Firm Access Study Approach and Assumptions Document

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1 Introduction

1.1 Background

The Firm Access Review process was established in December 2021, following CRU direction 20/060[1] which led EirGrid to publish the Firm Access Methodology Review Paper[2]. In June 2022, following engagement with industry and the RAs, EirGrid submitted an updated Firm Access Methodology Review Paper[3]. This led to a period of consultation[4] and the subsequent SEM Committee decision paper[5] on the firm access methodology.

In June 2023, the CRU published a consultation paper on the Firm Access Detailed Methodology (CRU/202363)[6]. The consultation paper sought to develop and define more detail on how the firm access methodology will be implemented. In November 2023, the CRU published its decision paper (CRU/2023114[7]) which directed that annual firm access reviews be completed. Subsequently in 2025, the CRU further directed that bi-annual firm access reviews be completed following CRU decision on the new Electricity Connection Policy – Generation & System Services (ECP-GSS) in Decision Paper CRU/2024101[8], published on 25 September 2024 which specifies two annual processing batches for generators applying to connect to the grid .

The methodology is based on the principle that firm access should be awarded to generators that can export energy to the transmission system without causing material transmission constraints, or where planned network reinforcements will alleviate those constraints within an acceptable timeframe.

Firm access is designed to reward generators that have developed in good locations. Good locations are defined as parts of the network that have capacity for new generation or have planned reinforcements that will deliver additional capacity in the area. A core feature of firm access has been the provision of locational signals for where generation should connect and providing an efficient investment signal to developers on that basis. The new methodology builds

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[1] CRU20060-ECP-2-Decision.pdf (divio-media.com)

[2] Firm-Access-Review-2021.pdf (eirgrid.ie)

[3] SEM-22-068a EirGrid Firm Access Methodology Proposal.pdf (semcommittee.com)

[4] SEM-22-068 SEMC Firm Access in Ireland consultation.pdf (semcommittee.com)

[5] SEM-23-004 SEMC Firm Access in Ireland decision.pdf (semcommittee.com)

[6] CRU202363 CRU Firm Access Detailed Methodology Consultation Paper

[7] CRU2023114_Firm_Access_detailed_methodology_decision.pdf (divio-media.com)

[8] CRU2034101_Electricity_Connection_Policy_Generation__System_Services_Decision_Paper.PDF

on the concepts introduced in CER/09/191 which emphasises the consideration of "the cost of alleviating transmission constraints (via transmission reinforcements) versus the cost of incurring the constraint costs". Thus recognising "the reality that when building the network, EirGrid, in keeping with its functions as licensed transmission system operator, develops the transmission system efficiently". The analysis completed as part of this review considers the interplay between three overarching features or lenses through which to view firm access:

End consumer:	Does the decision on generator firm access protect the end consumer from unreasonably high constraint payments?
Locational signals:	Does the decision on generator firm access provide an appropriate locational signal for where generation should connect?
System Development:	Is a specific constraint or group of constraints in an area sufficient justification for a specific reinforcement?

In attempting to answer these overarching questions, the firm access review must first identify the bottlenecks on the system which are becoming overloaded. It is then necessary to determine what generators are making a "material" contribution to these overloads. The firm access review must draw a distinction between "slight" and "material" contributions to an overload. This is done by considering the implications on the three overarching features of: end consumers, locational signals and system development.

1.2 Objectives of Firm Access Review

The Firm Access Review assesses the firm access status of committed non-firm generators and determines whether:

- Full/Partial firm access available immediately upon completion of connection works.
- Full/Partial firm access available following completion of a committed project(s) listed in the Transmission Infrastructure Delivery[9] (TID).
- No firm access available, project will remain non-firm and will be re-assessed in subsequent firm access reviews.

[9] Transmission Infrastructure Delivery (TID) Update

2 Assumptions

This section of the report describes the assumptions that have been applied to the firm access review.

2.1 Data Freeze

The firm access review requires numerous sequential steps of data collection, data validation, model setup, simulation runs and results analysis. Once the detailed models are prepared, they are run through power flow studies which simulate all 8760 hours of the study year. These simulations include contingency analysis that disconnects each network element on the system, in turn, and repeats the power flow simulation without that element.

The computational process can take in the order of four to six weeks to complete. Any changes to the input data, at any step in the process, will require a full restart of the process. It is therefore important to have a clearly defined data freeze date for the analysis.

