EirGrid Evidence Based Environmental Studies
Study 10: Landscape & Visual

Literature review and evidence based study on the landscape and visual effects of high voltage electricity infrastructure in Ireland

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The evidence contained in this study has been provided by RPS Group.

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SUMMARY

The Irish Government recently published a National Landscape Strategy for Ireland 2015-2025. It begins by simply stating, *"Our landscape is our ultimate resource"*.

Landscapes have been shaped by both natural and human factors. A landscape can provide food, water, building materials and natural defences. A landscape can also inspire and motivate people to paint, write and travel. It is how a person experiences or perceives an area that turns it into a landscape.

Transmission infrastructure has been part of the Irish landscape for many decades. Today, there is an extensive network of physical infrastructure across the country. We understand that the sustainable development of the electricity grid requires the landscape to be protected to the greatest extent possible.

The routing of transmission projects is a complex process. It requires a balance between a number of issues. These include:

- our obligations to ensure a safe and secure transmission grid;
- land use constraints;
- engineering and other technical requirements;
- cost; and
- environmental protection.

Aim of this study

This is an evidence-based study undertaken by experts in landscape and visual impact assessment (LVIA). This study examines the actual visual and landscape effect of the presence of transmission infrastructure over a range of Ireland's typical landscapes.

The purpose of this study is:

- to complete a literature review on Irish landscape character and international landscape and visual impact studies;

- to undertake field-based surveys at selected sites;
- to study the visual effect of transmission infrastructure over a range of distances, and to examine how different landscapes can influence visual impacts; and
- to identify measures that can reduce landscape and visual impacts.

Literature review

Our literature review found existing guidance to help local planning authorities carry out “Landscape Character Assessments (LCAs)” – essentially assessing the character and value of different types of landscape occurring within their administrative area. Different approaches to LCA were found, confirming that there is no uniformity to LCA between different counties.

At a national level, Ireland’s landscapes can be broadly divided into “Landscape Character Types (LCTs)”, like *“urban”* and *“river valley farmland”*.

Guidelines for Landscape and Visual Impact Assessment (GLVIA) are commonly used in windfarm developments. GLVIA have been used in this study.

A separate study found that visual perception is determined by design, distance from viewer, setting (i.e. hills, skyline), visibility and the viewer’s opinion. A study into windfarms by Scottish Natural Heritage (SNH) also found a range of factors affect perception and not just the size of structure or distance from the viewer.

The importance of well-established guidance in the siting of electricity infrastructure is evident but so too are modern ideas. For example, a new “T-pylon” design improves on the visual impact of the traditional lattice tower and has a smaller footprint. The review found no studies which confirm that existing features and conditions (such as low elevation, clear sky, vegetation etc.) can influence the landscape and visual impact of transmission infrastructure.

Actual Impact

In this study, the actual visual and landscape impact of towers and substations on Ireland’s landscape has been assessed. 30 towers and 21 substations in 12 LCTs were surveyed in summer and winter. The visual impact from 100 to 3,200 metre distances was examined. The purpose was to determine how landscape character affects the impact of transmission infrastructure and how this changes over distance.

Our study found significant landscape and visual effects from 110kV towers across 11 sites to occur within 400m but the most significant were within 200m. All significant landscape effects in lowland landscapes were found to occur within 600m but in upland areas, effects were found up to 800m. No significant effects were found after 800m. 110kV towers were found best absorbed within lowland rural landscapes. Screening from trees and hedgerows can reduce the prominence of 110kV towers.

Our study found significant landscape and visual effects from 220kV towers across 10 sites to occur within 800m but the most significant were within 400m. All significant landscape effects in lowland landscapes were also found to occur within 600m but in upland areas, effects were found up to 800m. No significant effects were found after 1600m. 220kV towers were found best absorbed within lowland rural landscapes. Screening is not as effective at reducing prominence as for 110kV towers but routing the towers against a background such as higher land (this is known as “backclothing”) is more important.

Our study found significant visual effects from 400kV towers across 9 sites to occur within 800m but the most significant were within 400m. No significant effects were found after 800m. 400kV towers were found best absorbed within urban and lowland agricultural landscapes but also high drumlin[1]. This is inconsistent with the findings for 110kV and 220kV. All significant landscape effects in lowland LCTs were found to occur within 700m but in upland areas, effects were found up to 1300m. Therefore 400kV towers were also found best absorbed within lowland rural landscapes. Screening is not as effective at reducing prominence but again the routing of lines to maximise “backclothing” is important.

The study found significant visual effects from 110kV substations across 8 sites to occur within 800m. No significant effects were found after 800m. 110kV substations

[1] A small hill generally found in the north-eastern area of Ireland which may appear elongated.

were found best absorbed within urban, lowland lakeland, lowland drumlin/esker[2], lowland plain and coastal estuary. The coastal site contained frequent hedgerows which helped to reduce the landscape effect. Landscape boundary planting was found to significantly reduce visual impacts.

The study found significant visual effects for 220kV substations across 8 sites to occur within 800m. No significant effects were found after 800m. 220kV substations were found best absorbed within similar LCTs as for 110kV. The most successful sites used 4-sided planting plans with mature stands to include native, thorny or evergreen species such as gorse, hawthorn, blackthorn and holly.

A detailed analysis of 400kV substations was not included in this study due to their limited number in Ireland; however, of those examined, no significant visual effects were found beyond 800m.

Summary

In summary, the study found that 95% of all significant effects were within 400m of all towers. No significant visual effects were found after 800m. Impacts reduce with distance. Screening helps to reduce the impact of 110kV towers and “backclothing” helps to reduce the impact of 220kV and 400kV towers. 86% of all significant effects for substations were found within 400m.

[2] A long ridge or elevated area made up of sand or gravel deposits.

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1 INTRODUCTION

1.1 THE SCOPE OF THIS PROJECT

In April 2012, EirGrid published the *Grid25 Implementation Programme 2011-2016*, and its associated Strategic Environmental Assessment (SEA).

The SEA identified a number of Environmental Mitigation Measures envisaged to prevent, reduce and, as fully as possible, offset any significant adverse impacts on the environment of implementing the Implementation Programme.

Environmental Mitigation Measure (EMM) 3 concerns *Preparation of Evidence-Based Environmental Guidelines*. These are intended to comprise a series of authoritative studies examining the actual effects of the construction and existence of transmission infrastructure in Ireland. The studies would thereby provide benchmarks to facilitate the robust preparation of projects with an evidence-based understanding of likely environmental impact.

Three types of studies are envisaged under EMM3:-

- **Environmental Benchmarking Studies**: to determine the actual effect, in respect of a number of environmental topics, of the construction and existence of transmission projects in a representative range of Irish environmental conditions – typical, non-standard, and worst-case. The studies, while authoritative, are conceived as an ongoing body of work that can be continuously updated to take account of new information and/or developments in understanding arising from practice and research;

- **Evidence-based Environmental Design Guidelines:** deriving from the factual basis and evidence contained in the initial Benchmarking Studies, these will provide practical guidance to practitioners and consultants in the planning and design of transmission infrastructure from the perspective of a particular environmental topic. These might comprise new guidelines, or the updating of existing guidelines;

- **Guidelines on EIA for Transmission Projects in Ireland:** Accompanying, or incorporated into the Design Guidelines, these are intended to provide an agreed and authoritative format for the preparation of EIA for transmission projects in Ireland, again in respect of particular environmental topics.

This Study is one of the Environmental Benchmarking Studies – to determine the actual effect of the construction and existence of transmission infrastructure in Ireland on its receiving environment.

1.2 THE AIMS OF THE STUDY

The aim of this Study is to determine the actual visual effect of the operation of physical infrastructure related to transmission infrastructure for a range of typical Irish Landscape Character Types (hereinafter generally referred to as LCTs[3]) and visual conditions.

In summary, the objectives for this study are:

- To undertake a literature review including identification of any comparable previous international studies.
- To establish a suitable range of Irish LCTs.
- To identify a suitable extent and type of existing transmission line infrastructure located within the identified Irish LCTs.
- To undertake relevant field based surveys at the selected infrastructure sites and determine the actual effects on landscape and visual amenity over a range of sites and conditions.
- To determine how the character of the landscape, and elements within it, influence the visual effect of 110kV, 220kV and 400kV transmission line structures, over a range of distances and to test if there is a reduced capacity to identify and recognise features over greater distances from the viewer[4].
- To detail where measures at substations have been taken to mitigate landscape and visual impacts and assess their *actual* effectiveness.
- To identify practices/conditions that give rise to greatest and least landscape and visual effects; and
- To identify lessons learned and make recommendations, if appropriate, for future actions or studies.

It is intended that the results of the Study will provide the factual basis for any future evidence-based Design Guidelines for transmission projects. Such Guidelines would assist in providing the basis for future specialist Environmental Impact Assessment (EIA) Guidelines for this sector.

[3] As per Landscape Institute (LI) and Institute of Environmental Management and Assessment (IEMA)
[4] This concept is known as *distance decay* (Bishop *et al* 1988)

1.3 THE TRANSMISSION NETWORK AND LANDSCAPE

Electricity supply is an essential service in Ireland's economy. The transmission system is an extensive network of high-voltage 400kV, 220kV and 110kV overhead lines and cables which carries bulk electricity from areas where it is generated to where it is needed (known as "demand centres").

The development of the transmission network is the responsibility of EirGrid, the Transmission System Operator (TSO). Grid development requires a careful balance between meeting the technical requirement for a project, the costs of that project, and the environmental impact of that project.

An overview of the primary types of transmission infrastructure, including an outline of construction methodology is in **Appendix A** of this study.

In Ireland, overhead transmission circuits are generally supported on intermediate poles (wooden) or towers (metal); towers are mostly associated with the higher voltage 220kV and 400kV lines. Angle towers are required where there is a change in circuit direction. They are lattice steel structures, designed to withstand considerable forces and are therefore larger structures in the landscape. While wooden polesets tend to range in height from 16m to 23m over ground level, the largest 400kV double circuit towers[5] can range up to 68m over ground level. They frequently have boundary planting and are carefully located using specific guidance The routing of transmission circuits follows well-established guidance known as the Holford Rules[6].

Substations are also an essential part of the transmission network, but also have the potential to negatively impact upon landscape character and visual amenity. Substations vary in type but they all require buildings, steel palisade security fencing and can have structures up to 28m high. They frequently have boundary planting and are carefully located using specific guidance known as the Horlock Rules[7] and therefore tend to not dominate the landscape.

In transmission infrastructure development, every effort is made during construction to cause least disturbance to landowners and local residents. However it is also necessary to ensure that the preferred/chosen route and substation sites do not adversely impact upon landscape character and visual amenity. This includes designated areas of national importance, as well as locally important viewing areas. The potential effects of transmission infrastructure on the landscape relate primarily to the potential for negative impacts on the viewer's visual perception of the landscape. EirGrid acknowledges that the Irish landscape resource is an integral part of the economic, cultural and social fabric of the country..

The significance of any effects on the Irish landscape depends on the location and scale of the infrastructure. A range of factors that can modify the landscape and visual impact of the infrastructure

[5] Double circuit is where two separate circuits are supported on a single set of towers
[6] Holford Rules (Refer to **Appendix B**)
[7] Horlock Rules (Refer to **Appendix C**)

also play an important part. The development of transmission infrastructure must carefully consider the landscape from an early project design stage.

1.4 STUDY LAYOUT

The study begins with a literature review (Section 2). Information on Irish LCTs and studies into the landscape and visual impact assessment (LVIA) of transmission infrastructure are presented.

Following this, the Study Methodology for 30 tower sites and 21 substations and the approach taken across the range of 110kV, 220kV and 400kV transmission infrastructure is described (Section 3).

A detailed assessment of the survey results is then presented for all of the tower and substation sites. Modifying factors that either increase or decrease the prominence of infrastructure are also presented (Section 4). The survey results are further discussed (Section 5) and the LCTs most able to absorb each type of infrastructure are concluded.

Recommendations to reduce the landscape and visual effects of transmission infrastructure are also provided (Section 6).

2 LITERATURE REVIEW

2.1 INTRODUCTION

A desk-based literature review was undertaken to gather together all existing information in relation to Irish Landscape Character, as well as a review of International Literature for similar studies into the landscape and visual impact of transmission lines and infrastructure. There are few directly comparable and recent studies related to the landscape and visual impact of electricity infrastructure available for review and rather it is the component parts of previous studies that offer relevance to this Study. Some of the more recent studies on wind farms are worthy of review, particularly work in relation to perception and also comparing actual effects of constructed projects in-situ with effects predicted by Environmental Impact Statements (EISs) carried out by Scottish Natural Heritage (SNH) for wind farms in Scotland (University of Newcastle, 2002).

At the outset it should be noted that this literature review found numerous examples of studies completed over the years that attempt to quantify the human perception of the impact of transmission lines; these include Furby *et al* (1988), Soini *et al* (2008) and Priestley (1992). Whilst this type of study or research is very relevant to understanding public attitudes to the perception of transmission lines and therefore viewer sensitivity, such studies do not explore *actual* landscape and visual effects and the relationships between transmission infrastructure size, distance and visibility in different landscapes. The studies reviewed as part of this literature review have been used to confirm that visual perception depends on a range of factors including the viewers experience, the visual field, the attention of the viewer, background to the view, contrast between object and background. This aspect of public perception with regards to the landscape and visual environment is explored further in sections 2.1.3 (Failte Ireland, 2012) and 2.1.5 (University of Newcastle, 2002 and Bishop *et al*, 1985).

The desktop and literature review exercise was conducted via electronic journal and citation databases and had no geographic restrictions. The literature review focused on key relevant and available primary research papers, academic and peer-reviewed journal papers and relevant secondary topic review papers. Findings are summarised and consolidated below under key topics and areas of focus and relevance for the Study.

2.1.1 Diversity of Ireland’s Landscape

The Irish landscape is about the relationship between people and place. The character of Irish landscape results from interactions between the physical/natural environment (geology, soils, climate and biodiversity) and social/cultural factors (land use, settlement, enclosure, human activities) both now and in the past. It is a person’s perception that turns land into landscape by creating a sense of place. The distinct colour, texture, pattern and form of the Irish landscape combines as visual components and in such a way is the viewer’s perception of individual landscapes influenced. The

Irish landscape is important because it matters to its people and contributes to the quality of life and historic/social context of its people.

The Irish landscape is vital to sustainability. It is recognised by Government as a central consideration in development decisions and policy making (DoEHLG, June 2000). Distinctive regional variations in landscape occur across Ireland and include many areas of outstanding quality that are valued nationally/internationally including as a tourism asset. It is the basis of tourism marketing campaigns (Failte Ireland, 2012) given that 91% of visitors to Ireland ranked scenery and also natural/unspoilt environment as an important part of a destination in Ireland. In March 2002, the Irish Government ratified the European Landscape Convention. In doing so the State acknowledged the contribution that Ireland's landscape makes to people's quality of life, the wide range of land uses that are working to transform the landscape and the importance for all land-users to cooperate in the protection, management and planning of our landscapes.

2.1.2 Consistency of County Landscape Character Assessment in Ireland

Current guidance for Local Planning Authorities (LPAs) on the completion of Landscape Character Assessments in Ireland is provided in Guidelines for Planning Authorities on Landscape Assessment (DoEHLG, June 2000). These guidelines aim to provide an approach for local authorities to appraise landscapes in a systematic and consistent way using Landscape Character Assessment (LCA). A review of the available Local Planning Authority County Landscape Character Assessments in Ireland as part of the Study was completed to assist in the identification of a suitable range of Irish Landscape character types (Section 3.3). This review has revealed that there is a lack in consistency in approach to landscape classification and terminology across Ireland. This finding has been confirmed by a study commissioned by the Heritage Council (Julie Martin Associates, 2006).

At a national and regional level, Ireland's landscapes can be broadly divided into distinct Landscape Character Types (LCTs). LCTs are distinct types of landscape that are relatively homogeneous in character. They are generic in nature in that they may occur in different areas or different parts of Ireland, but wherever they occur they share broadly similar combinations of geology, topography, drainage patterns, vegetation, historical land use and settlement pattern. For example, drumlins and mountain moorlands are recognised as two distinct LCTs.

While it is acknowledged that there are subsets of the broad nationwide LCTs that can be defined at a local level as Landscape Character Areas (LCAs) (e.g. Wicklow Upland Forested Landscape and River Suir Valley Farmland), the Study must stay at a broader national level to allow meaningful results with suitable existing transmission projects covering 110kV up to 400kV infrastructure identified for each typical LCT.

LCTs are sometimes referred to as physical units. However, the terms LCT and LCA are now widely recognised by landscape architects and in current best practice guidelines (LI-IEMA, 2013).

As set out in Section 3.3, a comparison has been completed of the Local Planning Authority County Council Landscape Character Types/Areas and the broader national LCTs used for the Study (**Appendix D**), that resulted in evidence of a good consistency between the Study LCTs and the LCTs and sensitivities defined by LPAs.

2.1.3 Perceptions of Landscape and Visual Effects

The literature review has confirmed that the values and perceptions of a landscape can range depending on the individuals perception. For different people, land or landscape is an economic resource (releasing a dividend through growing crops, grazing cattle or building houses), a tourism asset, a recreational asset, a family home or a natural place. These uses are translated into sets of values which are held by certain groups of people. Many people value rural areas and landscape for more than one reason.

From the review of literature on public perception it has been established that the majority of studies do not research the landscape and visual impact of transmission line infrastructure but rather focus on a range of more difficult to define aspects that surround attitude of individuals through exploring psychological impacts, property values, impact on health and under the general heading of aesthetics.

While not based on transmission infrastructure, an SNH study looked into the best practice for assessment of the visual impact of wind farms (University of Newcastle, 2002) and explored factors that influence and modify the perceptions of effects (Section 2.1.5). This study concluded that visual perception of impacts depends on more than scale, size and distance but also depends on a range of factors that influence discernibility and visibility. Therefore people use many cues to perceive impact and the visual context of view is important.

In Ireland, no study of the public perception of transmission lines in Irish landscapes has been identified by the literature review. The most similar type of perception study completed in Ireland is the 2012 Failte Ireland study to assess whether or not new wind farms would impact on tourist enjoyment of Irish landscapes (Failte Ireland 2012). In the study tourists were asked to rate the scenic beauty of five different Irish landscapes namely coastal, mountain, farmland, bogland and urban industrial landscapes and then rate the scenic beauty of each landscape and the potential impact of siting a wind farm in each landscape.

The Failte Ireland study found that coastal areas (91%) followed by mountain moorland (83%) and fertile farmland (81%) were rated as the most scenic. While wind farms are not directly similar to transmission lines it is interesting to note that these three landscapes were also identified as the locations with greatest resistance to wind farms, showing the public's view on the sensitivity of these landscapes. Failte Ireland found that each potential wind farm site must be assessed on its own merits, due to the scenic value placed on certain landscapes by the visitor and the preferred scale/ number of wind turbines within a wind farm. The Failte Ireland study also concluded that the type of Irish landscape in which a wind farm is sited can have a significant impact on attitudes.

Tikalsky *et al* (2007) reviewed aesthetics and public perception of transmission structures from the 1960s to the 1990s and concluded that it remains an elusive topic and that throughout 40 years of study and research the findings on aesthetics and public perception are far from definitive. The authors are critical of the majority of studies for lacking a scientific rigor and conclude that perception and aesthetics have proven difficult to correlate in a meaningful way.

Soini *et al* (2008) completed a Finnish study into the perception of power transmission lines among local residents who live in close proximity. The study firstly sought to identify the factors that contribute to the local perception of lines in the landscape and then analysed how the lines were perceived in comparison with other landscape elements. Finally the study sought to determine if there was any homogenous classes of residents that influenced perception (landownership; knowledge of power lines etc) using the latent class method. The study found that transmission lines were perceived negatively but it also established that there were also positive attitudes.

The study used a questionnaire that was mailed to 2172 households with 630 replies received. Sixteen statements were used to gauge perceptions of lines and the eight most responded to statements were negative ones; *"cause an uncomfortable feeling"* and *"deface the landscape"* received the most responses. The most agreed positive statement was that, *"powers lines are necessary and justified elements in the landscape"*, and also, *"that it is possible to get used to them"*.

The analysis of the results showed that residents who lived closer to power lines were more likely to have positive perceptions of the lines, indicating that the public can adapt to transmission lines as part of the landscape. The study found that objective knowledge of transmission line impacts and the personal belief of residents were two different issues influencing the residents' perception of landscape with most negative perceptions based on beliefs or feelings, rather than knowledge.

Bishop *et al* (1985) provide the most relevant study into the perception of the landscape and visual impact of transmission lines when they determined that visual impact depends on a range of factors including design and distance of the tower from the viewer; the setting, visibility and the disposition and preference of the observer. This paper is discussed in greater detail in Section 2.1.5.

2.1.4 Design of Electricity Infrastructure

Broad principles for overhead transmission line routeing were formulated by the late Lord Holford and published in 1959 by the Royal Society of Arts and are known as the 'Holford Rules'. The UK National Grid reviewed the Holford Rules in 1992 and they have become widely accepted by Transmission System Operators (TSOs) as the basis for overhead transmission line routeing and design. The Holford Rules are based on steel lattice towers and seek to minimise any adverse impacts associated with new overhead lines through the adoption of a series of rules. The seven rules and supplementary notes are provided in detail in **Appendix B**.

The Horlock Rules were established by the UK National Grid in 2009 and set out the approach to substation siting and design. The Horlock Rules are provided in detail in **Appendix C**. As with the Holford Rules, the Horlock Rules are widely used by TSOs as best practice guidelines for the siting and design of substations.

The component parts of transmission line infrastructure and the present designs in the UK and other parts of the world that influence landscape and visual impact are well described by Goulty (1990). Goulty (1990) states that the majority of modern towers have evolved from the 132kV towers (steel lattice) built in the UK in 1928 and are essentially of a functional and economic design that are the most widely used type of overhead line support throughout the world.

New tower designs are currently being appraised by authorities in countries across Europe in attempts to develop a more aesthetically appealing design of tower that may be more acceptable to a broader spectrum of public opinion (ENTSOE, 2012). As illustrated in Figure 2.1, a design competition was held of a new 400kV line in Denmark resulting in the tower illustrated below. Other countries such as UK and Ireland are exploring new designs with a new tower design implemented in-situ in the UK at Nottingham in April 2015. New tower designs may be costly and risky but may also ease the road to acceptance at planning stage. These new tower designs predominantly are based on a single tubular steel supporting tower with various types of lattice or steel cross members to string the lines. More extravagant curved and restructured "obelisk" lattice type towers have also been promoted elsewhere in Austria (ENTSOE, 2012) but there is simplicity about the single tubular steel tower promoted in Denmark.

Figure 2.1: A new tower design for a 400 kV connection between the cities of Aarhus and Aalborg, Denmark (ENTSOE, 2012)

In the UK in 2010 to 2011, the National Grid in conjunction with the Royal Institute of British Architects (RIBA) and the Department of Energy & Climate held a design competition for a new approach to the appearance of transmission towers. The winning design selected in 2011 was the "T-pylon" by Danish architectural firm Bystrup that is similar to the Aarhus to Aalborg tower design in Denmark and was chosen to be developed further with National Grid (Figure 2.2). Shortlisted designs included a

"Silhouette" by Ian Ritchie and a "Totem" by New Town Studio (Figure 2.3). In 2015 a test line was built in Nottingham, UK for training purposes only. The T-pylon is shorter in height (at approximately 36m) than current designs for steel lattice towers and is suitable for lines up to 400kV. The diamond arrangement is used to carry the cables in one arm requiring a smaller sectional area than current steel lattice towers. National Grid reported that the erection of the new tower design took only one day compared to up to one week for the erection of a steel lattice tower. The T-pylon has been designed to adapt to changing landscape character by being made available in painted, hot dip galvanized, Corten or stainless steel finishes.

