ECP 2.1 Constraints Forecast Report

Addendum

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Table of Contents

Overview **4**
RES Percentage **5**
Maintenance Sensitivity Study Report **6**
Aim and Assumptions 6
Results 6
Batteries **12**
Contingencies and Line Overload per Area **14**
Year - 2024 14
Year - 2026 with GL 15
Constraint Subgroups **18**
Sample observation 18
Area A, B, C and G North 20
Area J 21
Area E and F 22
Area H2 23
Area H1 24

Overview

The Enduring Connection Policy (ECP) 2.1 constraint forecast area reports were published in December 2021, according to the regulatory requirement to facilitate customers with information on estimated constraints at different nodes within the network. These constraint forecasts are based on assumptions that have been developed after continuous engagement with industry. Following the publication of the ECP 2.1 constraint forecast reports, additional information was requested from industry which has now been published on the EirGrid Website1. This document is an addendum to the area reports published and briefly presents additional information on:

- RES percentage in each study
- Maintenance sensitivity study
- Batteries working/operation
- List of Contingencies in core ECP 2.1 studies
- Constraint subgroups (brief note)

This report should be read in conjunction with the ECP 2.1 constraint forecast area reports.

[1] https://www.eirgridgroup.com/customer-and-industry/general-customer-information/ecp-2.1-constraint-report-1/index.xml

RES Percentage

Renewable Energy Source (RES) percentage is calculated using the base of the total load on the system, this represents the maximum utilization of RES to supply the demand in Ireland. The RES calculated below considers the wind, solar, hydro and wave generation and is given in

Table 1 and Figure 1. Small scale wind and solar generation (less than 0.5 MW) is not considered in this calculation.

$$RES\ \% = \frac{RES\ Generation\ (GWh)}{Total\ Load\ (GWh)}\ X\ 100$$

Table 1: ECP 2.1 studies Ireland RES %* (wind, solar, hydro & wave).

Row Labels	Initial	33pc	66pc	ECP	ECP + 1.7 GW offshore	ECP + 3.9 GW offshore
2024	44%	47%	49%	51%	-	-
2026	-	-	-	53%	62%	-
2026 with GL (Greenlink)	44%	48%	52%	54%	65%	-
2026 with GL and Celtic	-	-	-	56%	68%	-
Future Grid	-	-	-	47%	59%	69%

*small scale generation, storage, peat and waste plants are not included in this calculation.

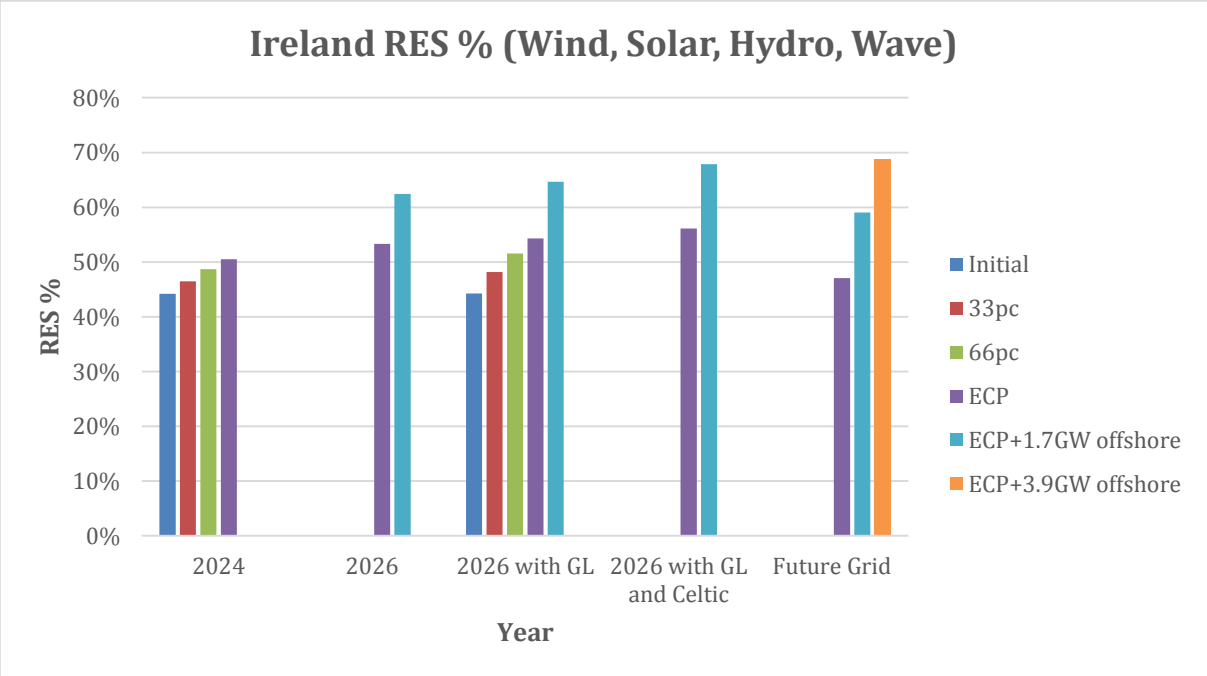

Figure 1: ECP 2.1 studies Ireland RES %* (wind, solar, hydro & wave)

Maintenance Sensitivity Study Report

Within ECP 2.1 Following ECP 1.0, we received a feedback from industry that including maintenance programme would be helpful; as part of ECP 2.1 this has now been included in the baseline models. The maintenance schedule was discussed with our internal operations team and it represents a typical outage programme for the network. However, every maintenance and outage season is different, and the results need to be interpreted with this in mind. This section provides a sensitivity with this maintenance schedule removed from the model.

Aim and Assumptions

Following a request from industry, a sensitivity study has been performed to quantify the impact of the maintenance schedule used in the ECP 2.1 Constraints Reports. The studies selected for the sensitivity are the 2024 ECP (All) scenario and the 2026 with Greenlink (GL) ECP (All) scenario. All other study assumptions have remained the same as the ECP 2.1 Constraints Analysis, however, the maintenance schedule has been removed.

Results

The area-wise/subgroup results are presented for the two studies - 2024 ECP (All) and 2026 with GL ECP (All). The difference in constraints are reported as the difference between the study with maintenance and the study without maintenance (Maintenance Study Constraints – No Maintenance Study Constraints = Difference). The constraints calculated are pro-rata distributed in their respective area/subgroup, as reported in the ECP 2.1 Constraints Reports. The percentage difference (**Error! Not a valid bookmark self-reference.** and Figure 2) is followed by the GWh difference tables (Table 3 and Table 4) and figures (Figure 3 and Figure 4).

Table 2: Difference in Constraint % (with - without maintenance)

Generation Category	Area	Subgroup	2024	2026 with GL
IE Solar not priority	A	ABC and G north	3.0%	2.7%
	B	ABC and G north	3.0%	2.7%
	C	ABC and G north	3.0%	2.7%
	D		6.3%	1.0%
	E		2.2%	1.1%
	F		2.2%	1.1%
	G	ABC and G north	3.0%	2.7%
	G	Area G main	-0.2%	0.0%
	H1		7.4%	7.0%
	H2	Carlow Waterford	0.2%	0.0%
	H2	Ballybeg Wexford	6.7%	2.9%
	I		5.5%	3.5%
	J	J city	-0.2%	0.0%
	J	J country	-0.1%	1.3%
	K		13.0%	9.5%
IE wind not priority	A	ABC and G north	2.9%	2.3%
	B	ABC and G north	3.0%	2.3%
	C	ABC and G north	2.9%	2.3%
	D		4.0%	1.2%

Generation Category	Area	Subgroup	2024	2026 with GL
	E		3.6%	1.5%
	F		3.6%	1.5%
	G	ABC and G north	2.9%	2.3%
	G	Area G main	1.4%	0.5%
	H1		4.3%	6.2%
	H2	Carlow Waterford	0.0%	-0.2%
	H2	Ballybeg Wexford	7.7%	5.3%
	J	J country	-0.2%	2.9%
	K		10.2%	8.6%
IE wind priority	A	ABC and G north	3.1%	2.4%
	B	ABC and G north	3.1%	2.4%
	C	ABC and G north	3.1%	2.4%
	D		4.3%	0.1%
	E		3.8%	0.4%
	F		3.8%	0.7%
	G	ABC and G north	3.1%	2.4%
	G	Area G main	1.5%	0.2%
	H1		4.6%	6.4%
	H2	Carlow Waterford	0.0%	-0.2%
	H2	Ballybeg Wexford	8.3%	5.5%
	J	J country	-0.2%	3.0%
	K		10.8%	8.9%