Following CRU decision on the new Electricity Connection Policy – Generation & System Services (ECP-GSS) in Decision Paper CRU/2024101[10], generator application batches are set to be closed on the 31st of March and 30th of September each year. The bi-annual firm access reviews are required to be completed following this timeline. The data freeze dates for the reviews are therefore set to follow the batch dates of March 31st and September 30th each year.

2.2 Non-Firm Committed Generators

Committed generators are defined as contracted generation that had executed their connection agreements by the data freeze date. This includes generators assessed in previous firm access reviews who were deemed to be non-firm.

2.3 Generation and Interconnection Included in the Study

In addition to the non-firm generators being assessed, the models also include the existing generation that was contracted or connected to the system at the time of the data freeze. For the avoidance of doubt, any generators that already had a firm access date from previous

[10] CRU2034101_Electricity_Connection_Policy_Generation__System_Services_Decision_Paper.PDF

reviews will retain their existing firm access status irrespective of the outcome of subsequent reviews.

The offshore phase 1 and phase 2 projects received a firm access decision as part of previous firm access reviews and are included in all subsequent reviews. Based on the assumed connection dates for these projects they are expected to only be included in the reinforced network model. While the generator firm access market rules do not apply to interconnectors, the power flows on interconnectors do influence the performance of the system. The models therefore also include any interconnectors that are existing or contracted at the time of the data freeze.

2.4 PLEXOS Dispatch

The PLEXOS model from the ECP constraint analysis forms the basis of the model used as part of the firm access review. PLEXOS was used to run a full simulation for every hour of a given year (8760). The PLEXOS simulation looks at the load for each hour and determines the optimum dispatch of the available generation for each hour. A surplus and curtailment simulation run was completed which determined the dispatch profiles of each unit based on market rules and considered:

- Assumed wind/solar profiles based on historical and industry data.
- Assumed interconnector profiles.
- Assumed generator prices based on technology types.
- Security Constraints: System non-synchronous penetration, inertia and min set rules are based upon the latest version of the Operational Policy Roadmap available on the data freeze date (Currently Operational Policy Roadmap 2025-2035[11]).
- Demand based on the forecasted median scenario of the All-Island Resource Adequacy Assessment (AIRAA) [12] available on the data freeze date.

2.5 PSSE Network Model

PSSE was used to study the power flows on the network in detail and attribute specific equipment overloads with specific generator outputs. Two main system models were considered as follows.

[11] https://cms.eirgrid.ie/sites/default/files/publications/EirGrid-SONI-Operational-Policy-Roadmap-2025-2035.pdf

[12] All-Island Resource Adequacy Assessment

2.5.1 Unreinforced System

The firm access test for the committed generators was initially performed on an "unreinforced system" model. This test identifies if firm access is immediately available on the system. The unreinforced system model corresponds to the system on the data freeze date. This allows for the determination of the level of overloads that could be expected to occur on the system before planned reinforcements are complete.

2.5.2 Reinforced System

The firm access test for the committed generators is subsequently performed on the "reinforced system" model. This test identifies if firm access will be available on the system following the completion of planned reinforcements. The reinforced system model builds on the unreinforced system model and considers a future year (e.g. 2031) when all current committed network reinforcement projects are delivered. It includes committed network reinforcements, future expected demand levels, and the Phase 1 and 2 Offshore connections. The most recent published TID at the time of the data freeze date is used to determine the status of future grid development projects[13].

2.6 Firm Threshold

Firm threshold is defined in the CRU consultation paper (CRU/202363[14]) as a minimum level of acceptable constraint. Where the analysis demonstrates that constraints are expected to be below this firm threshold it is recommended that the generator is granted firm access. The CRU decision paper (CRU/2023114[15]) defines the firm threshold for renewable generators as 2%. The firm threshold for non-renewable generators is 0%.

[13] Transmission Infrastructure Delivery (TID) Update

[14] CRU202363 CRU Firm Access Detailed Methodology Consultation Paper

[15] CRU2023114_Firm_Access_detailed_methodology_decision.pdf (divio-media.com)

2.7 General Assumptions

The following general assumptions were applied throughout the analysis:

- The PSSE power flow simulations apply contingency analysis which disconnects each network element on the system, in turn, and repeats the power flow simulation without that element. Apart from these specific contingencies, it is assumed that no other overlapping outages are scheduled[16]. This is based on the TSSPS[17] criteria which determines that generation redispatch can be performed to reduce potential overloads during system maintenance conditions.
- Consistent with the principles of firm access, this review is attempting to estimate the overall level of constraint that could be required in a specific area, in order to prevent specific overloads. Areas where the majority of the generation volume can export from the area, without issues, would be considered as having firm access for that generation. For this reason, the firm access review assumes that constraints will be applied equally among all generators that contribute to an overload, including existing firm and non-firm generators and priority/non-priority generators. This is done in order to stay true to the principles of the firm access concept and avoid the results being distorted by individual priority dispatch rules.
- Constraints are primarily only considered for generators that have a significant contribution to the issue.
- Constraints for certain regional or system wide area issues will be considered on a case-by-case basis in order to determine specific overload contributions.
- It is assumed that in the event of a constraint involving a mixture of renewable and non-renewable sources, the non-renewable sources would be constrained first ahead of any constraint being applied to the renewable sources. Following an in-depth review of the October 2025 firm access review, Biomass units even though they may be renewable, will also be constrained ahead of wind and/or solar.
- Constraints are calculated and applied so that the transmission system meets the requirements specified in the TSSPS[18] and OSS[19].

[16] It should be noted that maintenance and development works on the system will result in several circuits being out-of-service at any given time during the outage season. As a result, the constraints calculated as part of the firm access review may not align with constraints identified in other studies or which materialise real-time operation of the power system.

[17] EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf

[18] EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf

[19] OSS – Operating Security Standards (eirgrid.ie)

3 Methodology and Approach

This section of the report describes the general approach which has been applied to the firm access review. This is an important section of the report to assist the reader in understanding some of the concepts used in the review.

3.1 High-level overview

This section describes the steps involved in the firm access review at a conceptual level. The starting point for the firm access review is a PLEXOS model to perform surplus and curtailment analysis. The output of this analysis is then further processed with PSSE-based power flow analysis for a full year (8760 hours). The limiting transmission network elements (circuits, busbars, or transformers) are identified from the power flow analysis. The main portion of the analysis focuses on these limiting elements. Nodal constraints are computed for the network elements and corresponding contingencies. The general steps are briefly described as:

Step 1: Compile the list of committed non-firm generators to be analysed. This is based on committed generators as of the data freeze date.

Step 2: Finalise the key assumptions for study years, demand data, interconnector data, RES profile, etc. Develop PSSE and PLEXOS models based on these assumptions.

Step 3: Compile the list of system reinforcements and their assumed completion years based on the Transmission Infrastructure Delivery publications (TID).

Step 4: Run a PLEXOS simulation to provide a full year of hourly profiles for interconnectors, demand and available generation (after surplus generation and curtailed generation have been removed).

Step 5: Run a PSSE power flow simulation for a full year using the PLEXOS hourly profiles from the previous step to set the dispatch.

Step 6: Identify the network elements that become overloaded (or could be overloaded if an N-1 contingency occurred) in the hourly PSSE analysis. Compute Shift Factors and other specific results to help identify the generators that are contributing to the overloading of specific network elements.

Step 7: Estimate the volume of generation that would need to be reduced at each node in order to prevent overloading specific network elements.

Step 8: The post processing phase of the analysis considered if generators can be granted firm access or a time bound firm access date.

3.2 Model Validation

To ensure consistency of assumptions and modelling set up, the ECP constraints model is used as a starting point with the firm access assumptions added on top.
Four PSSE power flow cases are used as a starting point for the analysis. They constitute Summer Peak, Winter Peak, Summer Night Valley and Winter Night Valley cases for the network at the time of the data freeze date. These models are validated for the network and generators as follows.

- Connected firm
- Connected non-firm
- Contracted firm
- Contracted non-firm

3.3 PLEXOS Surplus and Curtailment run

PLEXOS models were simulated for the study year (rules in PLEXOS are based on the ECP constraints analysis) without network considerations or operational rules. This provides information on the specific generation that would be utilised in an unconstrained market for each hourly demand. This step effectively matches the specific hourly electricity demand with the appropriate equivalent volume electricity supply. The reduction of available renewable generation for surplus reasons is necessary when the total available generation exceeds system demand plus interconnector export flows. In this review, generation reduction for surplus is applied prior to curtailment and constraint. This step is referred to as the ***surplus*** run in this report.

Using the surplus run as a starting point, PLEXOS models were also run to consider operational rulesets and system wide limitations (such as SNSP, minimum conventional generation, etc.). This is referred to as the ***curtailment*** run. The results from the PLEXOS curtailment run are used as a starting point for the generation, interconnectors, and demand hourly profiles in PSSE analysis. This includes the profiles for renewable generation dispatches which come from PLEXOS.