In announcing the winner, Nick Winser Executive Director of National Grid stated that, *"In the T-pylon we have a design that has the potential to be a real improvement on the steel lattice tower. It's shorter, lighter and the simplicity of the design means that it would fit into the landscape more easily. In addition, the design of the electrical components is genuinely innovative and exciting."*

Figure 2.2: National Grid design competition winning "T-pylon" by Danish architects Bystrup on site (The Engineer Magazine April 2015)

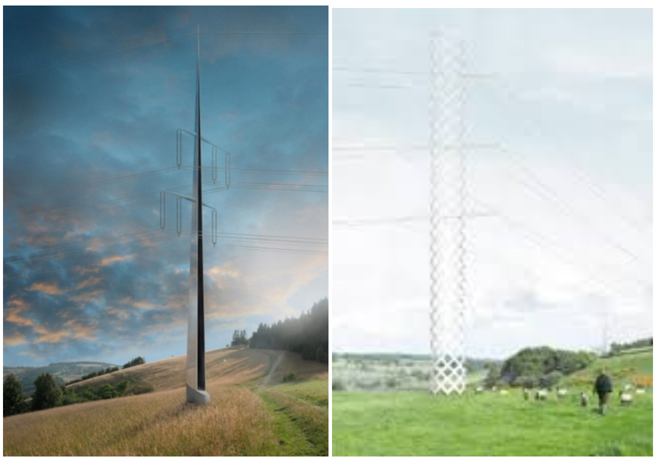


Figure 2.3: "Silhouette" by Ian Ritchie (left) and a "Totem" by New Town Studio (right) (RIBA)

2.1.5 Predicting Landscape & Visual Impacts of Electricity Infrastructure

In the SNH publication *Visual Assessment of Wind Farms Best Practice* (University of Newcastle, 2002), the authors state that the public visually perceive size, shape, depth and distance by using many cues and therefore SNH say that context is important. They conclude that visual perception depends on experience, the visual field, attention, background, contrast and expectation; and may be enhanced or suppressed. They also state that the magnitude of a development, and the distance between it and the viewer, are basic physical measures that affect visibility. They go on to state that the real issue is that human visual perception of visual impacts is not simply a function of size and distance but rather that a range of factors influence visual perception and therefore visual impact.

Examples include:

- proportion of the structure that is visible relative to the scale and form of the landscape and the skyline
- seasonal effects of light, distance, colour and contrast; skylining above hills and backclothing below hills, and
- elevation of the structure and the viewer; the character of the landscape and especially elements within it.

Therefore modifying factors can have potential to either reduce or increase apparent prominence of transmission infrastructure. It is only by considering these multiple factors that the magnitude or prominence of a development can be established. This conclusion is fully consistent with the Study methodology (Section 3).

By combining viewer sensitivity with the magnitude of visual impact it is possible to establish the significance of visual impact of a development. *Guidelines for Landscape and Visual Impact Assessment* (GLVIA) (LI-IEMA, 2013), state that the final assessment of significance must be based on the professional judgement of the landscape architect.

A paper of relevance to this assessment of the visual impact of transmission line infrastructure has been completed in Australia by Bishop *et al* (1985) who state that the visual impact of overhead transmission lines depends on numerous factors that relate to:

1. the design of the towers
2. the distance between the viewer and the tower
3. the setting of the tower including the space between the tower and the viewer
4. the degree to which the towers are visible, and
5. the disposition and visual preferences of those who observe the structures.

In their paper Bishop *et al* (1985) state that the degree to which towers are visible is easily addressed by computer software and use of ground terrain modelling. This would equate today to a computer generated Zone of Theoretical Visibility (ZTV) map that could be used to calculate the proportion of landscape within a set distance (radius) from the transmission tower that has potential visibility and is something that has been taken forward in the Study methodology for calibration purposes (Section 3.11). In bullet point 5, Bishop *et al (*1985) are discussing human perception and this approach is readily transferable to current best practice set out in the GLVIA (2013) of viewer sensitivity i.e. a resident with a view across a rural landscape has a high visual sensitivity, while a worker at a place of work has a low visual sensitivity.

Bishop *et al* (1985) used simple photomontages to represent views of towers in Australian landscapes over a range of distances. The authors found that many studies have demonstrated that photographs of landscapes can be used without significantly biasing an individual's evaluation of a visual quality (Daniel & Boster (1978) and Shuttleworth *et al* (1980)). This point helpfully supports the use of photographs in the Study methodology (Section 3.7).

The Bishop *et al* (1985) study identified five structures in use at the time by the State Electricity Commission of Victoria; 220kV single current (two tower types); 220kV double current (two tower types) and 500kV single current. A fixed tower position and a moving camera position were established to be the best approach over 500m, 250m and 125m. 500m was selected as the study found it difficult to find suitable locations that met the study criteria beyond 500m due to obstructions in the landscape. The 125m and 250m were selected to provide insight into the relationship between distance and visual impact. An Australian parkland setting was chosen for context within a single landscape type as it was thought to be the most sensitive with the authors stating that the chosen viewpoint must achieve the following specific criteria:

- the full structure must be visible from each distance
- there should be minimum intrusion from other man-made structures
- the context should be urban in character, and
- the corridor should be typical of a transmission corridor.

It is interesting to note and of relevance to the Study that the authors found that complete conformity with their study criteria was not possible but the authors did identify two sites that met most criteria. The suggestion that selecting views where there should be minimum intrusion from other man-made structures is a consideration that has been included in the methodology for the Study. The Bishop *et al* (1985) study used early photomontage techniques to prepare photomontages for the range of tower types and through experimentation it was established that an angle of 55 degrees to the towers was best to allow good recognition of the structural elements of the tower.

Under controlled conditions 33 academic staff and students evaluated the scenic quality pertaining before and after in each photomontage. Bishop *et al* (1985) state that academic staff are more likely to be sensitive to differences in scenic quality than the general public due to their training in aesthetic design. Statistical analysis was completed on the results of evaluation by the academic staff and students which indicated that:

- the presence/absence of transmission towers accounts of approximately 90% of variation in assessment
- towers are more intrusive than wooden poles
- distance and landscape setting moderates influences on visual impact, and
- tower design parameters are related to visual impact.

While the results of the Bishop *et al* (1985) study apply to one landscape character type only (urban parkland landscape) the findings that tower design does not alter visual impact and that wooden poles have less visual impact than steel towers is helpful and supports the Study findings.

Bishop *et al,* (1985) found that 90% of adverse effects occurred within 500m of the towers within a parkland landscape setting and that only 10% of the adverse reaction was caused by the design of the tower itself.

The use of trained evaluators is helpful in supporting the use of peer reviewers to verify the visual impact of selected viewpoints in various landscapes within the methodology of the Study.

Also helpful is the finding that in more visually complex landscape settings the negative visual impacts can be substantially reduced. Bishop *et al*. (1985) found that in views with greater vegetative and topographical complexity transmission towers became less visually prominent resulting in less visual impact. This finding is particularly relevant to the Study as will be shown later in that the Irish landscape predominantly consists of undulating lowlands with trees and hedgerows that combine to influence visibility.

Bishop and Hull, (1988) expanded their 1985 paper when they further considered the relationship between distance from and scenic impact of transmission infrastructure. The influence of landscape type on functional form was also explored. The study used three generic landscape types (rural, suburban and flat agricultural fields), and views without structures were identified that were very similar to views with structures with both sets photographed. A ten point scale was then used to rate the, “scenic beauty” of the views, and the “scenic impact” of the transmission line was calculated by subtracting the “scenic beauty” estimate of the view without the structure, from the view with the structure. They found that visual impact decreases rapidly with distance.

The authors found that most of the impact occurs within 100m to 1 km from transmission towers with the impact at 500m around 25% of the maximum and 10% at 1 km distance. The transmission towers “scenic impact” was also shown to be influenced by the landscape surrounding the tower, with towers having less impact in more complex landscapes, particularly at longer distances. This last finding is presumably due to the fact that the transmission towers become less of a focal point and also the fact that the viewer’s eye is drawn to other features in the more complex scenes.

A further and more recent Italian study (Tempesta & Marangon, 2007) followed similar methods in part to the Bishop and Hull studies and used actual photographs of 220kV and 380kV towers at various distances for assessment by 201 people. The findings of this Italian study concurred with the Bishop and Hull studies by concluding that the visual impact of all elements considered tended to reduce with distance and size.

The process of landscape and visual impact assessment is broadly subjective, (Julie Martin Associates, 2006). Subjectivity (as opposed to objectivity) in landscape and visual impact assessment is fine as long as subjective inputs are made in a systematic and transparent way and subject to stakeholder input. This is consistent with the GLVIA (LI-IEMA, 2013) and the Study methodology.

2.1.6 Factors influencing Magnitude of Impact and Significance

Modifying factors can influence the magnitude and significance of impacts on landscape and visual resources that can be caused by transmission infrastructure. While no studies have been found during this literature review relating directly to the modifying factors that influence magnitude of impact and significance of impact of transmission infrastructure, studies have been completed investigating the factors influencing the magnitude of impact and significance of wind farm developments, with specific consideration of the effect of distance (Sinclair (2001) and University of Newcastle (2002)).

While comparisons between wind turbines and transmission infrastructure must be carefully considered, due to the difference in scale and predominant location, (i.e. turbines on the top of open hills and skylines or transmission towers in lower lying lands amongst other vegetation), there are common themes in the landscape and visual impact assessment process suggested in the research from the University of Newcastle that is of relevance to this Study.

In *Visual Assessment of Wind Farms* by the University of Newcastle, it is indicated that while it would not be too controversial to state that wind turbines are highly prominent at close distances and lack clear prominence at long distances, it is unclear how prominent such structures are within middle distances. It states that prominence can be determined by considering a range of modifying factors that influence these middle distances and that can be divided into:

a) Modifying factors that tend to reduce apparent magnitude or prominence

- low visibility
- absence of visual clues
- mobile receptor
- towers not focal point
- complex scene
- low contrast
- complex background
- screening, and
- high elevation

b) Modifying factors that tend to increase apparent magnitude or prominence

- clear sky
- highlighting
- high visibility
- presence of visual clues
- static receptor
- towers as focal points
- high contrast
- lack of screening, and
- low elevation.

The process of assessing landscape and visual impact for wind turbines as described by the University of Newcastle (2002) uses methods drawn from the Landscape Institute and Institute of Environmental Impact and Assessment. These are the "*Guidelines for Landscape & Visual Impact Assessment* (GLVIA) (LI-IEMA, 2013) and are directly applicable and comparable to the Study as the process for landscape and visual impact assessment can be applied to all projects or developments.

Table 2.1 below sets out a prominence and magnitude class rating system that has been recommended for best practice for visual assessment of wind farms (University of Newcastle (2002) set against the frequency of potential modifying factors. Providing a wider range of magnitude classes, as shown in Table 2.1, allows more scope for the refinement of prediction of impact over a range of distances, as proposed by the Study, and this wider range of magnitude classes is consistent with the Study methodology (Section 3.8).

Table 2.1: Magnitude (Prominence) of Visual Impact (University of Newcastle, 2002)

Magnitude Class	Prominence	Description of visibility	Modifying Factors
Very Large	Dominant	Commanding, controlling the view	Few
Large	Prominent	Standing out, striking, sharp, unmistakable, easily seen	Few
Medium	Conspicuous	Noticeable, distinct, catching the eye or attention	Many
Small	Apparent	Visible, evident	Many
Very Small	Inconspicuous	Not obvious, indistinct, unclear	Many
Negligible	Faint	Weak, not read in the landscape	Few

With regards to significance, the GLVIA (LI-IEMA, 2013) states that, *"Significance is not absolute"*, and can only be defined in relation to each development and its location. It is for each assessment to determine the assessment criteria and the significance thresholds, using informed and well-reasoned professional judgement supported by thorough justification for their selection. This approach to significance is consistent with the methodology for this Study (Section 3.0).

3 STUDY METHODOLOGY

3.1 INTRODUCTION

This section sets out the overall approach to the Evidence Based Study on the impact of transmission line infrastructure on existing landscape and visual resources in Ireland. As will be described later, for the purpose of the Study, it is individual towers that have been assessed rather than overhead transmission lines and similarly it is the physical infrastructure inside the substation compound (including the boundary security fence) that have been assessed.

Set out in the following sub sections are the objectives of the Study, the key issues to be addressed and the overall methodology. At the outset it is important to summarise that the Evidence Based Studies are intended to describe the effects of transmission line projects for a range of *Typical, Non-standard* and *Worst Case* conditions in order to establish the full range of conditions that could occur.

Typical Conditions

The Study sets out to describe the typical landscape and visual effects of the selected transmission line infrastructure on a range of typical landscape character types, in order to establish the full range of typical conditions that could arise to describe the nature, magnitude and significance of the effects that have occurred. Within each type of landscape, a range of local circumstances or conditions can occur that affect the significance or extent of the effect and the Study sets out to identify these.

Most sites selected will represent typical conditions (low visibility; backclothing; enclosed landscape; complex scene; low contrast) resulting from a transmission line structure in the landscape under consideration as seen from increasingly distant locations. In an attempt to identify the distance and circumstances, where no or negligible changes to the appearance or character of the landscape occurs, such typical conditions will be represented by the lowland landscapes selected by the Study.

In addition to the typical conditions, there will also be an examination of two other conditions, Non-standard and Worst Case conditions. These can be used to determine the parameters within which the benchmarking of the environmental effects can be deemed to be reliably predictable.

Non-standard and Worst Case Conditions

Locations or circumstances in an otherwise typical landscape are identified, which have objective circumstances or factors that increase the potential for landscape or visual effects (steeper slope, open landscape, high contrast with lack of complex background, high elevation). These will be scrutinised and compared with typical conditions to describe the nature, magnitude and significance of the effects that have occurred. Such Non-standard or Worst Case Conditions are likely to be found in open Upland or Coastal landscapes selected by the Study.

Attention is to the specific Non-standard or Worst Case Conditions that give rise to more significant effects to determine how the adverse Non-standard or Worst Case effects occurred and how they could be avoided in future. By their nature Worst Case and Non-standard Conditions will lead to increased magnitude of effects and therefore more signficant effects (Figure 3.1). The Study aims to identify the conditions that give rise to the greatest and least landscape and visual effects.

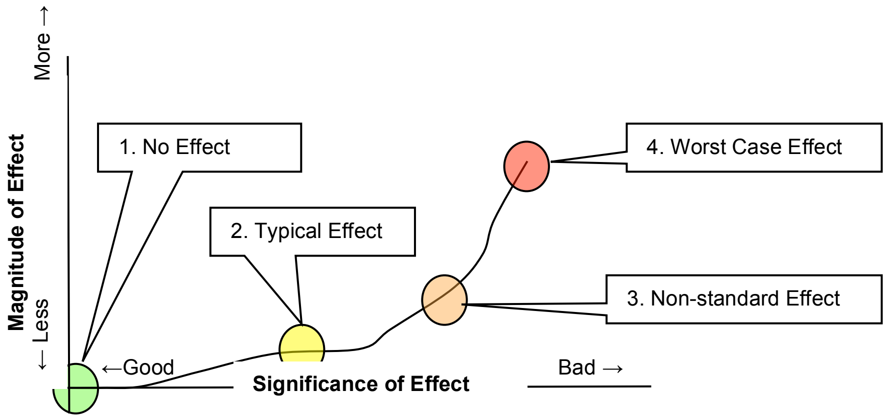


Figure 3.1: Typical, Non-standard and Worst Case Effects: Magnitude Vs Significance (EirGrid)

3.2 OVERALL APPROACH

The objective of the Study is to establish the actual landscape and visual impacts of transmission line infrastructure across a suitable range of landscape character types in Ireland. In summary, the overall approach is as follows:

- Establish a suitable range of Irish LCTs
- Identify a suitable range of existing transmission line infrastructure located within the identified Irish LCTs
- Describe the existing landscape character at the selected sites and their surroundings along with the visual amenity character of the sites
- Determine the actual effects of the selected transmission line infrastructure on landscape character and visual amenity over a range of sites and conditions - Typical, Non-standard and Worst Case
- Establish the visibility of the selected transmission line infrastructure, their visual impact and the ability of the different LCTs to absorb the selected infrastructure and test if there is a reduced capacity to identify and recognise features with greater distance from the viewer (known as distance decay)
- Describe practices that give rise to the greatest and the least landscape and visual effects

As set out below, the Study aims to draw on Bishop and Hull (1985; 1988) (Section 2) and seeks to establish the actual visual impact of existing transmission line infrastructure for a selection of viewpoints over a range of distances (100m, 200m, 400m, 800m, 1.6 km and 3.2 km) across a range of representative LCTs in Ireland.

3.3 IDENTIFICATION OF SUITABLE TRANSMISSION LINE INFRASTRUCTURE SITES WITHIN A RANGE OF IRISH LANDSCAPE CHARACTER TYPES

The Study established a broad range of typical LCTs that exist in Ireland through review of currently available County Council LCAs, by independent site survey and assessment, and by review of the Environmental Protection Agency (EPA) Corine Land Cover (CLC) data (EPA, 2012). Reference was also made to the Heritage Councils, *Guide to Habitats in Ireland* (Fossit, 2000).

At a national and regional level, Ireland's landscapes can be broadly divided into distinct LCTs (Julie Martin Associates, 2006). LCTs are distinct types of landscape. They are relatively homogeneous in character. They may occur in different areas or different parts of the country and as they are generic they share similar characteristics in drainage, vegetative cover, geology, topography and land use and settlement pattern. LCTs are also sometimes referred to as physical units. However, the terms LCT and LCA are now widely recognised by landscape practitioners and current best practice guidelines (GLVIA, LI-IEMA 2013).

The Irish LCTs can be subdivided into LCAs. LCAs are specific geographical areas of a particular landscape type that can be defined at a local or regional level. While it is acknowledged that these LCAs are subsets of the broad nationwide LCTs (e.g. Wicklow Upland Forested Landscape and River Suir Valley Farmland) the Study must stay at a broader, national level to allow meaningful results.

The Study identified 12 national LCTs as set out in Table 3.1. A detailed review of the completed Local Planning Authority County Council LCAs allowed a comparison to take place to benchmark the Study LCT. The review of completed County Council Landscape Character Assessments also assisted in identifying the landscape sensitivity of each LCT, to form the basis of the field studies that followed. The completed detailed review comparing the County Council LCA and LCTs with the 12 Study LCTs is provided in **Appendix D**.

The detailed review resulted in a very good consistency within the Study in terms of landscape descriptions/characteristics and landscape sensitivities and those set out by the LPAs. The landscape character and sensitivity of each of the Study LCTs are described in the completed Assessment Sheets for each selected site as per the example assessment sheet in **Appendix E**.

In addition to the comparison and review of the Study LCTs against the County Council LCAs, a review and comparison also took place to calibrate the landscape types against all major land cover and habitat types in Ireland as provided in the Appendices. As part of this review, reference was made to the EPA Corine Land Cover (CLC) data (EPA, 2006) and the Heritage Councils, *A Guide to Habitats in Ireland* (Fossit, 2000).

It is important to note that the EPA makes a distinction between land cover and land use but the CLC does not deal with land use. The EPA define land cover as the observed physical cover, as seen from the ground or through remote sensing, including natural or planted vegetation and human construction (buildings, roads, other curtilage), which cover the Earth's surface.

The EPA (2012) state that the main land cover type in Ireland is agricultural land, which accounts for two-thirds of the Irish landmass, with most of this being permanent grassland pasture. Peatlands and wetlands are the second most widespread land cover type in Ireland, covering almost one-fifth of the country, while forested areas only cover over one-tenth of the country. The EPA findings show that despite rapid urban development in parts of Ireland over the last 20 years, Ireland’s landscape is predominantly rural and agricultural. These EPA findings are reflected in the selection of the Study LCTs, as illustrated in tabular form in **Appendix F**.

Table 3.1: The broad Landscape Character Types and typical locations in Ireland selected for the Study

Landscape Character Types	Typical locations in Ireland
Urban Landscape/Townscape	Dublin, Galway and Cork
Lowland Lakeland Landscape	Westmeath, Roscommon, Clare and Cavan
Low Drumlin/Esker Agricultural Landscape	Parts of Cavan, Monaghan and Sligo
High Drumlin Agricultural Landscape	Monaghan, Cavan, Sligo
River Valley Farmland Landscape	Parts of Waterford, Limerick and Cork
Lowland Plain Agricultural Landscape	Galway, Clare, Laois, Louth, Longford and Offaly
Open Upland Smooth Moorland Landscape	Mayo, Galway, Tipperary and Wicklow
Open Upland Rocky Moorland Landscape	Donegal, Kerry, Galway
Upland Forested Landscape	Wicklow, Kerry, Mayo and Cork
Coastal Moorland Plateau	Mayo, Clare and Donegal
Coastal Estuary, Loughs and Bays	Coasts of Cork, Mayo, Kerry, Galway and Donegal
Coastal Plain and Dunes	Louth, Waterford, Clare and Sligo

A comparison of existing transmission lines with the broad LCTs set out in Table 3.1, allowed the identification of a total of 30 tower sites and 21 substation sites across the range of 110kV, 220kV and 400kV transmission line infrastructure to be included in the Study. Assessments are set out in Tables

3.2 and 3.3; 110kV towers and substations are indicated in Figure 3.2.; Figure 3.3 shows 220kV structures and substations; Figure 3.4 shows 400kV structures and substations.

It was not possible to identify suitable sites within all LCTs. In particular, due to the lack of geographic spread of existing 400kV transmission lines (Figure 3.4), it was only possible to identify 3 400kV substations. However it was possible to identify 9 400kV tower sites for each of the 12 separate LCTs.

Available sites across all LCTs were also limited for 220kV transmission lines with identification of 8 suitable 220kV substations. A total of 11 220kV tower sites were identified for the 12 Landscape character types. There was a good range of suitable 110kV tower sites available for the Study due to their more common use across all parts of Ireland and its landscape types.

The individual height of each tower is provided in Table 3.2. The height of all towers was provided by EirGrid but it should be noted that detailed height information was not available for five of the structures. However, this does not impact on the overall findings of the Study. The height of all towers was used by surveyors in the field to gain an understanding of the structure being assessed and also to allow an analysis of the differences between the effects of different structures.

It is important to note that all of the selected substation sites are AIS substations (refer to **Appendix A**) due to their greater number and wider distribution in Ireland. AIS substations therefore provide a worst case scenario in terms of potential landscape and visual effects due to their greater scale than GIS substations.