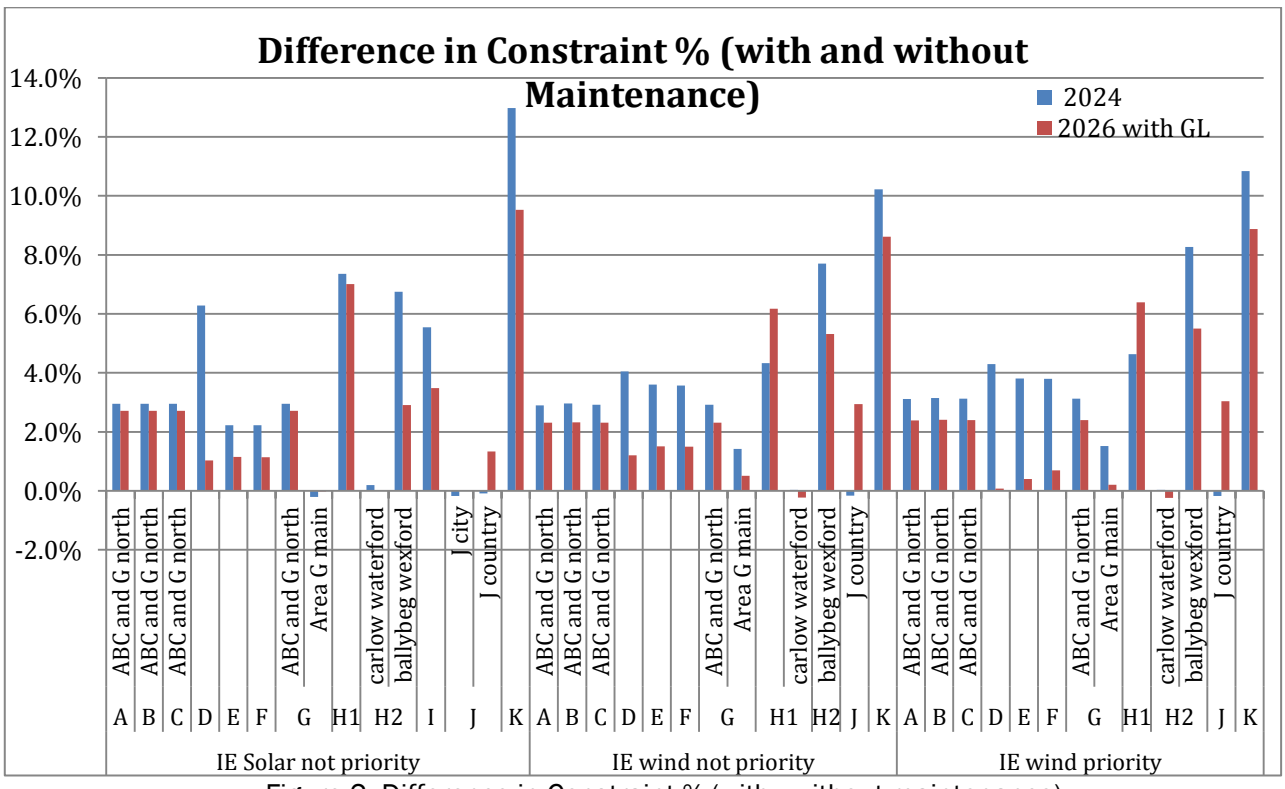

Figure 2: Difference in Constraint % (with - without maintenance)

Table 3: Area subgroup GWh difference in constraint (with - without maintenance) for 2026 with GL

			Dispatch Down (GWh)		
Generation Category	Area	Subgroup	Oversupply + Curtailment	Constraint without Maintenance	Difference in Constraint with Maintenance
solar not priority	A	ABC and G north	1	1	1
	B	ABC and G north	2	3	2
	C	ABC and G north	9	9	6
	D		1	0	0
	E		9	3	3
	F		1	0	0
	G	ABC and G north	0	0	0
	G	Area G main	13	11	(0)
	H1		8	4	15
	H2	Carlow Waterford	3	1	0
	H2	Ballybeg Wexford	18	54	14
	I		9	3	8
	J	J city	10	3	0
	J	J country	19	44	7
	K		8	6	20
wind not priority	A	ABC and G north	66	80	20
	B	ABC and G north	110	148	37
	C	ABC and G north	52	66	16
	D		7	0	1
	E		23	2	6
	F		19	1	4
	G	ABC and G north	18	22	6
	G	Area G main	5	0	0
	H1		27	5	23
	H2	Carlow Waterford	17	5	(1)
	H2	Ballybeg Wexford	9	3	6
	J	J country	93	81	36
	K		8	2	11
wind priority	A	ABC and G north	56	125	31
	B	ABC and G north	70	177	44
	C	ABC and G north	9	21	5
	D		34	13	1
	E		146	67	17
	F		13	5	2
	G	ABC and G north	12	29	7
	G	Area G main	5	1	0
	H1		53	18	80
	H2	Carlow Waterford	6	3	(0)
	H2	Ballybeg Wexford	26	16	34
	J	J country	10	16	7

	K		3	1	6

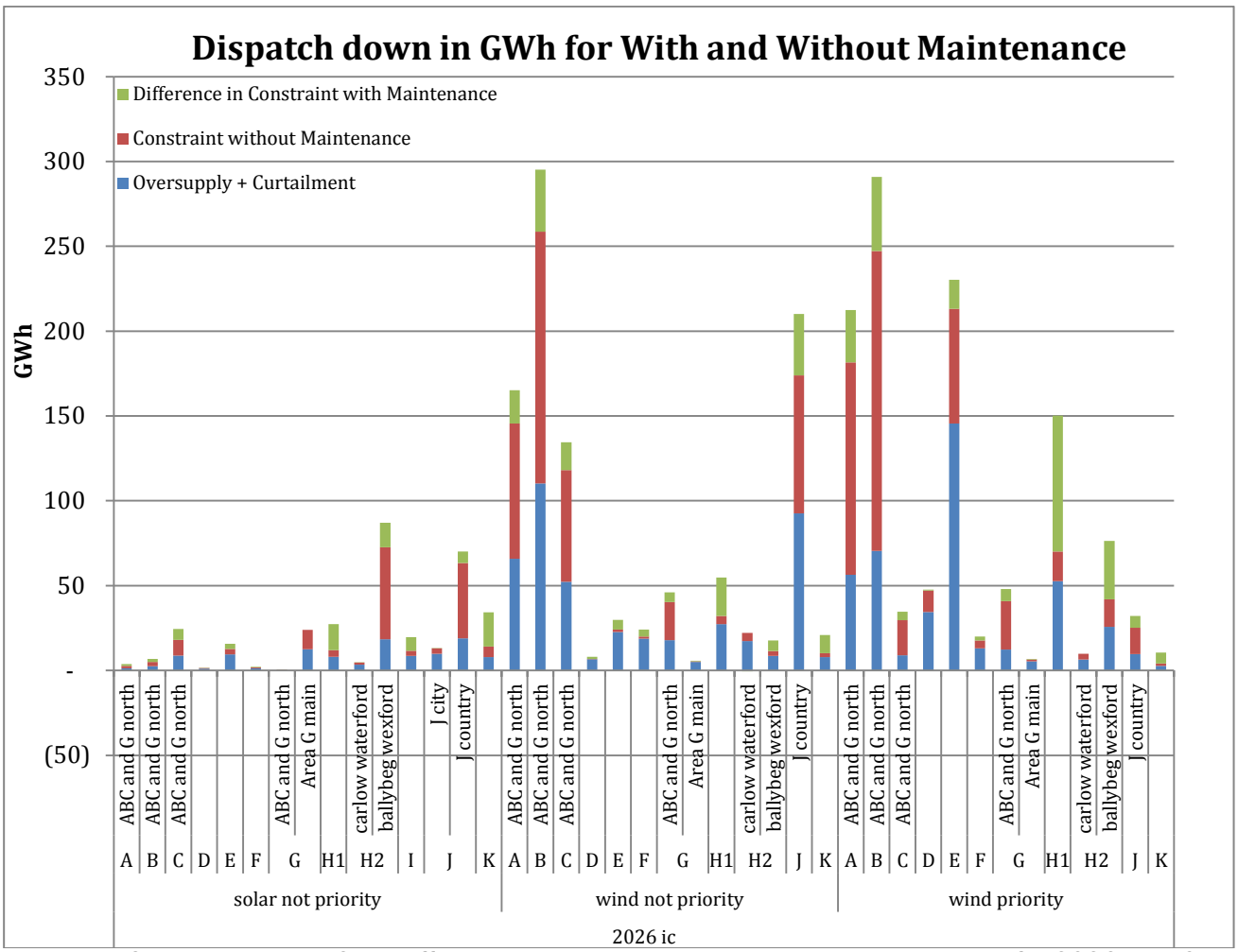

Figure 3: Area subgroup GWh difference in constraint (with - without maintenance) for 2026 with GL