3.4 PSSE-based 8760 Analysis

As mentioned in the previous sections, PLEXOS is used to obtain the 8760-hour demand and corresponding generation dispatch following market and operational rules. The dispatch data is then utilised to perform power flow simulations in PSSE. The PSSE case includes all the relevant connected and contracted generators, and these are dispatched each hour according to the PLEXOS dispatch.

PSSE is used to perform the power flow analysis, for intact network (N) and single contingencies (N-1 and N-G) as per TSSPS[20], for every hour in the study year providing details of hourly overloading for the various network elements. Potential transmission overload issues, that could be solved by constraining generators, are identified from this analysis. As per the TSSPS, the loading on all circuits must be within the required emergency limits following an N-1 event. From the PSSE analysis, it is possible to determine all the network elements with violations and the extent of their violations with temporal granularity of hours. The hourly overload information is used in the following steps to distribute constraints at various nodes.

3.5 Post-processing

The main results provided from the PSSE analysis are post-processed to determine the constraints required at each node to alleviate any overloads. To help calculate the constraint required at each node, a Shift Factor is calculated. The Shift Factor (in MVA/MW) is defined as: the resultant change in MVA flow on a circuit for a given change in MW at the node. Shift factors are calculated for every node (that has a generation unit which can be constrained), for every hour of the study year and for the related contingencies. The changes are observed for a set of key network elements that are chosen by the user depending on the results from PSSE analysis.

The Shift Factor (SF) of a node is defined in equation (1):

$$SF_{i,j,h} = \frac{\Delta F_{j,h}}{\Delta P_{i,h}}, \qquad (1)$$

where,

$i = 1, \dots, N$ is the node, and N is the total number of nodes,

$j = 1, \dots, Y$ is the network element, and Y is the total number of network elements,

$h = 1, \dots, 8760$ is the hour,

$\Delta F_{j,h}$ is the change in MVA power flow on the network element j during hour h,

$SF_{i,j,h}$ is the Shift Factor (SF) for the node i and network element j during hour h, and

$\Delta P_{i,h}$ is the change in generation at node i during hour h.

Smaller shift factors from nodes that are not material to circuit overloads are filtered out using a cut off value for the shift factors (SF_{cut}), then (1) changes to

$$SF_{i,j,h} = \frac{\Delta F_{j,h}}{\Delta P_{i,h}}, \text{ if } \frac{\Delta F_{j,h}}{\Delta P_{i,h}} > SF_{cut} \text{ , else } SF_{i,j,h} = 0 \qquad (2)$$

[20] EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf

The level of constraints which must be shared/distributed across each node in order to eliminate an overload is based on a form of pro-rata calculation considering the shift factor and the volume of generation at the node. This is based on the following equations:

$$\Delta P_{i,j,h} = \left(\frac{SF_{i,j,h}\, P_{i,h}}{\sum_{k=1}^{N} SF_{k,j,h}\, P_{k,h}}\right)\left(\frac{OL_{j,h}}{SF_{i,j,h}}\right) \quad (3)$$

where,

$P_{i,h}$ is the generation at bus i and hour h, and

$OL_{j,h}$ is the overloading MVA (excess of the rated MVA) for the network element j during hour h.

Based on this analysis an assessment of the volume of constraint required at each node is determined. If this constraint is beyond the firm threshold, then it is concluded that the generator should not have firm access. This process is repeated for the unreinforced and the reinforced network models.

For generators that were non-firm in the unreinforced network that end up firm in the reinforced network model, additional post processing steps are then required to determine which planned reinforcements are associated in alleviating the constraints on the generators or if any volume of partial firm access can be provided to a generator. The process is demonstrated with the following basic example.

3.6 Conceptual Example of Study Steps

The following example illustrates the core principles of the approach to firm access. The example is based on one specific hour (H) in the PSSE analysis for the study year. Assuming that the study year is a non-leap year, there would be 8760 PSSE cases corresponding to each hour of the study year. In this example, two overloads are identified on Circuits 1 and 2 within the system. Generation at Node A, Node B, Node C, and Node D are seen to be contributing to the overloads.

During the post-processing phase of the analysis, the studies reported that overloading would occur on the Circuit 1 and Circuit 2 in the event of N-1 contingencies. Note that overloading could occur on any network element (busbar section, transformer, circuit, etc.), this example assumes that only two circuits were overloaded, and four nodes were contributing to the overloads.