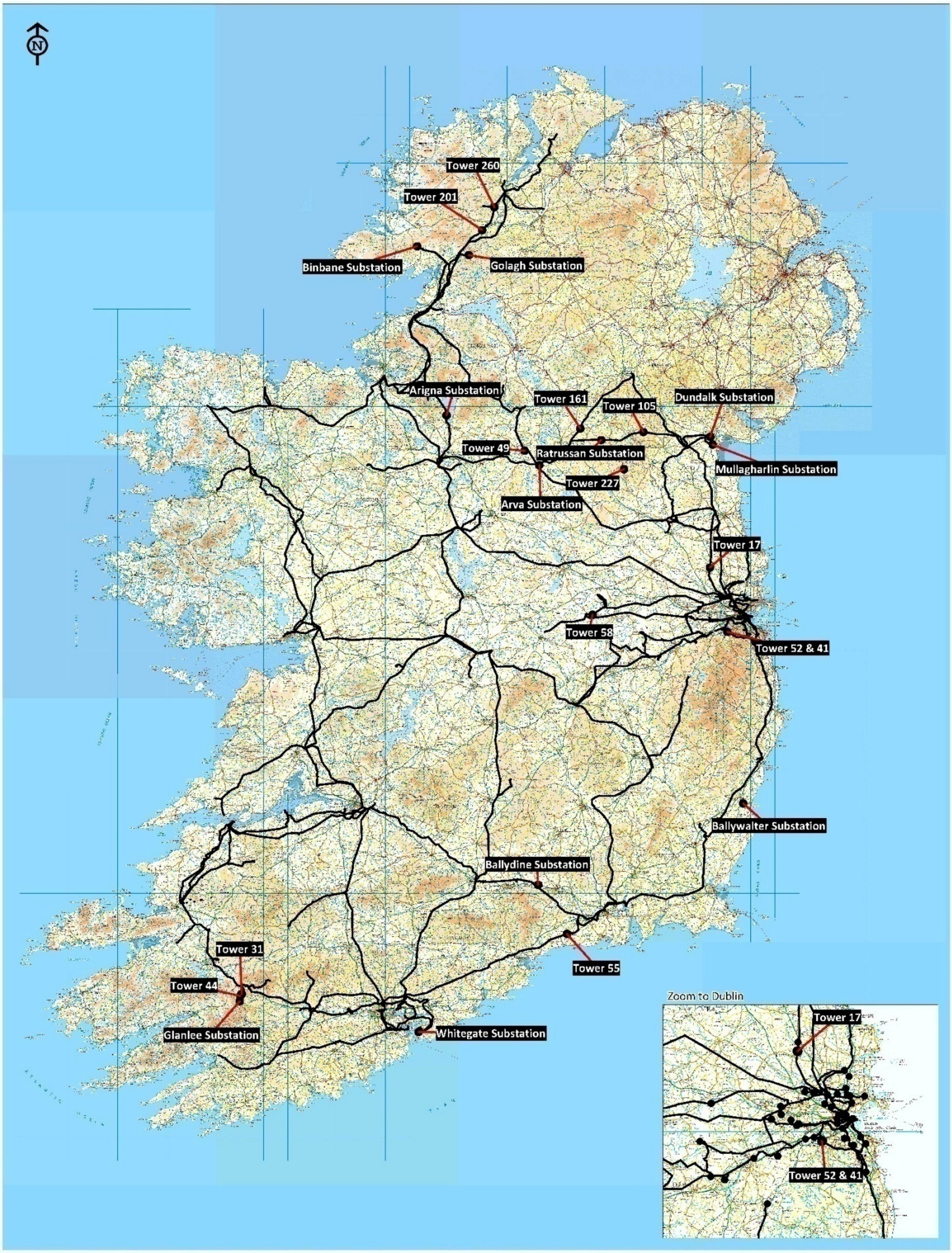


Figure 3.2: Location of selected 110kV structures and substations

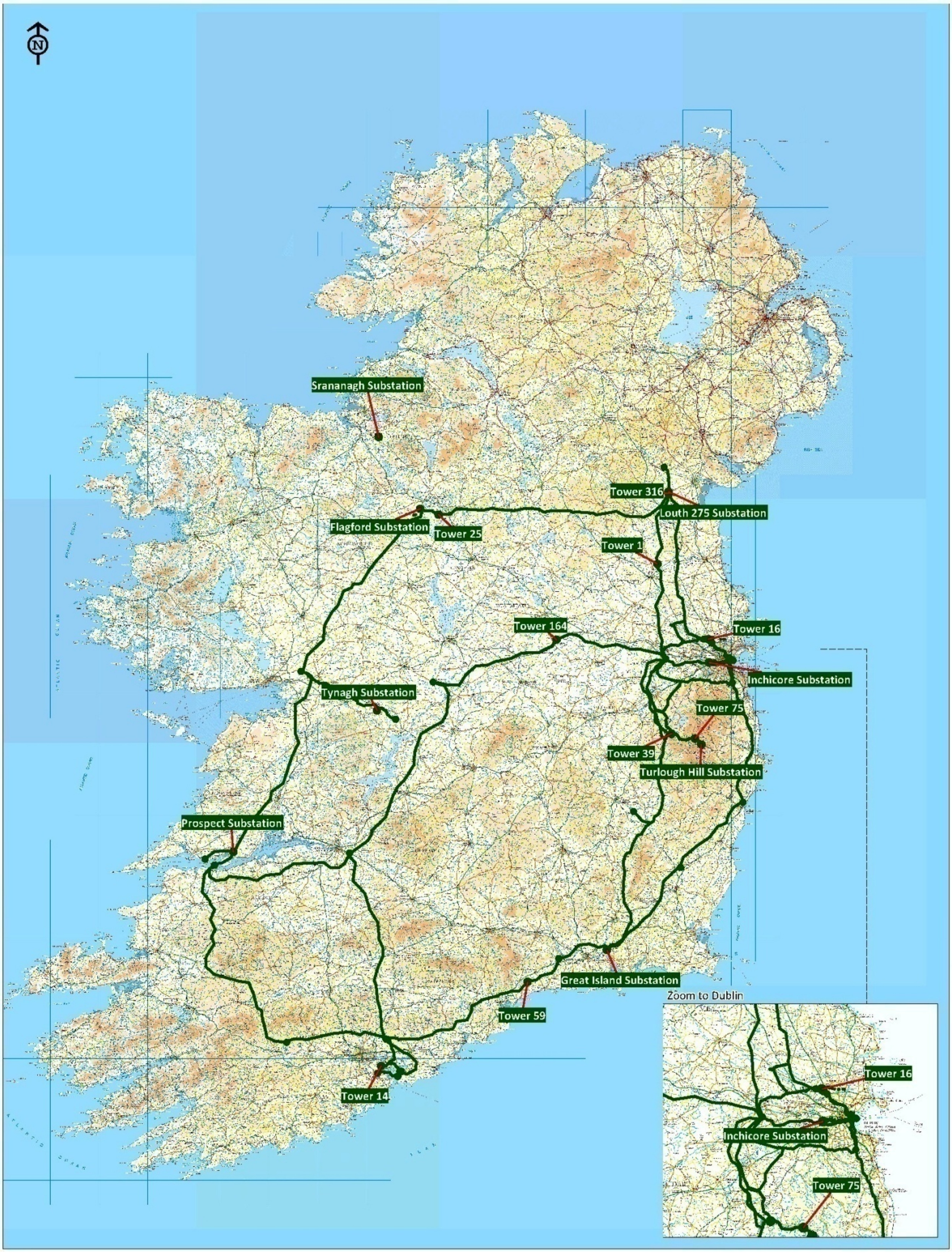


Figure 3.3: Location of selected 220kV structures and substations

Figure 3.4: Location of selected 400kV structures and substations

3.4 IDENTIFICATION OF VIEWPOINT LOCATIONS FOR SELECTED STUDY SITES

The established list of suitable transmission line infrastructure sites provided from Section 3.1 was reviewed against the list of LCTs provided in Table 3.1, to identify suitable viewpoints for assessment.

As discussed in Section 2.0, Bishop *et al* (1985) found that the impact of transmission line towers decreases rapidly with distance, with most impact occurring within the 100m to 1km range. This effect is known as “distance decay”.

To establish the effect of transmission line infrastructure with distance from the viewer across the selected Irish landscapes, a series of viewpoints were selected over a range of distances - 100m, 200m, 400m, 800m, 1.6km and 3.2km for each of the Study sites selected. The number of distance bands used in the Study was increased above those used by Bishop *et al* (1985) up to 3.2km, to further refine effects relative to distance.

Table 3.2 List of Transmission Line Tower Study sites against Study LCTs

LCT	Voltage	Site Name	Site ID	County Location	Figure	Structure Height (m)
Urban Landscape	400KV	Tower 4	L428	Kildare	A1.1	54.5
	220kV	Tower 16	L220	NW - Dublin	A1.2	N/A
	110kV	Tower 52 & 41	L125	South Dublin	A1.3	(52)24.5 (41)28.5
Lowland Lakeland	400kV	Tower 150	L452	Galway	A1.4	23
	220kV	Tower 25	L207	Roscommon	A1.5	18.87
	110kV	Tower 49	L108	Leitrim	A1.6	13
Low Drumlin/Esker	400kV	Tower 330	L421	Meath	A1.7	28
	220kV	Tower 316	L217	Louth	A1.8	30.3
	110kV	Tower 161	L111	Cavan	A1.9	12.5
High Drumlin	400kV	Tower 216	L450	Laois	A1.10	32
	220kV	Tower 227	L253	Cavan	A1.11	N/A
	110kV	Tower 105	L113	Monaghan	A1.12	12.5
River Valley Farmland	400kV	Tower 367	L449	Tipperary	A1.13	37
	220kV	Tower 1	L218	Meath	A1.14	30.5
	110kV	Tower 17	L156	Meath	A1.15	12.5
Lowland Plain	400kV	Tower 264	L422	Kildare	A1.16	28
	220kV	Tower 165	L224	Westmeath	A1.17	20.5
	110kV	Tower 58	L123	Offaly	A1.18	17
Open Upland Smooth	400kV	Tower 398	L448	Clare	A1.19	31
	220kV	Tower 39	L229	Wicklow	A1.20	20.5
	110kV	Tower 260	L154	Donegal	A1.21	N/A
Open Upland Rocky	400kV	No Subject			-	
	220kV	No Subject			-	
	110kV	Tower 44	L155	Kerry	A1.22	N/A
Upland Forested	400kV	Tower 245	L451	Galway	A1.23	30
	220kV	Tower 75	L230	Wicklow	A1.24	23.6
	110kV	Tower 201	L102	Donegal	A1.25	N/A
Coastal Moorland	400kV	No Subject			-	
	220kV	No Subject			-	
	110kV	No Subject			-	
Coastal Estuary	400kV	Tower 564	L444	Clare	A1.26	55.5
	220kV	Tower 14	L238	Cork	A1.27	39
	110kV	Tower 113	L145	Limerick	A1.28	N/A
Coastal Plain	400kV	no subject			-	
	220kV	Tower 59	L235	Waterford	A1.29	28.3
	110kV	Tower 55	L134	Waterford	A1.30	13.5

Table 3.3 Substation Locations against Study LCTs

LCT	Voltage	Site Name	Site ID	County Location	Figure
Urban Landscape	400KV	no subject			-
	220kV	Inchicore	S226	County Dublin (inner City)	A1.31
	110kV	Dundalk Station	S114	County Louth	A1.32
Lowland Lakeland	400kV	Oldstreet	S447	County Galway	A1.33
	220kV	Flagford	S206	County Roscommon	A1.34
	110kV	Arigna	S110	County Roscommon	A1.35
Low Drumlin/Esker	400kV	no subject			-
	220kV	Srananagh	S205	County Sligo	A1.36
	110kV	Arva	S109	County Cavan	A1.37
High Drumlin	400kV	no subject			-
	220kV	Louth 275	S216	County Louth	A1.38
	110kV	Ratrussan	S112	County Cavan	A1.39
River Valley Farmland	400kV	no subject			-
	220kV	Great Island	S233	County Wexford	A1.40
	110kV	Ballydine	S136	County Tipperary -South	A1.41
Lowland Plain	400kV	Dunnstown	S427	County Kildare	A1.42
	220kV	Tynagh	S246	County Galway	A1.43
	110kV	Ballywalter	S132	County Wexford	A1.44
Open Upland Smooth	400kV	no subject			-
	220kV	no subject			-
	110kV	Binbane	S104	County Donegal	A1.45
Open Upland Rocky	400kV	no subject			-
	220kV	no subject			-
	110kV	Glanlee	S140	County Kerry	A1.46
Upland Forested	400kV	no subject			-
	220kV	Turlough Hill	S231	County Wicklow	A1.47
	110kV	Golagh Tee	S103	County Donegal	A1.48
Coastal Moorland	400kV	no subject			-
	220kV	no subject			-
	110kV	no subject			-
Coastal Estuary	400kV	Moneypoint	S442	County Clare	A1.49
	220kV	Prospect	S243	County Clare	A1.50
	110kV	Whitegate	S137	County Cork	A1.51
Coastal Plain	400kV	no subject			-
	220kV	no subject			-
	110kV	Mullagharlin	S115	County Louth	A1.52

Ideally, the series of viewpoints for each of the selected structures aimed to be along a transect or perpendicular line from the existing transmission project within each LCT. This was to allow accurate comparison of views across a range of known distances each with similar light conditions and context. However as the Study progressed it was not always possible to achieve this perpendicular transect ideal, primarily due to the significant constraint that access to private lands was not readily available and therefore the Study had to use publicly accessed roads as far as possible. The identification of viewpoints was adjusted to allow alternative suitable viewpoints to be selected during site survey as long at the alternative site was located at the same distance band. This resulted in sometimes several photographic views being selected and made available for some distance bands as alternatives and the most representative viewpoint was then selected for inclusion in the Study. This constraint has not affected the survey results and provided a broader range of viewpoints for consideration within the Study as a worst case.

Viewpoints were predominantly selected that were located to the south of the selected site, as far as possible, to maintain a similar and consistent view with the selected tower or substation highlighted by sunlight rather than appearing in shadow but again due to the constraints outlined above this ideal was not always achievable.

Efforts were made to select viewpoints that excluded major interfering man-made structures and natural screening features such as hedges and trees that would otherwise have prevented views. If necessary, gaps in hedgerows were sought to obtain a view. (Avoidance of hedges was obviously difficult as they are predominant in Irish rural landscapes.)

The location of all viewpoints for each of the selected 110kV, 220kV and 400kV towers are provided in Figures A1.1 to A1.30. The location of all viewpoints for the selected 110kV, 220kV and 400kV substations are provided in Figures A1.31 to A1.52 (refer to **Appendices G-L**).

3.5 WOODEN POLESETS

Following initial consideration, the Study excluded the use of 110kV wooden polesets for a number of reasons:

- wooden polesets were found to have very variable visual appearance in terms of side and front elevation, pole colour and thickness and this fact would limit the effectiveness of comparing effects across a range of sites when compared to the uniform design and appearance of steel towers

- wooden polesets were found to be less prominent than steel towers and readily read with existing vegetation/screening, leading to difficultly in identifying individual polesets at longer distances in the field (as confirmed by Bishop *et al* 1985)

- no comparable studies were found in the literature review that referred to wooden polesets, and

- wooden polesets were found to be read more as linear features and not as a single point impact as with towers.

3.6 FIELD STUDIES

Field studies took place in both summer and winter months for selected viewpoints, to ensure that the worst case scenario was assessed. As far as possible, all field studies were completed on days of good visibility.

The purpose of the field studies was to determine how the character of the landscape and elements within it effect visual prominence of transmission structures over a range of distances. Drawing from the University of Newcastle study (2002), it would not be too controversial to state that transmission towers are prominent at close distances and lack clear prominence at long distances. However, it is unclear how prominent transmission towers are within middle distances. This Study aimed to assess prominence over a range of distances that would permit identification of visual impacts across these middle distances by using a wide range of magnitude (Table 3.3) and visual sensitivity categories (Table 3.4). The Study also considered a range of modifying factors that influence prominence over distances. More details are provided (3.8) on the range of potential modifying factors attributable. Modifying factors were recorded for each viewpoint where relevant.

Selected viewpoints were visited in both summer and winter months and GIS grid co-ordinates, field of view, site observations, background/contrasts and description of impact (magnitude/prominence as per Table 3.3) were recorded for each viewpoint using an Assessment Sheet (refer to **Appendix E** for Example Assessment Sheet). At each viewpoint a photograph at a focal length of 50mm was taken in suitable weather conditions to represent the view obtained by the human eye so as to support findings, allow off-site review and analysis, and independent peer review.

The landscape character within each distance band up to 3.2km of each site was described and recorded on Assessment Sheets. The landscape sensitivity and magnitude of impact of the individual structure across the entire 3.2km study area was also recorded on Assessment Sheets.

With regards to visual impact, the visual characteristics of the existing view, proximity to residential properties, and prominence of the individual structure were all recorded on Assessment Sheets.

Following consideration of the effects established during field studies, the visual impact for each project concludes with the identification of actual visual impacts. A matrix of viewer sensitivities, magnitude of visual resource change and actual visual impact across a range of distances and LCTs has been set out. The findings have been illustrated by examples using high quality photographs and images (refer to **Appendices G-L**) and supported by detailed assessment using the completed Assessment Sheets (refer to **Appendix M**).

To assist in the assessment of the actual effectiveness of any mitigation measures aerial mapping of substations was prepared for use in the field (refer to **Appendix N**). The Study focused on 220kV substations for this exercise due to their scale and availability of representative sites and due to the fact that for transmission lines mitigation is effectively built-in through the use of best practice that avoids and reduces potential landscape and visual effects by identification of constraints such as residential areas and sensitive landscapes during the route selection process. The effectiveness of any mitigation measures at the selected 220kV substation sites was completed using a combination of the aerial photography, field studies and the results from the Studies viewpoint assessment.

A number of calibration tests were also completed in the field as described in Section 3.9.

3.7 PHOTOGRAPHY METHODOLOGY

In order to produce consistent photographic records of each selected viewpoint, the following methods were adhered to:

- Photographs were taken in weather conditions of clear visibility
- The same exposure is used for all the frames i.e. manual exposure is used to avoid the photographs having different exposures. Alternatively a camera with exposure lock with a carefully set exposure was used especially where wider panoramas are taken where a proportion of the panorama may be taken partially looking towards the sun (which can be a particular problem in early morning/late afternoon/wintertime)
- A 50mm lens was used in a 35 mm format (as recommended in GLVIA Landscape Institute - IEMA Guidelines, 2013; and Advice Note 01/11 Landscape Institute)
- A 50% overlap was taken between photos to allow the sides of each photo to be removed when splicing the photos together to minimise distortion
- Panoramas were produced by splicing standard photographs with recognised software (e.g., Adobe Photoshop) and not by the use of specialist cameras in order to minimise distortion
- A levelled tripod was used. In addition, the camera was also levelled using a spirit level that sits in the flash socket of an SLR camera. This ensured that the sea horizon was in the centre of the frame
- A very high quality camera lens was used, the Canon 5D full frame sensor camera
- When taking the photo the precise location was recorded using a hand held GPS. The orientation to the proposed development, approximate altitude (ground level), date, time of day and weather conditions were recorded for each viewpoint
- The height from ground to centre of camera lens was recorded

- If, when on site, the proposed viewpoint location was screened by trees or minor variations in topography, the viewpoint was relocated to try to obtain a direct view of the chosen tower structure and the new location details recorded
- Where possible, the tower site was positioned in the middle of the view with frames taken either side to give context
- Reference points were recorded with GPS locations or compass bearings, and
- To ensure all photos align all shots were taken from the same location/grid co-ordinate by turning the tripod on the same spot.

Photograph Presentation

Study photographs are illustrated as a series of figures (**Appendices G-L**). The general format for photographs is A3 landscape. The photography and presentations have been prepared in accordance with Advice Note 01/11 Landscape Institute, *Photography and Photomontage in Landscape and Visual Impact Assessment.*

Each viewpoint is presented on an A3 sheet showing the existing view with specific camera information and distances to the feature tower or substation site. The A3 format allows for a 75° field of view, which should be viewed at approximately 300 mm from the image. If the print is curved around the viewer to give a constant 300 mm distance it produces an accurate reproduction of how the viewer would perceive things on site.

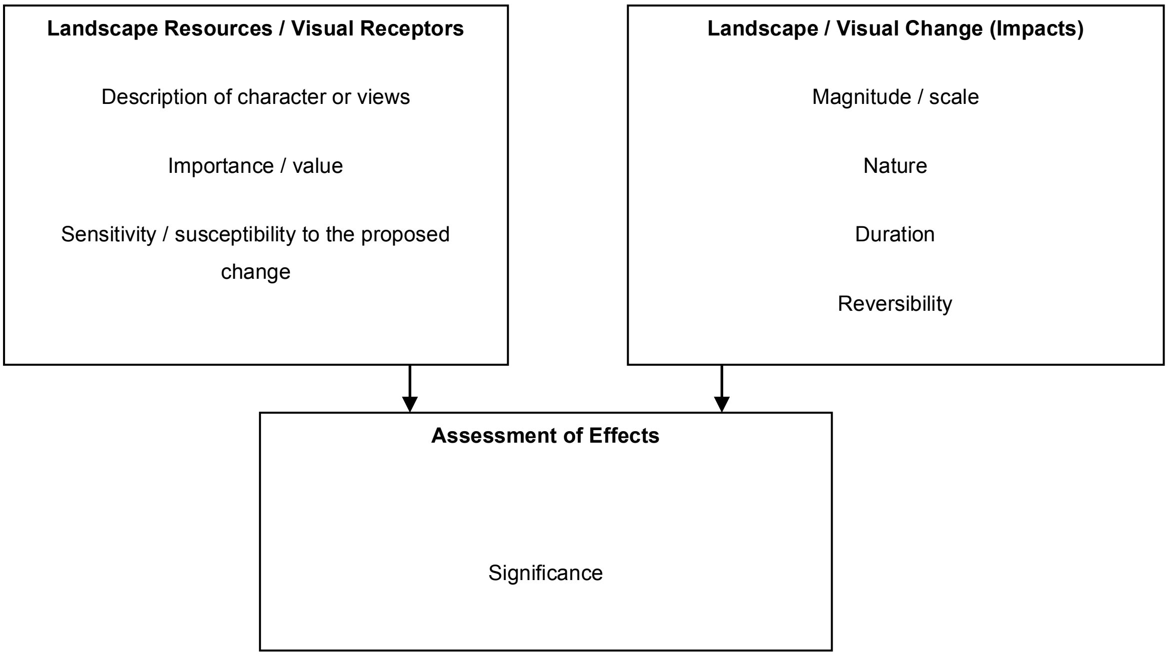
3.8 IMPACT ASSESSMENT

The Study began in 2012 using the GLVIA 2nd Edition (2002) but in April 2013, the GLVIA 3rd Edition was published and the Study's methodology was reviewed and updated as appropriate.

An assessment of the magnitude and extent of impact and the significance of any effects arising from the selected Study structures upon the landscape character and the existing visual environment has been undertaken and recorded using the Assessment Sheets (refer to **Appendix M**).

The effects on the landscape resources or visual receptors are assessed by considering the predicted change against the type of resource or receptor as summarised in Figure 3.5.

Figure 3.5 Summary of Methodology for Assessment of Landscape & Visual Effect (Adapted from GLVIA, 2013)



Magnitude of Landscape and Visual Impact

Direct impacts on the landscape character of each selected site are brought about by the introduction of the existing transmission line tower and its effects on the key landscape characteristics.

The magnitude of visual impact results from the scale of change in the view with respect to the loss or addition of features in the view and changes in the view composition, including proportion of the view occupied by the transmission line tower or substation. The categories and criteria used for magnitude of Landscape and Visual Impact are defined Table 3.4. Drawing from the findings of the literature review (University of Newcastle, 2002), a wide range of magnitude classes has been used to allow maximum potential for refinement of effects. This approach is consistent with GLVIA (2013). For completeness and to assist in identifying modifying factors the magnitude of visual impact was assessed for both summer and winter time views, (refer to **Appendix O**).

Table 3.4: Criteria for Magnitude of Landscape and Visual Impact

Magnitude	**Definition**	
	Landscape resource	***Visual resource***
Very Large	Total loss or addition of key elements/features/patterns of the baseline, i.e., pre-development landscape and/or introduction of dominant, uncharacteristic elements with the attributes of the receiving landscape.	Complete change in view dominant involving complete obstruction of existing view or complete change in character and composition of baseline, e.g., through removal of key elements. Tower commanding and controlling the view.

Large	Very substantial loss or addition of key elements/features/patterns of the baseline, i.e., pre-development landscape and/or introduction of prominent, uncharacteristic elements with the attributes of the receiving landscape.	Very substantial change in view prominent involving very substantial obstruction of existing view or change in character and composition of baseline, e.g., through removal of key elements. Tower standing out, striking, unmistakable and easily seen.
Medium	Partial loss or addition of or moderate alteration to one or more key elements/features/patterns of the baseline, i.e., pre-development landscape and/or introduction of elements that may be prominent, but may not necessarily be substantially uncharacteristic with the attributes of the receiving landscape.	Moderate change in view: which may involve partial obstruction of existing view or partial change in character and composition of baseline, i.e., pre-development view through the introduction of new elements or removal of existing elements. Change may be conspicuous, but would not substantially alter scale and character of the surroundings and the wider setting. Composition of the views would alter. Tower noticeable, distinct and catching the eye or attention.
Small	Minor loss or addition of or alteration to one or more key elements/features/patterns of the baseline, i.e., pre-development landscape and/or introduction of elements that may not be uncharacteristic with the surrounding landscape.	Minor change in baseline, i.e., pre-development view – change would be distinguishable from the surroundings whilst composition and character would be similar to the pre change circumstances. Tower visible or evident.
Negligible	Very minor loss or addition of or alteration to one or more key elements/features/patterns of the baseline, i.e., pre-development landscape and/or introduction of elements that are not uncharacteristic with the surrounding landscape approximating to a 'no-change' situation.	Very slight change in baseline, i.e., pre-development view – change barely distinguishable from the surroundings. Composition and character of view substantially unaltered. Tower not obvious, indistinct or unclear.
No change	No loss, alteration or addition to the receiving landscape resource.	No alteration to the existing view. Tower not read in the landscape.

Landscape and Visual Sensitivity

Landscape sensitivity is used to establish the capacity of the landscape to accommodate the type of development and is referred to in GLVIA (LI- IEMA, 2013) at paragraph 5.39, *"Landscape receptors need to be assessed firstly in terms of their sensitivity, combining judgements of their susceptibility to the type of change or development proposed and the value attached to the landscape."*

Viewer sensitivity is a combination of the sensitivity of the human receptor (i.e. resident, commuter, tourist, walker, recreationist, or worker) and the value or quality of view experienced by the viewer. The categories of landscape, and viewer sensitivity based on a five point scale (i.e. negligible, low, medium, high and very high) used in this assessment are provided in Table 3.5.

However, these tables can only illustrate general categories, as sensitivity is project specific, that is, how sensitive the resource or receptor is to the particular development type. Drawing from the findings of the literature review and research by the University of Newcastle (2002), a wide range of sensitivity categories has been used to allow maximum potential for refinement of predictions. This approach is consistent with the GLVIA (2013).

