major visual feature of any storage installation. The standard tanks used in Britain are approximately 150 feet (46 meters) high and 150 feet in diameter. A typical storage installation will include two or more such tanks along with associated structures and buildings. British Gas has adopted the approach that it is useless to attempt to camouflage the tanks, and instead attempts to use contrasting colors to integrate the tanks visibly with their surroundings. Rather than using singular striking colors to draw attention to the tanks in an "image-making" exercise as was considered in the case of the Flotta oil terminal, patterns of contrasting colors are developed for each specific situation to attempt to break up the mass of the tanks when viewed from sensitive viewpoints. Two existing LNG storage installations to receive such color treatment are at Glenmarvis in Scotland, and at Partington in Cheshire, England.

The installation at Glenmarvis includes two tanks with the possibility of a third future tank in a "greenfield site," an area with no existing industry. The site is an agricultural area on gently undulating topography and is equally visible for several miles in all directions. There are no topographic features to serve as a visual background. Thus, the tanks are viewed against the sky from throughout the viewshed.

A horizontal handing pattern of blue colors was developed to breakup the perceived verticality of the tanks and to attempt to give the impression that the tanks fade into the sky. The dark blue colors at the base of the tank visually anchor and associate it with the surrounding installation structures, while the progressively lighter blue colors moving up the tank are intended to merge the tank top with clouds in the background sky.

The LNG installation at Partington, Cheshire, is in a quite different situation. The three new tanks and associated structures are located within an existing industrial area and can be seen from three strikingly different viewpoints. From the west the tanks are viewed in the foreground from a residential area; from the east and southeast they are viewed in the middleground within an industrial panorama; and from the north they are viewed as background elements to an existing large petrochemical complex. The analysis examined several possible combinations of color and pattern for each of the three viewpoints recognizing that no single solution would be suitable for all three viewpoints.

Consequently, a scheme was selected involving painting the three sectors of each tank oriented toward each viewpoint with colors either to harmonize or contrast with the surrounding visual elements, as determined appropriate. A pattern of vertical stripes of varying widths was selected to reduce visually the square proportions of the tanks and to correspond to the other vertical industrial elements adjacent.

Four colors were selected, a deep violet, flat white, reflective aluminum and a yellow-orange. The violet and white combination is in the foreground from the housing area to the west and is intended to break up the massive silhouette of the tanks. The reflective properties of the aluminum colored stripes against the flat white stripes were intended to create light absorbing and reflecting "shimmer" effects when viewed from the southeast in the middleground panorama of the existing petrochemical complex. The predominately orange face of the tanks is intended to serve as a strong positive contrast to the dull monotone of the existing industrial complex, when viewed from the north as background elements to the existing petrochemical complex. The associated buildings and structures also receive architectural design and color treatment in order to link the tanks and associated structures visually as a single unified complex.

CONCLUSION

Concern for visual resources and their management has long been an objective of British countryside planning. However, increased pressure for industrial development in the countryside in recent years has forced the

[15/] See for example British Gas Corp. (1977b).

incorporation of visual impact assessment techniques into the development control process.

So far these techniques have largely been limited to manual and automated viewshed analysis and graphic representations of what the proposed facility will look like from sensitive viewpoints. Recently, significant cases of professional collaboration between engineers and designers in the overall layout and architectural design of oil and gas installations have resulted. Of these three major orientations toward visual impact assessment, collaboration between engineers and designers appears to have been the most successful in mitigating visual impacts. When such collaboration also occurs in the regional site selection studies, overall reduction in the visual impacts of the eventual development is even more likely.

Formal methods and techniques for visual impact assessment will continue to evolve, and their application will extend beyond oil and gas developments to include major energy and other industrial facilities.

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