Table 4: Area subgroup GWh difference in constraint (with - without maintenance) for 2024

			Dispatch Down (GWh)		
Generation Category	Area	Subgroup	Oversupply + Curtailment	Constraint without Maintenance	Difference in Constraint with Maintenance
solar not priority	A	ABC and G north	2	1	1
	B	ABC and G north	4	2	2
	C	ABC and G north	15	7	7
	D		2	0	2
	E		16	1	6
	F		2	0	1
	G	ABC and G north	0	0	0
	G	Area G main	20	7	-1
	H1		14	6	16

	H2	Carlow Waterford	3	0	0
	H2	Ballybeg Wexford	28	29	30
	I		15	1	13
	J	J city	17	1	0
	J	J country	22	3	0
	K		13	2	27
wind not priority	A	ABC and G north	118	82	25
	B	ABC and G north	123	101	31
	C	ABC and G north	94	68	21
	D		12	1	4
	E		41	2	13
	F		28	1	8
	G	ABC and G north	32	23	7
	G	Area G main	9	1	1
	H1		37	5	12
	H2	Carlow Waterford	8	0	0
	H2	Ballybeg Wexford	15	3	9
	J	J country	61	2	-1
	K		14	0	13
wind priority	A	ABC and G north	94	134	41
	B	ABC and G north	118	189	57
	C	ABC and G north	15	22	7
	D		59	13	41
	E		249	25	163
	F		22	2	13
	G	ABC and G north	21	30	9
	G	Area G main	9	2	2
	H1		88	24	58
	H2	Carlow Waterford	9	1	0
	H2	Ballybeg Wexford	43	16	52
	J	J country	18	1	0
	K		4	0	8

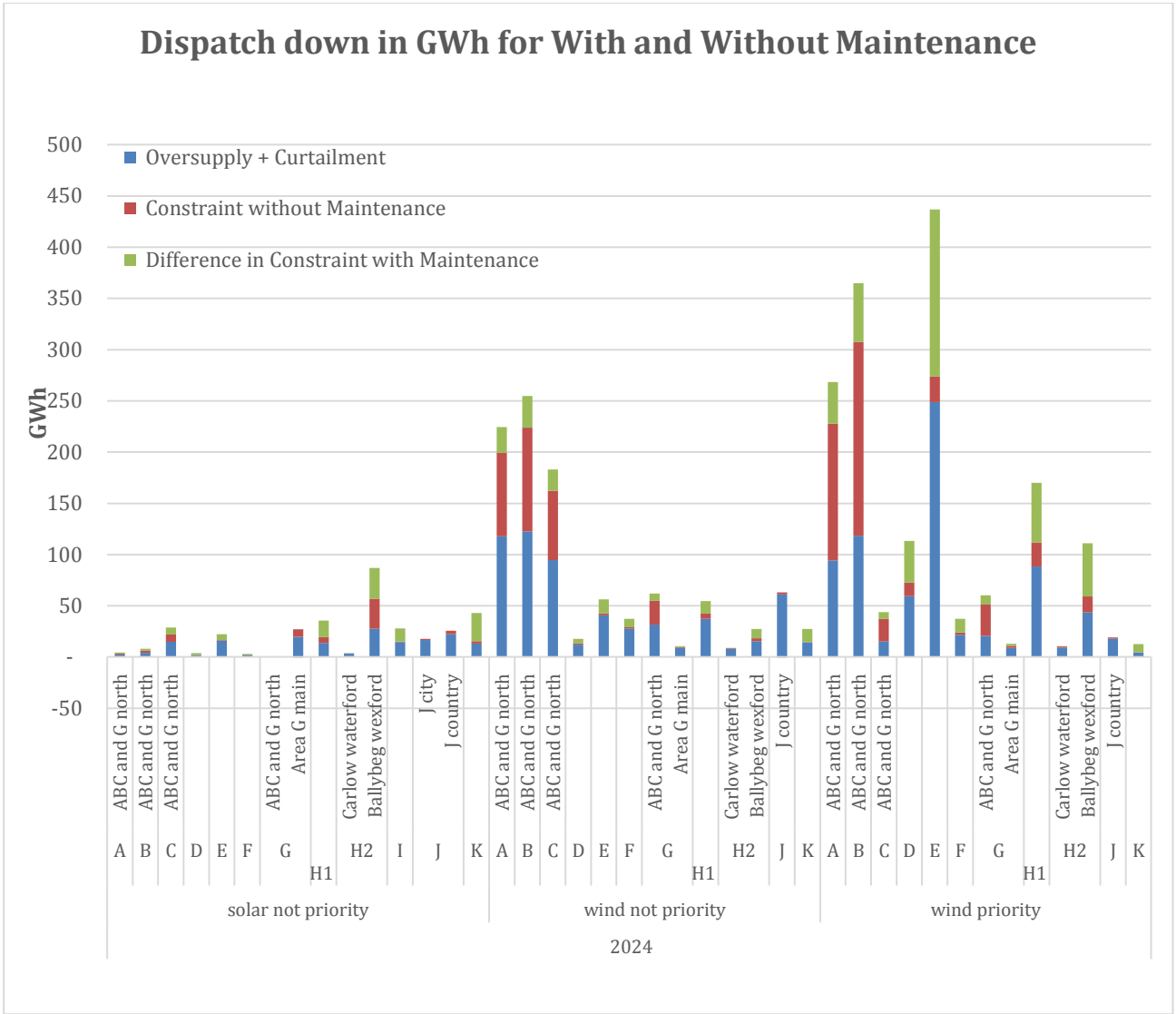

Figure 4: Area subgroup GWh difference in constraint (with - without maintenance) for 2024

Batteries

The batteries in the ECP 2.1 studies are modelled to respond to the system price. The batteries will charge when the system bid price is less than €5 per MWh and will discharge when the system price is more than €40 per MWh. This modelling approach means that batteries charge during times of high renewable generation, therefore integrating more solar and wind generation on the system. This modelling approach was evident from the sample observations at different nodes. In the constraint studies, the batteries are not discharging while the RES generators at the node were being dispatched down.

The figures below show that when the renewable generation is being dispatched down, the battery is not generating and therefore not contributing towards the dispatch down at that specific node. This can be seen in Figures 5 to 8. The figures are only showing instances when the dispatch down is enforced on the same node. The sample given here is for the 2026 with GL ECP (All) scenario.

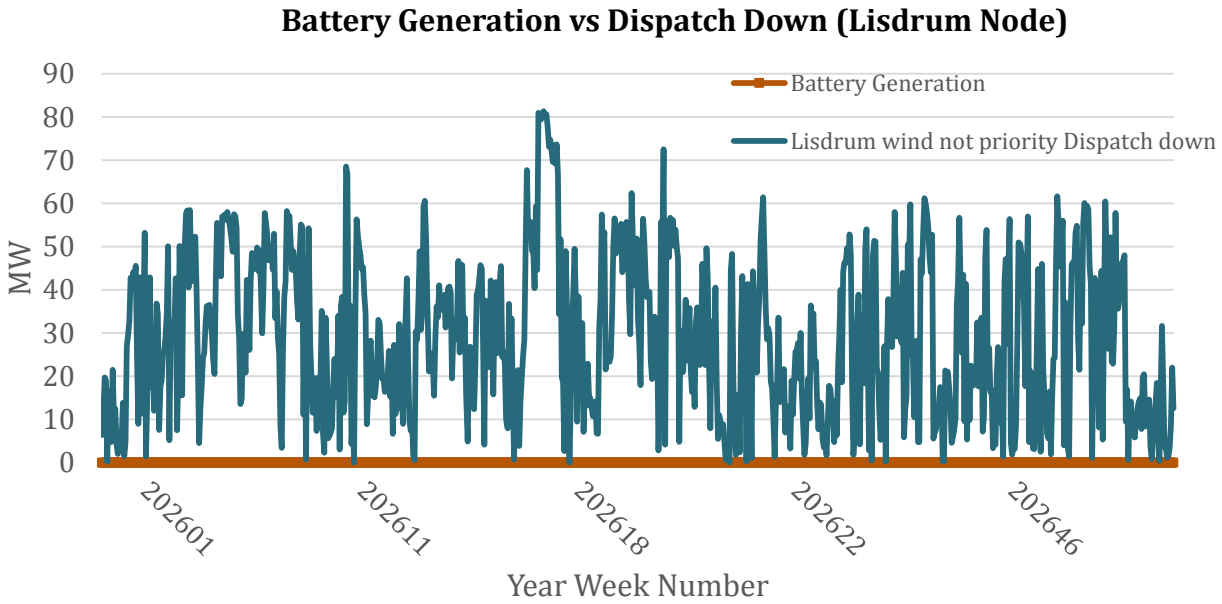

Figure 5: Battery Generation vs. Wind Dispatch Down (Lisdrum Node)

