Wind Dispatch Tool
Constraint Group Overview

01 February 2024

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1 INTRODUCTION

OVERVIEW

Wind and solar generation is treated as priority dispatch (per SONI and EirGrid licences, SEM Committee decision SEM-11-062 and subsequent mods) however it is sometimes necessary to constrain or curtail its output to maintain system security. Constraints result from power flow limitations due to the topology and characteristics of the transmission network. Constraints are applied locally. Curtailment arises due to binding all-island system wide limits such as the System Non-Synchronous Penetration (SNSP) limit or minimum inertia levels. Curtailment is applied All-Island.

We use the Wind Dispatch Tool (WDT) in the TSOs' Control Centres to manage wind/solar constraints and curtailment in real time operation of the power system. The WDT allows the application of active power (MW) limits to the outputs of individual, controllable, wind/solar farms. While curtailment is applied globally to all wind/solar farms, constraints are applied to individual wind/solar farms or groups of wind/solar farms associated with the constraint. This document provides an overview of the main wind/solar constraint groups for Ireland and Northern Ireland that are currently defined in the WDT.

We plan to review the Wind Dispatch Tool constraint groups on a regular basis. We want to work in partnership with industry and welcome any feedback that you may have for consideration in future iterations. Please send feedback on this document to info@eirgrid.com or info@soni.ltd.uk.

CONSTRAINTS

Through real time monitoring of power flows and voltages, and modelling of the impact of contingency events, we determine the location and magnitude of generation constraints required to ensure EirGrid and SONI Operating Security Standards (OSS) are maintained.

The constraints set out in this report reflect the requirement for EirGrid and SONI to maintain power flows on transmission circuits within their thermal rating and to maintain voltage stability. Constraints can arise under a number of different scenarios:

- Intact Network – Even with all transmission circuits in service there can still be cases when the level of wind/solar generation exceeds the thermal rating of the transmission circuits in the area. These issues are known as 'base case' overloads. Flows on transmission circuits must be maintained below the normal continuous circuit ratings of these limiting elements.
- Single Contingency – A contingency or tripping of a single item of transmission equipment (also known as a 'N-1' event) such as a transmission line, cable or transformer should not result in an unacceptable overload of any other item of transmission equipment. Flows on transmission circuits will be limited pre-contingency to ensure that the post-contingency flows are within acceptable limits.
- Planned Outage - During planned outages of transmission equipment, the transmission system must remain within limits in the 'base case' and for 'N-1' events. A contingency event that is coincident with a planned outage is known as a 'N-1-1' event.

Voltage stability issues can also arise under these scenarios. These tend to arise when large power flows cause voltages to sag and, if left unchecked, can result in voltage collapse. Restricting power flows resolves these issues.

CONSTRAINT GROUPS

In order to manage these constraints, wind/solar farms are grouped together depending on their effectiveness to alleviate constraints. The effectiveness is a measure of the change in wind/solar farm output relative to the change in the level of the 'base case', 'N-1' or 'N-1-1' overload. The effectiveness of each wind/solar farm is a function of the topology of the transmission network.

Wind/solar farms connected at the same transmission station will generally have the same effectiveness in controlling power flows from that station so they are grouped together from a constraint management perspective. An exception to this arises if the transmission station is split or sectionalised, i.e. different wind/solar farms are selected to feed their output onto different parts of the transmission network.

Wind/solar farms connected at different transmission stations that are geographically/electrically spread apart will generally have different effectiveness levels in controlling power flows from that part of the transmission system. The grouping of these wind/solar farms is based on analysis of their effectiveness in managing the constraint as outlined in Appendix 2. Wind/solar farms that can contribute to alleviating the constraint are included in the constraint group. Wind/solar farms that do not substantially contribute to alleviating the constraint are excluded from the constraint group.

APPLICATION OF CONSTRAINT GROUPS IN THE WIND DISPATCH TOOL

For each constraint group, all wind/solar farms with Controllability Category 2[1] connected to the transmission stations in that group (either connected directly to the transmission station or connected via the local distribution network) are included in the predefined constraint groups in the WDT.

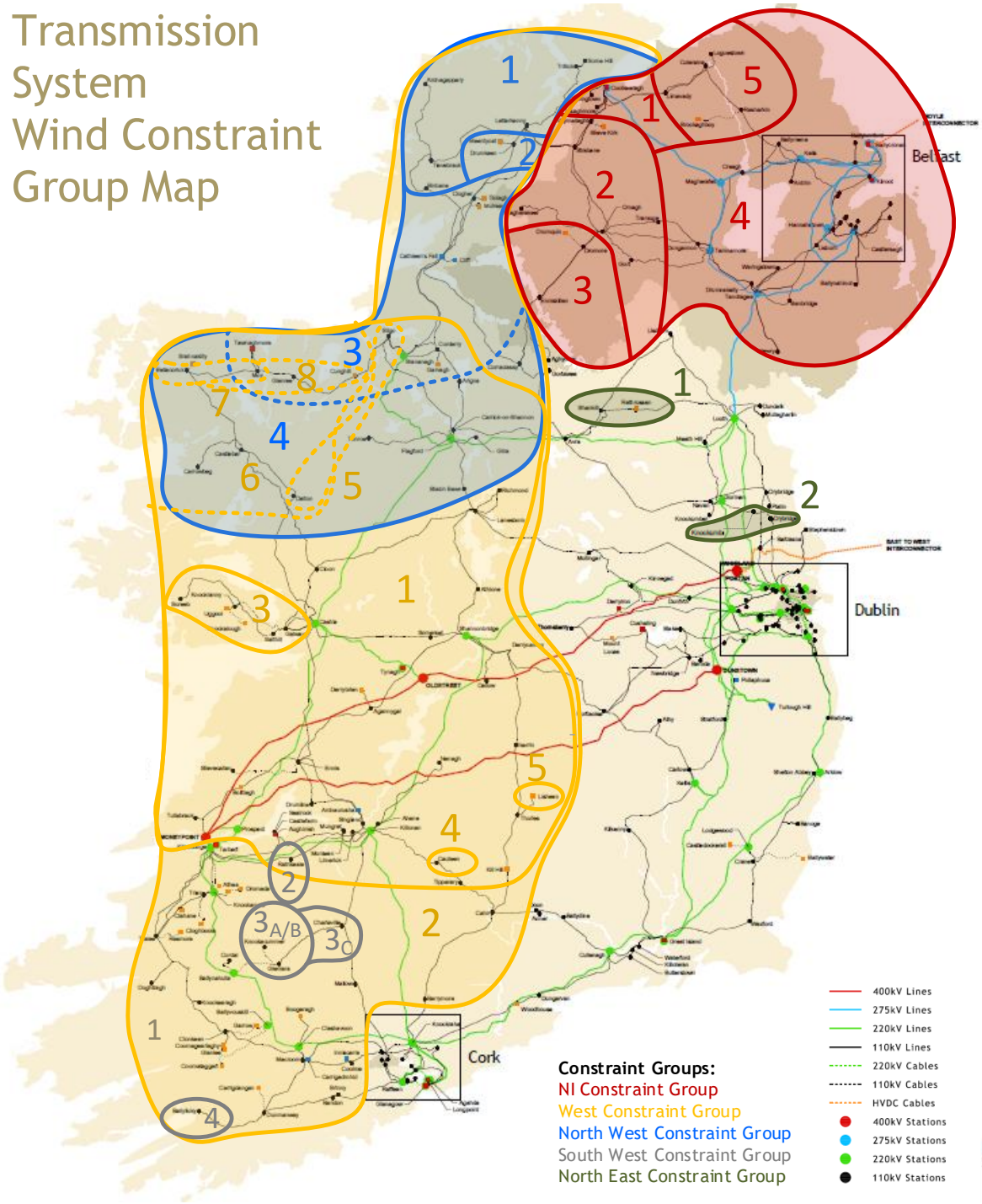
Constraint groups are predefined in the WDT to allow for their quick application in real time system operations.

Based on real time monitoring and analysis of the power system, we determine the need to apply and remove constraints. To apply a constraint, the appropriate predefined group is selected and a MW reduction level specified in the WDT. The WDT then calculates the MW setpoint for each wind/solar farm in the group and issues individual MW setpoints to the control system of each wind/solar farm. A description of how these MW setpoints are determined in the WDT is set out in Appendix 1.

The following presents a geographic illustration of the main constraint groups in the WDT.

[1] http://www.eirgridgroup.com/site-files/library/EirGrid/Wind%20Farm%20Controllability%20Categorisation%20Policy.pdf

Transmission System Wind Constraint Group Map



The following sections outline in more detail these constraint groups predefined in the WDT. Outages of transmission circuits and changes to the topology of the transmission system (new transmission circuits) will change the effectiveness of wind/solar farms to manage constraints. As a result, modifications will be made to existing constraint groups, new constraint groups will be created and no longer relevant constraint groups will be removed as power system conditions change.

This document reports on the results of an analysis carried out to determine all constraint groups required for a fully intact network at the time of publication and aims to address all key changes that will be required to these groups under outage conditions under the same network assumption. At times unforeseen issues present themselves in Real Time that require the application of a constraint group not covered in this publication.

The geographic spread of each constraint group is illustrated and a table of the transmission stations with controllable wind connected is provided.

2 NORTHERN IRELAND CONSTRAINT GROUPS

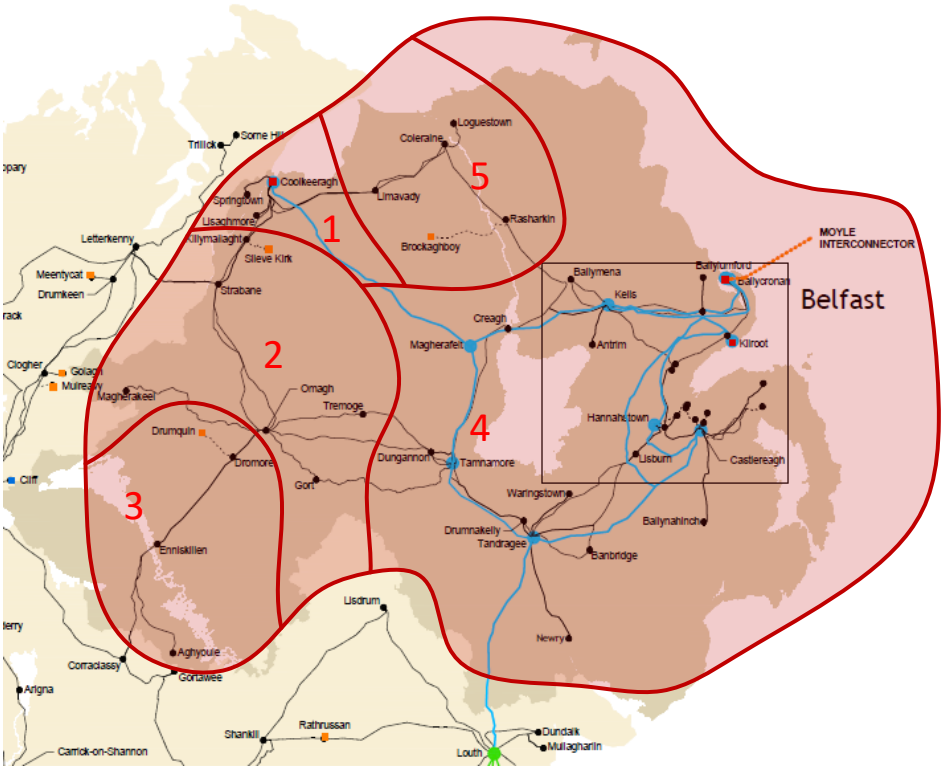


Figure 1: Northern Ireland Geographical Constraint Groups

2.1 Constraint Group number 1 – NW Northern

This constraint group is designed to resolve a contingency on the Kells-Rasharkin 110 kV line or the runback scheme, which would cause the largest potential overload to be on the Coolkeeragh – Limavady 110 kV line or on the Kells-Rasharkin 110 kV line respectively.

