APPENDIX H STUDY METHODS

H.1 INCREMENTAL TRANSFER CAPABILITY STUDIES FOR GENERATION

H.1.1 Background

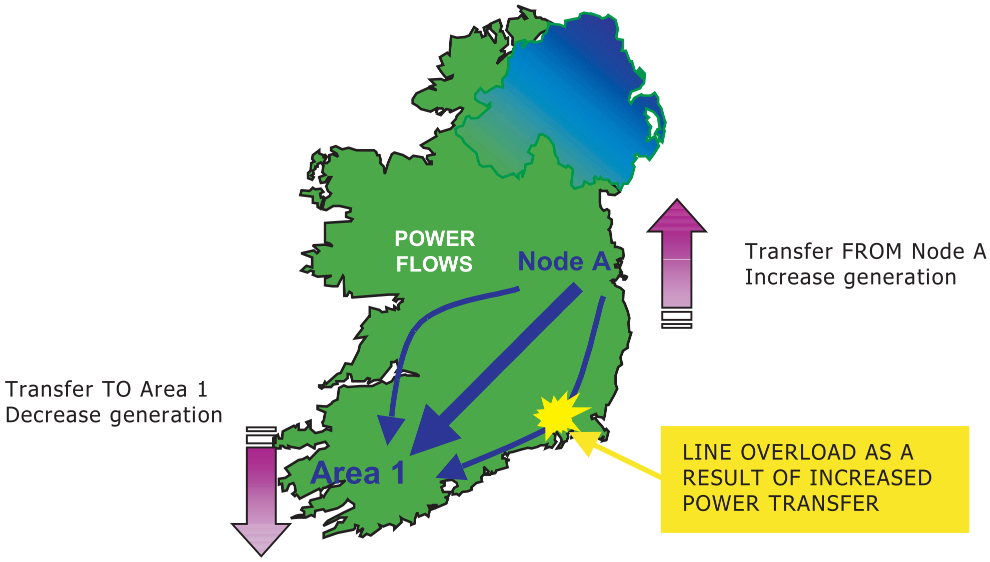
Transfer limit analysis has been used to determine the Incremental Transfer Capability (ITC) on the Grid. The ITC is a measure of the transfer capability remaining in the physical Grid for further commercial activity over and above already anticipated uses. It provides an indication of the flexibility of the Grid to accommodate future generation without further reinforcements.

The transfer analysis is intended as a pre-feasibility indication of opportunity for prospective generators. The methodology for determining ITC closely aligns with pre-feasibility study techniques.

Figure H-1 illustrates a power transfer between Node A and Area 1, where Node A is a transmission station and Area 1 represents a part of the system in which there is a concentration of existing capacity, in this example Dublin. The ITC is calculated on the basis that an increase in output from a hypothetical generator connected at Node A is offset by an equivalent reduction in generation output from generation in Area 1.

The hypothetical generation output is increased in small steps and a contingency analysis (i.e., the evaluation of the network following the simulated tripping of each circuit) is performed at each step until a thermal overload or voltage problem appears that violates the transmission planning standards. The incremental transfer at this point is the ITC.

Figure H-1 Example of Incremental Transfer Capability Methodology



H.1.2 Planning Criteria as applied in Transfer Limit Analysis for Generation

For the purposes of these transfer studies a subset of the planning standards has been applied to reduce the number of variables to a manageable level and allow completion of the studies in a reasonable time, while still giving indicative information of value. The standards that have been applied in these studies are detailed below.

H.1.2.1 Contingencies

Transfers are tested against thermal and voltage standards for an intact network, and following single (N-1) contingencies. In addition a limited set of combined generator/circuit (N-G-1) contingencies were tested involving the Lough Ree Power and West Offaly generators. For simplification, outages of other large generators are not considered because, in general, another generator in the same area could replace them. Trip-maintenance (N-1-1) contingencies were not considered. An assumption was made that the hypothetical generator can be constrained down or off during essential transmission circuit maintenance.

H.1.2.3 Thermal Limits

Line and transformer loadings were checked against 110% of their maximum continuous rated capacities. It is assumed that overhead lines can be operated for a short time at 110% of rated capacity. Transformers and underground cables can generally operate at higher levels than overhead lines if not heavily loaded before the emergency condition. In most locations on the Grid it is possible to perform network switching or generation redispatch after a fault to bring a 110% overload back below 100%. By checking against 110% only the results are, if anything, slightly optimistic.