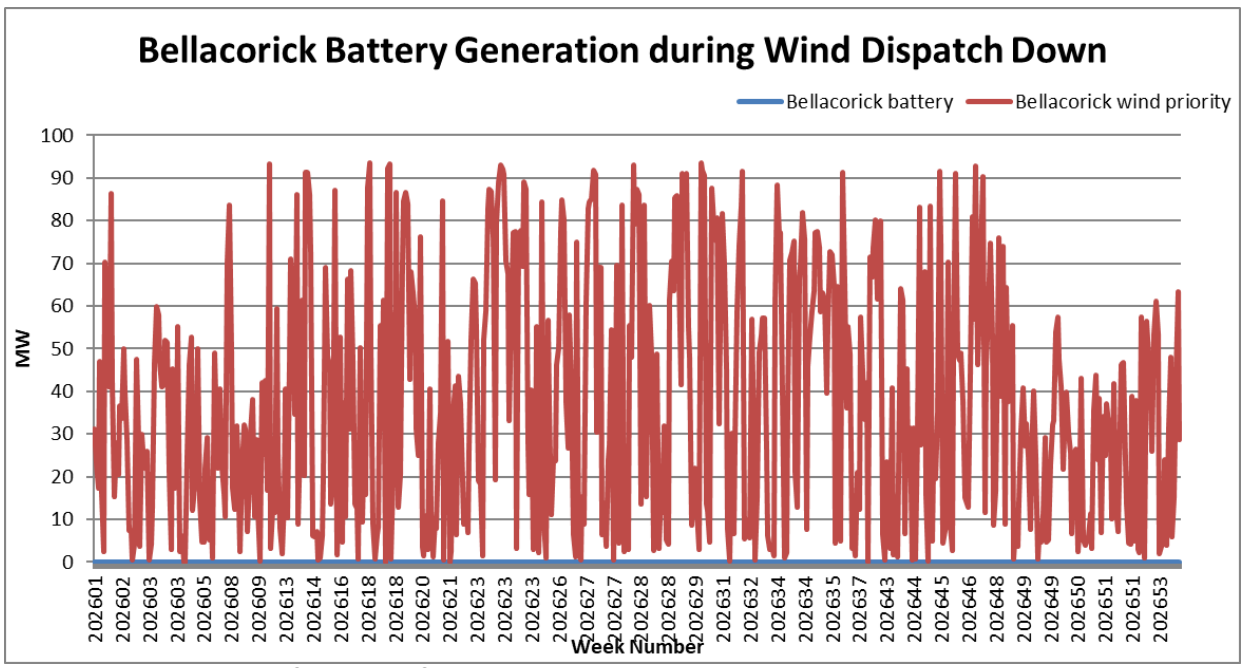

Figure 6: Battery Generation vs. Wind Dispatch Down (Bellacorick Node)

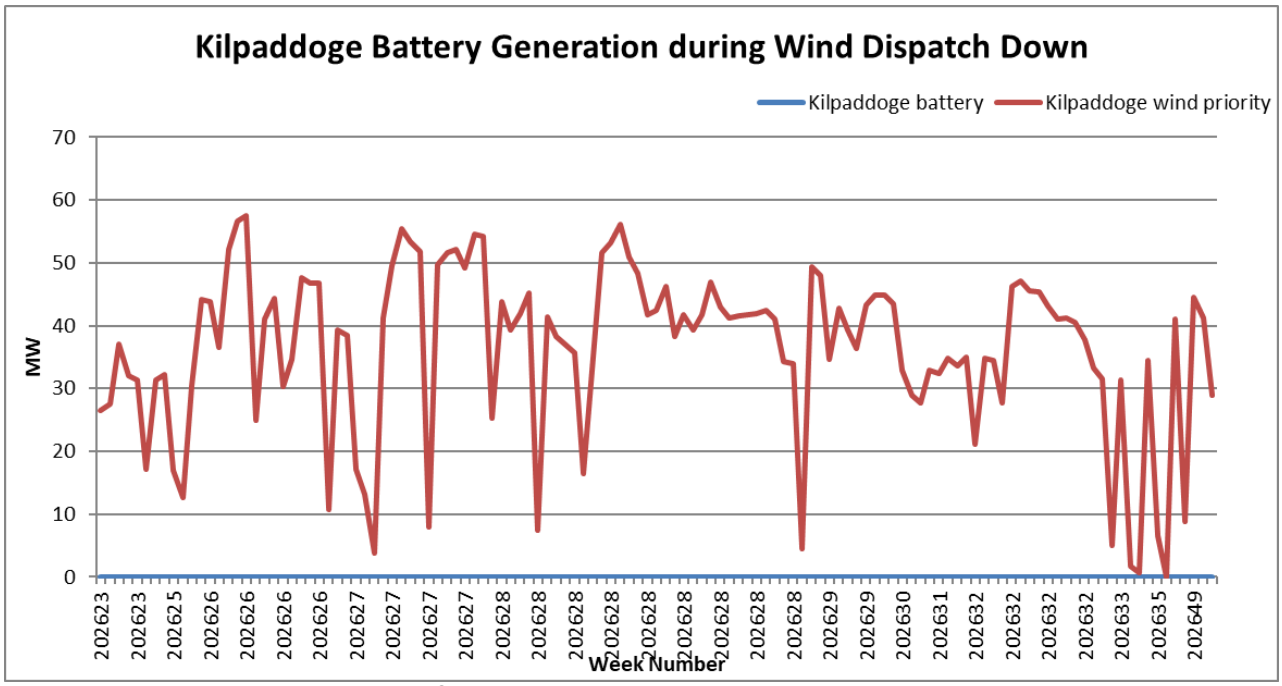

Figure 7: Battery Generation vs. Wind Dispatch Down (Kilpaddoge Node)

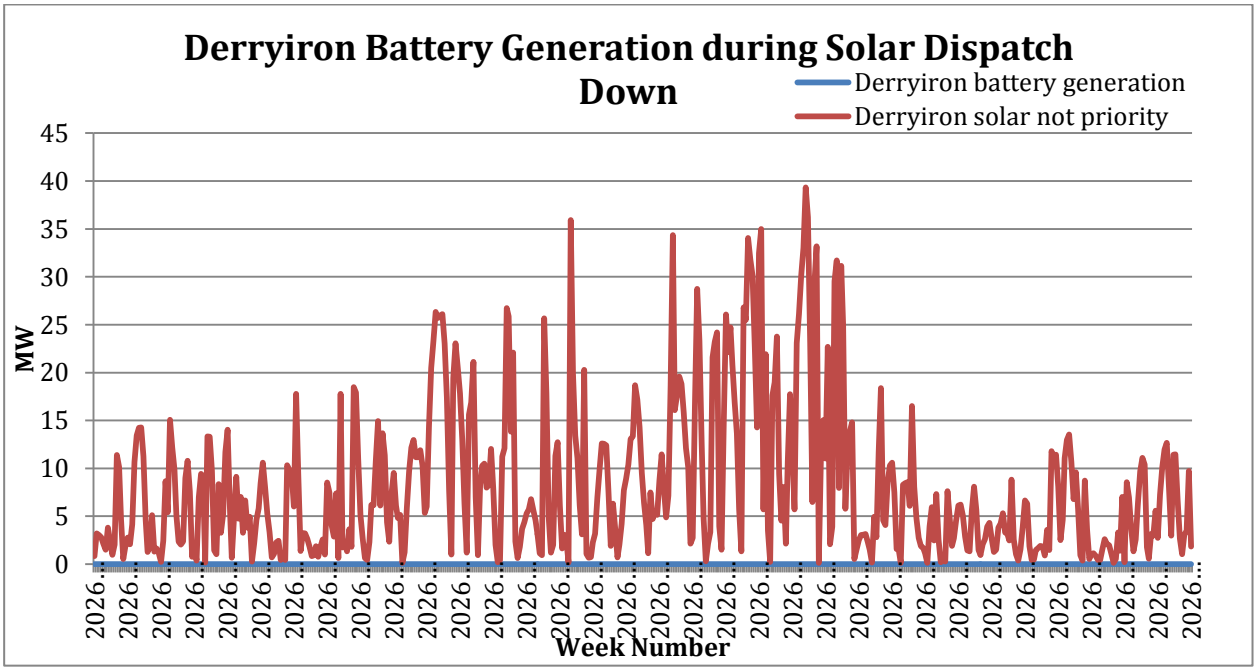

Figure 8: Battery Generation vs. Solar Dispatch Down (Derryiron Node)

Contingencies and Line Overload per Area

For different study scenarios, there were several transmissions boundaries that limit the power flow. Some of the main overload and contingency pairs binding for more than 100 hours for the two study years (2024 ECP (All) and 2026 with GL ECP (All)) can be seen below.