This constraint group includes all generation connected to the following transmission nodes;

Station	
Brockaghboy	Lisaghmore
Coleraine	Loguestown
Coolkeeragh	Rasharkin
Limavady	Garvagh

2.2 Constraint Group number 2 – NW Southern

This constraint group is used when the largest potential overloads are between Coolkeeragh - Strabane 110 kV line as a result of the loss of the Coolkeeragh -Killymallaght line.

This constraint group includes all generation connected to the following transmission nodes:

Station	
Aghyoule	Gort
Drumquin	Magherakeel
Strabane	Omagh
Enniskillen	Tremoge
Killymallaght	Slieve Kirk

2.3 Constraint group number 3 – Oma-Dromore

This constraint group is needed to relieve potential overloads between Dromore and Omagh 110 kV.

This constraint group includes all generation connected to the following transmission nodes:

Station
Aghyoule
Drumquin
Enniskillen

2.4 Constraint group number 4 – All NI

This constraint group is required to manage flows on the 275/220 kV tie-lines between Tandragee 275 kV station and Louth 220 kV Station. It includes all controllable renewable Northern Ireland generation.

2.5 Constraint group number 5 – Kells - Rasharkin

This constraint group alleviates contingencies on Coolkeeragh-Limavady or Limavady-Coleraine lines that can occur during standard operation but in particular, during times when there are outages in the area.

This constraint group includes all generation connected to the following transmission nodes:

Station	
Brockaghboy	Garvagh
Coleraine	Loguestown
Limavady	Rasharkin

3 IRELAND NORTH WEST CONSTRAINT GROUPS

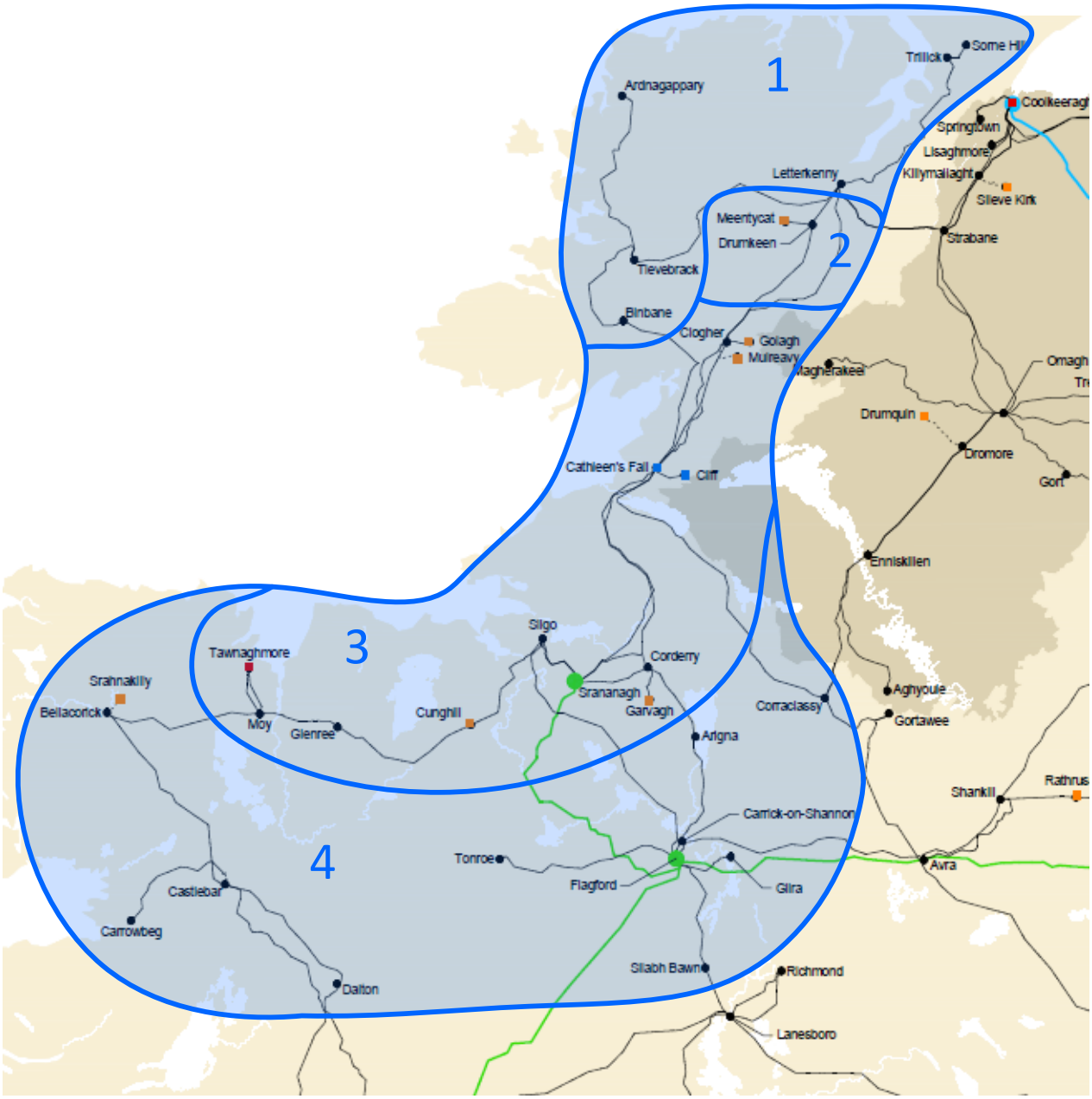


Figure 2: North West Geographical Constraint Groups

3.1 North West Constraint Group 1: Letterkenny A1 Busbar Flows

This constraint group is used when power export from North Donegal is limited for the post contingency risk of overloads on sections of the Letterkenny 110 kV busbar (or for excessive basecase loading of these busbar sections under outage conditions).

This Constraint Group is used to resolve excessive N-1 overloads on the Letterkenny 110 kV A1 busbar section for the tripping of 110 kV lines between Letterkenny and Binbane, most notably the Binbane-Cathaleen's Fall 110 kV circuit.

Intact Network Constraint Group:

Station
Ardnagappary
Binbane
Lenalea
Sorne Hill
Trillick

NORTH WEST CONSTRAINT GROUP 1: OUTAGE CONSIDERATIONS

Under certain outage conditions the North West Constraint Group 1 will have to be temporarily modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Lenalea and Letterkenny:

Sample outages that will result in this condition:

- Lenalea-Letterkenny 110 kV circuit

North West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station
~~Ardnagappary~~
~~Binbane~~
~~Lenalea~~
Sorne Hill
Trillick

Outage Condition 2: Disconnection of Electrical Connectivity Between Tievebrack and Lenalea:

Sample outages that will result in this condition:

- Lenalea-Tievebrack 110 kV circuit
- Tievebrack 110 kV Sectionalising Cubicle SA1-2

North West Constraint Group 2: Modification

Temporary Group for Outage Condition:

Station
~~Ardnagappary~~
~~Binbane~~
Lenalea
Sorne Hill
Trillick

Outage Condition 3: Disconnection of Electrical Connectivity Between Tievebrack and Binbane:

Sample outages that will result in this condition:

- Binbane-Tievebrack 110 kV circuit

North West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station
Ardnagappary
~~Binbane~~
Lenalea
Sorne Hill
Trillick

Outage Condition 4: Disconnection of Electrical Connectivity Between Tievebrack and Binbane A2:

Sample outages that will result in this condition:

- Binbane 110 kV Sectionalising Cubicle SA1-2 & Binbane T141

North West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station
Ardnagappary
Binbane A1
Lenalea
Sorne Hill
Trillick

Summary of changes:

- Binbane A2 node removed

3.2 North West Constraint Group 2: Letterkenny A2 Busbar Flows

This Constraint Group is used to resolve excessive N-1 overloads on the Letterkenny 110 kV A2 busbar section for the tripping of Clogher-Drumkeen 110 kV circuit.

Intact Network Constraint Group:

Station
Meentycat

NORTH WEST CONSTRAINT GROUP 2: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

3.3 North West Constraint Group 3: Sligo to Flagford or Flagford 220/110 kV Transformer Flows

This constraint group is used due to limitations on the Flagford-Sligo 110 kV circuit when there is an excessive export of wind/solar from the North West Donegal/Sligo/Mayo region which is not backed off by large wind/solar output from the Midlands and West regions.

A constraint is required to protect this circuit against the potential risk of the loss of the 220 kV circuit accommodating large flows from Srananagh to Flagford out of the region.

Intact Network Constraint Group:

Station	
Ardnagappary	Meentycat
Binbane	Moy
Cathaleen's Fall	Mulreavy
Corderry	Sligo
Cunghill	Sorne Hill
Garvagh	Tawnaghmore
Glenree	Trillick
Lenalea	

In order to minimise constraints on the 110 kV network in the North West, Flagford is often sectionalised at 110 kV in which the busbar is often split to restrict through flow on the busbar and force increased flows onto the 220 kV network which is capable of transferring more power to the east.

When Flagford is split at 110 kV the binding network issue that requires a constraint in the region moves from limitations on Flagford-Sligo 100 kV circuit to limitations on the Flagford 220/110 kV transformer, T2102, again for the loss of Flagford-Srananagh 220 kV circuit.

This could prompt coupling of Flagford again at 110 kV and constrain for limitations on Flagford-Sligo 110 kV or constrain this same constraint group for limitations on the Flagford 220/110 kV transformer, T2102.