Table 3.5 Definition of terms relating to the Landscape and Visual sensitivity

Sensitivity	**Definition**	
	Landscape resource sensitivity	***Visual sensitivity***
Very High	Exceptional landscape quality, no or limited potential for substitution. Key features well known to the wider public. Nationally/internationally designated/valued landscape, or key elements or features of nationally/internationally designated landscapes. Little or no tolerance to change.	Views of remarkable scenic quality, of and within internationally designated landscapes or key features or elements of nationally designated landscapes that are well known to the wider public. Observers, drawn to a particular view, including those who have travelled from around Ireland and overseas to experience the views. Little or no tolerance to change.
High	Strong/distinctive landscape character; absence of landscape detractors. Regionally/nationally designated/valued countryside and landscape features. Low tolerance to change.	Views from residential property, public rights of way and nationally designated countryside/landscape features with public access and National Trails. Observers enjoying the countryside from their homes or pursuing quiet outdoor recreation are more sensitive to visual change. Low tolerance to change.

Medium	Some distinctive landscape characteristics; few landscape detractors. Locally/regionally designated/valued countryside and landscape features. Medium tolerance to change.	Views from local roads and routes crossing designated countryside/landscape features and 'access land', as well as promoted paths. Observers enjoying the countryside from vehicles on quiet/promoted routes are moderately sensitive to visual change. Medium tolerance to change.
Low	Absence of distinctive landscape characteristics; presence of landscape detractors. Undesignated countryside and landscape features. High tolerance to change.	Views from work places, main roads and undesignated countryside/landscape features. Observers in vehicles or people involved in frequent or frequently repeated activities are less sensitive to visual change. High tolerance to change.
Negligible	Absence of positive landscape characteristics. Significant presence of landscape detractors. Undesignated countryside and landscape features. High tolerance to change.	Views from within and of undesignated landscapes with significant presence of landscape detractors. Observers in vehicles or people involved in frequent or frequently repeated activities are less sensitive to visual change. High tolerance to change.

Significance of Landscape and Visual Effects

The significance of effects on landscape and visual amenity has been evaluated according to a six-point scale: substantial, major, moderate, slight, negligible or none. A description of the significance criteria is provided in Table 3.6.

Table 3.6 Definition of terms relating to the significance of criteria for Landscape and visual effects

Significance of effects	Landscape resource	Visual resource/amenity
None	Where proposals would not alter the landscape character of the area.	Where proposals would retain existing views.
Negligible	Where proposed changes would have an indiscernible effect on the character of an area.	Where proposed changes would have a barely noticeable effect on views/visual amenity.
Slight	Where proposed changes would be at slight variance with the character of an area.	Where proposed changes to views, although discernible, would only be at slight variance with the existing view.
Moderate	Where proposed changes would be noticeably out of scale or at odds with the character of an area.	Where proposed changes to views would be noticeably out of scale or at odds with the existing view.
Major	Where the proposed changes would be uncharacteristic and/or would significantly alter a valued aspect of (or a high quality) landscape.	Where the proposed changes would be uncharacteristic and/or would significantly alter a valued view or a view of high scenic quality.
Substantial	Where proposed changes would be uncharacteristic and/or would significantly alter a landscape of exceptional landscape quality e.g., internationally designated landscapes, or key elements known to the wider public of nationally designated landscapes - where there is no or limited potential for substitution.	Where proposed changes would be uncharacteristic and/or would significantly alter a view of remarkable scenic quality, within internationally designated landscapes or key features or elements of nationally designated landscapes that are well known to the wider public.

For the purposes of the Study, those effects indicated as being of substantial, major or substantial, and moderate or major significance, as shaded in Table 3.7 below, are all regarded as significant.

Table 3.7 Matrix used for assessment of significance of Landscape and Visual Effects

Magnitude of impact	**Sensitivity**				
	Negligible	***Low***	***Medium***	***High***	***Very High***
No change	None	None	None	None	None
Negligible	Negligible	Negligible or Slight	Negligible or Slight	Slight	Slight
Small	Negligible or Slight	Negligible or Slight	Slight	Slight or Moderate	Moderate or Major
Medium	Negligible or Slight	Slight	Moderate	Moderate or Major	Major or Substantial
Large	Slight	Slight or Moderate	Moderate or Major	Major or Substantial	Substantial
Very Large	Slight	Moderate or Major	Major or Substantial	Substantial	Substantial

3.9 PILOT STUDIES AND CALIBRATION TESTING

3.9.1 Pilot Studies

Prior to completion of the bulk of the field studies, 15% of the selected sites were used as pilot studies, with their findings subjected to external verification by the nominated Peer Reviewer. As part of this calibration test, examples of field survey notes on completed Assessment Sheets with determined magnitude/prominence and accurate A3 printed photographs for viewpoints were provided to assist with the verification process. It was intended that this calibration process would allow verification of the findings by suitably qualified and experienced professionals and lend weight overall to the independence and re-application of the findings included within the final report. The results of the calibration test were very good. Overall there was agreement with the predictions.

3.9.2 Further Calibration

Calibration exercises were completed to further test and confirm the overall results encountered by the Study and factors affecting the visibility of structures. In addition, the reliability of the increasing use of photomontages in the landscape and visual impact assessment of transmission line projects was tested.

To further test the Study findings, three 220kV towers, each located in a typical lowland, upland and coastal landscape, were selected as follows: typical lowland landscape (Appendix R: Figure A1.5 - Tower 25 between Arva Co. Cavan and Flagford Co. Roscommon), typical upland landscape

(Appendix R: Figure A1.20 - Tower 39 between Turlough Co. Wicklow to Dunstown west of Granabeg) and typical coastal landscape (Appendix R: Figure A1.27 - Tower 14 between Rafeen and East Co. Cork.) Each site was examined in further detail at a desktop level by use of a Zone of Visual Influence (ZVI) map and on site by use of a Windshield Survey to calibrate the Study results.

Finally, three completed transmission projects were selected for which photomontages were available from the planning application stage; to allow a verification exercise in the field for selected viewpoints, to compare predicted visibility in photomontages with actual visibility post construction.

Taken together these three calibration techniques served to facilitate examination and discussion of the opportunities and limitations of the technical approaches used for the assessment of landscape and visual impacts and helped to provide a context for the application of the results of the surveys contained in the Study.

Zone of Theoretical Visibility Mapping (ZTV)

A Zone of Theoretical Visibility (ZTV) map – often also referred to as a Zone of Visual Influence (ZVI) map - was prepared for each of the selected structures named above. The ZTV map demonstrates the extent of the area from which the structure could be visible, without consideration of minor topography changes (<10m) or existing vegetation cover or buildings, using Ordnance Survey of Ireland (OSI) Digital Terrain Measurements (DTM). These are input to a terrain modelling software package along with the grid co-ordinates and total height of the three selected towers.

Such ZTV maps are theoretical because they are based on topography only. The prepared ZTV maps provide a useful reference point because such ZTV maps are frequently cited as part of LVIAs at EIS stage. The Study provides an opportunity to calibrate this theoretical visibility over a wide area with two further factors, namely the actual visibility resultant from obscuring micro-topography, walls, buildings, field boundaries and vegetation (as evidenced from the 'Windshield Survey' below), as well as the degree of visual dominance due to the effects of *distance decay,* as recorded by the site survey and assessment and illustrated by the accompanying photography. The results are described further in the Study.

Windshield Survey

By a process of field survey and on site appraisal within the predicted computer modelled ZTV map, the actual visibility of the three selected structures (rather than the theoretical visibility in the ZTV map), within each typical landscape was recorded from all points along public roads within 3.2km. This allowed comparison with the modelled ZTV map and visibility was illustrated by colour coding the roads as red (structure visible or partially visible) and yellow (structure not visible). The purpose of this calibration was to demonstrate the proportion of the overall potential publicly available viewing points from where the structures are actually visible and to compare with the selected viewpoints – having regard to the site selection criteria, as previously referred to in the Study.

Photomontage Calibration

Photomontages that show computer generated simulations of the likely appearance of proposed transmission line infrastructure are now frequently used in the assessment of landscape and visual impact. Photomontages are prepared by superimposing, on a photograph of the existing landscape, a realistically rendered computer-generated image of the proposed development using appropriate software packages. Best practice guidance for preparation of photomontages has been issued by the UK Landscape Institute (Landscape Institute, 2011). The Irish Planning Institute (IPI) is preparing guidance for Planning Authorities and An Bord Pleanála that will identify strengths and weaknesses of methodologies used for visual impact assessment and will discuss the preparation of photomontages.

The Study provided an opportunity to calibrate the reliability of the photomontages by comparing previously prepared photomontages with photography obtained of the same transmission infrastructure completed in the field. Three completed transmission line projects were selected for which suitable photomontages were available from the original EIS. The three selected schemes were Donegal 110kV Reinforcement Project, Flagford to Srananagh 220kV Project and Dalton to Galway 110kV (including Double Circuit line). For each project, four sample photomontage viewpoints were selected (refer to **Appendix R**). The grid co-ordinates for viewpoint locations were established and a site survey was completed to take a photograph similar to the photomontage image at each viewpoint.

Section 4.0 contains examples of views before the structure was built, the photomontage used during the impact assessment and the appearance of the transmission line infrastructure following completion of construction. The original prediction of visual impacts was also reassessed to establish how the post-construction effects compared with those in the original EIS.

4 SURVEY RESULTS

4.1 OVERVIEW

Site survey and detailed site assessment was completed for a total of 30 tower sites and 21 substation sites for a range of 110kV, 220kV and 400kV transmission infrastructure projects located across Ireland. This work involved extensive field survey and subsequent detailed assessment of up to 612 photographs (for both winter and summer views) that were taken from a total of 306 discrete viewpoints across landscapes in Ireland.

Following site survey during summer and winter months, all photography was collated and presented using the methodology described in Sections 3.6 and 3.7. The overall location of all selected Study transmission sites and the selected viewpoints within each distance band are provided in Figure 3.2 – 110kV sites; Figure 3.3 – 220kV sites; and Figure 3.4 – 400kV sites (refer to **Appendices G-L**). The summer and winter photographs for each distance band viewpoint, as well as viewpoint location maps for each site, are also presented in the Appendices.

Detailed LVIA was carried out using the collated photography and impacts were identified in accordance with the methodology described in Section 3.8. 110kV and 220kV structures have been examined in as many types of landscape in Ireland as possible and the results are presented below.

Because there are fewer 400kV lines present in Ireland these lines were found to pass through a low number of the Study landscape character types (LCTs). In total only 9 suitable 400kV tower sites were found for the 12 Study LCTs. The analysis of results has sought to reflect this low basis to avoid skewing the results and to attempt to lend more weight to the findings of the Study by focusing on the findings from 110kV and 220kV sites where necessary as well as only collating and comparing results for 400kV sites located in the same landscape types as the 110kV and 220kV sites.

Similarly, the Study's aim of identifying suitable substation sites across all 12 landscape types also proved difficult. Due to the small number of 400kV substations in Ireland located within the range of Study landscape types, it was not possible to include the results from assessment of 400kV substations in analysis with 110kV and 220kV substation results. However, the results for all substations are presented for consistency and to allow for potential future reference by any further studies that may occur.

The Study found difficulty in locating suitable viewpoint sites at the 100m distance band from selected towers and substations due to the frequent presence of private land at close quarters to the chosen sites that prevented access. The analysis of the results below has sought to adjust for this occurrence.

4.2 FINDINGS

4.2.1 Study Results for 110kV, 220kV and 400kV Tower sites

A detailed LVIA was completed for each of the 30 tower sites listed in Table 3.2 and the results were recorded on individual Assessment Sheets for each site using the template in **Appendix M**.

The results from the detailed assessment of towers are summarised for the 110kV, 220kV and 400kV tower sites in **Appendix P** (Tables 4.1A, 4.2A & 4.3A) in terms of viewer sensitivity; magnitude of change in winter/summer; prominence; and overall effect for each landscape character type. The findings set out in the summary tables in **Appendix P** should be read with the viewpoints for all selected sites provided in the **Appendices G-L**.

4.2.2 Analysis of Results of Visual Effects for 100kV, 200kV and 400kV Tower sites

The LVIA of the selected towers focused on the selected individual towers only during the assessment and not on any of the adjacent towers or lines to allow the evidence for the landscape and visual effect of the tower alone to be established to allow potential for comparisons to be made with Bishop *et a*l (1985).

Detailed statistical analysis of the Study results for the selected tower sites as set out in the Appendices has been limited due to the available number of sample sites. However, it has been possible to analyse the results to try to seek out any obvious trends and also to try to test results against the Study objectives. Tables 4.1 - 4.3 below provide an overall summary of the results for the assessment of significance of visual effect for all the Study's 110kV, 220kV and 400kV tower sites.

Table 4.1 Overall Summary of the Results for the Assessment of Significance of Visual Effect for 110kV Towers

	100m	200m	400m	800m	1600m	3200m
No Change	0	0	1	4	9	11
Negligible	0	0	0	0	0	0
Negligible / Slight	0	0	0	0	0	0
Slight	0	0	5	3	2	0
Slight / Moderate	0	1	1	4	0	0
Moderate	0	1	0	0	0	0
Moderate / Major	0	1	2	0	0	0
Major	0	0	0	0	0	0
Major / Substantial	0	3	2	0	0	0
Substantial	5	3	0	0	0	0
Total	5	9	11	11	11	11

Table 4.1 illustrates the Study findings for the assessment of 110kV towers that found that *no* significant effects occurred beyond a distance of 400m from the towers. This result is based on 11

110kV tower sites. The majority of significant effects were found to occur within 200m of the towers. Between 800m and 1600m low levels of effect were found (i.e. slight/moderate and slight). Beyond 1600m all sites were found to be no change.

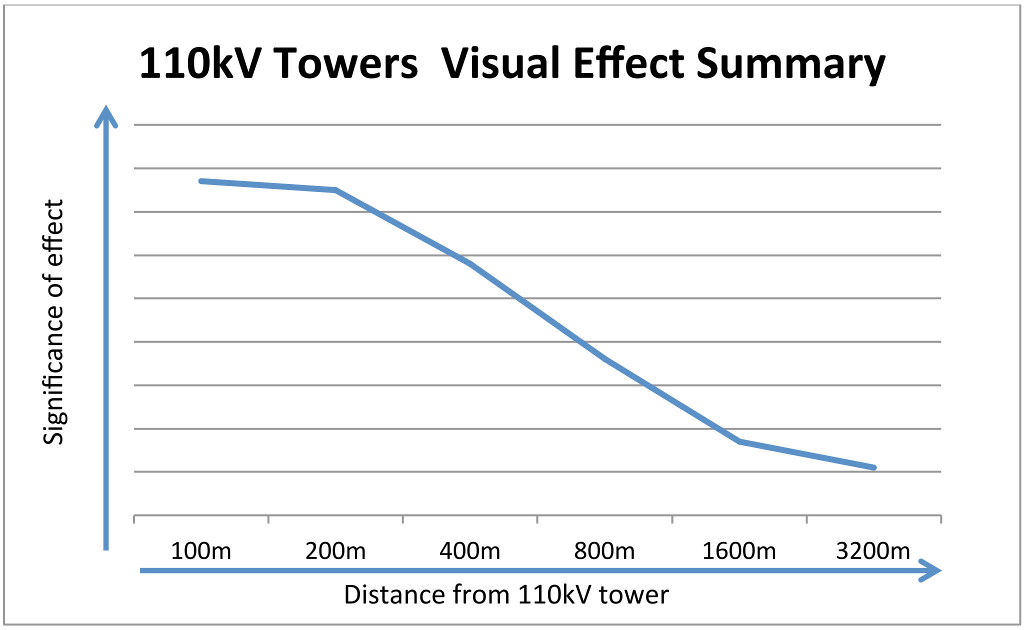


Figure 4.1 Weighted significance of visual effect compared with distance from 110kV towers

The results of the assessment of significant visual effects for all 110kV towers were weighted using a weighting of 0 for No Change (to discount views with no change), up to a weighting of 9 for Substantial. The Study found that it was difficult to find suitable viewpoints at 100m distance from towers and substations as these were frequently located within private lands.

In Figure 4.1 to address the low availability of viewpoints within 100m, it has been assumed that the same numbers of viewpoints at 200m are available at 100m and that the effects are as at least as significant at 100m as they are at 200m. This assumption is reasonable given the proximity to the structure at a distance of 100m. This adjustment makes the graph more representative of the actual significance of effect with distance from the towers. Figure 4.1 illustrates graphically a peak in significant effect at the 200m distance band and the rapid decrease in significance of effects with increased distance from the tower sites that compares well to the findings of Bishop *et a*l (1985) and Bishop and Hull (1988).

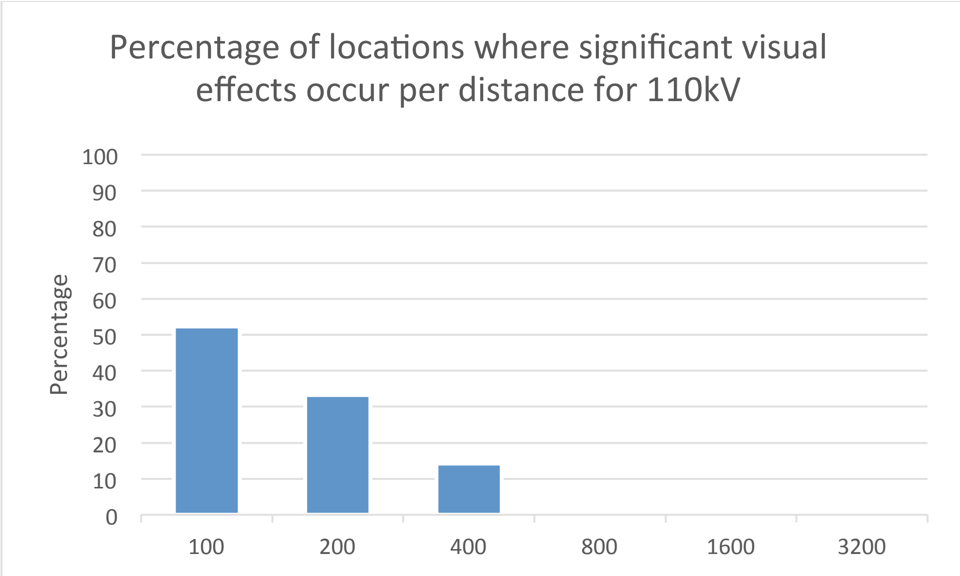


Figure 4.2 Percentage of locations where significant visual effects occur per distance band for 110kV towers

When the percentage of locations where significant visual effects occur per distance band are considered for 110kV towers (Figure 4.2) the effect of distance decay described by Bishop and Hull is well illustrated, with the most significant visual effects being found at close distances to the towers and no significant effects beyond 400m from towers. It would be anticipated that with a greater number of sample sites that this key finding of the Study would simply be strengthened and therefore correlate further with the findings of Bishop *et al* (1985) and Bishop and Hull (1988), in which most effects occurred within 500m.

Table 4.2 Overall Summary of the Results for the Assessment of Significance of Visual Effect for 220kV Towers

	100m	200m	400m	800m	1600m	3200m
No Change	0	0	4	3	5	10
Negligible	0	0	0	0	1	1
Negligible / Slight	0	0	0	0	1	0
Slight	0	1	0	1	2	0
Slight / Moderate	0	0	0	3	2	0
Moderate	0	1	2	0	0	0
Moderate / Major	0	2	3	2	0	0
Major	0	0	0	0	0	0
Major / Substantial	2	2	1	0	0	0
Substantial	1	2	1	0	0	0
Total	3	8	11	9	11	11

With regards to 220kV towers the Study results summarised in Table 4.2 show that no significant visual effects occur beyond 800m of the selected towers. The majority of significant effects were found to occur within 400m of the 220kV towers with only 2 viewpoint sites found to be significant beyond 400m, compared to 14 viewpoint sites within 400m. This result is based on the assessment of ten 220kV tower sites within the Studies 12 LCTs.

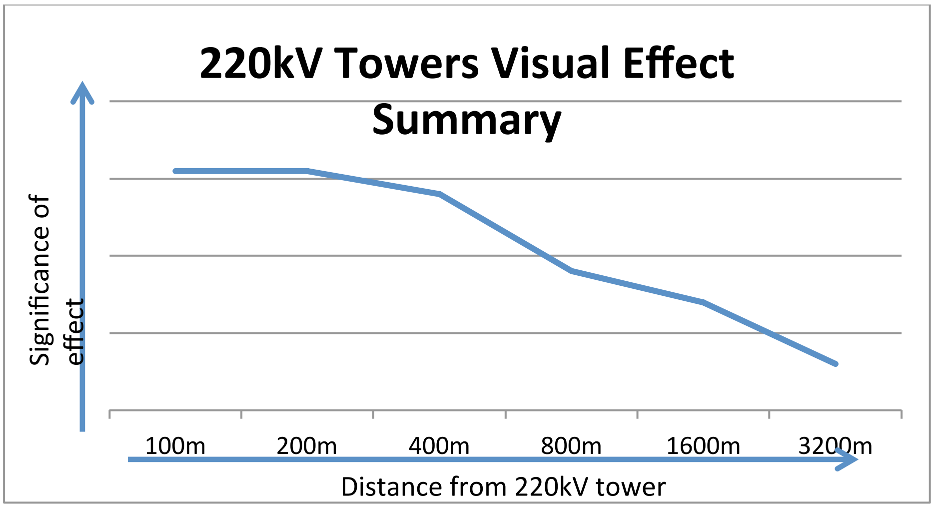


Figure 4.3 Weighted significance of visual effect compared with distance from 220kV towers

As with the analysis of the results for 110kV towers, to address the lower availability of viewpoints within 100m than at the 200m distance, it has been assumed that the same numbers of viewpoints at 200m are available as at 100m and that the effects are as at least significant at 100m as they are at 200m. Figure 4.3 concurs with the analysis of results for 110kV tower sites by illustrating that when the weighted significance of effects is compared with distance from the 220kV towers there is a peak in significant visual effects between 200 – 400m and a decline in effect within 800m to 3200m distances. The increased distance for significant effects for 220kV towers when compared to 110kV towers is to be reasonably expected due to the increase in scale of 220kV towers.

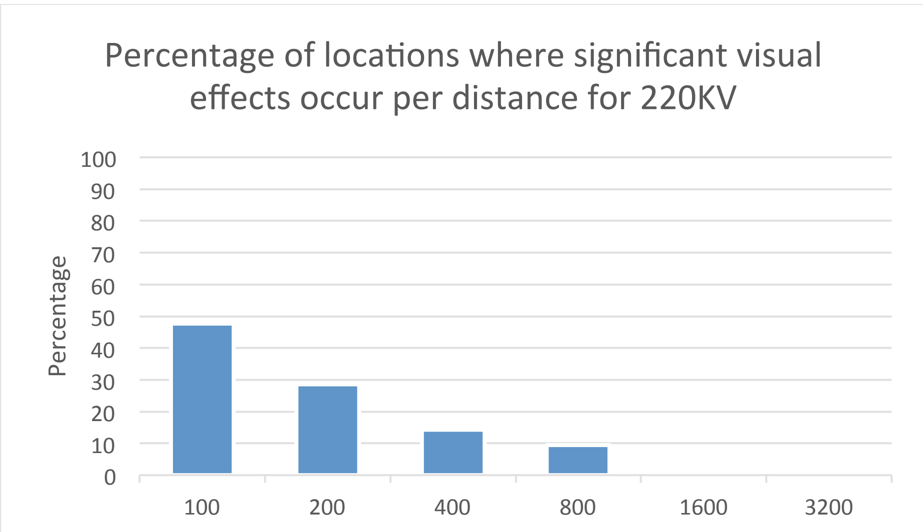


Figure 4.4 Percentage of locations where significant visual effects occur per distance band for 220kV towers

Analysing the results for 220kV towers further by considering the percentage of locations where significant visual effects occur per distance for 220kV towers (Figure 4.4), it is noticeable that there is a spread of significant visual effect up to 800m and that no significant effects occur beyond this distance.

Table 4.3 Overall Summary of the Results for the Assessment of Significance of Visual Effect for 400kV Towers

	100m	200m	400m	800m	1600m	3200m
No Change	0	0	0	4	6	9
Negligible	0	0	0	0	0	0
Negligible / Slight	0	0	2	2	1	0
Slight	0	0	0	2	1	0
Slight / Moderate	0	1	1	2	1	0
Moderate	0	0	2	0	0	0
Moderate / Major	0	3	0	0	0	0
Major	0	0	0	0	0	0
Major / Substantial	2	1	2	0	0	0
Substantial	3	4	2	0	0	0
Total	5	9	9	10	9	9

The Study results summarised in Table 4.3 for 400 kV towers indicate that *all* significant visual effects occur within 400m. *No* sites were found to have significant effects beyond 400m. Lower levels of effects (i.e. slight/moderate and slight) were found between 800m to 1600m. Beyond 1600m all sites were found to be no change. The Study results for 400kV towers are based on a total of 9 tower sites at 12 of the Study's LCTs that may have influenced the limit of effects to 400m.