Year - 2024

Table 5: Binding contingency and overloading lines in 2024 ECP (All) study

Line	Contingency Name	Hours Range
Line (Galway - Salthill_110_1)	Base	1250 - 1500
Line (Killoteran - Waterford_110_1)	Loss of Cullenagh-Waterford_110	1250 - 1500
Line (Blundelstown_Mullingar_110_1)	Loss of Oldstreet Woodland 400	1000 - 1250
Line (Cashla - Dalton_110_1)	Loss of Cunghill Sligo_110	1000 - 1250
Line (Arklow T2101)	Loss of Arklow Lodgewood 220	1000 - 1250
Line (Louth - Ratrussan_110_1)	Loss of Arva Navan_110	1000 - 1250
Line (Flagford - Sligo_110_1)	Loss of Carrick on Shannon - Arigna T_110	1000 - 1250
Line (Carlow - Kellis_110_1)	Loss of Carlow Kellis_110_2	1000 - 1250
Line (Flagford - Sligo_110_1)	Loss of Srananagh 220-110 2	750 - 1000
Line (Drybridge - Louth_110_1)	Loss of Gorman Louth 220	750 - 1000
Line (Arklow T2101)	Loss of Arklow 220-110 2	750 - 1000
Line (Maynooth - Shannonbridge_220_1)	Loss of Oldstreet Woodland 400	750 - 1000
Line (Clonee - Woodland_220_1)	Loss of Corduff Woodland 220 1	750 - 1000
Line (Clonee - Woodland_220_1)	Loss of Kellystown (Ryebrook) - Woodland 220	750 - 1000
Line (Maynooth - Shannonbridge_220_1)	Loss of Dunstown Moneypoint 400	500 - 750
Line (Castlebar - Dalton_110_1)	Loss of Cunghill Sligo_110	500 - 750
Line (Louth - Ratrussan_110_1)	Loss of Flagford Louth 220	500 - 750
Line (Bandon - Dunmanway_110_1)	Loss of Clashavoon Knockraha 220	500 - 750
Line (Moneypoint T4201)	Base	500 - 750
Line (Corduff - Woodland_220_1)	Loss of Clonee Woodland 220	500 - 750
Line (Carrick on Shannon - Arigna-T_110_1)	Loss of Srananagh 220-110 2	500 - 750
Line (Crane - Wexford_110_1)	Loss of Arklow Carrickmines 220 1	250 - 500
Line (Crane - Wexford_110_1)	loss of Great Island – Rosspile_110	250 - 500
Line (Great Island - Kellis_220_1)	Loss of Arklow Carrickmines 220 1	250 - 500
Line (Firlough - Glenree 110 1 newish)	Loss of Bellacorick coupler	250 - 500
Line (Drybridge - Louth_110_1)	Loss of Louth-Oriel_220	250 - 500
Line (Bellacorick coupler a to b_110_1)	Loss of Cunghill Sligo_110	250 - 500
Line (Firlough - Moy_110_1 newish)	Loss of Bellacorick coupler	250 - 500
Line (Carrickmines - Poolbeg_220_1)	Loss of Inchicore Irishtown 220 1	250 - 500
Line (Cashla - Shantallow_110_1)	Loss of Dunstown Moneypoint 400	250 - 500
Line (Ballynahulla - Glenlara_wind_110_1)	Base	250 - 500
Line (Flagford - Sligo_110_1)	Loss of Flagford-Srananagh 220 circuit 1	250 - 500
Line (Cashla - Shantallow_110_1)	Loss of Oldstreet Woodland 400	250 - 500
Line (Carlow - Kellis_110_2)	Loss of Carlow Kellis 110	250 - 500
Line (Cathaleens Fall - Srananagh_110_2)	Loss of Cathaleens Fall -Srananagh 110_1	250 - 500
Line (Louth - Ratrussan_110_1)	Loss of Lisdrum Louth_110_1	< 250

Line	Contingency Name	Hours Range
Line (Cashla - Dalton_110_1)	Loss of Castlebar Cloon_110_1	< 250
Line (Blundelstown_Mullingar_110_1)	Loss of Dunstown Moneypoint 400	< 250
Line (Sligo - Srananagh_110_1)	Loss of Sligo Srananagh_110_2	< 250
Line (Baltrasna - Corduff_110_1)	Loss of Drybridge Gastkinstown_110	< 250
Line (Maynooth - Ryebrook_110_1)	Loss of Clonee Woodland 220	< 250
Line (Crane - Wexford_110_1)	Loss of Great Island - Lodgewood 220	< 250
Line (Athy - Carlow_110_1)	Loss of Arklow Carrickmines 220 1	< 250
Line (Ratrussan - Shankill_110_1)	Loss of Arva Navan_110	< 250
Line (Cashla - Galway_110_2)	Loss of cashla galway_110_3	< 250
Line (Maynooth - Ryebrook_110_1)	Loss of Maynooth to (Ryebrook or) Woodland 220	< 250
Line (Oldstreet - Tynagh_220_1)	Loss of Moneypoint 400-220 1	< 250
Line (Killonan - Shannonbridge_220_1)	Loss of Dunstown Moneypoint 400	< 250

Year - 2026 with GL

Table 6: Binding contingency and overloading lines in 2026 with GL ECP (All) study

Line	Contingency Name	Hours Range
Line (Blundelstown_Mullingar_110_1)	Loss of Oldstreet Woodland 400	1750 - 2000
Line (Galway - Salthill_110_1)	Base	1500 - 1750
Line (Clonee - Woodland_220_1)	Loss of Corduff Woodland 220 1	1500 - 1750
Line (Flagford - Tonroe_110_1)	Loss of Cunghill Sligo_110	1250 - 1500
Line (Maynooth - Timahoe North_110_1)	Loss of Kinnegad Harristown 110	1250 - 1500
Line (Lisdrum - Louth_110_1)	Loss of Louth – Ratrussan_110	1250 - 1500
Line (Great Island - Kellis_220_1)	Loss of Arklow Carrickmines 220_1	1250 - 1500
Line (Flagford - Sligo_110_1)	Loss of Flagford-Srananagh 220_1	1000 - 1250
Line (Arklow T2101)	Loss of Arklow Lodgewood 220	1000 - 1250
Line (Cashla - Dalton_110_1)	Loss of Bellacorick-Moy 110	1000 - 1250
Line (Great Island T2102)	Loss of Great Island - Kellis 220	1000 - 1250
Line (Killoteran - Waterford_110_1)	Loss of Cullenagh-Waterford_110	750 - 1000
Line (Corduff - Woodland_220_1)	Loss of Clonee Woodland 220	750 - 1000
Line (Arklow T2101)	Loss of Arklow 220-110 2	750 - 1000
Line (Clonee - Woodland_220_1)	Loss of Kellystown (Ryebrook) - Woodland 220	750 - 1000
Line (Maynooth - Ryebrook_110_1)	Loss of Maynooth to (Ryebrook or) Woodland 220	750 - 1000
Line (Crane - Wexford_110_1)	loss of Great Island – Rosspile_110	500 - 750
Line (Baroda - Monread_110_1)	Loss of Coolnabacky Dunstown 400	500 - 750
Line (Lisheen - Thurles_110_1)	Base	500 - 750
Line (Carrick on Shannon - Arigna-T_110_1)	Loss of Srananagh 220-110 2	500 - 750
Line (Arklow T2101)	Loss of Lodgewood 220-110 1	500 - 750
Line (Drybridge - Louth_110_1)	Loss of Gorman Louth 220	500 - 750
Line (Crane - Wexford_110_1)	Loss of Arklow Carrickmines 220 1	500 - 750
Line (Ballynahulla - Glenlara_wind_110_1)	Base	500 - 750
Line (Maynooth - Timahoe North_110_1)	Loss of Rinawade Dunfirth_110	250 - 500
Line (Blundelstown_Mullingar_110_1)	Loss of Coolnabacky Moneypoint 400	250 - 500
Line (Great Island T2102)	Loss of Cullenagh-Great Island 220	250 - 500
Line (Lisdrum - Shankill_110_1)	Loss of Louth – Ratrussan_110	250 - 500