NORTH WEST CONSTRAINT GROUP 3: OUTAGE CONSIDERATIONS

Under certain outage conditions the North West Constraint Group 3 will have to be temporarily modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Corderry and Srananagh:

Sample outages that will result in this condition:

- Corderry-Srananagh 110 kV circuit

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
Ardnagappary	Meentycat
Binbane	Moy
Cathaleen's Fall	Mulreavy
~~Corderry~~	Sligo
Cunghill	Sorne Hill
~~Garvagh~~	Tawnaghmore
Glenree	Trillick
Lenalea	

Outage Condition 2: Disconnection of Electrical Connectivity Between Cunghill and Sligo:

Sample outages that will result in this condition:

- Cunghill-Sligo 110 kV circuit

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
Ardnagappary	Meentycat
Binbane	~~Moy~~
Cathaleen's Fall	Mulreavy
Corderry	Sligo
~~Cunghill~~	Sorne Hill
Garvagh	~~Tawnaghmore~~
~~Glenree~~	Trillick
Lenalea	

Outage Condition 3: Disconnection of Electrical Connectivity Between Cunghill and Glenree:

Sample outages that will result in this condition:

- Cunghill-Glenree 110 kV circuit

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
Ardnagappary	Meentycat
Binbane	~~Moy~~
Cathaleen's Fall	Mulreavy
Corderry	Sligo
Cunghill	Sorne Hill
Garvagh	~~Tawnaghmore~~
~~Glenree~~	Trillick
Lenalea	

Outage Condition 4: Disconnection of Electrical Connectivity Between Cunghill and Glenree A1:

Sample outages that will result in this condition:

- Glenree 110 kV Sectionalising Cubicle SA1-2

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
Ardnagappary	Meentycat
Binbane	~~Moy~~
Cathaleen's Fall	Mulreavy
Corderry	Sligo
Cunghill	Sorne Hill
Garvagh	~~Tawnaghmore~~
Glenree A2	Trillick
Lenalea	

Summary of changes:

- Glenree A1 node removed
- Moy node removed
- Tawnaghmore node removed

Outage Condition 5: Disconnection of Electrical Connectivity Between Glenree and Moy:

Sample outages that will result in this condition:

- Glenree-Moy 110 kV circuit

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
Ardnagappary	Meentycat

Binbane	~~Moy~~
Cathaleen's Fall	Mulreavy
Corderry	Sligo
Cunghill	Sorne Hill
Garvagh	~~Tawnaghmore~~
Glenree	Trillick
Lenalea	

Outage Condition 6: Disconnection of Electrical Connectivity Between Cathaleen's Fall and Srananagh:

Sample outages that will result in this condition:

- Cathaleen's Fall-Srananagh 110 kV circuit no.1 & Cathaleen's Fall Srananagh 110 kV circuit no.2

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
~~Ardnagappary~~	~~Meentycat~~
~~Binbane~~	Moy
~~Cathaleen's Fall~~	~~Mulreavy~~
Corderry	Sligo
Cunghill	~~Sorne Hill~~
Garvagh	Tawnaghmore
Glenree	~~Trillick~~
~~Lenalea~~	

Outage Condition 7: Disconnection of Electrical Connectivity Between Bellacorick and Castlebar:

Sample outages that will result in this condition:

- Bellacorick-Castlebar 110 kV circuit

North West Constraint Group 3: Modification

Temporary Group for Outage Condition:

Station	
Ardnagappary	Meentycat
Binbane	Moy
Cathaleen's Fall	Mulreavy
Corderry	Sligo
Cunghill	Sorne Hill
Garvagh	***Srahnakilly***
Glenree	Tawnaghmore
Lenalea	Trillick

Summary of changes:

- Srahnakilly node added

3.4 North West Constraint Group 4: Carrick-on-Shannon to Arva Flows

This constraint group is used due to limitations on the Arva-Carrick-on-Shannon 110 kV circuit when there is an excessive export of wind/solar from the entire West and North West Regions to the East of the Network.

A pre-constraint is required to protect this circuit against the potential risk of the loss of a section of a parallel path out of the region from Cathaleen's Fall to Arva.

Sectionalising of the Network is often carried out in order to greatly reduce constraints in the region. This can involve splitting Flagford or Arva 110 kV stations or a combination of both. This puts greater stress on the Arva-Carrick-on-Shannon 110 kV circuit making this condition binding.

Intact Network Constraint Group:

Station	
Ardnagappary	Meentycat
Binbane	Moy
Castlebar	Mulreavy
Cathaleen's Fall	Sliabh Bawn
Corderry	Sligo
Cunghill	Sorne Hill
Dalton	Srahnakilly
Garvagh	Tawnaghmore
Glenree	Trillick
Lenalea	

⚠ North West Constraint Group 4: Outage Considerations

Under certain outage conditions the North West Constraint Group 4 will have to be temporarily modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Cathaleen's Fall and Srananagh:

Sample outages that will result in this condition:

- Cathaleen's Fall-Srananagh 110 kV circuit no.1 & Cathaleen's Fall Srananagh 110 kV circuit no.2

North West Constraint Group 4: Modification

Temporary Group for Outage Condition:

Station	
~~Ardnagappary~~	~~Meentycat~~
~~Binbane~~	Moy

Castlebar	~~Mulreavy~~
~~Cathaleen's Fall~~	Sliabh Bawn
Corderry	Sligo
Cunghill	~~Sorne Hill~~
Dalton	Srahnakilly
Garvagh	Tawnaghmore
Glenree	~~Trillick~~
~~Lenalea~~	

3.5 North West Constraint Group 5 (Outage Driven): Sliabh Bawn to Lanesboro Flows

When the wind/solar in the West and Midlands is much less than the wind/solar in the North West as per the binding condition for constraint group 4, there is a risk that the Lanesboro-Sliabh Bawn 110 kV circuit will get overloaded for the loss of Flagford-Srananagh 220 kV circuit during a range of Transmission Outage conditions in the region and particularly outages driving the need to couple Flagford at 110 kV.

"N-1-1" Network Constraint Group:

Station	
Ardnagappary	Lenalea
Binbane	Meentycat
Cathaleen's Fall	Mulreavy
Corderry	Sliabh Bawn
Cunghill	Sligo
Garvagh	Sorne Hill
Glenree	Trillick

3.6 North West Constraint Group 6 (Outage Driven): Binbane to Cathaleen's Fall Flows

When the North West is under very onerous outage conditions in which the connection between Cathaleen's Fall to Clogher is disconnected, weakeness materialise on the Binbane-Cathaleen's Fall 110 kV circuit trying to export power out of the region. This condition is driven by double circuit outages of the Cathaleen's Fall – Clogher 110 kV circuits.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Network Constraint Group:

Station	
Ardnagappary	Mulreavy
Binbane	Sorne Hill
Lenalea	Trillick
Meentycat	

3.7 North West Constraint Group 7 Corderry to Srananagh Flows (Retired)

This constraint group was used due to limitations on the Corderry-Srananagh 110 kV circuit. Since the uprate of this circuit this constraint group is **no longer active**. The group remains coded in the WDT.

Retired Constraint Group:

Station
Corderry
Garvagh

4 IRELAND WEST CONSTRAINT GROUPS

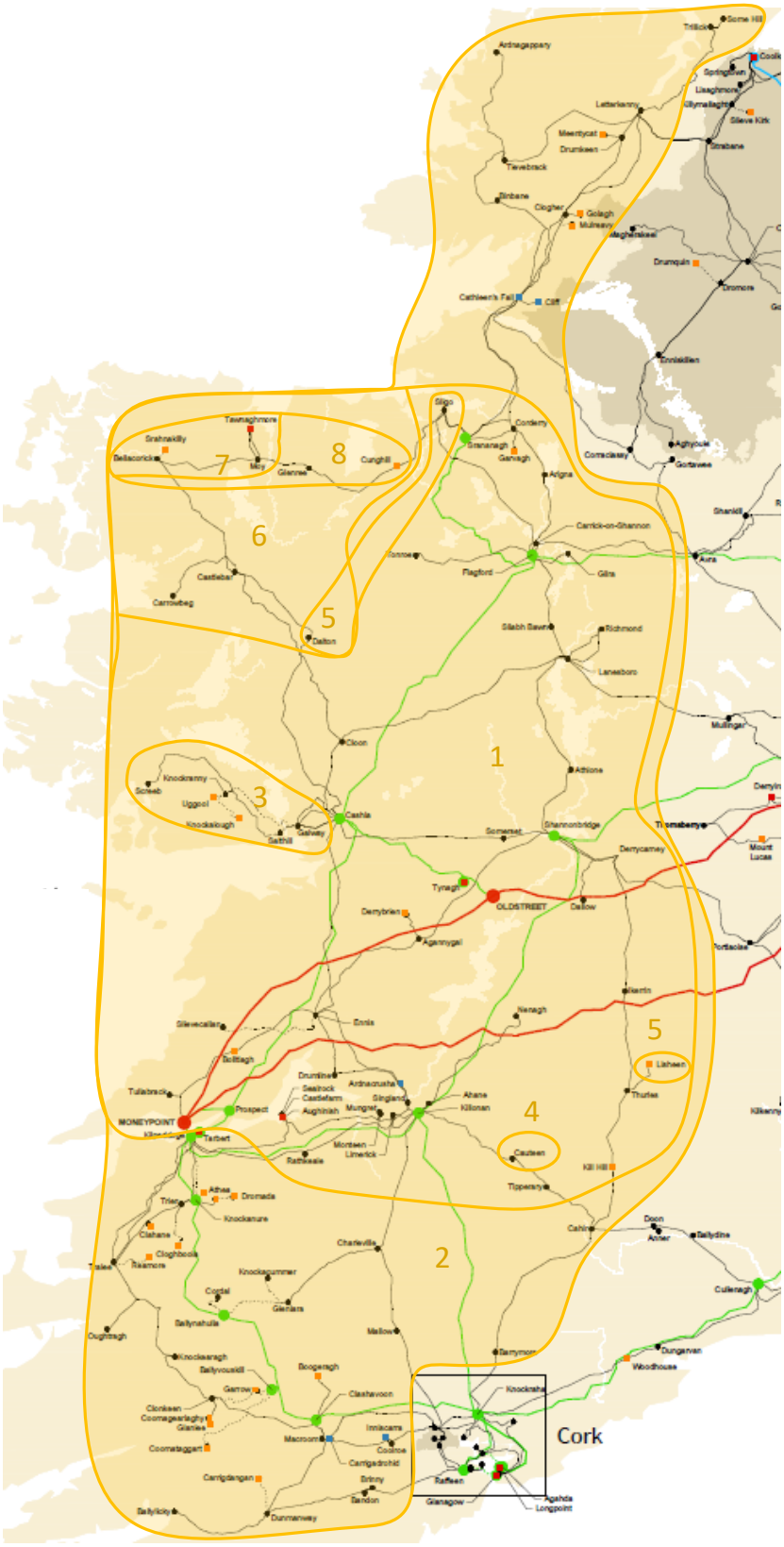


Figure 3: West Geographical Constraint Groups

4.1 West Constraint Group 1: Lanesboro to Mullingar or Lanesboro Busbar Flows

This constraint group is used due to limitations on the Lanesboro-Mullingar 110 kV circuit or sections of the Lanesboro 110 kV busbar when there is an excessive export of wind/solar from the entire West Region to the East of the Network.

A pre-constraint is required to protect this equipment against the potential risk of the loss of a path to the 400 kV network from Oldstreet to Woodland to transfer power from the West to the East of the network.

Sectionalising of the Network is often carried out in order to greatly reduce constraints in the region. This can involve opening the Kinnegad 110 kV circuit breaker in Mullingar 110 kV station or splitting the Flagford busbar at 110 kV.

Intact Network Constraint Group:

Station	
Ardnacrusha	Knockalough
Booltiagh	Lisheen
Buffy	Moneypoint
Castlebar	Moy
Cauteen	Rathkeale
Corderry	Salthill
Cunghill	Sliabh Bawn
Dallow	Slieve Callan
Dalton	Sligo
Derrybrien	Srahnakilly
Garvagh	Tawnaghmore
Glenree	Thurles
Ikerrin	Tullabrack
Kill Hill	Uggool

WEST CONSTRAINT GROUP 1: OUTAGE CONSIDERATIONS

Under certain outage conditions the West Constraint Group 1 will have to be temporarily modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Dallow and Shannonbridge:

Sample outages that will result in this condition:

- Dallow Tee-Shannonbridge 110 kV circuit section.

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	Lisheen
Buffy	Moneypoint
Castlebar	Moy
Cauteen	Rathkeale
Corderry	Salthill
Cunghill	Sliabh Bawn
~~Dallow~~	Slieve Callan
Dalton	Sligo
Derrybrien	Srahnakilly
Garvagh	Tawnaghmore
Glenree	Thurles
Ikerrin	Tullabrack
Kill Hill	Uggool

Outage Condition 2: Disconnection of Electrical Connectivity Between Flagford and Sliabh Bawn:

Sample outages that will result in this condition:

- Flagford-Sliabh Bawn 110 kV circuit.