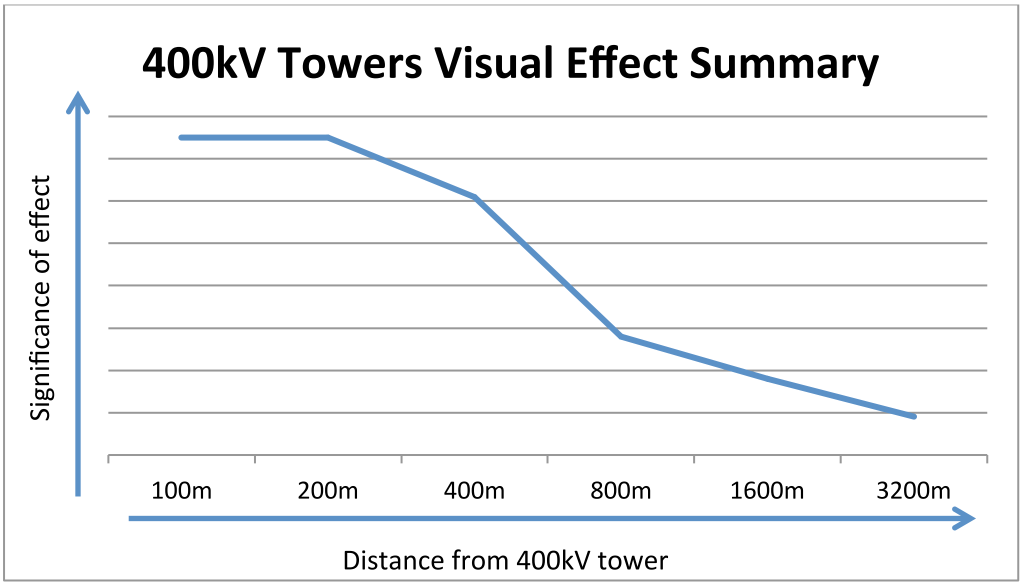


Figure 4.5 Weighted significance of visual effect compared with distance from 400kV towers

Making the adjustment for the low number of 100m viewpoints and calculating the weighted significance of visual effect for 400kV towers compared to distance (Figure 4.5), it has been established that there is a decline in significance of effect between 400m to 3200m. Despite the low number of 400kV sample sites within the Study landscape types, the results show a high level of consistency with the findings for 110kV and 220kV towers, and a broadening of the significance of effects across the distance bands which has been well illustrated in Figure 4.6 below. Analysis of a greater number of 400kV tower sites would be required to strengthen the Study findings and if this were to take place it is anticipated that significant effects would be found to extend beyond the 400m distance band to 800m and therefore be consistent with the findings for 220kV towers.

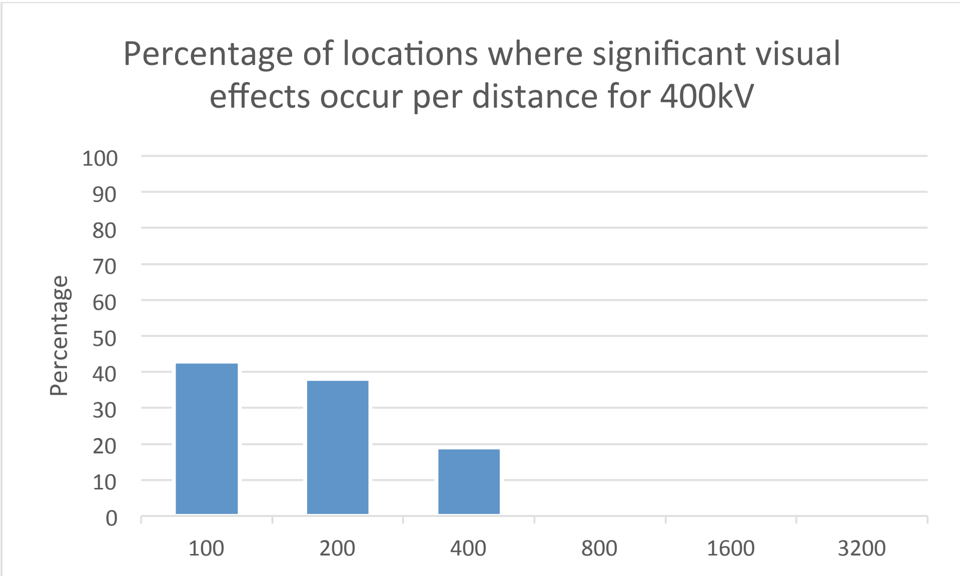


Figure 4.6 Percentage of locations where significant visual effects occur per distance band for 400kV towers

4.2.3 Analysis of Results of Visual Effects per Landscape Character Type for 110kV, 220kV and 400kV Tower sites

Analysis of the results for each structure type within the Study LCTs was completed to establish if there was a relationship between LCT and the ability to visually absorb towers. For consistency, only landscape types that the Study found suitable viewpoints across all of the 200m to 3200m distance bands were included in the analysis and therefore Coastal Plain and Open Upland Rocky landscapes were excluded, as there was found to be no suitable 400kV structures in these landscapes. To achieve a comparison between landscapes, the effects for 110kV, 220kV and 400kV across 200m to 3200m were scored 0 (*no change*), to 9 (*substantial effect*). The combined total score for each structure within each landscape was then calculated and the results illustrated (Figure 4.7).

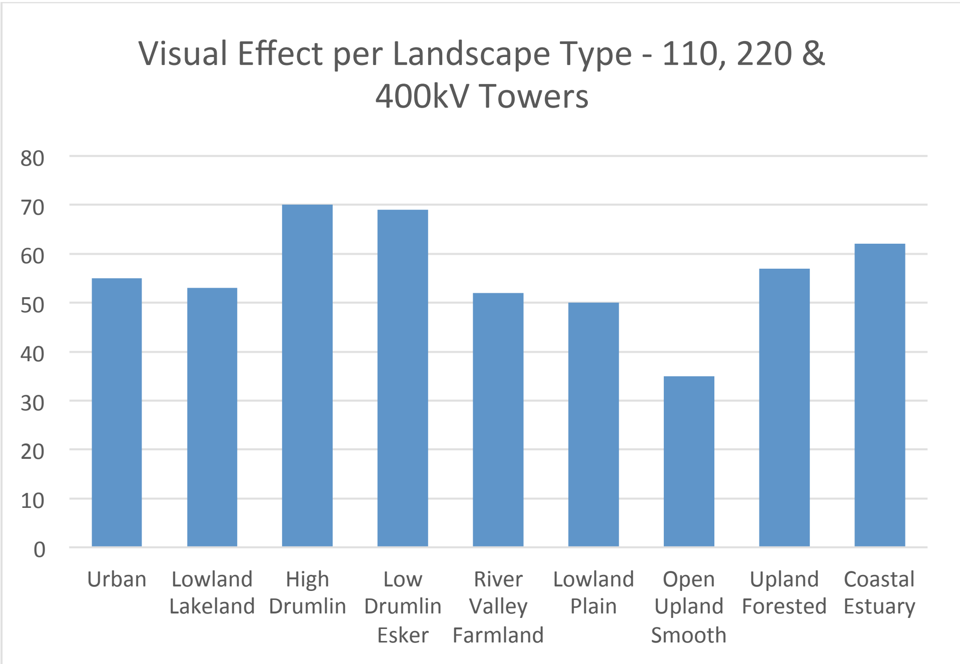


Figure 4.7 Overall Visual Effect per Landscape Type – 110kV, 220kV and 400kV Towers combined

When the visual effects across each structure type are combined per landscape type, the Study results show that the lowest visual effects are found within urban, lowland lakeland, river valley farmland, lowland plain and upland forested landscapes. The majority of the sites with lowest visual effects were found to be lowland agricultural landscape types. The highest visual effects were found within high drumlin and low drumlin esker landscapes.

Such findings show a generally good consistency with the known characteristics of each LCT that have been previously defined in the Study (also refer to Appendices). The results for open upland smooth landscape are not consistent with the findings for the other landscape types assessed and are lower than would be expected due to the presence of forestry at the sample sites. The Study results appear to indicate that lowland agricultural type landscapes will more readily absorb structures. The reasons for this finding result from a number of apparent factors that include less potential for skylining and an increased frequency of screening from hedgerows, shrubs and trees which interrupt views. Higher and more open landscapes (High Drumlin and Coastal Estuary) clearly have less potential to benefit from these modifying factors that decrease magnitude and prominence.

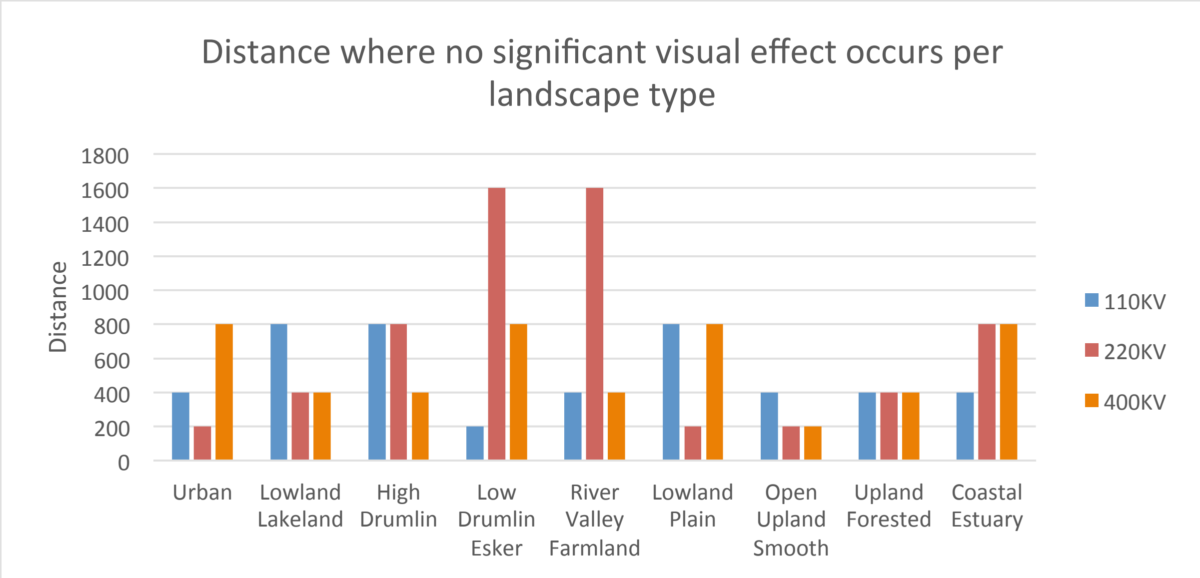


Figure 4.8 Distance where no significant visual effect occurs for towers per landscape type

When significant visual effects for each tower type are analysed per Study landscape type, it would have been expected that there was an obvious trend with lower effects for 110kV towers increasing with 220kV and 400kV proportionately. This was not found to be the case (Figure 4.8) with all landscape types. However, there is an indication that such a trend would be shown more convincingly with a greater sample base. Upland forestry shows a good consistency of results that indicates how forestry can screen towers quickly in an enclosed landscape.

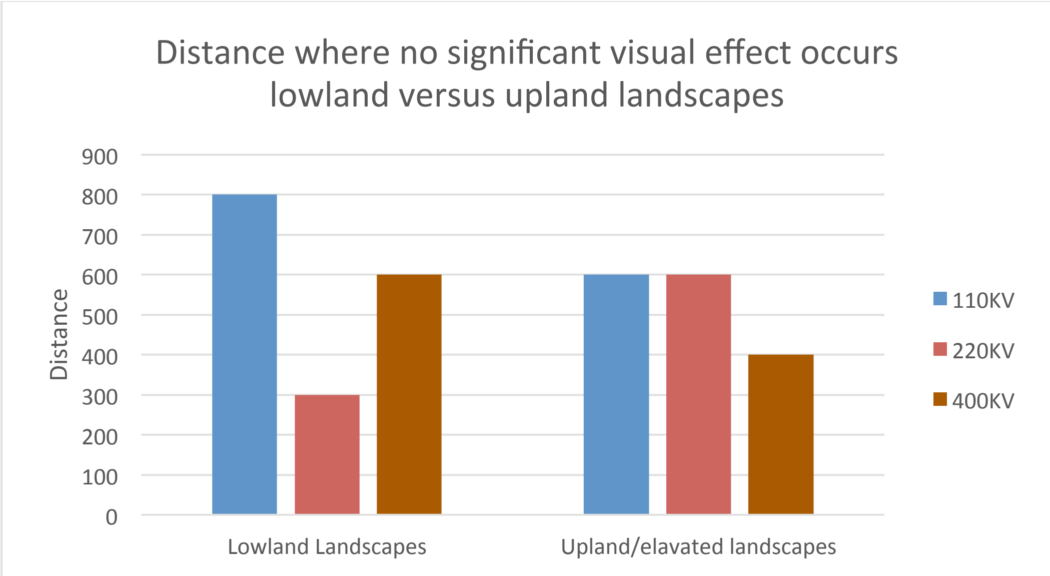


Figure 4.9 Distance where no significant visual effect occurs for towers for lowland and upland landscape types

Looking at all lowland landscape types in the Study, against all upland or elevated landscape types, per tower type, by averaging the distances where significant effects occur, it was *not* possible to draw satisfactory conclusions with regards to comparisons of upland and lowland landscape types beyond strengthening the findings already established; that *significant visual effects do not occur beyond 600 to 800m from towers* and this therefore suggests that Irish landscapes have the capacity to absorb towers at distances beyond the 800m distance band.

4.2.4 Study Results for 110kV, 220kV and 400kV Substation sites

A detailed LVIA was completed for each of the selected 21 substation sites listed in Table 3.3 and the results were recorded on individual Assessment Sheets for each site using the template in **Appendix E**. All completed assessment sheets for 110kV, 220kV and 400kV substations included in the Study have been provided in **Appendix M**. The results are also summarised for 110kV, 220kV and 400kV substation sites in terms of viewer sensitivity; magnitude of change in winter/summer; prominence; and overall effect for each LCT (Tables 4.8A, 4.9A & 4.10A). The findings set out in **Appendices P & Q** should be read with the viewpoints for all selected sites provided also in the **Appendices (G-L).**

4.2.5 Analysis of Results of Visual Effects for 110kV, 220kV and 400kV Substation sites

As with the LVIA of towers, the assessment of the selected substation sites only focused on the infrastructure within the substation compound during the assessment and not on any of the adjacent towers or lines outside the compound, to allow the evidence for the landscape and visual effect of the substation alone to be established and in a similar method to that used by Bishop *et a*l (1985). Tables

4.4 - 4.6 below provide an overall summary of the significance of visual effect for 110kV, 220kV and 400kV substations, as set out in Tables 4.8A to 4.10A in **Appendix P**.

Table 4.4 Overall Summary of Significance of Visual Effect for 110kV Substations

	100m	200m	400m	800m	1600m	3200m
No Change		2	4	3	11	11
Negligible						
Negligible / Slight			1			
Slight			2	4		
Slight / Moderate			2	2		
Moderate						
Moderate / Major		2	1	1		
Major						
Major / Substantial		2		1		
Substantial	3					
Total	3	6	10	11	11	11

The Study found that for 110kV substations, there were no sites with significant visual effects beyond 800m. The majority (80%) of significant visual effects occurred within 400m with only two viewpoint sites found to have significant effects up to 800m for the selected substation sites. Beyond a distance of 800m all viewpoints were found to have no visual change in effect. This result is based on the assessment of eleven 110kV substation sites within the Study's LCTs across Ireland.

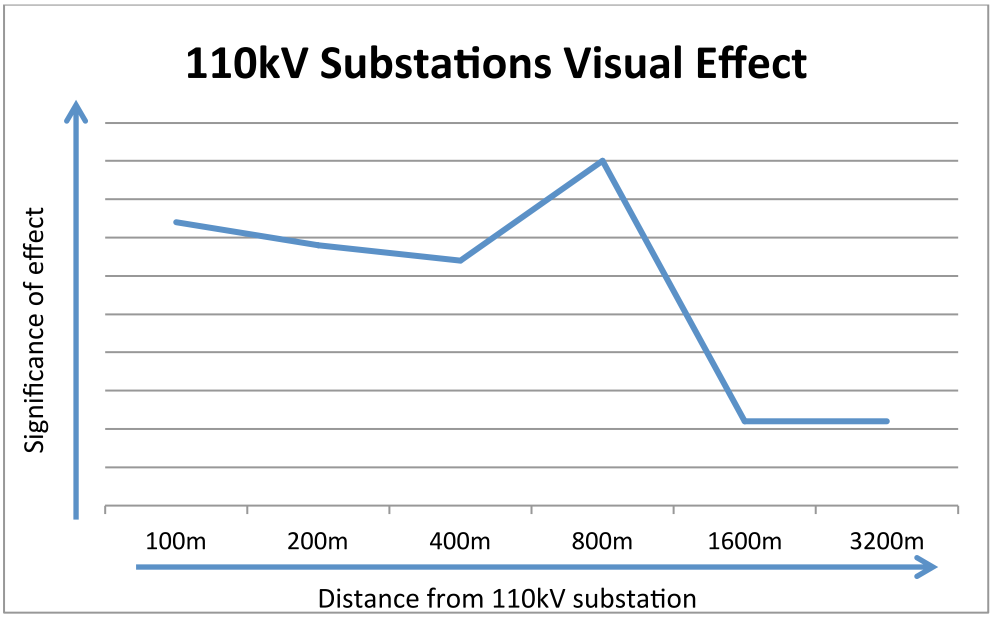


Figure 4.10 Weighted significance of visual effect compared with distance from 110kV substations

Table 4.5 Overall Summary of Significance of Visual Effect for 220kV Substations

	100m	200m	400m	800m	1600m	3200m
No Change		1	1	2	6	8
Negligible						
Negligible / Slight						
Slight			3	2	1	
Slight / Moderate			1	2	1	
Moderate						
Moderate / Major		2	2	2		
Major		1				
Major / Substantial	4	2				
Substantial		2	1			
Total	4	8	8	8	8	8

For 220kV substation sites the Study found that there were no sites with significant visual effects beyond 800m. The majority (87.5%) of significant visual effects occurred up to 400m and only 2 viewpoint sites out of 16 had significant effects between 400m to 800m from the selected substation sites. Lower levels of visual effect (i.e. slight/moderate and slight) were found between 800m and 1600m and beyond 600m no *change* in visual resource occurred for all selected sites. This result is based on the assessment of eight 220kV substation sites.

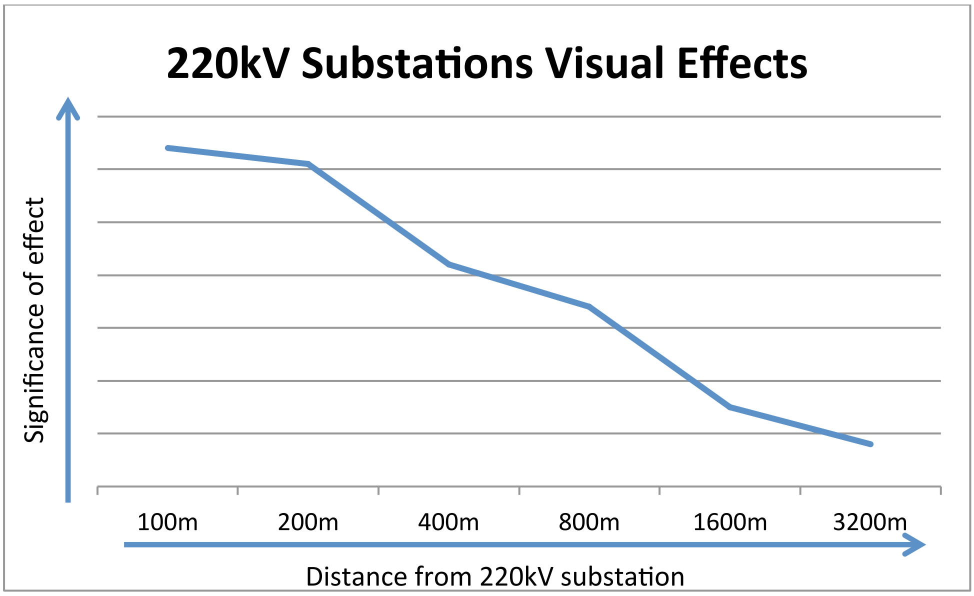


Figure 4.11 Weighted significance of visual effect compared with distance from 220kV substations

Table 4.6 Overall Summary of Significance of Visual Effect for 400kV Substations

	100m	200m	400m	800m	1600m	3200m
No Change				2	3	3
Negligible						
Negligible / Slight						
Slight						
Slight / Moderate						
Moderate						
Moderate / Major			2	1		
Major						
Major / Substantial			1			
Substantial						
Total	0	0	3	3	3	3

With regard to 400kV substations, the Study found that no significant visual effects occurred beyond 800m from the selected sites. Beyond the distance band of 800m, all sites were recorded as no change in visual resource. As previously mentioned there are a low number of 400kV substations in Ireland, particularly when compared to the spread of 110kV substations. This resulted in a low number of suitable sites for the Study and the results in Table 4.6 are based on only 3 sites. However, it is interesting to see how the graph in Figure 4.12 displays a greater spread of significant effect than for the previous graphs for towers and substations (110kV and 220kV), suggesting that, as would be expected, the larger 400kV substations have greater visual effects at closer distances than 110kV and 220kV substations.

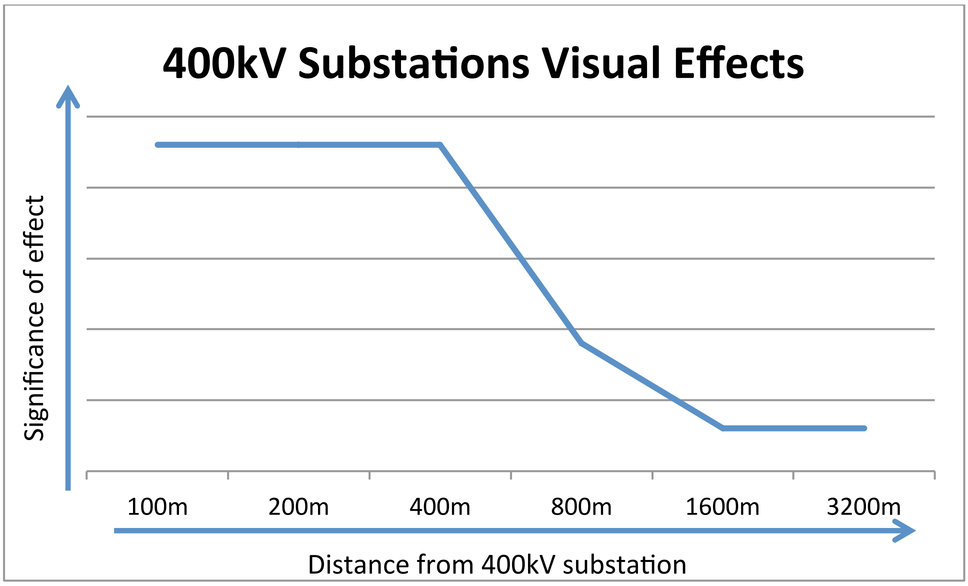


Figure 4.12 Weighted significance of effect compared with distance from 400kV substations

4.2.6 Analysis of Results of Visual Effects per Landscape Type for 110kV, 220kV and 400kV Substation sites

Assessment of the results for selected substations within each LCT as set out in the **Appendix P** (Tables 4.8A, 4.9A & 4.10A) was completed to investigate if it was possible to establish a relationship between each LCT and their ability to absorb the substations. For consistency, the results have focused on the findings for 110kV and 220kV substations because there were only three suitable sites found in the identified landscape types for 400kV substations. In addition, only directly comparable landscapes with suitable sites for 110kV and 220kV substations were reviewed and therefore Coastal Plain, Coastal Moorland, Open Upland Smooth and Open Upland Rocky landscapes were excluded from further analysis and comparisons. To achieve a comparison between landscapes, the effects for 110kV and 220kV substation sites across 200m to 3200m were scored 1 (no change) to 10 (substantial effect). 400kV substations were omitted due to the small number of available survey sites. The combined total score for each substation within each landscape type was calculated and the results illustrated (Figure 4.13).