3.6.1 Basic Shift Factors

This step calculates the basic shift factor based on equation 1. This links the generation at each node to the impact it can have on the overloads on each circuit.

Nodes A, B, C and D have constrainable generation of 30 MW, 10 MW, 3 MW, and 40 MW, respectively. The limiting network elements are Circuit 1 with 5 MVA overloading (beyond its capability), and Circuit 2 with 10 MVA overloading (beyond its capability). The overloading MVA is the maximum which could occur within that hour, either during intact network or single contingencies.

The Shift Factors shown in Table 1 are based on Equation (1). In simple terms this means that a reduction in generation of 1 MW at Node A would cause a reduction in power flow of 0.55 MVA in Circuit 1 and 0.35 MVA in Circuit 2. Conversely, a reduction of 1 MW of generation at Node C will only reduce power flows on Circuit 1 by 0.15 MVA and Circuit 2 by 0.05 MVA.

The table illustrates how a high shift factor indicates that a generator is electrically quite close to a given circuit and therefore will have a large contribution to the power flows on that circuit.

Table 1: Example of raw shift factors for nodes and circuits.

Shift Factor for Hour "H"	Circuit 1 (5 MVA)	Circuit 2 (10 MVA)
Node A (30 MW)	0.55	0.35
Node B (10 MW)	0.25	0.35
Node C (3 MW)	0.15	0.05
Node D (40 MW)	0.25	0.30

3.6.2 Filtered Shift Factors

This step filters the shift factors to only focus on the nodes which are having a material contribution to the specific overloads. (This approach is explained in more detail in Section 3.7.1) For example, a shift factor cut-off value of 0.3 ($SF_{cut} = 0.3$) is chosen and applied the raw shift factors in Table 1. Any shift factor that is below the cut-off is set as 0. This focuses in on the generators that can be seen to be having a material contribution to the power flows on the overloaded circuits. These filtered shift factors are summarised in Table 2.

Table 2: Filtered shift factors (assuming a 0.3 cut-off)

Shift Factor for Hour "H"	Circuit 1 (5 MVA)	Circuit 2 (10 MVA)
Node A (30 MW)	0.55	0.35
Node B (10 MW)	0	0.35
Node C (3 MW)	0	0
Node D (40 MW)	0	0.30

3.6.3 Overload Distribution

This step of the analysis determines how much of each specific circuit overload should be apportioned to each of the associated nodes. The shift factors combined with the volume of generation export is used to compute a ratio of how much each node is contributing to the overload. As stated already, higher shift factors correspond to nodes which are electrically closer or more relevant to the overloaded network element.

The approach taken to apportioning the volume of constraint amongst nodes with available generation is a ratio between the shift factor and the volume of generation. This is formulated in equations (2)-(3). In the example below it is determined that, of the 10 MVA of overload on the Circuit 2, 4.1 MVA of a reduction should be derived from the Node A, 1.3 MVA from the Node B and 4.6 MVA from the Node D. In this manner, the ratio of the generation export at a node, combined with the shift factor for that node determines what proportion of the reduction should come from each node.

Table 3: MVA overload distribution

MVA association for Hour "H"	Circuit 1 (5 MVA)	Circuit 2 (10 MVA)
Node A (30 MW)	5 MVA	$\left(\frac{0.35*30}{0.35*30+0.35*10+0.3*40}\right)*10 = 4.1$ MVA
Node B (10 MW)	0	$\left(\frac{0.35*10}{0.35*30+0.35*10+0.3*40}\right)*10 = 1.3$ MVA
Node C (3 MW)	0	0
Node D (40 MW)	0	$\left(\frac{0.3*40}{0.35*30+0.35*10+0.3*40}\right)*10 = 4.6$ MVA

3.6.4 Nodal constraints

The combination of the shift factor and the overload distribution is used to compute the actual volume of generation constraint that will be required at each node, in order to deliver an overall reduction of 5 MVA on the Circuit 1 and 10 MVA on the Circuit 2. For Circuit 1 the analysis is very straight forward as Node A is determined to be the only node having a material contribution to the overload. In order to reduce the overload on the line by 5 MVA, a node with a shift factor of 0.55 would have to reduce its generation by 9 MW in order to create a resultant reduction of 5 MVA on Circuit 1.