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	Lisheen
Buffy	Moneypoint
Castlebar	Moy
Cauteen	Rathkeale
~~Corderry~~	Salthill
~~Cunghill~~	Sliabh Bawn
Dallow	Slieve Callan
Dalton	~~Sligo~~
Derrybrien	Srahnakilly
~~Garvagh~~	Tawnaghmore
Glenree	Thurles
Ikerrin	Tullabrack
Kill Hill	Uggool

Outage Condition 3: Disconnection of Electrical Connectivity Between Lanesboro and Sliabh Bawn:

Sample outages that will result in this condition:

- Lanesboro-Sliabh Bawn 110 kV circuit.

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	Lisheen
Buffy	Moneypoint
Castlebar	Moy
Cauteen	Rathkeale
~~Corderry~~	Salthill
~~Gunghill~~	~~Sliabh Bawn~~
Dallow	Slieve Callan
Dalton	~~Sligo~~
Derrybrien	Srahnakilly
~~Garvagh~~	Tawnaghmore
Glenree	Thurles
Ikerrin	Tullabrack
Kill Hill	Uggool

Outage Condition 4: Disconnection of Electrical Connectivity Between Ikerrin and Shannonbridge:

Sample outages that will result in this condition:

- Ikerrin Tee-Shannonbridge 110 kV circuit section.

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	~~Lisheen~~
Buffy	Moneypoint

Castlebar	Moy
Cauteen	Rathkeale
Corderry	Salthill
Cunghill	Sliabh Bawn
Dallow	Slieve Callan
Dalton	Sligo
Derrybrien	Srahnakilly
Garvagh	Tawnaghmore
Glenree	~~Thurles~~
~~Ikerrin~~	Tullabrack
~~Kill Hill~~	Uggool

Outage Condition 5: Disconnection of Electrical Connectivity Between Thurles and Shannonbridge:

Sample outages that will result in this condition:

- Ikerrin Tee-Thurles 110 kV circuit section.
- Ikerrin-Shannonbridge-Thurles 110 kV circuit

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	~~Lisheen~~
Buffy	Moneypoint
Castlebar	Moy
Cauteen	Rathkeale
Corderry	Salthill
Cunghill	Sliabh Bawn
Dallow	Slieve Callan

Dalton	Sligo
Derrybrien	Srahnakilly
Garvagh	Tawnaghmore
Glenree	~~Thurles~~
Ikerrin	Tullabrack
~~Kill Hill~~	Uggool

Outage Condition 6: Disconnection of Electrical Connectivity Between Kill Hill and Thurles:

Sample outages that will result in this condition:

- Kill Hill-Thurles 110 kV circuit section.

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	Lisheen
Buffy	Moneypoint
Castlebar	Moy
Cauteen	Rathkeale
Corderry	Salthill
Cunghill	Sliabh Bawn
Dallow	Slieve Callan
Dalton	Sligo
Derrybrien	Srahnakilly
Garvagh	Tawnaghmore
Glenree	Thurles
Ikerrin	Tullabrack
~~Kill Hill~~	Uggool

Outage Condition 7: Disconnection of Electrical Connectivity Between Limerick and Rathkeale:

Sample outages that will result in this condition:

- Limerick-Rathkeale 110 kV circuit section.

West Constraint Group 1: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Knockalough
Booltiagh	Lisheen
Buffy	Moneypoint
Castlebar	Moy
Cauteen	~~Rathkeale~~
Corderry	Salthill
Cunghill	Sliabh Bawn
Dallow	Slieve Callan
Dalton	Sligo
Derrybrien	Srahnakilly
Garvagh	Tawnaghmore
Glenree	Thurles
Ikerrin	Tullabrack
Kill Hill	Uggool

4.2 West Constraint Group 2: Shannonbridge to Maynooth Flows

When there is an excessive export of wind/solar from the entire West Region to the East of the Network, for the loss of the link from the 220 kV to 400 kV network from Tynagh to Oldstreet or the loss of the 400 kV link from Oldstreet to Woodland, there is a risk of excessively overloading the Maynooth-Shannonbridge 220 kV circuit. At times this issue can be reduced by sectionalizing Maynooth at 220 kV, isolating the Shannonbridge 220 kV cubicle from the higher load north Dublin bound feeders, Kellystown and Gorman.

Due to the increased tendency for power to flow up onto the 220 kV network before transferring to the east of the network, this constraint group is made up of a wider range of Westerly nodes.

Intact Network Constraint Group:

Station	
Ardnacrusha	Glenree
Ardnagappary	Ikerrin
Athea	Kill Hill
Ballylickey	Kilpaddoge
Bandon	Knockacummer
Barrymore	Knockalough
Binbane	Knockearagh
Boggeragh	Lenalea
Booltiagh	Lisheen
Buffy	Macroom
Carrigdangan	Meentycat
Castlebar	Midleton
Cathaleen's Fall	Moneypoint
Cauteen	Moy
Charleville	Mulreavy
Clahane	Oughtragh
Cloghboola	Rathkeale
Coolnanoonagh	Reamore

Coomagearlaghy	Salthill
Coomataggart	Sliabh Bawn
Cordal	Slieve Callan
Corderry	Sligo
Cunghill	Sorne Hill
Dallow	Srahnakilly
Dalton	Tawnaghmore
Derrybrien	Thurles
Dromada	Tobertoreen
Dunmanway	Tralee
Garrow	Trien
Garvagh	Trillick
Glanlee	Tullabrack
Glenlara	Uggool

⚠ West Constraint Group 2: Outage Considerations

Under certain outage conditions the West Constraint Group 2 will have to be temporarily modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Dallow and Shannonbridge:

Sample outages that will result in this condition:

- Dallow Tee-Shannonbridge 110 kV circuit section.

West Constraint Group 2: Modification

Temporary Group for Outage Condition:

Station	
Ardnacrusha	Glenree

Ardnagappary	Ikerrin
Athea	Kill Hill
Ballylickey	Kilpaddoge
Bandon	Knockacummer
Barrymore	Knockalough
Binbane	Knockearagh
Boggeragh	Lenalea
Booltiagh	Lisheen
Buffy	Macroom
Carrigdangan	Meentycat
Castlebar	Midleton
Cathaleen's Fall	Moneypoint
Cauteen	Moy
Charleville	Mulreavy
Clahane	Oughtragh
Cloghboola	Rathkeale
Coolnanoonagh	Reamore
Coomagearlaghy	Salthill
Coomataggart	Sliabh Bawn
Cordal	Slieve Callan
Corderry	Sligo
Cunghill	Sorne Hill
~~Dallow~~	Srahnakilly
Dalton	Tawnaghmore
Derrybrien	Thurles
Dromada	Tobertoreen
Dunmanway	Tralee

Garrow	Trien
Garvagh	Trillick
Glanlee	Tullabrack
Glenlara	Uggool

4.3 West Constraint Group 3: Salthill To Galway Salthill To Cashla and Knockranny To Galway Flows

This constraint group is used due to limitations exporting wind out of the Galway region in low load conditions and weaknesses on the Galway-Salthill, Cashla-Salthill and Galway Knockranny 110 kV circuits. These weaknesses are further enhanced if either of the three circuits are on outage.

Intact Network Constraint Group:

Station
Buffy
Knockalough
Salthill
Uggool

⚠ WEST CONSTRAINT GROUP 3: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

4.4 West Constraint Group 4: Cauteen 110 kV Station Voltage Stability

This constraint group is used to prevent post-contingency voltage instability at Cauteen 110 kV for the loss of Cauteen-Tipperary 110 kV circuit.

Voltage stability is maintained at Cauteen 110 kV station for the loss of the Cauteen-Killonan 110 kV circuit through the operation of a Special Protection Scheme (SPS).

Intact Network Constraint Group:

Station
Cauteen

WEST CONSTRAINT GROUP 4: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

4.5 West Constraint Group 5: Lisheen to Thurles Flows

This constraint group is used to manage base case flows on the Lisheen-Thurles 110 kV circuit when there is high outputs of wind/solar out of Lisheen and under high temperature conditions.

Intact Network Constraint Group:

Station
Lisheen

WEST CONSTRAINT GROUP 5: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

4.6 West Constraint Group 6: Castlebar To Cloon or Dalton To Cashla Flows

For a number of Transmission conditions in the Mayo region of the network, post contingency weaknesses materialise on the Castlebar-Cloon 110 kV circuit, the Cashla-Dalton 110 kV circuit and the Dalton 110 kV busbar when high wind is trying to export out of the region particulary when a path to Cashla or a path to Cloon is temporarily disconnected. These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of this constraint group.

Intact Network Constraint Group:

Station	
Castlebar	Moy
Cunghill	Srahnakilly
Dalton	Tawnaghmore

Glenree	

⚠ West Constraint Group 6: Outage Considerations

Under specific outage conditions the West Constraint Group 6 may need to be modified to account for the resultant change in load flows.

Outage Condition 1: Disconnection of Electrical Connectivity Between Castlebar and Dalton:

Sample outages that will result in this condition:

- Castlebar-Dalton 110 kV circuit

West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station	
Castlebar	Moy
Cunghill	Srahnakilly
~~Dalton~~	Tawnaghmore
Glenree	

Outage Condition 2: Disconnection of Electrical Connectivity Between Cunghill and Glenree:

Sample outages that will result in this condition:

- Cunghill-Glenree 110 kV circuit

West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station	
Castlebar	Moy
~~Cunghill~~	Srahnakilly

Dalton	Tawnaghmore
Glenree	

Outage Condition 3: Disconnection of Electrical Connectivity Between Cunghill and Glenree A1:

Sample outages that will result in this condition:

- Glenree 110 kV Sectionalising Cubicle SA1-2

West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station	
Castlebar	Moy
~~Cunghill~~	Srahnakilly
Dalton	Tawnaghmore
Glenree A1	

Summary of changes:

- Cunghill node removed
- Glenree A2 node removed

Outage Condition 4: Disconnection of Electrical Connectivity Between Glenree and Moy:

Sample outages that will result in this condition:

- Glenree-Moy 110 kV circuit

West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station	
Castlebar	Moy
~~Cunghill~~	Srahnakilly
Dalton	Tawnaghmore

~~Glenree~~	

Outage Condition 5: Disconnection of Electrical Connectivity Between Moy and Bellacorick:

Sample outages that will result in this condition:

- Bellacorick-Moy 110 kV circuit

West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station	
Castlebar	~~Moy~~
~~Cunghill~~	Srahnakilly
Dalton	~~Tawnaghmore~~
~~Glenree~~	

4.7 West Constraint Group 7: Moy To Glenree Flows

This constraint group is used when power export from North Mayo is limited for the post contingency risk of overloads on the Moy-Glenree 110 kV circuit for the loss of Bellacorick-Castlebar 110 kV circuit (or for excessive basecase loading of this circuit under outage conditions).

An SPS is being developed to mitigate the need for this constraint when the system is intact and the SPS is in service. This constraint group will then, largely be used during outage conditions on the system.

Intact Network Constraint Group:

Station	
Moy	Tawnaghmore
Srahnakilly	

WEST CONSTRAINT GROUP 7: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

4.8 West Constraint Group 8: Cunghill To Sligo Flows

This constraint group is used when power export from North Mayo is limited for the post contingency risk of overloads on the Cunghill-Sligo 110 kV circuit for the loss of Bellacorick-Castlebar 110 kV circuit (or for excessive basecase loading of this circuit under outage conditions).

An SPS is being developed to mitigate the need for this constraint when the system is intact and the SPS is in service. This constraint group will then, largely be used during outage conditions on the system.