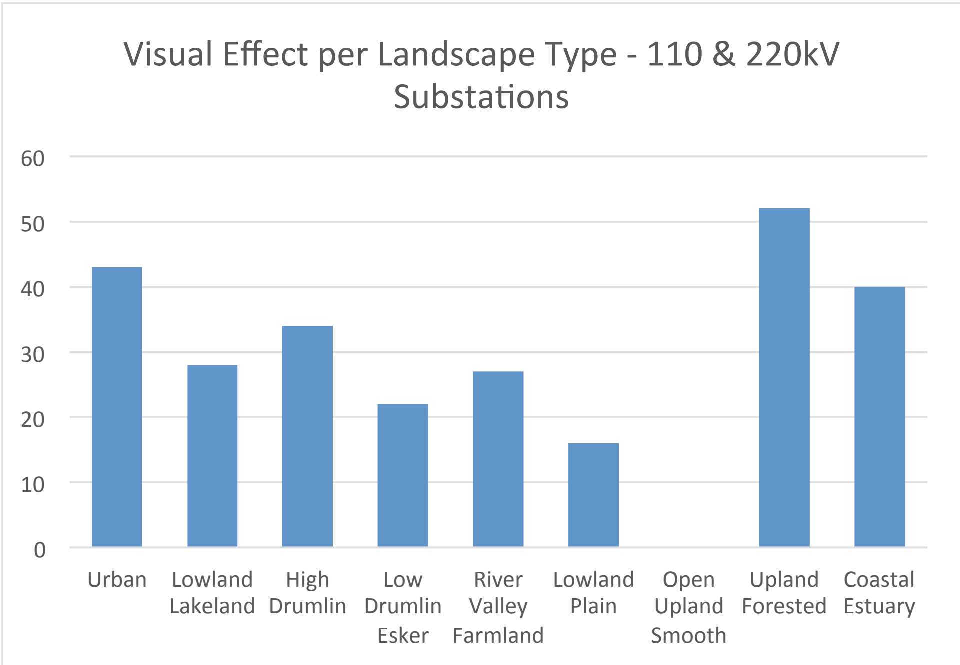


Figure 4.13 Overall Visual Effect per Landscape – 110kV and 220kV Substations

The result of the assessment of visual effect for suitable substation sites is based on sixteen substations across eight of the Study LCTs. The lowest degree of visual effect was found to be within Lowland Lakeland, Low Drumlin/Esker, River Valley Farmland and Lowland Plain. The results indicate that lowland agricultural landscapes absorb substations more effectively than higher elevated and open landscapes (i.e. Coastal Estuary) but more sample sites would be required to strengthen this conclusion. The high result for Upland Forested landscape was due to the sample sites not having sufficient forest cover at the time of the site surveys.

4.2.7 Overall summary of Landscape Effects for 110kV, 220kV and 400kV Tower Sites

The landscape effects of each selected tower (110kV, 220kV and 400kV) were established by site appraisal and review of the viewpoint photography across each of the Study distance bands. The landscape assessment examined the magnitude of change in landscape resource over 100m, 200m, 400m, 800m, 1600m and 3200m radii from each tower. The assessment focused on the individual tower and the adjacent towers of transmission line to allow comparison with Bishop *et al* (1985). The results of the full landscape assessments are provided in detail in the completed Assessment Sheets in **Appendix M**.

Tables 4.7 - 4.9 below provide an overall summary of the results for the assessment of significance of landscape effect for all the 110kV, 220kV and 400kV tower sites as extracted from completed Assessment Sheets.

	100m	200m	400m	800m	1600m	3200m
No Change	0	0	0	0	3	11
Negligible	0	0	0	0	0	0
Negligible / Slight	0	0	0	1	4	0
Slight	0	1	2	8	4	0
Slight / Moderate	0	0	0	1	0	0
Moderate	0	0	3	1	0	0
Moderate / Major	2	5	3	0	0	0
Major	0	0	0	0	0	0
Major / Substantial	4	2	3	0	0	0
Substantial	5	3	0	0	0	0
Total	11	11	11	11	11	11

Table 4.7 Overall Summary of Significant Landscape Effects for 110kV Towers

Table 4.7 illustrates the Study findings for the landscape assessment of 110kV towers where it was found that no significant landscape effects occurred beyond a distance of 400m from the tower sites based on 11 110kV tower sites. Slightly elevated effects were identified at 800m and it would be of interest to examine in any future study if it was possible to refine the distance between 400m and 800m where no significant landscape effects would occur, with Bishop *et al* (1985) finding that 90% of all significant effects occurred within 500m. Between 1600m and 3200m from the selected tower sites, low levels of landscape effect were found to occur.

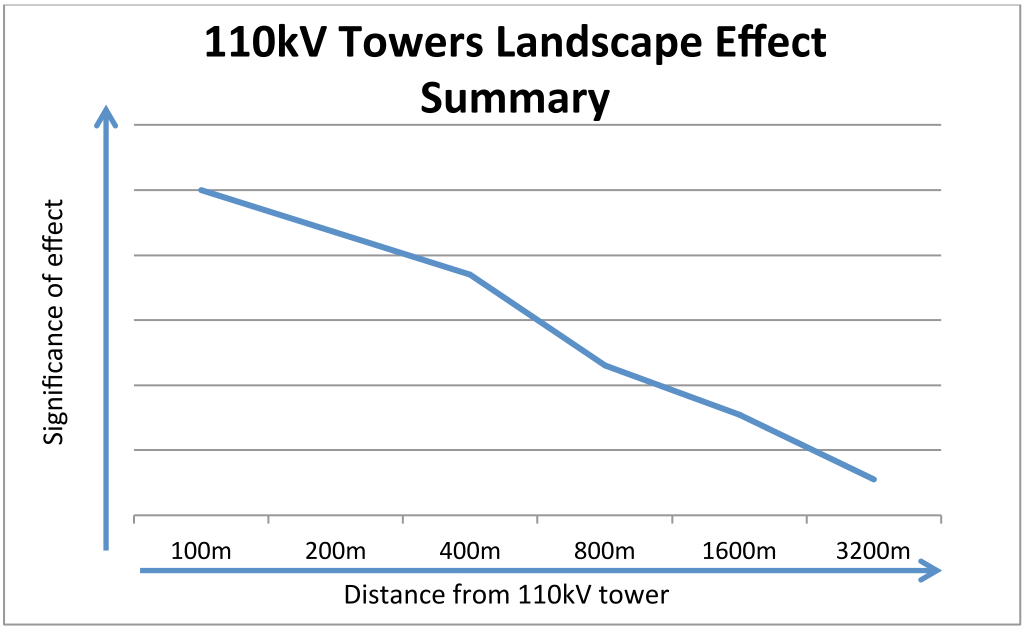


Figure 4.14 Weighted significance of landscape effect compared with distance from 110kV Towers

The results of the assessment of significant landscape effects for all 110kV towers were weighted using a weighting of 1 for No Change, up to a weighting of 10 for Substantial. Figure 4.14 illustrates graphically how there is a rapid decrease in the significance of landscape effects with increased distance from the 110kV tower sites, indicating how the wider landscape can absorb towers. Further analysis for different landscape types has been completed and presented in Figure 4.17 below.

	100m	200m	400m	800m	1600m	3200m
No Change	0	0	0	0	4	8
Negligible	0	0	0	0	0	0
Negligible / Slight	0	0	1	4	5	2
Slight	0	1	2	5	1	0
Slight / Moderate	0	0	0	0	0	0
Moderate	1	1	2	0	0	0
Moderate / Major	3	4	3	1	0	0
Major	0	0	0	0	0	0
Major / Substantial	3	1	2	0	0	0
Substantial	3	3	0	0	0	0
Total	10	10	10	10	10	10

Table 4.8 Overall Summary of Significant Landscape Effects for 220kV Towers

The Study results summarised in Table 4.8 show that no significant landscape effects occur beyond 800m of the selected 220 kV towers based on 10 landscape types. There were reasonably high levels of significant effects up to 400m, with only one site significant at 800m.

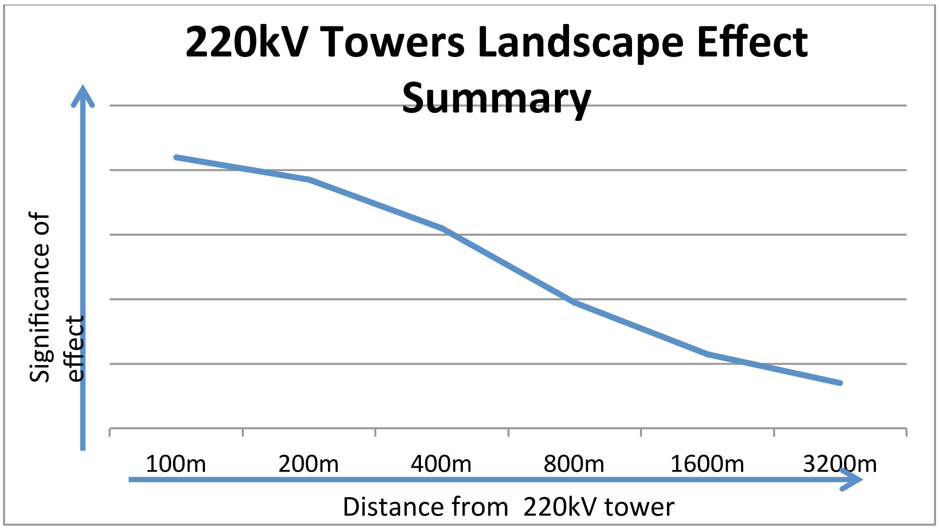


Figure 4.15 Weighted significance of landscape effect compared with distance from 220kV Towers

When the weighted significance of landscape effect is considered, as illustrated in Figure 4.15, it was found that there was a similar trend for 220kV towers compared to 110kV towers albeit with additional elevated landscape effects between 100m to 800m, as would be expected due to the increase in scale of 220kV towers.

	100m	200m	400m	800m	1600m	3200m
No Change	**0**	**0**	**0**	**0**	**0**	**4**
Negligible	**0**	0	0	0	0	0
Negligible / Slight	**0**	0	0	0	1	1
Slight	**0**	0	0	3	6	3
Slight / Moderate	**0**	0	0	1	1	0
Moderate	**0**	0	1	1	0	0
Moderate / Major	**0**	3	3	2	0	0
Major	**0**	0	0	0	0	0
Major / Substantial	**4**	2	3	1	0	0
Substantial	**4**	3	1	0	0	0
Total	**8**	8	8	8	8	8

Table 4.9 Overall Summary of Significant Landscape Effects for 400kV Towers

The Study results summarised in Table 4.9 for 400kV towers indicate that all significant landscape effects occurred within 800m based on a total of 9 tower sites at nine of the Study LCTs. The results indicate an *increased* level of significance of landscape effect across sample sites when compared to both the 110kV and 220kV tower sites.

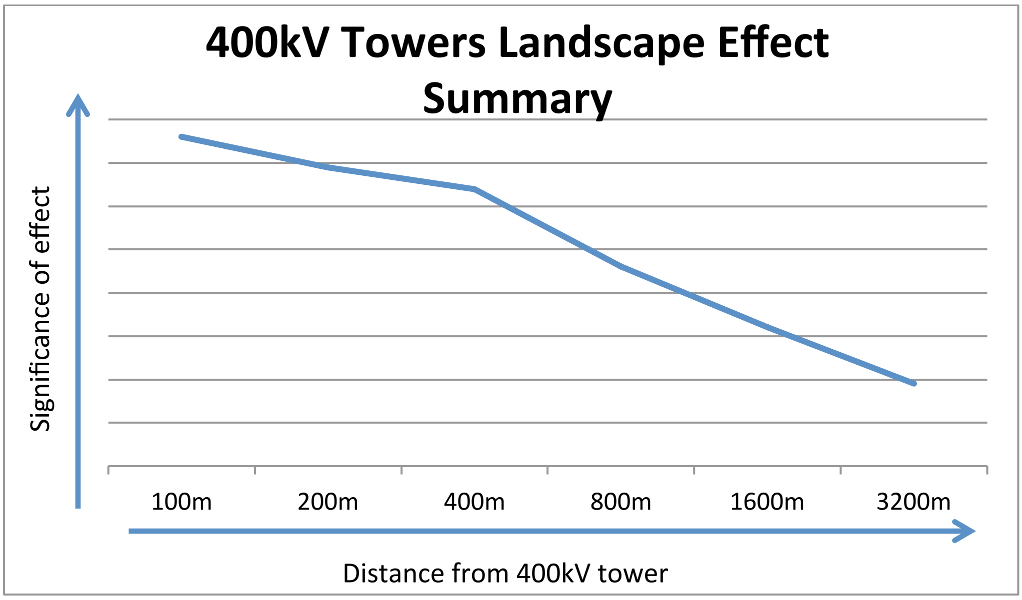


Figure 4.16 Weighted significance of landscape effect compared with distance from 400kV Towers

By calculating the weighted significance of landscape effect for 400kV towers compared to distance (Figure 4.16) the more elevated level of significance of landscape effect for 400kV towers is graphically illustrated. The results for the 400kV towers sites show a high level of consistency with the findings for 110kV and 220kV towers in terms of decrease in significance of landscape effect beyond the 800m distance band.

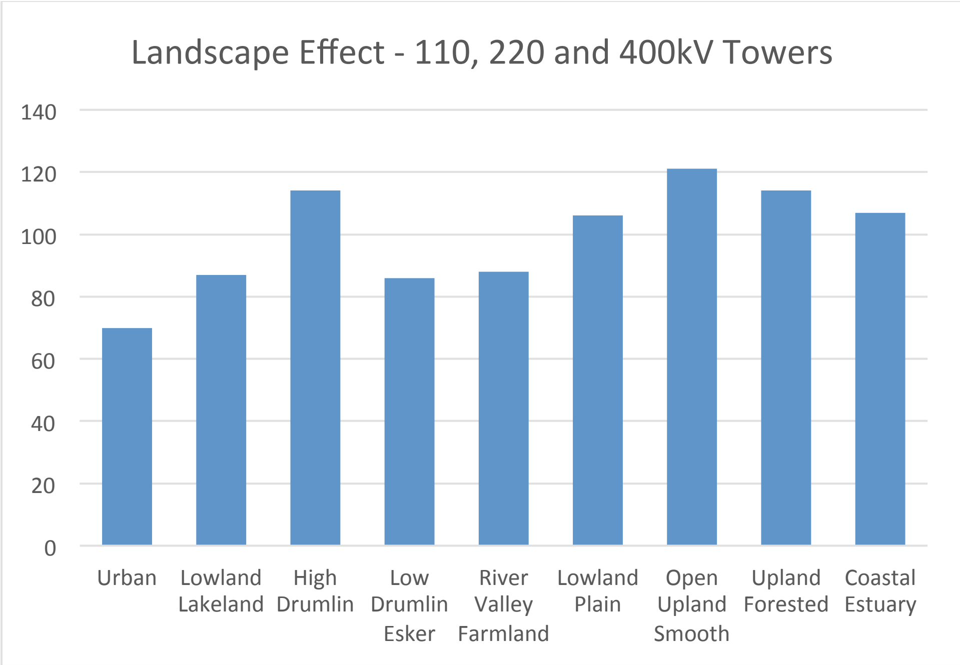


Figure 4.17 Overall Landscape Effect per Landscape – 110kV, 220kV and 400kV Towers

When the landscape effects for each structure type are combined per landscape for the available comparable landscape types, (urban, lowland lakeland, high drumlin, low drumlin/esker, river valley farmland, lowland plain, open upland smooth, upland forested and coastal estuary) the Study results (Figure 4.17) show that the least landscape effects are found within urban, lowland lakeland, low drumlin/esker and river valley farmland landscapes. The greatest landscape effects were found within high drumlin, open upland smooth, upland forested and (more open) coastal estuary landscapes.

As with the results of visual effects per landscape the findings are consistent with the known characteristics of each LCT. The results appear to further support the finding that lowland agricultural type landscapes have key characteristics that will more readily absorb structures when compared to open upland and elevated LCTs.

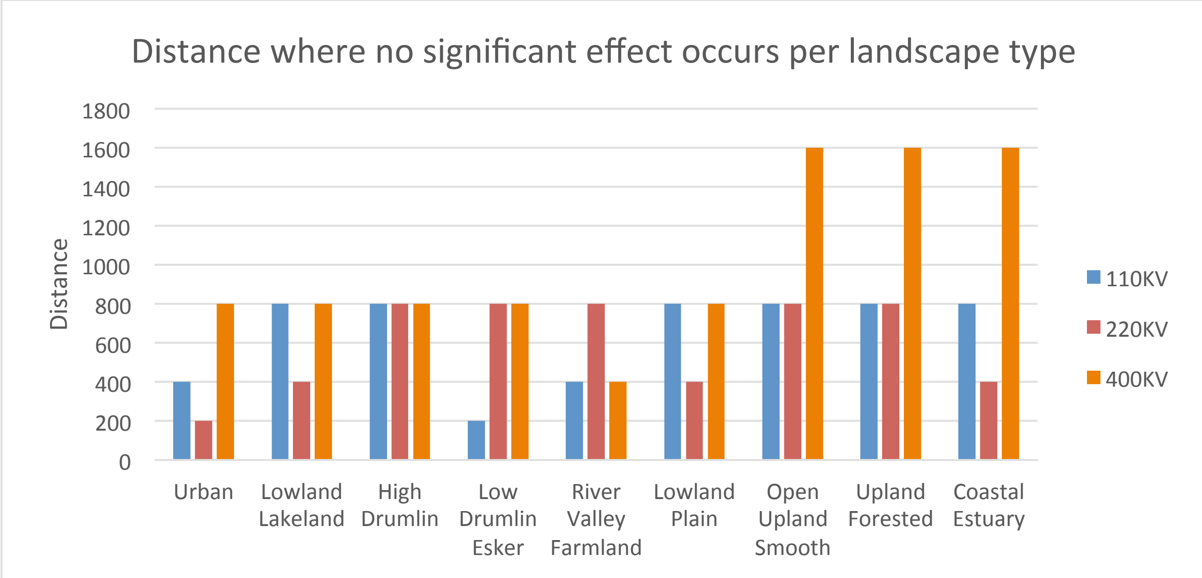


Figure 4.18 Distance where no significant landscape effect occurs for towers per landscape type

When significant landscape effects for each tower type are analysed per Study landscape type (Figure 4.18) the study results in the majority of cases do indicate lower effects for 110kV towers increasing with 220kV and 400kV. This trend would likely be strengthened by a more numerous sample base. The worst landscape effects occur for elevated and open landscape character types.

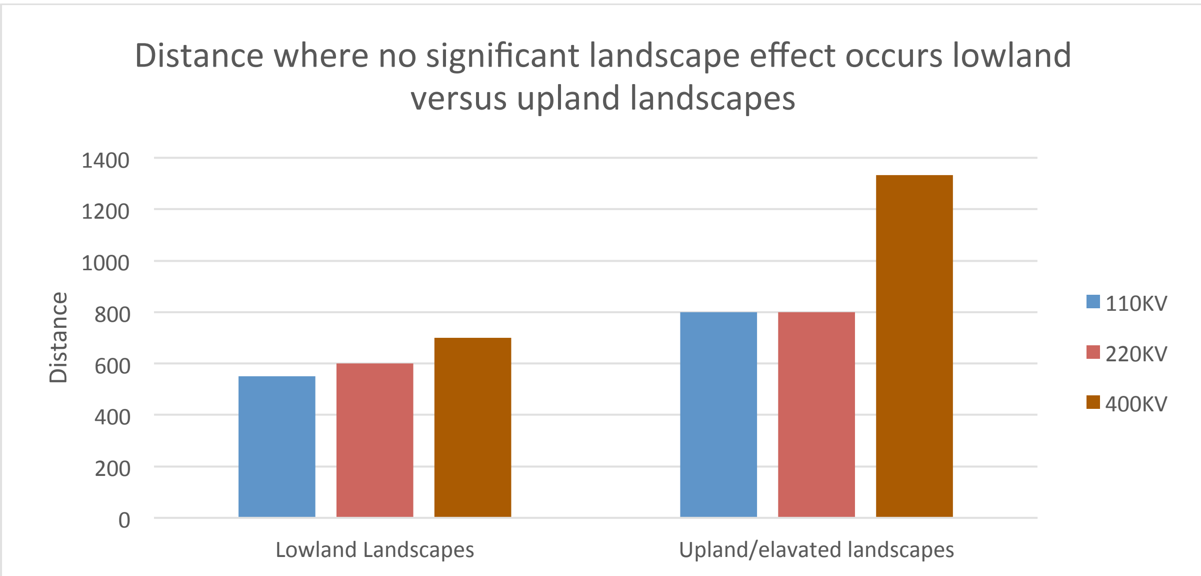


Figure 4.19 Distance where no significant landscape effect occurs for towers for lowland and upland landscape types

Looking at all lowland landscape types in the Study, against all upland or elevated landscape types, per tower type, by averaging the distances where significant landscape effects occur (Figure 4.19), indicates for lowland landscapes a good correlation between tower height and distance of landscape effect. For upland/elevated landscapes, it is notable that the distance of significant effect is greater than that for lowland landscapes and although 110kV and 220kv towers are found to have the same limit for significant effects, it is clear that landscape effects are more widespread for 400kV, as would be expected.

4.2.8 Overall summary of Landscape Effects for 110kV, 220kV and 400kV Substation Sites

Tables 4.10 and 4.11 below provide an overall summary of the significance of landscape effect for 110kV and 220kV substation sites, as set out in the completed Assessment Sheets. Analysis of 400kV substations was omitted due to the lower number of suitable 400kV substation sites within the selected Study LCTs.

	100m	200m	400m	800m	1600m	3200m
No Change					3	7
Negligible						
Negligible / Slight				3	1	
Slight			3	2	7	4
Slight / Moderate			1	2		
Moderate	1	3	1			
Moderate / Major	1	3	3	4		
Major						
Major / Substantial	6	3	3			
Substantial	3	2				
Total	11	11	11	11	11	11

Table 4.10 Overall Summary of Significant Landscape Effects for 110kV Substations

The Study found that for 110kV substations there were no sites with significant landscape effects beyond 800m. There was found to be an extension of significant effects over a greater range of distance bands up to 800m for the selected substation sites when compared to results for towers. Beyond a distance of 800m landscape effects tailed off. This result is based on the assessment of 11 nr 110kV substation sites within the Study LCTs. The weighted significance of landscape effect illustrated in Figure 4.20 shows a gradual gradient than for the tower sites above, indicating a broadening of significance of effects across all sites.

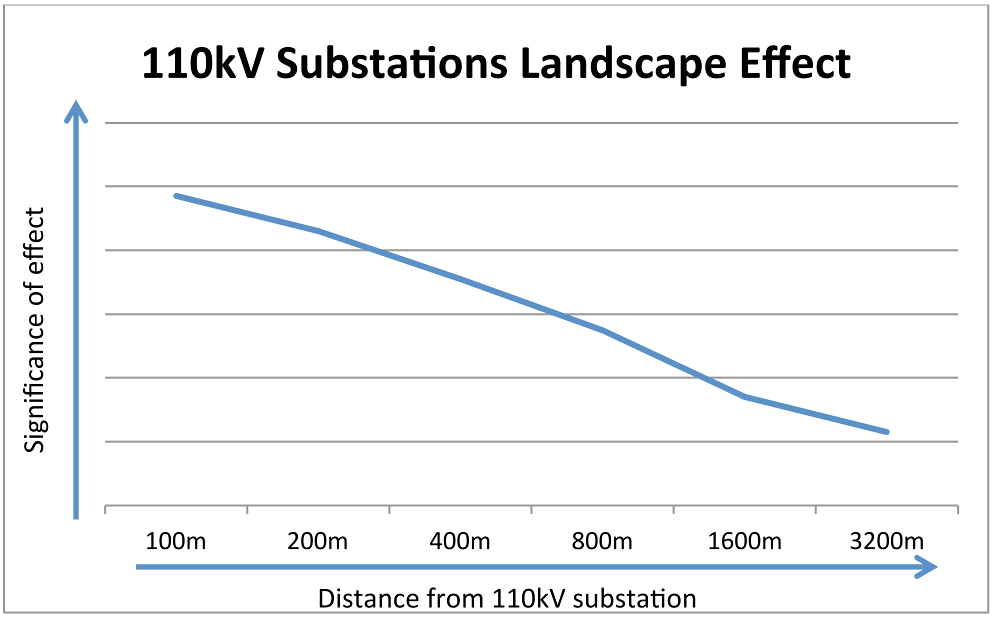


Figure 4.20 Weighted significance of landscape effect compared with distance from 110kV Substations

	100m	200m	400m	800m	1600m	3200m
No Change					2	7
Negligible						
Negligible / Slight				1	3	
Slight			2	5	2	1
Slight / Moderate			1			
Moderate	1	1	3			
Moderate / Major	3	5	1	1	1	
Major						
Major / Substantial	2	1	1	1		
Substantial	2	1				
Total	4	8	8	8	8	8

Table 4.11 Overall Summary of Significant Landscape Effects for 220kV Substations

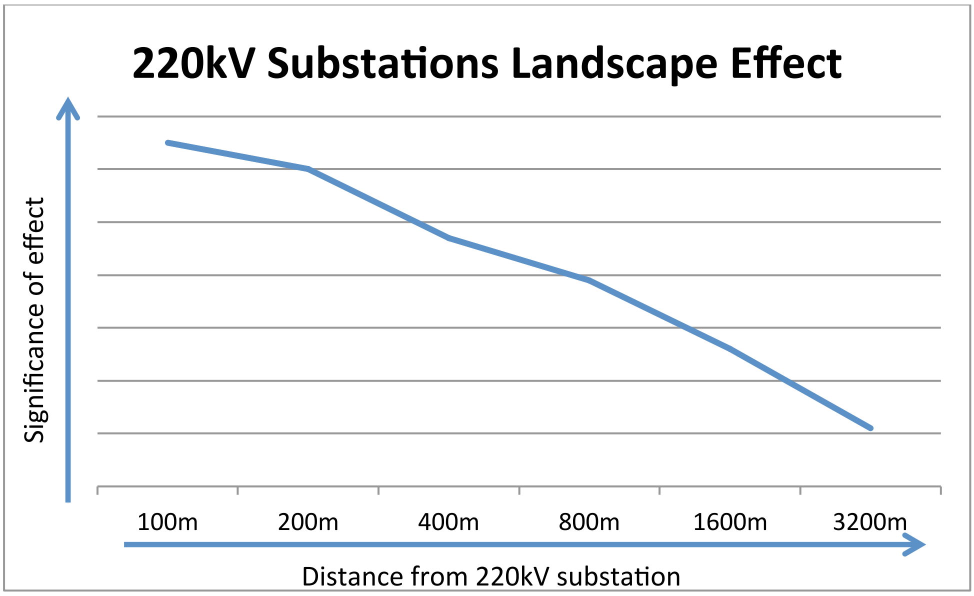


Figure 4.21 Weighted significance of landscape effect compared with distance from 220kV Substations

For 220kV substation sites the Study found that there were no sites with significant landscape effects beyond 800m (Table 4.21). Although based on only 8 sites, the findings are consistent with the results of 110kV substation sites and also the overall Study findings for towers. The Study did find that a number of the selected 220kV substation sites had been carefully chosen at their pre-construction stage, making use of existing vegetation and topography and this would appear to have been reflected in the results with a lowering of significance of effect within the 400m distance bands, when compared to the 110kV substation sites.