Line	Contingency Name	Hours Range
Line (Great Island T2102)	Loss of Great Island - Lodgewood 220	250 - 500
Line (Maynooth - Rinawade_110_1)	Loss of Maynooth - Timahoe North_110	250 - 500
Line (Cashla - Shantallow_110_1)	Loss of Coolnabacky Moneypoint 400	250 - 500
Line (Flagford - Sligo_110_1)	Loss of Srananagh 220-110 2	250 - 500
Line (Maynooth - Ryebrook_110_1)	Loss of Clonee Woodland 220	250 - 500
Line (Baroda - Monread_110_1)	Loss of Mount Lucas – Thornsberry_110	250 - 500
Line (Castlebar - Dalton_110_1)	Loss of Bellacorick-Moy _110	250 - 500
Line (Baroda - Monread_110_1)	Loss of Derryiron Timahoe North_110	250 - 500
Line (Maynooth - Shannonbridge_220_1)	Loss of Coolnabacky Moneypoint 400	250 - 500
Line (Ratrussan - Shankill_110_1)	Loss of Flagford Louth 220	250 - 500
Line (Cahir - Doon_110_1)	Loss of Cullenagh-Knockraha 220	250 - 500
Line (Baroda - Monread_110_1)	Loss of Maynooth - Timahoe North_110	250 - 500
Line (Athlone - Lanesboro_110_1)	Loss of Corduff Blundelstown _110	250 - 500
Line (Dunstown T4202)	Loss of Oldstreet Woodland 400	250 - 500
Line (Baltrasna - Corduff_110_1)	Loss of Drybridge Gastkinstown_110	250 - 500
Line (Dunstown - Maynooth_220_2)	Loss of Oldstreet Woodland 400	250 - 500
Line (Dunstown T4202)	Loss of Dunstown 400-220 1	250 - 500
Line (Cullenagh - Waterford_110_1)	Loss of Cullenagh-Great Island 220	250 - 500
Line (Cathaleens Fall - Srananagh_110_2)	Loss of Cathaleens Fall -Srananagh_110_1	250 - 500
Line (Bracklone - Portlaoise_110_1)	Loss of Coolnabacky Dunstown 400	250 - 500
Line (Maynooth - Shannonbridge_220_1)	Loss of Coolnabacky Dunstown 400	250 - 500
Line (Cathaleens Fall - Srananagh_110_1)	Loss of Cathaleens Fall -Srananagh_110 _2	250 - 500
Line (Carlow - Kellis_110_1)	Loss of Carlow Kellis_110_ 2	250 - 500
Line (Crane - Wexford_110_1)	Loss of Great Island - Kellis 220	< 250
Line (Great Island - Kellis_220_1)	Loss of Great Island - Lodgewood 220	< 250
Line (Cashla - Dalton_110_1)	Loss of Castlebar Cloon_110_1	< 250
Line (Baroda - Monread_110_1)	Loss of Newbridge Blake T_110	< 250
Line (Baroda - Monread_110_1)	Loss of Dunstown 400-220 1	< 250
Line (Cashla T2104)	Loss of Cashla 220-110 2	< 250
Line (Crane - Wexford_110_1)	Loss of Great Island - Lodgewood 220	< 250
Line (Carrickmines - Poolbeg_220_1)	Loss of Inchicore Irishtown 220 1	< 250
Line (Arva - Carrick on Shannon_110_1)	Loss of Corraclassy Gortawee_110	< 250
Line (Cashla - Galway_110_2)	Loss of Cashla Galway_110_3	< 250
Line (Killoteran - Waterford_110_1)	Loss of Cullenagh-Great Island 220	< 250
Line (Derryiron - Thornsberry_110_1)	Loss of Cushaling Newbridge_110	< 250
Line (Cashla - Shantallow_110_1)	Loss of Oldstreet Tynagh 220	< 250
Line (Derryiron - Timahoe North_110_1)	Loss of Kinnegad Harristown 110	< 250
Line (Blundelstown - Corduff_110_1)	Loss of Lanesboro - Shanonagh_110	< 250
Line (Carrick on Shannon - Flagford_110_2)	Loss of Carrick on Shannon – Flagford_110	< 250
Line (Blundelstown - Corduff_110_1)	Loss of Oldstreet Woodland 400	< 250
Line (Maynooth - Timahoe North_110_1)	Loss of Derryiron Kinnegad_110	< 250
Line (Maynooth - Timahoe North_110_1)	Loss of Cushaling - Mount Lucas_110	< 250
Line (Blundelstown - Corduff_110_1)	Loss of Coolnabacky Moneypoint 400	< 250
Line (Flagford - Sligo_110_1)	Loss of Carrick on Shannon - Arigna T_110	< 250
Line (Lanesboro - Sliabh Bawn_110_1)	Loss of Cashla-Flagford 220	< 250
Line (Drybridge - Louth_110_1)	Loss of Clonee Woodland 220	< 250
Line (Kilpaddoge T4201 new)	Loss of Moneypoint 400-220 1	< 250
Line (Cashla - Galway_110_3)	Loss of Cashla Galway_110 2	< 250
Line (Cauteen - Killonan_110_1)	Loss of Cauteen - Tipperary_110	< 250

Line	Contingency Name	Hours Range
Line (Galway - Knockranny A1_110_1)	Base	< 250
Line (Clonee - Woodland_220_1)	Loss of gen HNC	< 250
Line (Cauteen - Killonan_110_1)	Loss of Cahir-Doon_110	< 250

Constraint Subgroups

The constraint forecast study performed using Plexos software applies mathematical optimization to minimize the cost of the energy and dispatch the generators to achieve the same. To ensure the model is impartial, the assumptions on the cost of renewable generators remain the same, irrespective of technology or location, and are always less than that of conventional plant. This ensures a higher merit order for renewable generators in the Plexos optimization. However, due to network congestion caused by line limits and N-1 contingency security checks, the power flows in certain lines are limited causing dispatch down in RES generators which may affect one generator or multiple generators chosen by Plexos' internal logic. During various initial studies, it was observed that Plexos may repeatedly choose the same generator(s) to dispatch down to manage an issue in a region shared by multiple generators.

To ensure a fair allocation of constraints among generators sharing the bottlenecks, constraint subgroups are created within an area or spanning multiple different areas. The subgroups are selected based on an assessment of the raw Plexos results and based on our experience of dispatch down on the real system. The subgroups are chosen to group those generators into a constraint group that are expected to experience similar constraint levels. The subgroups are selected on the basis that they share a common transmission bottleneck, or they are electrically close to a congested area within the network. This was in line with the approach in the ECP 1 constraint report, though some subgroups in the ECP 2.1 studies had to be changed based on the contingencies seen in the study to ensure a fair allocation of constraints.

The subgroup definition is essentially based on the network topology. Typically, the 110 kV network will provide electrical paths for other high voltage circuits in parallel. The general flow of power is from the West towards the Dublin load centres and to the interconnectors through the 400 kV, 220 kV and the 110 kV network. The loss of Oldstreet – Woodland 400 kV circuit is one of the major contingencies in the ECP 2.1 studies and it affects the power flow in most of the circuits pushing power to Dublin. Contingencies involving a high voltage circuit may thus span multiple areas involving multiple generators. Therefore, it is important that the network constraints are allocated appropriately.

Network subgroups will evolve as the network reinforcements are rolled out. This means that previously identified sub-groups may be grouped together (or split) as the congestion bottlenecks shift around the network.

A sample data and observation is presented below followed by short note on the constraint groups.

Sample Observation

A sample observation from one of the study cases is given below in Table 7 for a contingency raised by the loss of Carrick on Shannon - Arigna_110_1, the loss of Arva - Navan_110_1 and the loss of Srananagh T2102 (shown in Figure 9). The available MWh and constraint dispatch down MWh for a set of generators in the area is given in Table 7. It can be observed that during the contingency, all generators in the table are dispatched down completely except for wind generation at Binbane and Garvagh. The Binbane wind generation connects to Cathaleen's Fall 110 kV station, where the power from Croaghonagh wind and Mulreavy wind flows into. The contingency is essentially shared by all connections to Cathleen's Fall 110 kV station, yet the optimization tool treats these generators differently. To ensure a fair approach, a constraint group shares these constraints among the generators in the area on a pro-rata basis.