Intact Network Constraint Group:

Station	
Cunghill	Srahnakilly
Glenree	Tawnaghmore
Moy	

WEST CONSTRAINT GROUP 8: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

4.9 West Constraint Group 9 (Outage Driven): Thurles Instability

During the long term outage of Thurles CAP2, required to install a new Statcom in the station, there is a risk of voltage instability in the Thurles region during additional outage and high wind conditions until the Statcom is installed. If Thurles CAP1 or the Cahir-Kill Hill 110 kV circuit goes on outage this constraint group might have to be restricted to ensure voltage stability in the region.

"N-1-1" Network Constraint Group:

Station	
Ikerrin	Lisheen
Kill Hill	Thurles

WEST CONSTRAINT GROUP 9: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

5 IRELAND SOUTH WEST CONSTRAINT GROUPS

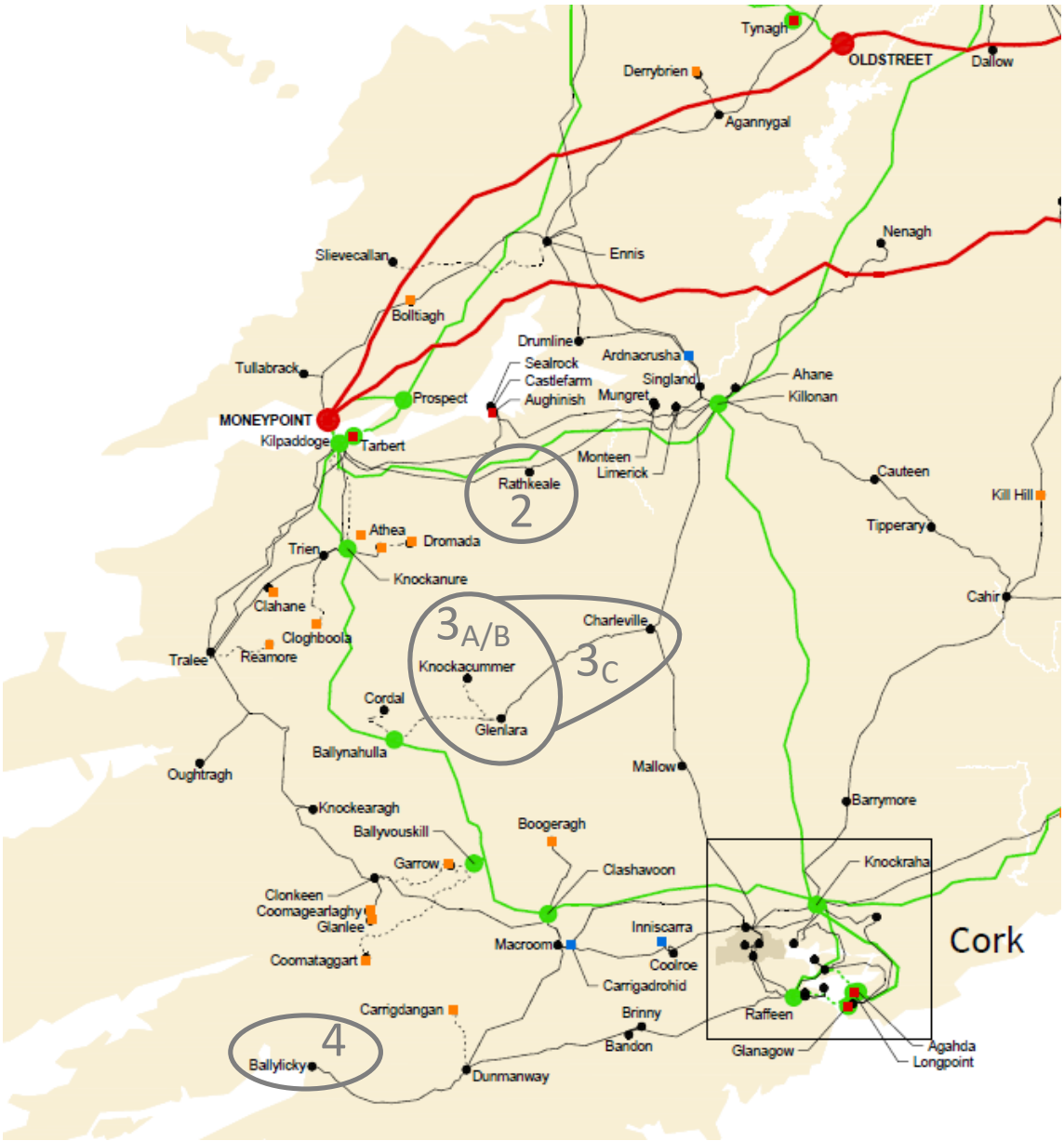


Figure 4: South West Geographical Constraint Groups

5.1 South West Constraint Group 1: Moneypoint 400/220 kV Transformer 2 (Retired)

This constraint group was used due to limitations on the Moneypoint 400/220 kV Transformer No.2. Since this transformer was replaced this constraint group is **no longer active**. The group remains coded in the WDT.

Intact Network Constraint Group:

Station	
Ardnacrusha	Dunmanway
Athea	Garrow
Ballylickey	Glanlee
Bandon	Kilpaddoge
Boggeragh	Knockearagh
Booltiagh	Macroom
Carrigdangan	Moneypoint
Clahane	Oughtragh
Cloghboola	Rathkeale
Coolnanoonagh	Reamore
Coomagearlaghy	Slieve Callan
Coomataggart	Tobertoreen
Cordal	Tralee
Derrybrien	Trien
Dromada	Tullabrack

5.2 South West Constraint Group 2: Rathkeale to Limerick Flows

This constraint group is used due to limitations on the Limerick -Rathkeale 110 kV circuit when exporting wind/solar from Kerry when there is less midlands and west wind/solar to back off flows transferring the export across the 110 kV network.

Pre-contingency constraints are required to protect the circuit for the risk of tripping North Kerry 220 kV circuits.

Intact Network Constraint Group:

Station
Rathkeale

South West Constraint Group 2: Outage Considerations

No changes to group identified under transmission outage conditions.

5.3 South West Constraint Group 3a: Glenlara to Ballynahulla Flows

This constraint group is used due to basecase limitations on the Ballynahulla - Glenlara 110 kV circuit.

Intact Network Constraint Group:

Station
Glenlara A1
Knockacummer

South West Constraint Group 3a: Outage Considerations

Under certain combined outage conditions the South West Constraint Group 3 will have to be modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Charleville and Glenlara:

Sample outages that will result in this condition:

- Charleville-Glenlara 110 kV circuit.
- Charleville 110 kV A1 busbar.
- Glenlara 110 kV Sectionslising Cubicle SA1-2 & Glenlara T142

South West Constraint Group 3a: Modification

Temporary Group for Outage Condition:

Station
Glenlara
Knockacummer

Summary of changes:

- Glenlara A2 node added

5.4 South West Constraint Group 3b: Glenlara to Charleville Flows

This constraint group is used due to basecase limitations on the Charleville - Glenlara 110 kV circuit.

In order to minimise constraints in the entire South West region, Glenlara is often operationally tail fed into Charleville resulting in the presence of this constraint group. This constraint grouop is also required during outages of the Ballynahulla-Glenlara 110 kV circuit.

Intact Network Constraint Group:

Station
Glenlara
Knockacummer

SOUTH WEST CONSTRAINT GROUP 3B: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

5.5 South West Constraint Group 3c: Charleville to Mallow Flows

This constraint group is used due to post contingency overloads on the Charleville – Mallow 110 kV circuit for the loss of the Charleville-Killonan 110 kV circuit.

In order to minimise constraints in the entire South West region, Glenlara is often operationally tail fed into Charleville resulting in the presence of this constraint group. This constraint group is also required during outages of the Ballynahulla-Glenlara 110 kV circuit.

Intact Network Constraint Group:

Station
Charleville
Glenlara
Knockacummer

SOUTH WEST CONSTRAINT GROUP 3C: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

5.6 South West Constraint Group 4: Ballylickey Voltage Stability

This constraint group is used due to the risk of voltage instability at Ballylickey 110 kV station if its connection point at Dunmanway is tailed post contingency under high wind/solar conditions.

Intact Network Constraint Group:

Station
Ballylickey

SOUTH WEST CONSTRAINT GROUP 4: OUTAGE CONSIDERATIONS

No changes to group identified under transmission outage conditions.

5.7 South West Constraint Group 5 (Outage Driven): Dunmanway to Bandon Flows

For a number of Transmission Outage conditions in the Cork/Kerry region of the network, post contingency weaknesses materialise on the Bandon-Dunmanway 110 kV circuit when high wind is trying to export out of the region to the Cork urban load. This is generally required when the system is subject to a large 220 kV outage in the region or when the electrical connection form the South West to Kilbarry is disconnected

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station	
Ballylickey	Dunmanway
Boggeragh	Garrow
Carrigdangan	Glanlee
Coomagearlaghy	Knockearagh
Coomataggart	Macroom
Cordal	

SOUTH WEST CONSTRAINT GROUP 5: OUTAGE CONSIDERATIONS

Under certain combined outage conditions the South West Constraint Group 5 will have to be modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Ballynahulla and Ballyvouskill:

Sample outages that will result in this condition:

- Ballynahulla-Ballyvouskill 220 kV circuit.

South West Constraint Group 5: Modification

Temporary Group for Outage Condition:

Station	
Ballylickey	Dunmanway
Boggeragh	Garrow
Carrigdangan	Glanlee
Coomagearlaghy	Knockearagh
Coomataggart	Macroom
~~Cordal~~	

Outage Condition 2: Disconnection of Electrical Connectivity Between Clonkeen and Knockearagh:

Sample outages that will result in this condition:

- Clonkeen-Knockearagh 110 kV circuit.

South West Constraint Group 5: Modification

Temporary Group for Outage Condition:

Station	
Ballylickey	Dunmanway
Boggeragh	Garrow
Carrigdangan	Glanlee
Coomagearlaghy	~~Knockearagh~~
Coomataggart	Macroom
Cordal	

Outage Condition 3: Disconnection of Electrical Connectivity Between Charleville and Glenlara:

Sample outages that will result in this condition:

- Charleville-Glenlara 110 kV circuit.
- Charleville 110 kV A1 busbar
- Glenlara 110 kV Sectionslising Cubicle SA1-2 & Glenlara T142

South West Constraint Group 5: Modification

Temporary Group for Outage Condition:

Station	
Ballylickey	Garrow
Boggeragh	Glanlee
Carrigdangan	***Glenlara***
Coomagearlaghy	Knockearagh
Coomataggart	***Knockacummer***
Cordal	Macroom
Dunmanway	

Summary of changes:

- Glenlara node added
- Knockacummer node added

Please note:

If outage condition 3 occurs in conjunction with any of outage conditions 1-2, a hybrid group will be created with the nodes added to the South West Constraint Group 5 as per outage condition 3 and nodes removed from the group as per outage condition 1-2.

5.8 South West Constraint Group 6 (Outage Driven): Garrow to Clonkeen Flows

For a number of Transmission Outage conditions in the Cork/Kerry region of the network, post contingency weaknesses materialise on the Clonkeen-Garrow 110 kV circuit when high wind is trying to export out of the region. This is generally required when the system is subject to a large 220 kV outages between Clashavoon and Kilpaddoge.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station
Coomataggart
Cordal
Garrow

SOUTH WEST CONSTRAINT GROUP 6: OUTAGE CONSIDERATIONS

Under certain combined outage conditions the South West Constraint Group 6 will have to be modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Ballynahulla and Ballyvouskill:

Sample outages that will result in this condition:

- Ballynahulla-Ballyvouskill 220 kV circuit.