For Circuit 2 this is more complex as the constraint has to be shared across Nodes A, B and D in order to create an overall reduction of 10 MVA on Circuit 2. For example, Node A is required to contribute a 4.1 MVA reduction. Given that it has a shift factor of 0.35 relative to Circuit 2, 12 MW of generation reduction would be required from Node A in order to create a resultant reduction of 4.1 MVA on Circuit 2.

Table 4: Nodal constraint requirement (MW) for hour (H)

Constraints MW for Hour "H"	Circuit 1 (5 MVA)	Circuit 2 (10 MVA)
Node A (30 MW)	5 MVA/0.55 = 9MW	4.1 MVA/0.35=12 MW
Node B (10 MW)	0	1.3 MVA/0.35=3.7 MW
Node C (3 MW)	0	0
Node D (40 MW)	0	4.6 MVA/0.3=15.3 MW

Every PSSE case (corresponding to each hour) will have a volume of generation that must be constrained at specific nodes in order to alleviate overloads on specific network elements. These results are compiled into a matrix of nodes vs network elements for that hour. A results matrix is created (by adding up matrices corresponding to all the hours in the study year), to obtain the total MWh constraints for nodes and network elements for the year. This can be viewed as either a percentage constraint result or a GWh volume of constraint. The results matrix forms the core basis of the firm access review. From this matrix it is possible to tell:

- what circuits are overloaded?
- what nodes are contributing to the overload?
- how much generation would need to be constrained at each node in order to alleviate the overload?

The percentage constraints for a generator is defined as Constrained MWh (8760) / Total available MWh (8760). In the example above, if it was determined that due to the overload on Circuit 2 it was necessary to constrain Node A by over 15% throughout the entire year, then the generation at Node A would be considered non-firm. This node would then be considered for further post-processing to determine if there are any potential reinforcement solutions or if there is any partial firm access available at that node.

3.7 Firm Access Post-processing

This section of the report expands on the conceptual example described in Section 3.6 in order to further explain the main post-processing phase of the analysis. In this phase of the analysis the constraint results are processed in order to identify the "material" constraints and the "slight" constraints. Depending on the firm threshold selected, this phase of the analysis may identify that some generators are experiencing very little constraints and should be considered for being allocated firm access. Other generators may be seen to be having significant contributions to specific overloads and therefore require substantial constraint which would mean these generators would not be granted firm access.

3.7.1 Detailed consideration of Shift Factors and overload causation

This phase of the analysis concentrates on the generators with high constraint in order to understand their issues and make sure that they are credible. Decisions around granting firm access need to consider, inter alia, the following principles:

End consumer: Does the decision on generator firm access protect the end consumer from high constraint payments?

Locational signals: Does the decision on generator firm access provide an appropriate locational signal for where generation should connect?

System Development: Is a specific constraint or group of constraints in an area sufficient justification for a specific reinforcement?

The Shift Factor used in the analysis is critical in identifying the primary generators which are contributing to specific regional overloads on the system. The analysis will typically apply a higher shift factor in order to identify the generators that are making material contributions to overloads. However, in some circumstances additional screening analysis will consider a lower shift factor in order to gain a full understanding of overload causation.

If a shift factor of 0.1 is used, this will result in "casting the net" very wide. With this approach a generator could also be associated with overloads far outside of its regional network, even with circuits on the other side of the country. This could result in the generator remaining non-firm. In these situations, it needs to be considered if this approach sends an appropriate locational signal, if it protects end consumers and if it aligns with system development principles.

A Shift Factor of 0.3 is consistent with the locational signal principles of firm access and, by extension, of linking generators to major regional bottlenecks. A generator with a Shift Factor above 0.3 will most likely be making a large contribution to an overload. It is reasonable to conclude that this generator must remain non-firm in order to protect the end consumer and send an appropriate locational signal regarding this area. In consideration of CER/09/031 it could generally be expected that for a generator with a Shift Factor above 0.3, the cost of incurring the constraints would be higher than the cost of alleviating constraints via transmission reinforcements (in addition to the economic considerations of a reinforcement, the technical, social acceptance and deliverability perspectives also need to be considered). The core principle here is that generators with a shift factor of 0.1 or below would generally not be a contributing factor in the justification for a system reinforcement and for that reason should not be directly linked to those issues. Conversely, a generator with a shift factor of 0.3 or above is making a material contribution to a system overload(s) and thereby is most likely contributing to a system reinforcement need.