Table 7: Generator Available and Dispatch Down (MWh) for sample hour

Available and Dispatch Down (MWh)							
	Croaghonagh wind not priority	Sorne Hill wind priority	Mulreavy wind priority	Binbane wind not priority	Corderry wind not priority	Sligo wind priority	Garvagh wind priority
Available	127.1	44.3	87.6	34.2	15.0	13.7	75.4
Dispatch down	127.1	44.3	87.6	0	15.0	13.7	11.6

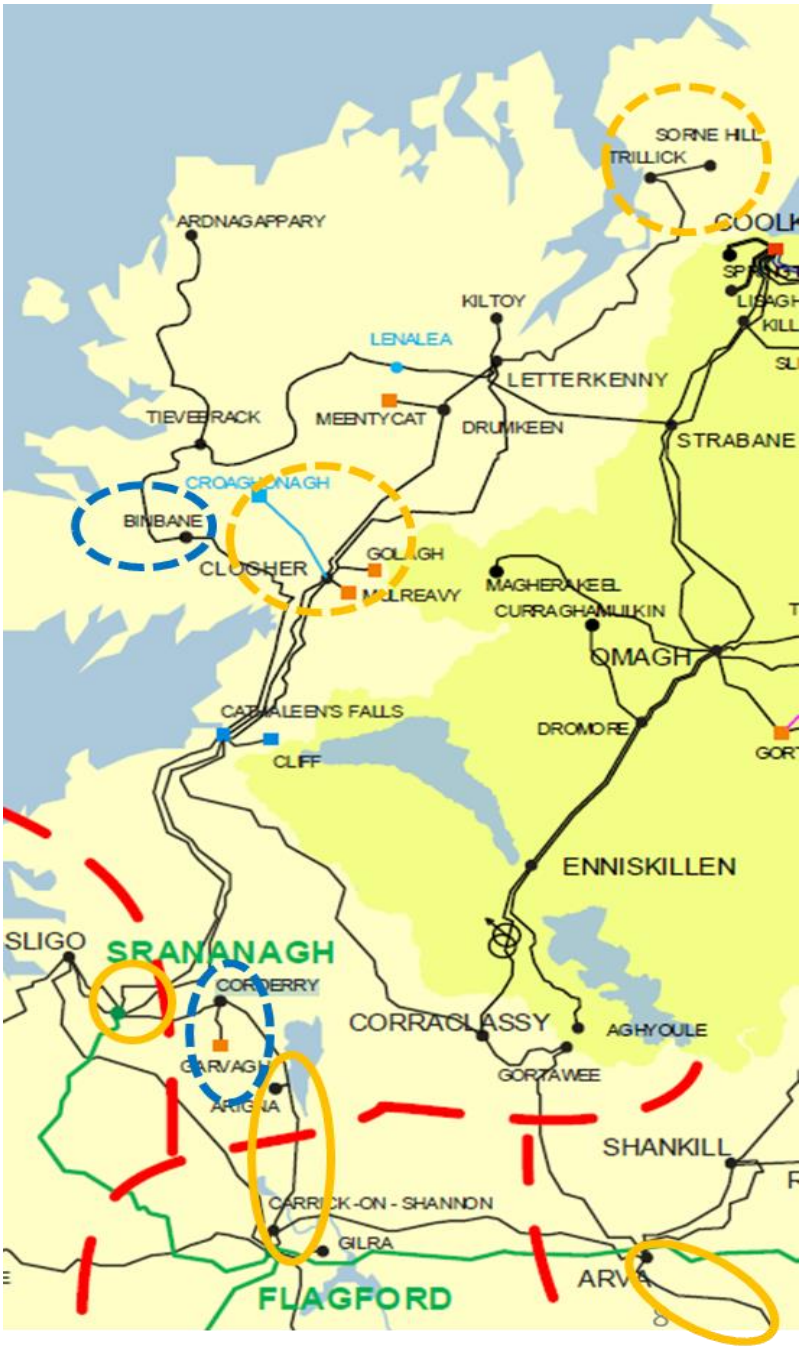

Figure 9: Map showing Area A and shared contingencies

Area A, B, C and G North

Some of the major overloading lines in this subgroup (Area A, B, C and G North) are included in Table 5 and Table 6. The lines overloading in these areas cause generators to be dispatched down in Area A, B, C and G North depending on the contingency in the area. The power from each of these areas tends to flow onto the 220 kV circuits, and then towards the load centres in Dublin (Figure 10). Any loss of these 220 kV circuits will put additional stress on the supporting 110 kV circuits, causing dispatch down of RES generators in the area. Additionally, the 110 kV parallel paths are critical transmission infrastructure in these areas during times of high wind. Any loss of these 110 kV parallel lines results in additional dispatch down. For example, at times, a loss of a circuit in Area C can trigger dispatch down in Area A – and therefore constraints need to be shared amongst this subgroup. The Loss of Flagford-Louth 220 kV circuit or Srananagh 220/110 kV transformer can also create significant power flow constraints.

The general flow of power towards Dublin transits through Area G North. A bottleneck in Area G North can cause power from Areas A, B and C to re-route to manage the issue and cause dispatch down in these areas. Thus it was logical to share the constraints in Area G North with Areas A, B and C. Additionally, with the planned reinforcement of Louth – Ratrussan 110 kV line in 2026, the bottleneck moves to the Lisdrum – Louth 110 kV and Lisdrum – Shankill 110 kV circuits.

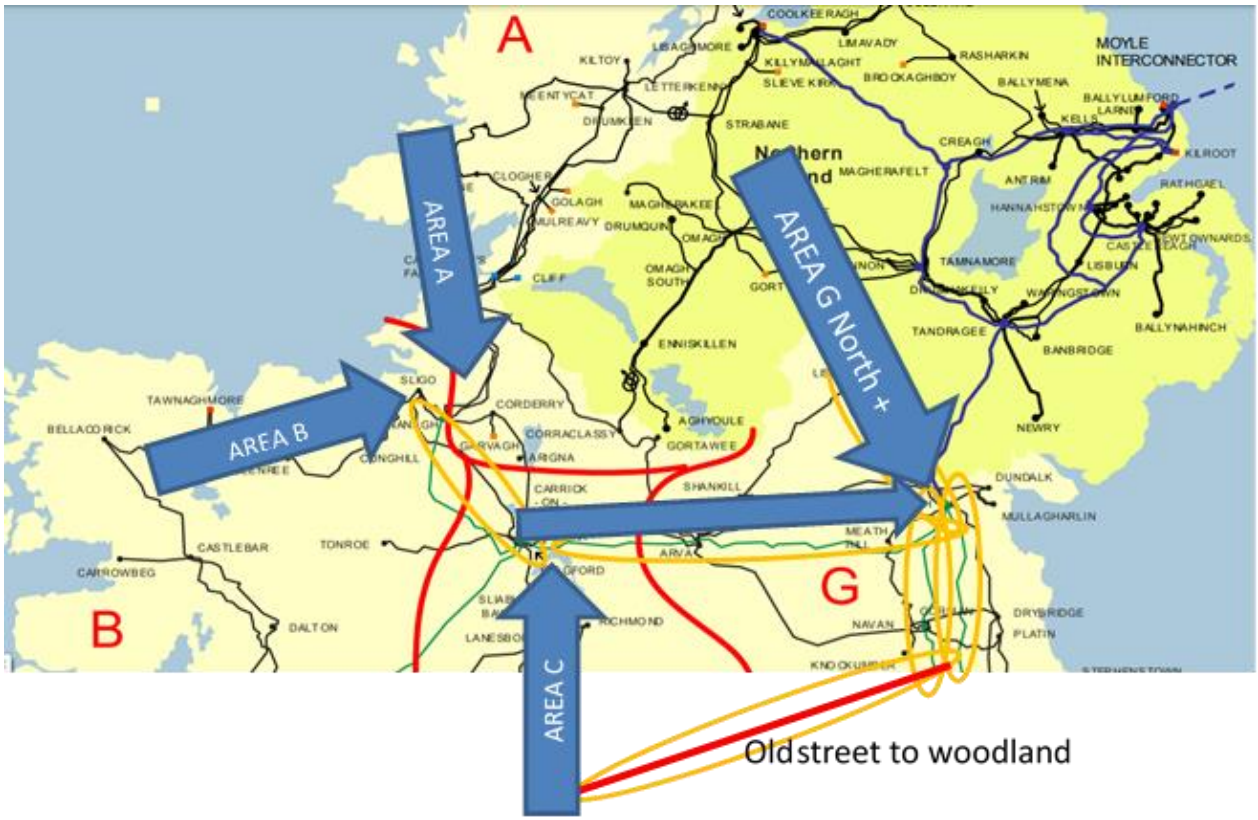

Figure 10: General power flow trend in Area A, B, C and G

Area J

Area J includes the major Dublin load centres. The power in the meshed 110 kV circuits in the midland (J-country) subgroup flows to the East, towards the 220 kV stations which feed the load centres (Figure 11). With increasing generation in the 110 kV network in the midlands, the power flow increases which causes bottlenecks in the circuits that have lower ratings. A loss of a circuit in the midlands area creates overloading in other circuits and therefore results in RES generation being dispatched down.

It was observed that the Plexos internal logic was constantly choosing the same set of generators to dispatch down with respect to multiple contingencies in the area, thus identifying a need to share the constraints. The contingencies and overloaded lines associated with the area are included in the Table 5 and Table 6. Additionally, the loss of a 220 kV and 400 kV circuit exerts additional stress on the 110 kV circuits in the region.