H1.2.4 Voltage Limits

The system is planned so that the voltage remains equal to or above 95% of nominal voltage under base case conditions and equal to or over 90% of nominal voltage for contingency conditions.

H.1.2.5 Short Circuit Limits

Short circuit levels are not calculated with the test generation connected.

H.1.2.6 Dynamic studies

No dynamic studies were carried out. Dynamic stability issues can usually be overcome with control equipment.

H.1.3 Methodology for calculating Transfer Limits for Generation

H.1.3.1 DC Loadflows

A DC loadflow method was used to screen for critical contingencies and thermal overloads, followed by AC loadflow studies to confirm the results of the DC loadflows and to identify voltage limitations. Voltage standards were checked using parametric analysis (P-V) curves. This combination of linear and non-linear loadflow methods allows the solution of a complex multi-variable problem. It would be extremely difficult to study the effect of all contingencies at all transfer levels, using AC loadflow methods only.

H.1.3.2 Application to the Grid

Transfers were considered between ten major 220kV stations and five areas in which existing generation is concentrated (Dublin, the south-east, the south-west, Moneypoint, and Northern Ireland). The 220kV stations are Maynooth, Finglas, Louth, Flagford, Cashla, Shannonbridge, Killonan, Knockraha, Arklow and Great Island. For the purposes of the following explanation, Node N refers to the 220kV station from which the transfer was evaluated, and Area A refers to the area of existing generation, to which the power was transferred.

The initial generator dispatches for the transfer capability studies are presented in Table D-3 in Appendix D. These were also used in the power flow diagrams. The interconnectors with Northern Ireland were considered to be floating i.e., zero flows were assumed. Generation local to Node N is maximised to ensure the access rights of existing generation. In some instances it is unreasonable to maximise all local generation output. Hydro generation was dispatched at half capacity during summer to account for lower rainfalls, and open-cycle gas turbines in North Wall and Aghada were not dispatched. To maintain the supply-demand balance generation in other areas was scaled back accordingly.

To calculate the ITC, generation was added in increasing amounts at the Node N. This increase was offset by an equivalent reduction in output from the existing generation in Area A. The limits of increased transfers were established by checking the Grid post-contingency performance against thermal and then voltage standards.

Problems on the Grid were not considered limiting if they were insensitive to the incremental transfers under examination. For the purposes of the studies carried out for this report the following sensitivity factors were used:

Type of Planning Criteria Violation	Threshold below which violation is considered insensitive to transfer
Voltage Violations	3% reduction in voltage / 100MW transfer
Line and Transformer Overloads	5MW change in loading / 100MW transfer

Overloads on 220/110kV transformers at a transfer station were not considered limiting. Increased transformer capacity, if required for a generation connection, can usually be achieved within the lead time of a shallow connection. The minimum permissible flow increase from these tests was reported as a matrix of ITCs, classified as low, medium, high or very high. The results are discussed in Chapter 7 and detailed in Appendix E.

Incremental Transfer Capability is directional in nature. For instance, the ITC from Dublin to Cork is entirely different to the ITC from Cork to Dublin. In general power transfers that are against the major transmission flows are less likely to require reinforcements than transfer in the same direction as existing flows. Transfers that go against the major transmission flows help to reduce line loadings, and hence allow increased utilisation of the Grid.

H.2 INCREMENTAL TRANSFER CAPABILITY STUDIES FOR DEMAND

H.2.1 Background

The method for analysing the capability of the backbone system to transfer power to meet increased demand in an area is similar to the analysis for generation. The ITC calculated is a measure of the transfer capability remaining in the physical Grid for further commercial activity over and above already anticipated uses. It provides an indication of the flexibility of the Grid to accommodate future large-scale demand increases in selected areas without the requirement for further reinforcements.

The transfer analysis is intended as a pre-feasibility indication of opportunity for increased demands. The methodology for determining ITC closely aligns with pre-feasibility study techniques.

H.2.2. Planning Criteria as applied in Transfer Limit Analysis for Demand

The application of planning standards for the analyses of demand and generation is the same in all respects except for the contingencies considered. In the generation studies trip-maintenance (N-1-1) contingencies were not considered. An assumption was made that the hypothetical generator can be constrained down or off during essential transmission circuit maintenance. However demands are not dispatchable, and so it is not acceptable to assume that the hypothetical demand may be constrained off during a maintenance outage. It is necessary, therefore, to assess the network performance against standards for trip-maintenance contingencies in the analysis of increased demands.