The principle described above for shift factors holds true when dealing with unidirectional power flow issues. This is the case for much of the Irish power system where the network is not very meshed. Power from generators in a specific region will tend to always flow in the same direction on a limited number of circuits out of that region. This principle may not work for more complex meshed parts of the network where lots of different generators can impact on power flows. In these complex parts of the network, the magnitude and direction of power flows can vary significantly based on the prevailing generation and demand patterns. This tends to be a feature of some of the more central parts of the network. Attributing causation to overloads on these inter-regional network elements can become quite complex.

From a system development perspective, it is often quite clear that a reinforcement is justified for these network elements. However, it is often not clear if individual clusters of generators, in-and-of themselves, would be drivers for the reinforcement. For that reason, keeping projects non-firm for these issues may not be consistent with the overarching features of firm access (protecting end consumers, locational signals and system development). In analysing overloads occurring on these meshed parts of the network it has been observed that a Shift Factor of 0.3 will isolate only the local generators which are closest to the overload. It has also been noted, that only

constraining these local generators may not be sufficient to fully alleviate the overload. In other words, an accumulation of generators with smaller Shift Factors are also contributing to the overload. It could therefore be considered unequitable and not in accordance with the general principles of firm access for only these local generators to be considered responsible for the overloads. In such circumstances, there is justification for using a lower Shift Factor of 0.1. This will cast the net wider in order to identify the broader spectrum of generators which are identified as contributing to a given overload.

Based on the list of generators identified as contributing to a complex inter-regional overload with a shift factor of greater than 0.1, the following factors will be considered:

1. With a shift factor of 0.1 the required volume of constraint will be shared across a larger number of generators. This may mean that the volume of constraint required by the local generators which are closest to the overload will drop below the firm threshold. In this case it is expected that all generators should be considered as firm.
2. In other situations, all generators will be identified as having constraints of greater than the firm threshold due to their total contribution to overloads on complex inter-regional parts of the network. In these cases, it will have to be determined if the generator will remain non-firm. This decision will have to be made cognisant of the implications on the three overarching features of firm access; end consumers, locational signals and system development.
3. In some instances, the review of generators contributing to an overload will suggest that there may be some anomalies in the dispatch profiles. This can be particularly noticeable if the dispatch profile suggests an unorthodox combination of conventional generation dispatches and interconnector power flows. In these cases, it will have to be determined if the scenario is reasonable and if keeping any associated generators non-firm would meet the overarching principles of firm access. In this case it is expected that all generators should be considered as firm.

3.8 Reinforcement post-processing

This phase of the analysis is focused on the reason(s) why a generator receives firm access in the reinforced network model. The overloads causing constraints in the unreinforced model are compared against power flows in the reinforced model in order to identify the reason(s) for the change.

The assessment comprises the following steps:

- **Review constraint causes.** Use the nodal constraint results to establish why constraints are high in the unreinforced network model and why they are reduced/eliminated in the reinforced network model.
- **Identify reinforcement dates.** Identify the planned reinforcements that relieve the constraints and the expected completion dates, as set out in the Transmission Infrastructure Delivery[21](TID) publication.
- **Assess reinforcement effectiveness.** The step may require further analysis depending on the overload, the type of network element and the affected generators. For example, if a circuit with a rating of 99 MVA could become overloaded to a maximum of 150% in the unreinforced network model and if this circuit is due to be uprated to 200 MVA, then it is clear that this uprate resolves the constraint. The effect of a new circuit is less straightforward, further analysis is needed to determine if the resultant changes in power flows were sufficient to alleviate the constraint. If a specific reinforcement resolves the worst-case hourly overload, it is considered sufficient to alleviate all overloads on that circuit and is therefore considered wholly or partly responsible for enabling the generator to receive firm access (in cases where a generator is constrained due to potential overloads on more than one circuit, a specific reinforcement may only be partially responsible for the generator receiving firm access).
- **Assign a firm access date to generators.** A firm access date is assigned to each firm generator based on the latest completion date for the associated reinforcement projects, as set out in the TID. In some cases, a generator may qualify for firm access in the reinforced network model without being linked to a specific network reinforcement. This may be due to overall power-flow changes occurring for a number of reasons, for example, the effects of surplus generation, the impact of demand increases, changes in "push/pull" of power flows on the system due to changes in generation or the system-wide impact of new reinforcements. In these cases, the generator is assigned a firm access date corresponding to the reinforced network study year.

[21] Transmission Infrastructure Delivery (TID) Update

3.9 Partial Firm Access post-processing

For any generators deemed to be non-firm, there are additional studies to determine if partial firm access is available. These studies use the same tools, principles and methodologies of the original firm access assessment. The post processing step (outlined in Section 3.5) is re-run for each non-firm node and an amount of partial firm is assumed for each node. This process is done in blocks of 20 MW.