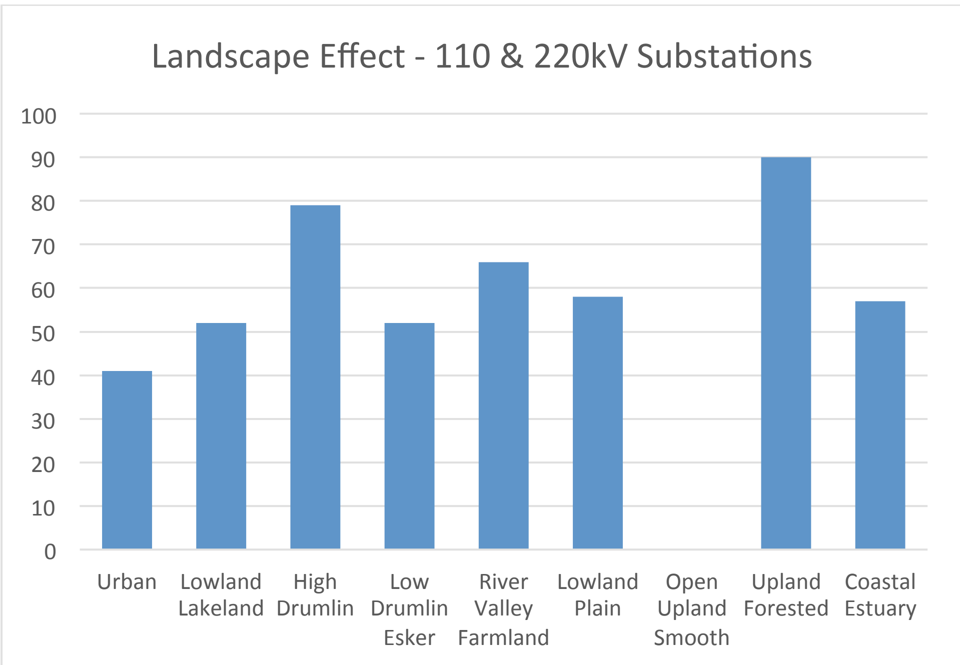


Figure 4.22 Overall Landscape Effect per Landscape – 110kV and 220kV Substations

The result of the overall assessment of landscape effect for suitable substation sites is based on 16 substations at locations across Ireland. The results appear consistent with the results for the landscape effects for tower sites in that urban and lowland agricultural landscape types absorb substations more effectively than higher elevated and open landscape (i.e. high drumlin and upland forested). More sample sites would be required to strengthen this conclusion and balance out any anomalies such as a lower than expected effect for Coastal Estuary.

When significant landscape effects for 110kV and 220kV substations at 8 comparable landscapes are analysed per Study landscape type (Figure 4.23), the study results in the majority of cases do indicate lower landscape effects for 110kV substations, increasing for 220kV sites. The results also indicate that open elevated landscapes (high drumlin and upland forested) have less ability to absorb substations.

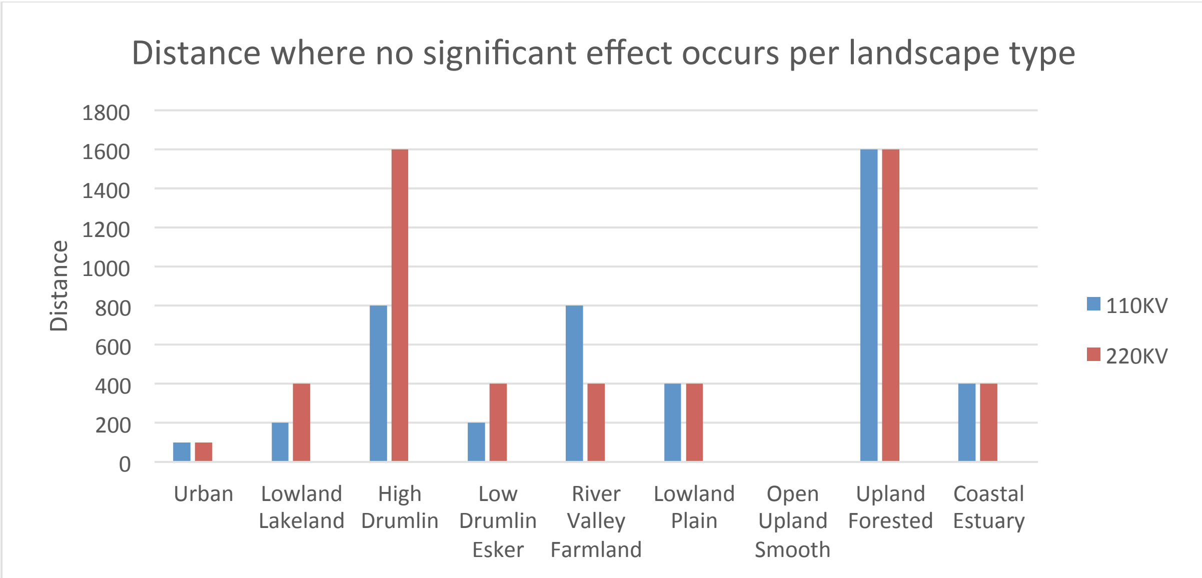


Figure 4.23 Distance where no significant landscape effect occurs for 110kV and 220kV substations per landscape type

4.2.9 Overall summary of findings for modifying factors increasing or decreasing prominence

The detailed assessment of each tower and substation site selected for the Study established the modifying factors that increase or decrease both landscape and also visual prominence of transmission infrastructure at the selected Study sites. The Study considered a range of potential modifying factors (Section 2.1.6). The results of the assessment are provided in the completed Assessment Sheets in the Appendices. Summary data has then been used to prepare Tables 4.12 - 4.14 to illustrate the Study results. Modifying factors are critically important to identify likely effects and they influence both visual and landscape effects. The modifying factors are basically characteristics of the landscape types into which the transmission infrastructure has been located. Such characteristics influence the scale of landscape and visual prominence of transmission projects.

Overall the summarised findings in the tables below indicate that for all 110kV to 400kV towers, the key modifying factor increasing prominence is skylining, while the key modifying factors decreasing prominence are screening and backclothing. This basic result does indicate what is reasonably well known that when towers are read on the skyline they will lead to greater landscape and visual effects than when towers have the benefit of being located near screening vegetation and/or against a topographical background. This results in lower landscape and visual effects.

It can be assumed that as substations are generally subject to different site selection procedures at the pre-construction stage (e.g. Holford and Horlock Rules), they are frequently suitably well located within the landscape. The Study results for skylining effects indicate much lower levels of skylining for substations compared to towers. The Study results appear to support this assumption.

As would be expected, when towers' acting as a focal point are considered, the Study results found that this is a more common factor for increasing prominence for 220kV and 400kV towers than it was for the smaller 110kV towers. It should also be noted that the Study towers are predominantly angle towers that are more likely to be prominent than intermediate towers.

Factors Increasing	**Total 110kV Towers**	**%**	**Total 110kV Substations**	**%**
Skylining	23	39.66	13	24.07
Open Landscape	2	3.45	1	1.85
Acting as Focal Point	3	5.17	12	22.22
Factors Decreasing				
Screening	51	87.93	49	90.74
Backclothing	17	29.31	9	16.67
Enclosed Landscape	2	3.45	0	0
Built Elements	5	8.62	7	12.96

Table 4.12 Factors modifying landscape and visual effects of 110kV towers and substations

Factors Increasing	**Total 220kV Towers**	**%**	**Total 220kV Substations**	**%**
Skylining	25	51.02	17	38.64
Acting as Focal Points	6	12.24	0	0
Uncomfortable Scale	1	2.04	17	38.64
High Elevation	0	0	3	6.82
Factors Decreasing				
Screening	46	93.88	42	95.45
Backclothing	13	26.53	15	34.09
Built Elements	5	10.20	1	2.27
Complex Scene	2	4.08	0	0
Enclosed Landscape	2	4.08	0	0
Low Elevation	0	0	1	2.27
Other elements	0	0	3	6.82

Table 4.13 Factors modifying landscape and visual effects of 220kV towers and substations

Factors	Total 400kV Towers	%	Total 400kV	Substations%
Skylining	26	52	4	33.33
Acting as Focal	6	12	1	8.33
Open Landscape	8	16	2	16.67
Factors				
Screening	43	86	12	100.00
Backclothing	23	46	1	8.33
Built Elements	1	2	2	16.67
Low contrast	0	0	2	16.67

Table 4.14 Factors modifying landscape and visual effects of 400kV towers and substations

4.2.10 Effectiveness of Mitigation Measures

When considering the effectiveness of mitigation measures for transmission projects it is difficult to identify mitigation measures that have been built into the design process from field survey and desktop analysis alone. Good design of transmission line routes using established methods of route selection and site selection effectively builds in mitigation by avoidance and reduction of potential effects. Good design results in transmission projects that seek to avoid resident areas and clusters; have a good set back from residential properties; avoid sensitive and protected landscapes; and avoid steep topography. Clear evidence of mitigation measures at constructed transmission projects is therefore only readily evident at substations, where landscape planting and berms can be used in combination with in-built best practice site design measures.

The Study selected eight 220Kv substations for analysis. A combination of field surveys using aerial mapping and the results of the assessment of viewpoints for the selected sites was used to consider the effectiveness of mitigation measures if any. The eight 220kV substation sites selected for the Study at Inchicore, Flagford, Srananagh, Louth 275, Great Island, Tynagh, Turlough and Prospect, were each reviewed to establish if any mitigation measures were apparent. No site development plans were reviewed as part of this process.

The sites found to have apparent landscape and visual mitigation measures of relevance to the Study were Flagford, Srananagh, Louth 275, Great Island and Prospect (refer to **Appendix N**).

Flagford substation in County Roscommon has landscape planting maturing on all four sides. The site is located in a lowland lakeland landscape with Killukin River on the western boundary and a local road at the site entrance to the north boundary. The site location makes use of existing screening vegetation at the Killukin River that screens views from the west and the R368. The landscape planting on the northern, eastern and southern boundaries is not to a great depth and consists of predominantly birch species that although relatively quick in growth rates do have a light canopy that decreases their effectiveness for screening, particularly when the planting belts are narrow.

More effective has been the use of a hawthorn hedgerow although this has been trimmed to a low level at the site entrance, reducing its potential effectiveness. The combination of hedgerow and tree planting does, when combined with existing vegetation at Killukin River, result in some screening of the ground level features of the substation (up to fence height) but the taller infrastructure within the site remains visible at local locations up to a distance of 800m.

At the time of the Study, Srananagh substation in County Sligo did not have any mitigation planting but the site has been carefully selected to make use of the existing undulating topography and vegetation (particularly to the immediate west, south-west and south of the site). The Study found that although visible at very close quarters (<200m) the substation was effectively absorbed into the lowland drumlin esker landscape at distances greater than 200m.

At Louth substation there are long belts of linear landscape planting on all sides. Most planting has been provided on the north and south boundaries. The planting is maturing and has not reached its design height yet. Due to the scale of the Louth substation and the height of the substation infrastructure, it is directly visible from the R178 to the north and from a local road that extends along the site's western boundary. The open aspect of the high drumlin landscape does not offer much existing screening and the fact that the planting has not reached maturity yet, results in significant effects recorded up to 800m from the substation site.

Great Island substation in County Wexford is located in close proximity to the existing power station. The site is located at the confluence of the River Suir and River Barrow. Extensive and deep planting belts have been created on the sites eastern and south-eastern sides. The site makes use of rising topography to the north and west. The riverside location results in no views from the south. A combination of careful siting within the local river valley farmland landscape and use of the topography, along with dense planting to the eastern side, results in very limited visibility of the substation from the surrounding landscape and no significant effects.

Prospect substation in County Clare is smaller than the substations considered above. The site has mitigation planting on all sides. The effectiveness of the planting varies. There is a good belt of evergreen based planting (pine trees) on the sites north-east corner nearest to the R473 that creates an effective screen at this location in views from the road. However further west this tall planting gives way to shrub type planting that offers little screening. The site does benefit from proximity to strong hedgerows in adjacent field boundaries and at roadsides that typify the coastal estuary landscape in this part of County Clare, resulting in a significant decrease in visibility with distance from the site.

The results of the assessment of mitigation measures are discussed further in Section 5.

4.2.11 Zone of Theoretical Visibility (ZTV) Calibration (Appendix R)

ZTV mapping was prepared for the three 220kV tower sites to calibrate the theoretical visibility against the actual visibility as evidenced by the Study itself and by a Windshield Survey (Section 4.2.11). The results of the ZTV maps (**Appendix R**) for the three selected coastal, lowland and upland sites in Counties Cork (Figure A1.53), Roscommon (Figure A1.54) and Wicklow (Figure A1.55) show, as would be expected, a wide theoretical visibility over the 3.2km radius study area particularly for the typical lowland site in Roscommon. The lowland landscape in Roscommon theoretically offers a high potential for views when low topography (<10m), vegetation and buildings are ignored across the entire 3.2km radius study area. The stronger (more distinct) topography that surrounds the upland site in Wicklow, does limit theoretical visibility with visibility beyond 1600m radius restricted to bands due east and west and southeast. The coastal landscape of Cork Harbour resulted in a theoretical visibility that covered the entire 800m radius from the selected structure. It was limited to the northwest and southeast for up to 1600m, and with high visibility to the northeast, east, and south between the 2400m to 3200m distance bands. There was found to be good consistency between the ZTV map and the selected Study viewpoints for each structure.

4.2.12 Windshield Survey Calibration (Appendix S)

The theoretical visibility illustrated by the ZTV maps for the three selected tower sites was tested by completion of a Windshield Survey in the field. The results of the Windshield Survey are illustrated in Figures A1.56, A1.57 and A1.58 for Towers 14, 25 and 39 respectively (**Appendix S**). The Windshield Survey established that only a small percentage of the public roads within each of the three 3.2km study areas, had a view or partial view towards the selected towers.

For Tower 25, in a low landscape in County Roscommon, it was found by site survey that there was 95% of the public road network that didn't have a view of the selected structure. For Tower 14 in County Cork, within a coastal landscape, the results showed that there was 88% of the public road network that did not have a view of the structure. For Tower 39 in an upland landscape in County Wicklow, the site survey revealed 66% of the public road network did not have a view of the structure. The results of the Windshield Survey have shown that ZTV maps have major limitations and are only suitable or beneficial to assist a Landscape Architect during the completion of a LVIA by identification of locations from where a structure *can't be observed*, thereby assisting in defining a study area for further detailed landscape and visual assessment.

The areas within a ZTV map that are predicted to have visibility clearly need to be carefully assessed on-site to establish the actual visibility of a structure. A ZTV map cannot be relied on as an accurate representation of the visibility of a structure due to a range of modifying factors.

The results of the Windshield Survey for the three selected sites, provides good support for the findings of the Study that the actual visibility of structures in Irish landscapes is restricted by intervening micro-topography, field boundaries and vegetation, as well as manmade structures such as walls and buildings, as illustrated by the Study results.

4.2.13 Photomontage Calibration

As previously described, a post-construction photograph was taken on site (April/May 2015), at each of the photomontage viewpoint locations selected from the original ES for three transmission projects namely; Dalton to Galway 110kV transmission project; Flagford to Srananagh 220kV transmission project; and Donegal 110kV reinforcement project.

The Dalton to Galway 110kV transmission project received planning permission in 2006 and is located to the northeast of Galway City and immediately east of Claregalway. A total of three suitable photomontage locations were found. The viewpoints were referenced as viewpoints 1, 2 and 3 in the original ES. The constructed scheme was visited on a day with similar weather conditions shown in the original photomontage. It is apparent in comparing the photomontages with the existing site photography that there has been some micro-siting of towers but this is common practice and required to agree final locations with landowners and reflect very local constraints and final design requirements. However, despite this fact the photographs of the completed project show an *excellent* consistency with the original ES photomontages.

In the ES viewpoint 1 (Figure 4.24), from the R339, the nearest double circuit tower is similar in height and prominence in both the photomontage and the existing image (Figure 4.25). The towers to the rear of this nearest tower appear slightly more prominent in the photomontage than currently on site. In the ES viewpoint 2 from a local road, the surrounding vegetation has grown since the original photomontage but the tower appears in similar scale and proportions in both images. ES viewpoint 3 from the N63 shows a slight change to the “as built” scheme, with a braced wooden poleset now used for the nearest structure to the viewpoint. The steel tower immediately to the rear of this poleset was found to be similar in both images. Overall the photographs of the actual completed project compared *very well* with the ES photomontages and the predicted landscape and visual effects in the ES would remain unchanged on this basis.

Figure 4.24 Example original ES photomontage (ES Ref: Viewpoint 1) Dalton to Galway 110kV double circuit line

Figure 4.25 Photograph of "as built" Dalton to Galway 110kV double circuit line for ES Ref: Viewpoint 1

The Flagford to Sranangh 220kV transmission project received planning permission in 2002 and extends from Flagford 220kV substation to a new substation in east Sligo at Srananagh. The transmission line is predominantly located in County Roscommon. Four suitable photomontages were selected from the ES where they were referenced as Viewpoints 2, 10, 12 and 13. Again the visibility on the day of the site visit was similar to the weather conditions illustrated in the photomontages. The site visit established that ES viewpoint 2, from the R370, was completely obscured due to maturing trees located between the constructed structure and the viewpoint.

In the ES viewpoint 10 (Figure 4.26), from a local road (known locally as Wynnes View), the photomontage in the centre of the view appears in a similar location to that constructed tower shown in the (Figure 4.27). The tower was found to be similar in scale and appearance on site when compared to the photomontage. ES viewpoint 12, from the R293, was found to have been affected by maturing vegetation in the foreground but the two visible towers showed a good consistency with their location in the photomontage and their scale and degree of prominence on the horizon was also consistent. In the ES, viewpoint 13, from the R293, showed an accurate location and scale comparison but with the photomontage showing the towers slightly more prominent than found in the field. Overall there was found to be a good consistency in the accuracy of the photomontages and the landscape and visual impacts predicted in the published ES on this basis would remain as stated.

Figure 4.26 Example original ES Photomontage of Flagford to Srananagh 220kV line for ES Ref: viewpoint 10

Figure 4.27 Photograph of "as built" Flagford to Srananagh line for ES Ref: viewpoint 10

The Donegal 110kV Reinforcement Project received planning permission in 2009. The new transmission lines follow a y-shaped path from the south of Donegal County near Binbane, to a switching station at Glenties, from where the line splits to serve both Derrybeg and Letterkenny. A total of four photomontages were selected from the ES being referenced as viewpoints 2, 5, 11 and 13. The weather conditions were similar during the day of the site visit to capture photography for the calibration but in slightly brighter conditions than the weather at the time of the original ES photomontages.

The site visit established that for ES viewpoint 2, bird flight diverters had been added to the overhead line in accordance with ecological mitigation measures. The flight diverters had not been included in the original ES photomontage but the site survey found that this did not significantly increase the visibility of the overhead line in this view. The tower location and height was found to be similar on site as per the photomontage (Figure 4.28 & 4.29).

At ES viewpoint 5, the steel tower was found to be slightly more prominent due to its apparent closer location to the viewpoint. The upper portion of the tower was found to just break the skyline but overall the tower is still read against the background hills and forestry. The site survey established that for ES viewpoint 11, the lower and visible linear line of wooden polesets "as built" locations and heights compared well with the ES photomontage locations and line. Polesets were found to be read against the background topography. At ES viewpoint 13, the visible steel tower was found to be at a slightly different position for the "as built" arrangement compared to the location shown in the photomontage. From examination of this finding with the design and construction teams it is believed that this slight variation may be due to the original photomontage. However, the tower and line were found to be a similar scale. Overall for the Donegal 110kV scheme although some changes (micro-siting) were found during the site survey of the "as built" scheme, the changes and slight differences were *not* found to be sufficient to alter the original prediction of effects for the ES.

In overall summary, the calibration exercise for the three selected transmission projects constructed on site found that there was a good consistency in the accuracy of photomontages when compared with the "as built" scenario. The photomontages therefore formed a reliable tool to assist the prediction of landscape and visual effects in the original ES for each of the selected schemes. The Study has shown that photomontages have been a helpful and reliable tool in the assessment of landscape and visual effects.

Figure 4.28 Example original ES Photomontage of Donegal 110kV line Reinforcement Project for ES Ref: viewpoint 2

Figure 4.29 Photograph of "as built" Donegal 110kV line Reinforcement Project for ES Ref: viewpoint 2

5 DISCUSSION AND CONCLUSION

5.1 DISCUSSION ON SURVEY RESULTS FOR 110KV TOWERS

As set out above, to enable the Study results to be meaningfully compared with the findings of Bishop *et al* (1985), the Study focused on the landscape and visual effects of individual towers and not on overhead lines. This approach is justifiable as individual towers are principally read in most landscapes, predominantly rural lowland landscapes, as standalone features and it is the totality of such individual and local effects that allows the overall prediction of effect for a transmission project.

With regard to significance of visual effect, the Study findings for 110kV towers found that for the 11 selected sites there is a clear indication that most significant visual effects occur within 400m of the towers. The Study has established that by 800m distance from 110kV towers, no significant visual effects occur. Beyond 400m from the towers there is a steep fall off in significance of visual effect exponentially until at 3200m, all sites recorded no change. The Study results for 110kV towers were found to have compared well with the findings of Bishop *et al* (1985) and the Study results have confirmed the principle of *distance decay*.

The average height of 110kV towers at the selected sites was 16.75m, which represents a higher than average height than would be generally found for 110kV towers. The 110kV towers included some above normal heights, as at Structure 41 (28.5m) on the Carrigmines – Cookstown line. These taller structures that are higher than normally found across Ireland has ensured that a worst case scenario has been used by the Study.

It is important to note that 110kV towers are generally steel angle masts that are different from the wooden pole sets used for the majority of the length of 110kV lines. Wooden poles are much more difficult to read in the wider landscape and therefore have a lower visual impact (Section 1.0; Bishop *et al* (1985)). In the literature review, Bishop *et a*l (1985) used five tower types based on 220kV and 500kV double and single current. This Study has found no evidence that an equivalent study has ever been completed with which to compare the findings for the smaller 110kV towers as per Bishop *et al*.

Although there were numerous selected 110kV sites that did not provide a suitable viewpoint at the 100m distance band (54% of sample), this does not alter the significance of the findings. It is not unreasonable to assume that at this close distance, all towers would be dominant in the view and have a significant effect as presented by the results when 100% of the tower sites had significant visual effects at 100m.