H.2.3 Methodology for calculating Transfer Limits for Increased Demand

As in the generation analysis, DC loadflow techniques were used to screen for critical contingencies and thermal overloads, followed by AC loadflow studies to confirm the results of the DC loadflows and to identify voltage limitations. Voltage standards were checked using parametric analysis (P-V) curves.

Transfers were considered between three areas in which existing generation is concentrated (Dublin, the south, and Northern Ireland) and the following ten 220kV stations, Maynooth, Finglas, Louth, Flagford, Cashla, Shannonbridge, Killonan, Knockraha, Arklow and Great Island. For the purposes of the following explanation, Node N refers to the 220kV station to which the transfer was evaluated, and Area A refers to the area of existing generation, from which the power was transferred.

The initial generator dispatches for the transfer capability studies are presented in Table D-2 in Appendix D. The interconnectors with Northern Ireland are considered to be floating (i.e., zero flows). These dispatches were used for single contingency (N-1) studies. For N-G-1 and N-1-1 contingencies, the generation local to Node N was maximised, to create a more favourable dispatch for the maintenance case.

To calculate the ITC, demand at 95% power factor was added at the Node in increasing amounts. This was balanced by an equivalent increase in generation output from the existing generation in Area A. In cases where full capacity was reached on all generation units, the maximum capacities were increased to allow further transfer. The limits of increased transfers were established by checking the Grid post-contingency performance against thermal and then voltage standards.

The minimum permissible flow increase from these tests was reported as a matrix of ITCs, from each generation area to each 220kV station, presented to the nearest 10MW.

To assist the reader, this matrix is reduced by combining the results of the ITCs from Dublin and the South to each of the ten 220kV stations, to provide an indication of the capabilities for increased demand at each station. When considering single contingencies (N-1) on an intact network the minimum ITC from Dublin or the South is chosen. However, when considering trip-maintenance contingencies (N-1-1), the greater of the ITCs from Dublin or the South is chosen. This is based on the assumption that less onerous generation dispatches can be scheduled to accommodate maintenance outages.

The results are discussed in Chapter 7 and detailed in Appendix E.

H.3 INCREASED CAPABILITY AT 110KV STATIONS STUDIES

H.3.1 Increased Generation Capability at 110kV Stations

The studies to identify the capability of the Grid to accommodate generation at the eighteen selected 110kV stations were identical to the ITC generation studies on the backbone system. However in the case of the 110kV stations the summer night valley condition was also examined. The reason is that during the summer night valley, the amount of output from the hypothetical generator that is absorbed by local demand is at a minimum. The amount of generation output that must be transported away from the station is therefore at a maximum. This is not a real concern for 220kV connected generation, but is for some 110kV stations.

For the winter and summer peak studies, generation is maximised in the area of the node under examination, just as in the ITC analysis. For the summer night valley cases, centrally-dispatchable generation that is local to the node is not maximised. Wind generation, which is assumed non-dispatchable, is maximised in these cases.

Transfers are examined from the eighteen 110kV stations to four areas of generation concentration, Dublin, the south-west, the south-east and Northern Ireland. The capability for increased generation at each node is taken as the most limiting of these transfers. The capability results are presented in Table 7-2 in Chapter 7 and Table F-1 in Appendix F.

H.3.2 Increased Demand Capability at 110kV Stations

The studies to identify the capability of the Grid to accommodate additional demand in excess of the projected demands at the eighteen selected 110kV stations were identical to the ITC demand studies on the backbone system.

Transfers are examined from three areas of generation concentration (Dublin, the south, and Northern Ireland) to the eighteen 110kV stations. The demand capability results are presented in identical Tables 7-3 in Chapter 7 and F-2 in Appendix F. In these tables, the results of the ITCs from Dublin and the South to each of the eighteen 110kV stations are combined, to provide an indication of the capabilities for increased demand at each station, over and above the anticipated demand. When considering single contingencies (N-1) on an intact network the minimum ITC from Dublin or the South is chosen. However, when considering trip-maintenance contingencies (N-1-1), the greater of the ITCs from Dublin or the South is chosen. This is based on the assumption that less onerous generation dispatches can be scheduled to accommodate maintenance outages. For the majority of the eighteen stations, the transfer limits are the same regardless of where the generation is being increased.