The output from this analysis then calculates the constraint on the assumed partially firm portion. If this calculated constraint is below the threshold, then the node has partial firm access available. If a node is found to have partial firm access available, then the process is repeated with the next 20 MW block until the partial limit is reached.

3.10 Process Flow

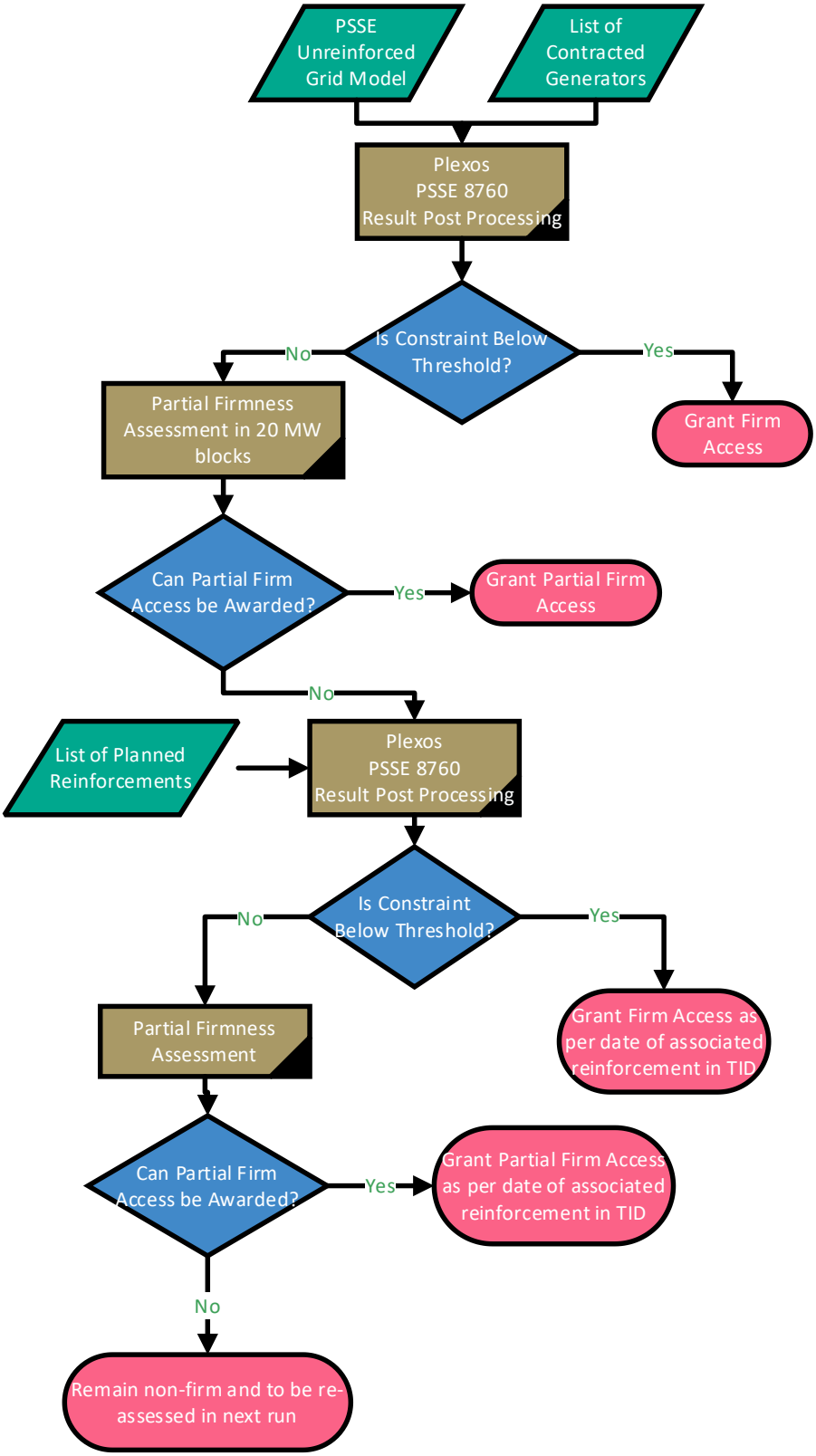


Figure 1: Outline of the sequence of steps of the firm access analysis.