South West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station
Coomataggart
~~Cordal~~
Garrow

Outage Condition 2: Disconnection of Electrical Connectivity Between Charleville and Glenlara:

Sample outages that will result in this condition:

- Charleville-Glenlara 110 kV circuit.
- Charleville 110 kV A1 busbar
- Glenlara 110 kV Sectionslising Cubicle SA1-2 & Glenlara T142

South West Constraint Group 6: Modification

Temporary Group for Outage Condition:

Station
Coomataggart
Cordal
Garrow
Glenlara
Knockacummer

Summary of changes:

- Glenlara node added
- Knockacummer node added

Please note:

If outage condition 2 occurs in conjunction with outage condition 1, a hybrid group will be created with the nodes added to the South West Constraint Group 6 as per outage condition 2 and nodes removed from the group as per outage condition 1.

5.9 South West Constraint Group 7 (Outage Driven): Knockanure to Kilpaddoge (110 kV) Flows

For a number of Transmission Outage conditions in the Cork/Kerry region of the network, post contingency weaknesses materialise on the Kilpaddoge-Knockanure 110 kV circuit when high wind is trying to export out of the region onto the 400 kV network. This is generally required when the system is subject to a large 220 kV outages between Clashavoon and Kilpaddoge.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station	
Athea	Dromada
Clahane	Tobertoreen
Cloghboola	Trien
Cordal	

SOUTH WEST CONSTRAINT GROUP 7: OUTAGE CONSIDERATIONS

Under certain combined outage conditions the South West Constraint Group 7 will have to be modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Ballynahulla and Knockanure:

Sample outages that will result in this condition:

- Ballynahulla-Knockanure 220 kV circuit.

South West Constraint Group 7: Modification

Temporary Group for Outage Condition:

Station	
Athea	Dromada
Clahane	Tobertoreen
Cloghboola	Trien
~~Cordal~~	

Outage Condition 2: Disconnection of Electrical Connectivity Between Clahane and Trien:

Sample outages that will result in this condition:

- Clahane-Trien 110 kV circuit.
- Trien 110 kV A1 busbar.

South West Constraint Group 7: Modification

Temporary Group for Outage Condition:

Station	
Athea	Dromada
~~Clahane~~	Tobertoreen
Cloghboola	Trien
Cordal	

Outage Condition 3: Disconnection of Electrical Connectivity Between Charleville and Glenlara:

Sample outages that will result in this condition:

- Charleville-Glenlara 110 kV circuit.
- Charleville 110 kV A1 busbar
- Glenlara 110 kV Sectionslising Cubicle SA1-2 & Glenlara T142

South West Constraint Group 7: Modification

Temporary Group for Outage Condition:

Station	
Athea	***Glenlara***
Clahane	***Knockacummer***
Cloghboola	Tobertoreen
Cordal	Trien
Dromada	

Summary of changes:

- Glenlara node added
- Knockacummer node added

Please note:

If outage condition 3 occurs in conjunction with any of outage conditions 1-2, a hybrid group will be created with the nodes added to the South West Constraint Group 7 as per outage condition 3 and nodes removed from the group as per outage condition 1-2.

5.10 South West Constraint Group 8 (Outage Driven): Clashavoon to Macroom Flows

For a number of Transmission Outage conditions in the Cork/Kerry region of the network, in particular a key 220 kV circuit from Clashavoon to Kilpaddoge coupled with an outage of one of the Clashavoon-Macroom 110 kV circuits, creates post contingency weaknesses on the remaining Clashavoon-Macroom 110 kV circuit when high wind is trying to export out of the region into the large Cork urban load centre.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station	
Ballylickey	Cordal
Boggeragh	Dunmanway
Carrigdangan	Garrow
Coomagearlaghy	Glanlee
Coomataggart	Knockearagh

⚠ South West Constraint Group 8: Outage Considerations

Under certain combined outage conditions the South West Constraint Group 8 will have to be modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Ballynahulla and Ballyvouskill:

Sample outages that will result in this condition:

- Ballynahulla-Ballyvouskill 220 kV circuit.

South West Constraint Group 8: Modification

Temporary Group for Outage Condition:

Station	
Ballylickey	~~Cordal~~
Boggeragh	Dunmanway
Carrigdangan	Garrow
Coomagearlaghy	Glanlee
Coomataggart	Knockearagh

Outage Condition 2: Disconnection of Electrical Connectivity Between Clonkeen and Knockearagh:

Sample outages that will result in this condition:

- Clonkeen-Knockearagh 110 kV circuit.

South West Constraint Group 8: Modification

Temporary Group for Outage Condition:

Station	
Ballylickey	Cordal
Boggeragh	Dunmanway
Carrigdangan	Garrow
Coomagearlaghy	Glanlee
Coomataggart	~~Knockearagh~~

Outage Condition 3: Disconnection of Electrical Connectivity Between Charleville and Glenlara:

Sample outages that will result in this condition:

- Charleville-Glenlara 110 kV circuit.
- Charleville 110 kV A1 busbar
- Glenlara 110 kV Sectionalizing Cubicle SA1-2 & Glenlara T142

South West Constraint Group 8: Modification

Temporary Group for Outage Condition:

Station	
Ballylickey	Dunmanway
Boggeragh	Garrow
Carrigdangan	Glanlee
Coomagearlaghy	***Glenlara***
Coomataggart	Knockearagh
Cordal	***Knockacummer***

Summary of changes:

- Glenlara node added
- Knockacummer node added

Please note:

If outage condition 3 occurs in conjunction with any of outage conditions 1-2, a hybrid group will be created with the nodes added to the South West Constraint Group 8 as per outage condition 3 and nodes removed from the group as per outage condition 1-2.

5.11 South West Constraint Group 9 (Outage Driven): Trien to Knockanure Flows

For a number of Transmission Outage conditions in the Kerry region of the network, in particular a key 110 kV circuit out of Trien that prevents the ability to sectionalise the network in the region and produces an excess post contingency overload on the Knockanure-Trien 110 kV circuit no.2 when power is trying to export onto the 400 kV network.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station
Clahane
Cloghboola
Trien

SOUTH WEST CONSTRAINT GROUP 9: OUTAGE CONSIDERATIONS

Under certain combined outage conditions the South West Constraint Group 9 will have to be modified to account for changes in the resultant power flows for the duration of that outage condition. Some of the key changes that can be expected in this constraint group are summarised here.

Outage Condition 1: Disconnection of Electrical Connectivity Between Clahane and Trien:

Sample outages that will result in this condition:

- Clahane-Trien 110 kV circuit.
- Trien 110 kV A1 busbar.

South West Constraint Group 9: Modification

Temporary Group for Outage Condition:

Station
~~Clahane~~
Cloghboola
Trien

5.12 South West Constraint Group 10 (Outage Driven): Clahane to Tralee Flows

For a number of Transmission Outage conditions in the Kerry region of the network, in particular a key 110 kV circuit out of Trien that prevents the ability to sectionalise the network in the region and produces an excess post contingency overload on the Clahane-Tralee 110 kV circuit when power is trying to export onto the 400 kV network.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station
Clahane
Cloghboola
Trien

5.13 South West Constraint Group 11 (Outage Driven): Cauteen to Killonan Flows

For a number of Transmission Outage conditions in the midlands network, most notably key 110 kV links from Cahir to Cullenagh, most notably Cahir-Doon 110 kV circuit, post contingency weakenesses develop on the Cauteen-Killonan 110 kV circuit with midlands generation trying to find an alternative path to feed the Eastern load centres.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station	
Barrymore	Lisheen
Cauteen	Thurles
Kill Hill	

6 IRELAND SOUTH EAST CONSTRAINT GROUPS

In general, it is not deemed necessary to constrain renewable generation feeding into the South East of the network under fully intact system conditions.

Binding constraints in the South East region are rare and the region is generally managed by a combination of conventional generation re-dispatch or system sectionalising.

Temporary constraint groups are required however, when the network in the South East is under outage conditions.

6.1 South East Constraint Group 1 (Outage Driven): Arklow to Ballybeg Flows

For a number of Transmission Outage conditions in the South East region of the network, in particular key 220 kV outages feeding into South Dublin and outages that prevent the ability to sectionalise the network in the region, post contingency weaknesses develop on the Arklow-Ballybeg 110 kV circuit and the Arklow 220/110 kV transformers trying to export power from the 110 kV South East Network to the large urban load centre in Dublin.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

"N-1-1" Constraint Group:

Station	
Arklow	Crory
Ballywater	Great Island
Banoge	Rosspile
Castledockrell	Waterford
Crane	Wexford

6.2 South East Constraint Group 2 (Outage Driven): Arklow to Ballybeg Secondary Flows

For extreme outage conditions issues on the Arklow-Ballybeg 110 kV circuit and the Arklow 220/110 kV transformers cannot be fully resolved by constraining the wind available in the South East Constraint Group 1. Under these conditions and when all the available wind is exhausted

from the South East Constraint Group 1, a secondary group may be required to be constrained using a group of less effective nodes as follows;

"N-1-1" Constraint Group:

Station	
Ballylickey	Garrow
Bandon	Glanlee
Barrymore	Ikerrin
Boggeragh	Kill Hill
Carlow	Lisheen
Carrigdangan	Macroom
Cauteen	Midleton
Coomagearlaghy	Thurles
Coomataggart	Woodhouse
Dunmanway	

SOUTH EAST CONSTRAINT GROUP 2: OUTAGE CONSIDERATIONS

Under certain combined outage conditions the South East Constraint Group 2 will need to be revised. As this constraint group is so infrequently required, outage considerations wlll only be considered when the system is in the condtion that will require this group to be active.

6.3 South East Constraint Group 3 (Outage Driven): Thornsberry to Derryiron Flows

This group is required due to weaknesses on the Derryiron-Thornsberry 110 kV circuit when wind/solar is being exported from the South East/Midlands up into the Dublin urban load center, particularly when subject to 110 kV circuit outages south of Cushaling.

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group

"N-1-1" Constraint Group:

Station
Mount Lucas
Kilcumber

6.4 South East Constraint Group 4 (Outage Driven): Crane to Wexford Flows

This group is required due to weaknesses on the Crane-Wexford 110 kV circuit when wind/solar is being exported from the South East to the load center at Wexford and onto the 220 kV network at Great Island. This constraint group is required when the connection from this group of nodes is cut off from a 220 kV path East of Great Island. This can occur during outages of a 110 kV link between Arklow and Crane for for an outage of the Lodgewood 220/110 kV transformer.

This constraint group might have to be restricted to prevent N-1 overloads on Crane-Wexford during these outage conditions.