The J City subgroup is located in the east of Dublin. This subgroup receives connections from future offshore which are also grouped in this constraint subgroup. The J City subgroup mostly consists of 220 kV cables and is connected to the J Country subgroup through 110 kV and 220 kV stations.

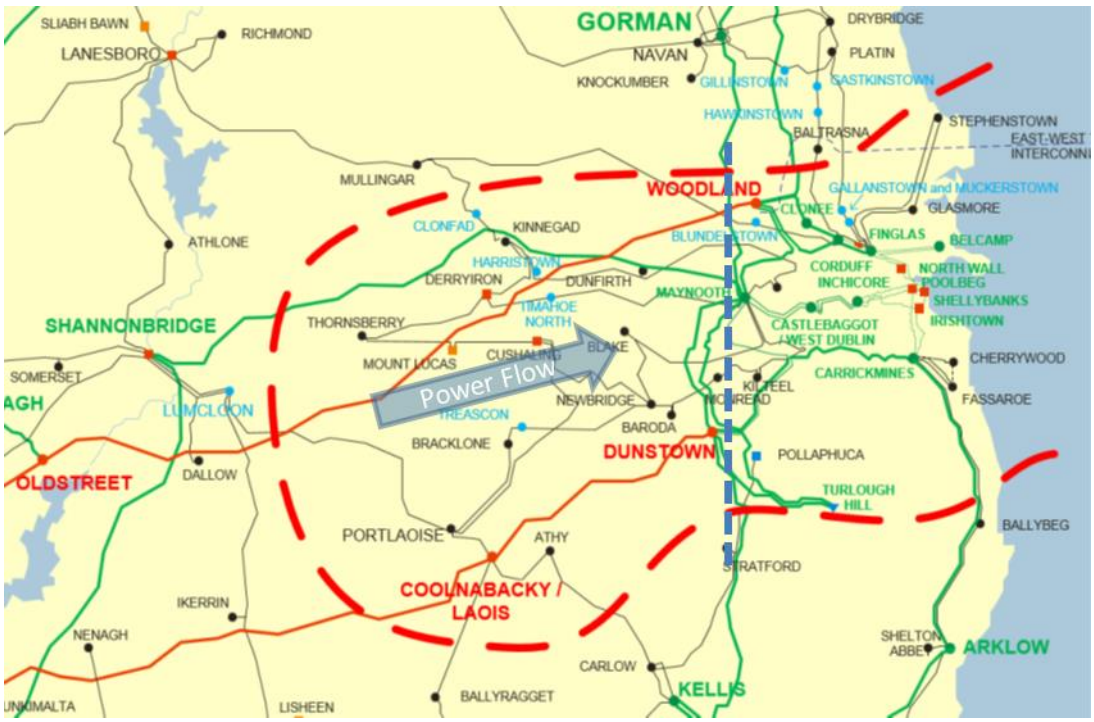

Figure 11: General power flow trend in Area J

Area E and F

The power from Area E tends to flow onto the 220 kV circuit running from Kilpaddoge towards Knockraha. The wind dispatch tool has already identified a constraint group in Area E. Any issues with the 220 kV circuit or with parallel paths can limit the generation in this area. Furthermore, the loss of Clashavoon – Knockraha 220 kV causes overloading in the Area F circuits causing dispatch down of RES in Area F. This contingency also leads to additional power flowing through the 220 kV towards the 400 kV circuit (Figure 12). Additionally, the issues binding for the circuits in Area E can create additional stress on the Area F circuits, as they merge with rescue flow towards Knockraha. The loss of Oldstreet – Woodland 400 kV circuit is one of the major contingencies in the ECP 2.1 studies and it affects the power flow in most of the circuits pushing power to Dublin. Treating Area E and F as a constraint group allows generators to share the bottlenecks in the area equably.

Figure 12: General power flow trend in Area F

Area H2

The east of Area H2 has one of the major bottlenecks in the Irish network, due to a parallel 220 kV circuit and 110 kV circuit from Great Island to Carrickmines. Additionally, the lower rating of the Arklow 220/110 kV transformer is also a major bottleneck in the area. The loss of Arklow - Carrickmines 220 kV circuit can impose constraints on RES generators along the east of area H2, whose power now has to flow on the 110 kV Arklow - Ballybeg line. Loss of Arklow - Carrickmines 220 kV circuit causes overloads on the Crane - Wexford 110 kV line limiting generators' ability to push power through the area. This corridor is thus considered as a subgroup. The west side of H2 including the Great Island - Kellis 220 kV circuit is in parallel to 110 kV circuits through Kilkenny. Any issue in this area is shared across the generators in the region. The meshed section towards Coolnabacky in 2026 will provide additional circuits for rescue flows.

Figure 13: General power flow trend in Area H2

Area H1

For both wind and solar in area H1, the contingencies are shared by all generators. Essentially the power from the area flows towards the Dublin load centre via the 220 kV circuits. The loss of the Oldstreet-Woodland 400 kV circuit overloads Shannonbridge - Maynooth 220 kV line, which can constrain power flow flowing from area H1 towards Dublin. Similarly, the loss of Dunstown - Moneypoint 400 kV line leads to overloads on Killonan - Shannonbridge 220 kV circuit. Additionally, the loss of Cullenagh – Great Island 220 kV can limit access of generators in area H1 to 220 kV circuits towards Dublin from the south. The meshed 110 kV network in H1 has wider access to the network, however, the 110 kV network is also affected by issues outside the area. Constraint grouping allows generators to share the underlying issues affecting the area equally.

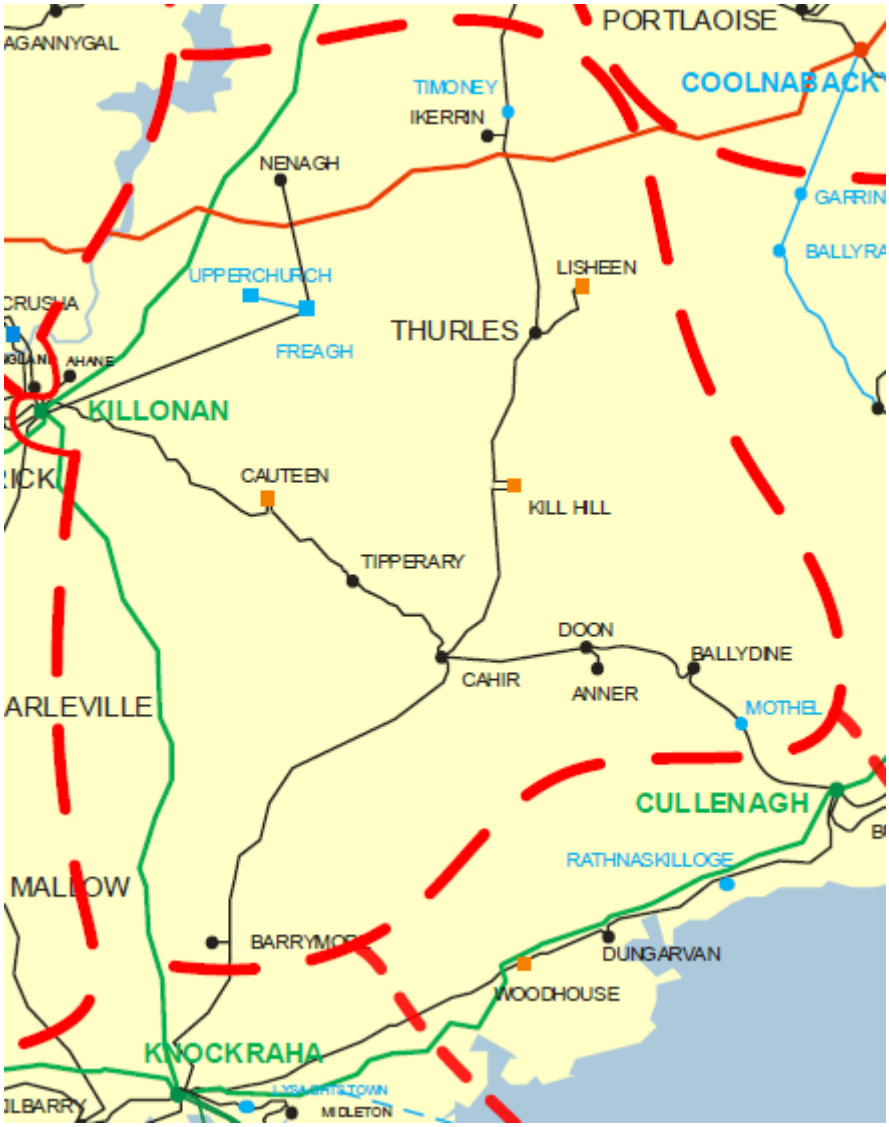

Figure 14: Area H1