It was more important that there were a suitable range of study viewpoints at the middle distances to allow potential analysis of the visual decay effect between locations in close proximity where towers are prominent and locations at 3.2km where towers have poor visibility. The Study had a high number of viewpoints within the middle distance range (100% for 400m and 800m distance bands) and this supports the robustness of the Study findings and has allowed examination of the actual distances where significant landscape and visual effects occur from towers and also to examine where such significant effects stop.

When modifying factors were assessed, the Study found that skylining was less of a factor for increasing the prominence of 110kV towers compared to 220kV and 400kV towers. This finding would be expected for 110kV towers that are a typically smaller type of transmission line structure. In contrast, screening was found to be a greater factor for reducing prominence of 110kV towers than when compared to both 220kV and 400kV towers, indicating the benefit that can occur from locating transmission line routes within lowland landscapes with more potential for screening from topographical and vegetation features.

To examine if there was a benefit from vegetation cover, and to consider the visual effect in the worst case (i.e. in winter months without leaves on trees) the Study considered both winter and summer viewpoints for the entire selected towers. The Study has found that it was only at the distance band when towers had begun to have lower visibility that summer vegetation screening had a noticeable effect. This predominantly occurred around the 400m distance band. Therefore the conclusion is that if the tower is visible at closer distances, its effect remains the same in winter and summer months, due to its prominence in the view.

With regard to significance of landscape effect, the Study findings for 110kV towers concurred with the Study results for significant visual effects and the most significant landscape effects were found to occur within 400m of the towers and that by 800m no significant landscape effects were found. The results did indicate higher levels of significant landscape effects within the 400m distance band indicating that there is potential for significant effects beyond 400m and more detailed survey would be required with a greater number of survey sites and refined distance bands to refine the study findings and attempt to establish the distance between 400m and 800m where significant effects end. Beyond 100m from the towers there is an exponential decline in landscape effect with distance until at 3200m, all sites recorded no change.

The Study sought to determine if it was possible to establish the LCTs and their characteristics that more readily absorbed transmission line infrastructure.

The Study landscapes found to absorb the 110kV towers best were found to be low drumlin/esker, river valley farmland and urban landscape character types. This would indicate that lowland agricultural landscapes and those with more urban characteristics are best at absorbing 110kV towers. The Study landscapes found to have the lowest potential to absorb 110kV towers were open upland smooth, upland forested, high drumlin and coastal estuary. These are all landscapes with open characteristics and with less potential for screening apart from upland forested. At the selected upland forested site the forestry was found to have been felled at many locations during the survey work. Also the Study found that lowland lakes and lowland plain landscapes had higher landscape effects than for related lowland landscape types i.e. low drumlin/esker, river valley farmland. Further study would be required to further validate the Study results for these landscapes.

The Study results for 110kV towers were analysed to examine if there were notable differences between lowland and upland landscape. The Study found that lowland landscapes had lower landscape effects with significant landscape effects at approximately 600m radius or less. Upland/ elevated landscapes all had significant landscape effects up to 800m radius from tower sites. The Study results confirm that lowland rural landscapes have greatest potential to absorb 110kV towers.

5.2 DISCUSSION ON SURVEY RESULTS FOR 220KV TOWERS

With regard to significance of effect, the Study of 220kV towers found that for the 10 selected sites there is a clear indication that most significant visual effects occur within 800m of 220kV towers. The Study has established that by 1600m distance from 220kV towers, no significant visual effects occur. The Study results have shown that from close proximity to the towers outwards there is a steep fall off in significance of visual effect exponentially until at 3200m all sites recorded no change.

The average height of 220kV towers at the selected sites was 26.4m The average height was high due to the selection of several taller towers namely Structure 1 (30.5m) Gorman – Louth line and Structure 316 on Flagford – Louth line.

Bishop *et al* (1985) Study used 5 tower types overall with 3 of these towers based on 220kV double and single circuit. The Bishop and Hull concluded that 90% of adverse effects occurred within 500m of the towers in an urban parkland landscape. This compares well to the findings of the Study where 87.5% of significant visual effects were found to occur within 400m of 220kV towers. While a high degree of visual effect has been predicted within close proximity to the Study selected tower sites, and while it is widely accepted that transmission lines are perceived more negatively than positively, Soini et al (2008) did find that residents who live closer to transmission lines were more likely to have positive perceptions and this potential for the public to adapt to transmission line infrastructure following construction is worthy of further Study.

Bishop *et al* (1985) found that it was difficult to conform with all their study criteria when selecting sites and viewpoints and a similar difficulty was found during the Study. There were low levels of suitable viewpoints at the 100m distance band (27% of total) due to access difficulties to private lands but a better number of viewpoints at the 200m distance band (72% of total). As mentioned, the lack of sites within these ranges is not of great importance as it can be assumed that most significant effects will occur in such close proximity. There was a suitable range of viewpoints at the middle distances to allow analysis of the distance decay effect with 97% for 400m, 800m and 1600m, again increasing the robustness of the findings.

The Study has shown that the magnitude and size of 220kV towers and the distance between them and the viewer are basic physical measures that affect visibility (University of Newcastle 2002). This has displayed the effect known as distance decay.

The Study has gone further to explore the factors that influence human perception by considering the modifying factors displayed by Irelands various landscape types. For modifying factors the study found that skylining for 220kV towers was a slightly higher factor for increasing prominence when compared to 110kV towers but new factors were also recorded such as towers as focal points. This would be as expected with taller structures being more prominent at closer proximity and above adjacent landscape features. There was a slight decrease in effectiveness of screening in decreasing prominence but greater recording of backclothing as a modifying factor for 220kV towers when compared to 110kV towers.

When winter and summer viewpoints were considered there was no variance in effect. The effect of the taller 220kV towers (compared to 110kV towers) remains the same in winter and summer months due to their greater height and therefore a greater prominence in views.

With regards to significance of landscape effect, the Study findings for 220kV towers differed from the results for 110kV towers in that the majority of significant landscape effects occur within 800m of the towers and that by 1600m no significant landscape effects were found. As 800m is large distance between these bands further detailed survey would be required with refined distance bands to examine further the distance between 800m and 1600m where significant landscape effects end. As with 110kV towers, the Study found that from 100m radius from the towers there is an exponential decline in landscape effect with distance until at 3200m radius all sites were recorded as no change, illustrating the effect of distance decay for landscape effect.

The landscapes found to absorb the 220kV towers best were urban, lowland lakeland, lowland plain and coastal plain landscape character types. The findings for low drumlin esker and river valley farmland were not consistent with the results for 110kV towers and not what would be expected for landscape types with characteristics generally more favourable to absorbing towers as set out above. The high drumlin, open upland smooth and upland forested landscapes were found to have significant landscape effects at longer distance than the three lowland landscapes above, indicating a lower ability to absorb towers.

The Study results for 220kV towers were analysed to examine if there were notable differences between lowland and upland landscapes. The Study found that for 220kV towers, lowland landscapes had lower landscape effects with all significant landscape effects at approximately 600m radius. Upland/elevated landscapes all had significant landscape effects located up to 800m radius from tower sites. The Study results confirm that lowland rural landscapes have greatest potential to absorb 220kV towers.

Bishop *et a*l (1985) found that in a more complex setting the potential negative visual impact of towers can be substantially reduced, even at short distances and that landscape characteristics can make towers more (or less) pronounced. The Study results for landscape and visual effects concur with this finding.

5.3 DISCUSSION ON SURVEY RESULTS FOR 400KV TOWERS

With regard to significance of visual effect, the Study findings for 400kV towers found that for the 9 selected sites there is a clear indication that most significant visual effects occur within 400m of the towers. The Study has established that by 800m distance from 400kV towers that no significant visual effects occur. Beyond 400m from the towers there is a steep fall off in significance of visual effect exponentially until at 3200m all sites recorded no change.

It should be noted that in Ireland 400kV towers are found in a smaller range of types of landscape and there are less 400kV towers found in the more open Irish landscapes such as Open Upland Rocky, Coastal Moorland and Coastal Plain. Therefore the average distance at which visual effects diminish is likely to be greater if there was evidence from 400kV lines traversing more open landscapes. Existing 400kV lines tend not to traverse such landscapes. A further refinement would be beneficial in future studies to explore in greater detail for as many landscape types as possible the distances between 400m to 800m with addition of 500m and 600m distance bands to further test these findings.

However, overall the Study findings for 400kV towers compare very favourably with the Bishop *et al* (1985) study with 100% of significant visual effects being found to occur within 400m of 400kV towers as compared with the Bishop *et al* (1985) study that found 90% of adverse visual effects within 500m.

In the Study the average height of 400kV towers at the selected sites was 35.44m. The average height was high due to the selection of two very tall towers namely Structure 4 (54.5m), Dunnstown - Moneypoint line; and Structure 564 (55.5m), Moneypoint - Oldstreet line. Beyond 400m the recorded effects were low, being highest for two towers on the Moneypoint – Oldstreet and Dunnstown – Moneypoint lines, at slight/moderate significance located within the coast estuary and lowland plain landscape character types respectively. It is important to note that one of these towers (Structure 564) on the Moneypoint – Oldstreet line was the tallest tower recorded in the Study, with an overall height of 55.5m. This obviously influences its greater visibility within an open coastal landscape.

There was found to be a high number of viewpoints available within the 100m to 200m distance bands with 100% available at 200m for the nine 400kV towers assessed. However as previously mentioned it was more difficult to find suitable sites within all the identified landscape character types due to the limited extent of 400kV infrastructure across Ireland.

With regards to modifying factors that increased prominence, the Study found that there was a slight increase in skylining as a factor when compared to 220kV towers but similar numbers of sites were recorded where the 400kV towers acted as focal points. There was an increase of sites where open landscape was identified as a factor for increasing prominence but this may be more reflective of the available 400kV sites in Ireland. There was a further decrease in effectiveness of screening in decreasing prominence when compared to 110kV and 220kV towers and a greater recording of backclothing as a modifying factor. This beneficial effect of backclothing for the tall 400kV towers highlights the importance of this factor when choosing routes and tower locations for 400kV lines.

Towers with a background of hills or rising topography will potentially have lower prominence in views from the wider landscape as found by Bishop *et al* (1985).

As would be expected for the tallest type of towers assessed when winter and summer viewpoints were considered for 400kV towers, there was no variance in effect and results remained the same in winter and summer months, due to their overall prominence in the view.

With regard to significance of landscape effect, the Study findings for 400kV towers differed from the results for significant visual effect for 400kV towers as the most significant landscape effects occur within 800m of the towers and that by 1600m no significant landscape effects were found. Again it would be beneficial to further refine the distances between 800m and 1600m from where no significant landscape effects occur. As with 110kV and 220kV towers beyond 100m from the 400kV towers there is an exponential decline in landscape effect with distance until at 3200m all sites recorded no change. The decline is however steepest from a distance beyond 400m.

The landscape found to absorb the 400kV towers best was river valley farmland with the next best a group made up of urban, lowland lakeland, high drumlin, lowland drumlin/esker and lowland plain. The result for high drumlin is not consistent with the findings for landscape effects for 110kV and 220kV towers. The landscapes with least ability to absorb 440kV towers was found to be the open landscape character types of open upland smooth, upland forested and coastal estuary. With a distance of significant landscape effects extending to 1600m the Study findings indicate the low suitability of these landscape character types for 400kV transmission lines.

When the results for landscape effects for 400kV towers were averaged across the comparable landscapes and analysed to examine if there were notable differences between lowland and upland landscape the Study found that, as with 110kV and 220kV towers, lowland landscapes had lower landscape effects with all significant landscape effects at approximately 700m radius while upland/elevated had all significant landscape effects located up to 1300m radius from tower sites. The Study results confirm that lowland rural landscapes have greatest potential to absorb 400kV towers.

5.4 DISCUSSION ON SURVEY RESULTS FOR 110KV SUBSTATIONS

With regards to significance of visual effect the Study findings for 110kV substations found that for the 8 nr selected sites there is a clear indication that most significant visual effects occur within 800m of the substation sites. The Study has established that beyond 800m distance from 110kV substations that no significant visual effects occur. Beyond 800m from the substations there is a rapid fall off in significance of visual effect until at 1600m all sites recorded no change.

The Study found that there was a noticeable difference in magnitude of visual impact between winter and summer months for a small number of 110kV substations. The difference between winter and summer was once again recorded more frequently at greater distances from the sites. The effectiveness of mitigation is discussed further below in section 5.7. The findings indicate the significant benefit that can be obtained from appropriate landscape planting at the boundaries.

With regards to landscape effects, the landscapes found to more readily absorb 110kV substations were urban, lowland lakeland, lowland drumlin/esker, lowland plain, and coastal estuary landscape character types. The coastal estuary 110kV substation site used for the Study was located in a coastal landscape with more frequent hedgerows that aided the ability of this landscape to absorb the substation in conjunction with the existing landscape treatment and this resulted in a lower than expected landscape effect. The landscapes with the lowest ability to absorb 110kV substations were found to be high drumlin and upland forested.

5.5 DISCUSSION ON SURVEY RESULTS FOR 220KV SUBSTATIONS

As with the findings for 110kV substations, the findings for 220kV substations showed a clear limit to significant effects at the 800m distance band. Beyond 800m the significance of effect was recorded as slight and slight/moderate for 2 sites at 1600m and no change for all sites at 3200m. At the 800m distance band there was an overall decrease in effect but significant effects remained for 2 sites. Again further refinement of this assessment would allow conclusions to be made about how far beyond 800m significant effects remain.

With regards to significance of visual effect the Study findings for 220kV substations found that for the 8 selected sites there is a clear indication that most significant visual effects occur within 800m of the substation sites. The Study has established that beyond 800m distance from 220kV substations that no significant visual effects occur. The significance of visual effect has been shown to decrease exponentially from the substation boundary illustrating the effect of distance decay.

There was limited difference in magnitude of impact between winter and summer months for 220kV substations. The difference between winter and summer was once again recorded more frequently at greater distances from the sites. This result must be put in the context of the use of good design practice (such as Horlock Rules) and careful site selection, that results in most substations having built-in landscape and visual mitigation by maximising use of screening topography and vegetation.

With regard to landscape effects, the landscapes found to more readily absorb 220kV substations were urban, lowland lakeland, lowland drumlin/esker, river valley farmland, lowland plain, and coastal estuary landscape character types. As with 110kV substations, the landscapes with the lowest ability to absorb 220kV substations were found to be high drumlin and upland forested.

The Study findings for substations appear to show how substation designers have reflected the Horlock Rules (2009) in terms of techniques such as perimeter treatments, earth shaping and planting to assist in reducing landscape and visual effects. Overall, no significant landscape and visual effects occurred beyond 800m from both 110kV and 220kV substations in lowland landscapes.

5.6 DISCUSSION ON SURVEY RESULTS FOR 400KV SUBSTATIONS

The limited number of available 400kV substation sites for the Study in Ireland prevented detailed analysis within the Study on their actual landscape and visual effects.

5.7 EFFECTIVENESS OF MITIGATION MEASURES

As has been previously mentioned, the existing transmission infrastructure network in Ireland at the route/site selection stage and pre-construction design stage, will have already applied best practice principles such as those set out in the Holford Rules (1992) and the Horlock Rules (2009). These will have built-in mitigation measures to the completed projects now found in Ireland.

There will of course be a balance between landscape and visual impact and a range of other environmental and engineering constraints that will have resulted in the location and appearance of the transmission projects examined by the Study. This is particularly relevant to transmission lines where effective landscape and visual mitigation measures are those built-in and are therefore less apparent when subsequently assessed post-construction, such as within the Study. Rather the Study has focused on establishing the landscapes and factors that lead to the greatest and least landscape and visual effect of towers and these have been discussed above.

It is therefore substations that have been considered as part of the Study where the physical evidence of mitigation and its effectiveness are more apparent. The Study looked at 220kV substations and found evidence of landscape screening at five of the selected sites namely Flagford, Srananagh, Louth 275, Great Island and Prospect. The Study results for four of the substations showed effective use of mitigation measures both built-in through site selection and also landscape planting that limited significant landscape and visual effects to within 400-800m distance.

The exception to this result was Louth 275 substation. This can be explained by the scale of the site and the range of infrastructure, when combined with its location in a high drumlin landscape that has an open character. Nevertheless Louth 275 was found to have greater landscape and visual effect beyond 800m and less effective mitigation measures.

The most effective mitigation for substations has been shown by the Study to be careful site selection that maximises the benefits from topography, existing vegetation, distance from local roads and potential public viewpoints; combined with the use of landscape mitigation planting[8] at the site boundary that reflects the local landscape characteristics.

[8] To conserve local biodiversity only native tree and shrub species from locally indigenous sources should generally be planted.

Alternative tower designs

The Study has reviewed the evolving approach across the UK and Europe to the design of transmission towers. The T-pylon design is currently being considered in the UK and Denmark. Whilst there are differences between the steel lattice and T-pylon designs, they share similar technical characteristics. Both are capable of carrying high voltage electricity; both are capable of carrying three sets of twin conductor bundles on each side of a supporting structure; both have a standard span between each of the structures; and both structures would have similar finishes.

Apart from the difference in physical appearance, the National Grid has also highlighted the main differences between the current steel lattice design and the T-pylon when selecting routes. The T-pylon allows the designers to minimise the use of large angles of deviation by allowing changes in direction. It uses a flying angle pylon design that can accommodate a change in direction up to ten degrees. The National Grid has also reported that the T-pylon has a smaller construction and permanent footprint when compared to a 400kV steel lattice tower.

The Literature Review completed as part of the Study found no evidence of any previous research that correlates visual perception and aesthetics in a meaningful way (Tikalsky *et al* 2007). However, as recommended by the Holford Rules (1992), the Study has shown that the evaluation of alternative tower designs has the potential to address landscape and visual effects. Such a step would be an appropriate action for consideration in future transmission line projects, particularly those that may be required to cross a sensitive Irish landscape. It will be interesting to gauge public perception of the National Grid’s T-pylon tower. Subsequent lessons learnt from the National Grid pilot project should be monitored for future reference.

5.8 EFFECTIVENESS OF PHOTOMONTAGES AND ZTV MAPPING AS TOOLS FOR LANDSCAPE & VISUAL IMPACT ASSESSMENT (LVIA)

University of Newcastle (2002) completed extensive research into ZTV mapping and found that they are never accurate. The Study analysis has confirmed through calibration at three sites for 220kV towers that they are a reliable basis for predicting visibility from within the viewshed of a tower. The Study has confirmed that they are a useful tool for selecting potential viewpoints for assessment with the caveat that they must be subjected to detailed site survey consideration.

ZTV maps always exhibit the worst case as they are based on a topographic digital terrain model only and don’t reflect small changes in topography, vegetation and buildings. The latest developments in software do permit the addition of data such as forests, woodlands and other elements in the landscape but the same caveats remain.

The term Zone of Visual Influence (ZVI) has been widely discounted by the landscape profession and the adopted common term is now, “Zone of Theoretical Visibility” (ZTV). This term emphasizes the theoretical nature of the information shown in such a map. ZTV maps remain a useful tool to assist the landscape professional to predict effects but as shown by the Study, ZTV maps are not a reliable tool to represent the actual effects.

Considering the study results with regards to recommending a radius for ZTV maps to use in LVIA chapters for EIA, in relation to the overall height of towers or substations, a ZTV map that extends to 3200m from the site of the tower or substation will capture all of the locations where likely significant landscape and visual effects will occur. The use of photographs, wireframes and photomontage is now commonplace and expected in EIA.

The University of Newcastle (2002) found that photographs and photomontages are subject to a range of limitations. These may include poor reproduction of small objects, texture, colour, light levels and scale; contrast is generally lower than in reality. However despite these limitations the University of Newcastle (2002) concurs with the findings of the Study that photomontages are a useful and essential tool in the completion of LVIA. The Study found that despite slight variations in the appearance of the completed transmission line projects compared to the available EIA photomontages, the *predictions* of landscape and visual impact remained valid.

A photomontage should seek to recreate an accurate view of a tower or substation in terms of its positioning, spatial distribution, size and height in relation to its landscape setting, through use of a recognised photomontage software package. Landscape Institute (LI) (2011) Advice Note 11 contains guidelines on photography and photomontage preparation for LVIA and until a similar guideline is available in Ireland (Irish Landscape Institute and Irish Planning Institute), these LI guidelines should be promoted as standard best practice to maintain a consistency of approach and output photomontages for EIA completed for transmission line projects across Ireland.

Consideration should also be made of the wider use of wireframes, as these can be as useful as photomontages and are cheaper to produce, allowing potential for a greater number to be produced at a lower cost than photomontages. Wireframes do not purport to offer anything beyond indication of the potential visibility of a tower or substation for the landscape professional to use as a tool in the field for the prediction of landscape and visual effects.

5.9 CONCLUSIONS

When all towers in the 110kV, 220kV and 400kV ranges were assessed it was found that 95% of significant effects occurred within 400m. This finding is consistent with the only similar study completed by Bishop *et al* (1985) that found 90% of adverse effects occurred within 500m based on 220kV and 500kV tower types.

Overall for all towers the findings recorded that there was a decrease in effect with distance thereby exhibiting the principle of distance decay such that beyond 800m there was effectively *no* significant visual effect.

When factors that modify landscape and visual effects were considered, screening was the most frequent factor in decreasing prominence for all tower types but particularly 110kV towers.

In addition, backclothing more frequently reduced the prominence of taller 220kV and 400kV towers.

The study results would benefit in further refinement by increasing the number of survey sites per landscape, by considering refinement of distance bands between 400m and 800m from structures and by assessing the effects across broad lowland and upland landscape types.

The study found for substations at 110kV and 220kV sites, that 86% of significant visual effects occurred within 400m. There were more sites with significant effects at the 800m distance (5 sites) for substations than found for all towers. This reflects the larger scale of substations when compared to towers resulting in an overall greater potential for visibility up to 800m. However there was a greater decrease in effects at distances beyond 800m for substations when compared to towers. The results reflect the high percentage of sites with topographical and vegetation screening located at the substation boundaries and also reflects the benefits of the original site selection to “best fit” in the local landscape in accordance with best practice.

The use of alternative designs for towers to offer potential for reduction of landscape and visual effects, as well as improving efficiency of tower construction and betterment in the provision of transmission line services, is advancing well in countries such as the UK and Denmark. While this process would require a long lead-in time (i.e. design competitions, pilot projects and testing), there remains a case for similar exploration for alternative tower designs that could benefit future transmission projects in Ireland, that may have to cross more sensitive landscapes as recommended by the Holford Rules (1992).

The calibration of ZTV maps through a windshield survey has shown how effectively 220kV towers are absorbed into the wider landscape with distance from the towers providing further support to the Study findings outlined above.

The calibration of photomontages has shown they are a reliable tool for the prediction of landscape and visual effects.

The techniques and methodology set out by the Study, taken together, can enable a public/professional landscape and visual assessment of transmission line infrastructure. The results of the Study can make a significant contribution to the landscape and visual assessment of future transmission line projects.

This study opens the potential for future studies to further validate the study findings by selecting more 220kV tower sites within fewer and broader landscape character types for upland and lowland landscape types. These are the landscapes most widely affected by transmission routes in Ireland.

The study has identified the benefits of the modifying effects of background and contrast. This suggests the need to further study a range of backgrounds for the broad landscape types recommended above. Such a refinement in conjunction with the Study findings would permit the determination of the actual distance limits of landscape and visual effect beyond the Study's broad distance bands.

Overall the study results can be the basis for guidance on future transmission projects.

6 RECOMMENDATIONS

6.1 FURTHER STUDIES

This work forms part of a suite of similar studies of other environmental effects – cultural and ecological. The studies are conceived as an on-going body of work that are to be updated and amended from time to time to take account of developments in understanding – arising from practice or research.

The study has also indicated that it may be possible to further refine the distance that significant effects occur within the 400m to 800m distance bands. This would have to be achieved by a transect from selected towers or substations, that crossed private lands and therefore not be constrained to existing roads. It is therefore recommended that consideration is given to a supplementary Study that would further validate the findings of this Study and refine the significant effects across middle distance bands.

6.2 RECOMMENDATIONS IN PRACTICE

The evidence presented by the study analysis conclusively demonstrates that the following practices have the greatest potential to reduce landscape and visual effects:

- Siting new towers within landscapes with high vegetation, particularly 110kV towers
- Routing that increases 'backclothing', particularly 220kV and 400kV towers, and
- Routing that avoids encroaching within 400m of sensitive receptors.

These recommendations and overall detailed findings should be interpreted into any future Evidence-Based Design Guidelines for transmission infrastructure - route selection, siting and line design.

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