"N-1-1" Constraint Group:

Station	
Ballywater	Crory
Banoge	Crane
Castledockrell	

7 IRELAND NORTH EAST CONSTRAINT GROUPS

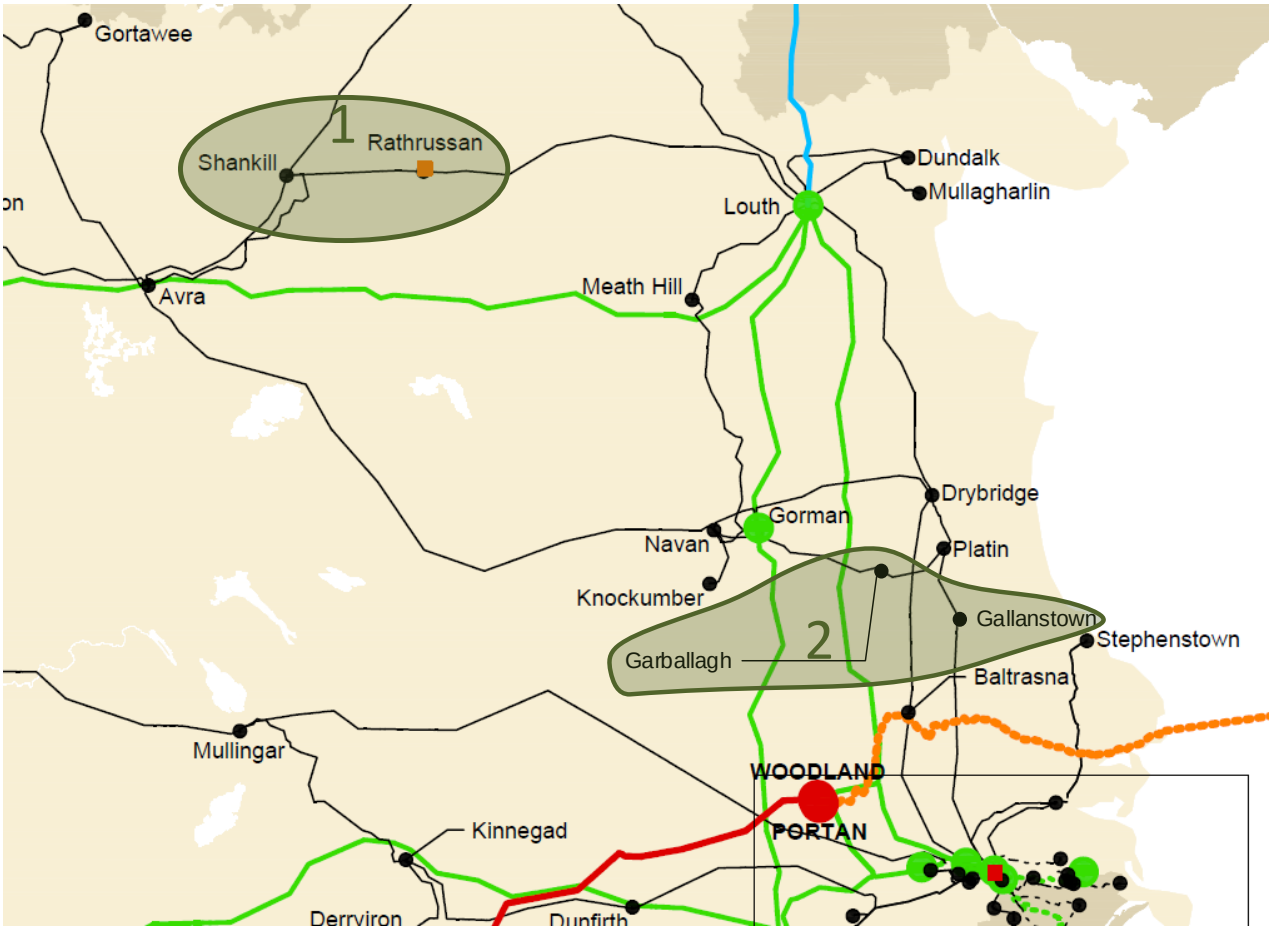


Figure 5: North East Geographical Constraint Groups

7.1 North East Constraint Group 1: Ratrussan to Louth Flows

This constraint group is required due to weaknesses in the Louth-Ratrussan 110 kV circuit when large amounts of renewables are exporting from the North West/North East of the network to the load catchment area in Louth having a direct feed to Northern Ireland and Dublin load centers.

Pre-contingency constraints may need to be applied to this group to protect this circuit against overloads for the tripping of 110 kV connections between Shankill, Lislea, Lisdrum and Louth.

Intact Constraint Group:

Station
Ratrussan
Shankill

7.2 North East Constraint Group 2: Platin to Drybridge Flows

This constraint group is required due to weaknesses in the Oldbridge-Platin, Drybridge-Oldbridge and Gorman-Garballagh 110 kV circuits when trying to export large amounts of solar to Dublin and Northern Ireland load centers

These contingency issues might need to be managed by restricting the output of renewable generation connected to the following nodes as part of a temporary constraint group.

Intact Constraint Group:

Station
Garballagh
Gallanstown

8 IRELAND NATIONWIDE CONSTRAINT GROUP

8.1 Constraint group number 1 – All IE

This constraint group is required to manage flows on the 275/220 kV tie-lines between Tandragee 275 kV station in Northern Ireland and Louth 220 kV Station. It includes all controllable Category 2 renewable generation in Ireland.

APPENDIX 1 APPLICATION OF CONSTRAINT IN THE WIND DISPATCH TOOL

The level of constraint/curtailment is determined by monitoring real time power system conditions. Through real time modelling of contingency (N-1) events and system limits we identify what generation is effective and what level of reduction in generation is required to ensure that system security standards are maintained. The application, updating and removal of constraints/curtailment is a dynamic process that considers: the variability in wind production, the ability of other non-wind units to respond to changes in energy production and the often interacting nature of constraints and curtailment.

In both constraint and curtailment scenarios, we use the Wind Dispatch Tool (WDT) to implement the required constraint/curtailment levels on individual wind/solar farms. The WDT determines the active power (MW) set point for each wind/solar farm based on: a) selection of the wind/solar farms impacting the constraint (or all wind/solar farms if a system wide limit) as determined by the control room operator and b) the total constraint/curtailment level (MW) required as specified by the control room operator. The following sections describe how the individual wind/solar farm active power (MW) set-points for constraint/curtailment are calculated in the WDT.

Wind Dispatch Tool Active Power Set Point Calculation Methodology

The wind/solar farm active power set point calculation in the WDT accounts for the impact of wind/solar farms providing frequency response, the control category of wind/solar farms and SEMC wind farm constraint groups. In order to illustrate the key aspect of the calculation we have provided a simplified example below that ignores the additional complexities introduced by the items specified above. Further details on the impact of frequency response are included at the end of this appendix.

In this example, four wind/solar farms form a defined constraint group although the same logic would apply to application to global curtailment. The constraint on each wind/solar farm is applied pro-rata using the following formula:

Wind/Solar Farm “A” dispatch set point = Wind/Solar Farm “A” Active Power output – (group total constraint down required)*(Wind/Solar Farm “A” Active Power output /Sum of Wind/Solar Farm Active power output of all wind/solar farms in the operator defined group)

Time T, applying a constraint

Total Availability of Wind/Solar Farm Group	400 MW	Total Output of Wind/Solar Farm Group	400 MW	Wind/Solar Constraint Down Required	100 MW

	Wind/Solar Farm A	**Wind/Solar Farm B**	**Wind/Solar Farm C**	**Wind/Solar Farm D**
Permissible Capacity	100 MW	150 MW	250 MW	200 MW
Available Active Power	50 MW	100 MW	150 MW	100 MW
Active Power Output	50 MW	100 MW	150 MW	100 MW
Dispatch Instruction	50 – (100*50/400) = 37.5 MW	100 – (100*100/400) = 75 MW	150 – (100*150/400) = 112.5 MW	100 – (100*100/400) = 75 MW
Constraint	12.5 MW (25%)	25 MW (25%)	37.5 MW (25%)	25 MW (25%)

So the 100 MW constraint is applied in proportion to the active power output of each wind/solar farm which, for the initial application of the constraint, is also equal to the available active power of each wind/solar farm.

If the wind/solar farms are further dispatched down as the constraint/curtailment becomes worse this will always be pro-rata based on the wind/solar farm actual output and does not consider the changing availability of the wind/solar farm.

Time T+1, additional wind/solar available, further constraint

Total Availability of Wind/solar Farm Group	530 MW	Total Output of Wind/solar Farm Group	300 MW	Wind/solar Constraint Down Required	100 MW

	Wind/solar Farm A	Wind/solar Farm B	Wind/solar Farm C	Wind/solar Farm D
Permissible Capacity	100 MW	150 MW	250 MW	200 MW
Available Active Power	100 MW	80 MW	200 MW	150 MW
Active Power Output	37.5 MW	75 MW	112.5 MW	75 MW
Dispatch Instruction	37.5 – (100*37.5/300) = 25 MW	75 – (100*75/300) = 50 MW	112.5 – (100*112.5/300) = 75 MW	75 – (100*75/300) = 50 MW
Constraint	75 MW (75%)	30 MW (37.5%)	125 MW (62.5%)	100 MW (66.67%)

When a constraint/curtailment is being released, the amount being released pro-rata on each wind/solar farm will be relative to the dispatch head room available on each wind/solar farm. This head room will be based on the point in time difference between the available active power (for constraints) or the minimum of available active power and last binding constraint set point (for curtailments) to the active power output of the wind/solar farm. Although a release will use the wind/solar farms point in time available active power in the calculation, this will only be used to distribute the amount of constraint/curtailment being released more evenly among the wind/solar farms given updated availabilities as opposed to distributing the group total constraint/curtailment at the point of time more evenly across all wind/solar farms given updated availabilities.

Time T+2, relaxing the constraint

Total Availability of Wind/solar Farm Group	530 MW	Total Output of Wind/solar Farm Group	200 MW	Wind/solar Constraint Relaxed by	100 MW

	Wind/solar Farm A	Wind/solar Farm B	Wind/solar Farm C	Wind/solar Farm D
Permissible Capacity	100 MW	150 MW	250 MW	200 MW
Available Active Power	100 MW	80 MW	200 MW	150 MW
Active Power Output	25 MW	50 MW	75 MW	50 MW
Head Room	100-25 = 75 MW	80-50 = 30 MW	200-75 = 125 MW	150-50= 100 MW
Dispatch Instruction	25 + (100*75/330) = 47.7 MW	50 + (100*30/330) = 59.1 MW	75 + (100*125/330) = 112.9 MW	50 + (100*100/330) = 80.3 MW
Constraint	52.3 MW (52.3%)	20.9 MW (26.1%)	87.1 MW (43.6%)	69.7 MW (46.4%)

Impact of Frequency Response

In 2017, the WDT calculation methodology was updated to account for Frequency response.

Instead of the active power output used in the calculation we use a frequency adjusted power output but the same trend in the calculation output is seen. This calculation aims to both evenly distribute a constraint/curtailment at a point in time and also account for wind/solar farms that are not contributing to frequency response as expected. Additional constraints or curtailments to this wind/solar farm group will again not take into consideration updated wind/solar farm availabilities. For curtailment/constraint releases wind/solar farm availabilities will be used to assist in the relative pro-rata release of the constraint/curtailment but again as above will not re-distribute the total group constraint/curtailment based on the new availabilities at that point in time.

The frequency adjusted power output is calculated as follows;

1. The nominal power output of all wind/solar farms assuming no frequency response is approximated
    a. This is assumed to be the available active power or
    b. The previous dispatch set point
2. The difference between all active and nominal outputs is calculated for all wind/solar farms in the constraint group and this is deemed the groups full frequency response
3. The nominal output of each wind/solar farm is adjusted based on a pro-rata distribution of the group's frequency response relative to the permissible capacity of each wind/solar farm in the group. This is termed the frequency adjusted power output of each wind/solar farm.

APPENDIX 2 PROCEDURE TO DETERMINE AND CHANGE WDT CONSTRAINT GROUPS IN IRELAND

Case Creation/Study Assumptions

1. Develop a low load analysis using the control centre EMS load flow analysis tool with all electrical equipment assumed in their standard operating configuration. This assumes summer equipment ratings for all equipment.

   [Please note renewable generation constraint groups are based on the most onerous system condition. If N/N-1/N-1-1 security violations occur under winter/spring/autumn conditions the WDT constraint group will still be valid.]

2. In the region being analysed, all renewable generators within the region itself and in the neighbouring regions are dispatched up to a maximum output in the STNET save case.
3. EWIC is assumed to have a high export profile in the study case in line with general high wind conditions.
4. Implement all actions in line with SEM-11-062 to maximise the secure dispatch of renewables on the system including the following;
   - Dispatch down/off conventional generation/lower priority generation from the system that is contributing to the contingency issues presented in the case while maintaining a secure system in line with all published generation constraints found at the following link;

     https://www.sem-o.com/publications/general-publications/

   - Where possible transmission equipment is operationally sectionalised to maximise the output of renewable generation in line with the principles of SEM-11-062 while also maintaining operational security standards

     Operating Security Standards (eirgridgroup.com)

Reviewing the Results of the Study Case

When all available actions to maximise the output of renewable generation are carried out, a number of issues will remain in the case making it non-compliant with the Operational Security Standards. When a base case analysis is complete for all regions of the system, a list of base case and N-1 issues is created. The only ability for control room operators to resolve these issues is through the constraint of a group of renewable generators feeding into the problematic part of the network. Each network issue identified will require the creation of a constraint group in the WDT. A shift factor analysis is carried out on all

generation nodes containing category 1 or category 2 renewable generators to determine which renewable generators should be included in each constraint group.

WDT Constraint Group Determination

For each network issue noted above

- Note the base case or post contingency current flow for the relevant circuit violation in the STNET save case.

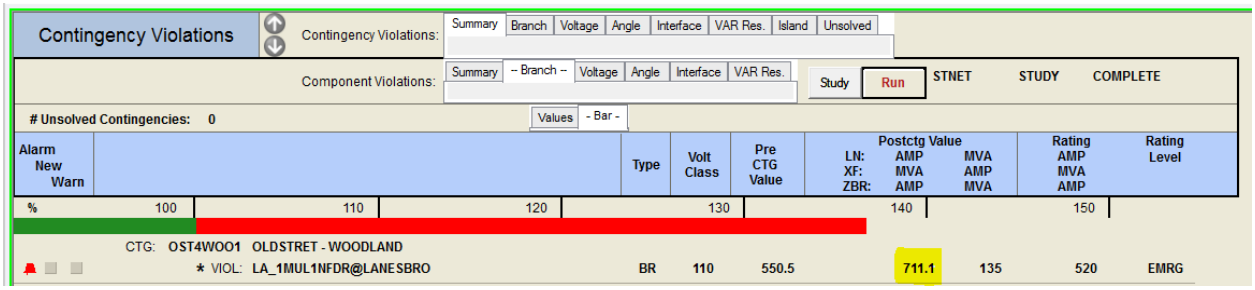


Figure 1: Post Contingency AMP value before changing wind farm output (Amp 1)

- Reduce the power output of one renewable generator at each node feeding into the Transmission issue by 10 MW. Balance this decrease in generation by adding 10 MW to another conventional generator far removed from the Transmission issue in the Generator Overview page in STNET.

Note: Only one wind farm per node requires studying as each will have the same effectiveness at alleviating the constraint.

- Run the case and note the new post contingency current flow. This will be used to calculate the Shift Factor for the node.

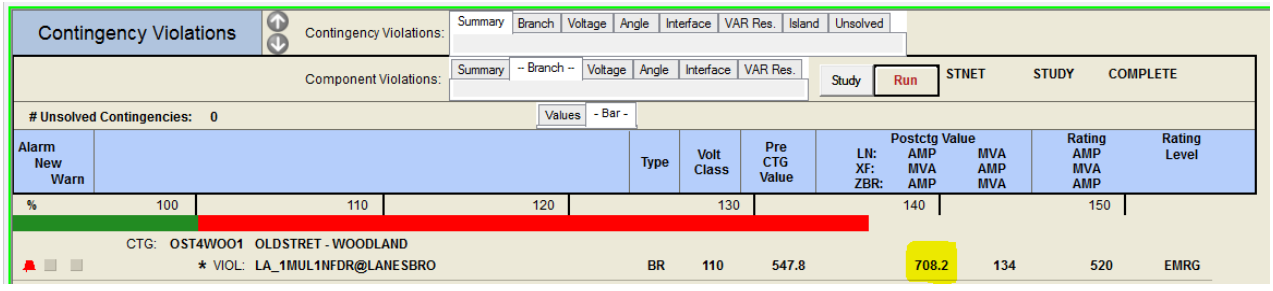


Figure 2: Post Contingency AMP value after changing wind farm output (Amp 2)

- Return this wind farm to its maximum output value and repeat the study for additional renewable generation nodes in the problematic region ensuring the remote balancing generator is always the same.

- The Shift Factor of a wind node is defined as follows:

$$SF_{e,n} = \frac{\Delta f_e}{\Delta P_n}$$

$$e = network\ element\ index$$
$$n = wind\ node\ index$$
$$\Delta f_e = change\ in\ AMP\ current\ flow\ on\ network\ element\ e\ when\ a\ reduction\ in\ \ generation\ of\ \Delta P_n\ occurs\ at\ n$$
$$P_n = reduction\ in\ generation\ at\ wind\ node\ n$$

- A shift factor greater than 0 indicates that the renewable generator is effective in reducing the relevant contingency or base case issue. When the shift factor is 0 or below, it is not effective in reducing the relevant contingency and will not be included the constraint group.
- It is necessary to decide on a Shift Factor Threshold above which relevant renewable generators are included constraint group. This threshold will differ for each contingency issue and will be based on the relative effectiveness of the renewable generators in alleviating the contingency violation. In general, the value will be based on a significant step change in the shift factors calculated for the relevant renewable generators. The Shift Factor threshold ensures that constraints are applied only to those renewable generators that have the biggest impact on alleviating a particular constraint, and that those with a much smaller impact are not constrained down inefficiently, which would ultimately be inconsistent with the principles of SEM-11-062.

WDT Constraint Group Determination For transmission outages

- Using the STNET save case created, increase the MW generation of each renewable generator in the constraint group being analysed to their maximum output. [STNET> Powerflow > Network Unit Summary]
- Apply the relevant transmission outage being assessed to the STNET study case, sectionalise the network to maximise the output of renewable generation and run the study. Balance generation with available conventional generation. The case is now ready to carry out a shift factor analysis.
- Note the post contingency current flow for the relevant circuit violation.

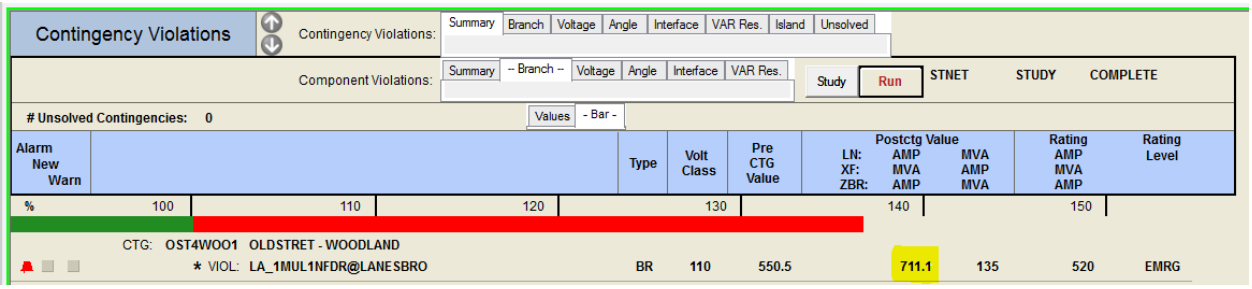


Figure 3: Post Contingency AMP value before changing wind farm output (Amp 1)

- Reduce the power output of one renewable generator by 10 MW. Balance this decrease in generation by adding 10 MW to another conventional generator remote of the Transmission issue in the Generator Overview page in STNET.

Note: Only one wind farm per node requires study as each will have the same effectiveness at alleviating the constraint.

- Run the case and note the new post contingency current flow value. This will be used to calculate the Shift Factor for the renewable generation node.

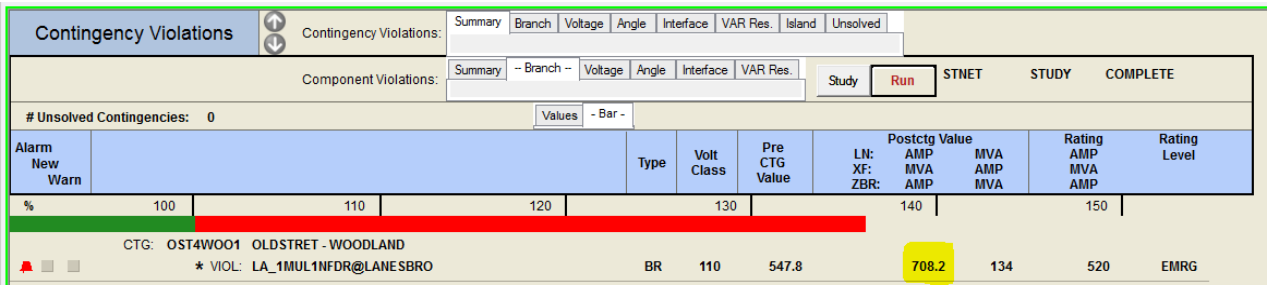


Figure 4: Post Contingency AMP value after changing wind farm output (Amp 2)

- Return this renewable generator to its maximum output and repeat the study for additional renewable generation nodes in the constraint group. Studies may also be required for renewable generators not originally included in the constraint group that have become effective in alleviating the constraint due to the transmission outage.

- The Shift Factor of a wind node is defined as follows:

$$SF_{e,n} = \frac{\Delta f_e}{\Delta P_n}$$

$$e = network\ element\ index$$
$$n = wind\ node\ index$$
$$\Delta f_e = change\ in\ AMP\ current\ flow\ on\ network\ element\ e\ when\ a\ reduction\ in\ generation\ of\ \Delta P_n\ occurs\ at\ n$$
$$P_n = reduction\ in\ generation\ at\ wind\ node\ n$$

- A shift factor greater than 0 indicates that the renewable generator is effective in reducing the relevant contingency. When the shift factor is reduced by a significant step change as a result of an outage, it is no longer as effective in reducing the relevant contingency and will be removed from the constraint group. Additionally, a renewable generator not previously included in the constraint group may now return a positive shift factor of the same order to other effective renewable generators already in the constraint group and these generators will now be added to the constraint group.

Example 1.1: Calculating Shift Factor for Wind Farm1 for LA-MUL Group (Intact Network)

Node	Wind Farm	P1 (MW)	P2 (MW)	Delta P	Amp 1	Amp 2	Delta AMP	Shift Factor
Node 1	WF1	5	-5	10	711.1	708.2	2.9	0.29

Example 1.2: Calculating Shift Factor for Wind Farm 1 for LA-MUL Group (LA-SLB on Outage)

Node	Wind Farm	P1 (MW)	P2 (MW)	Delta P	Amp 1	Amp 2	Delta AMP	Shift Factor
Node 1	WF1	5	-5	10	583.8	584	-0.2	-0.02

- Example 1.1: Wind Farm 1 is included in the West Constraint Group 1: Lanesboro to Mullingar constraint group for an intact network
- Example 1.2: Wind Farm 1 should be removed from the West Constraint Group 1: Lanesboro to Mullingar constraint group when Lanesboro-Sliabh Bawn 110 kV circuit is on outage, as the shift factor is <0.