Policy Statement on Busbar Configuration for 110 kV, 220 kV and 400 kV Transmission Substations

Pol_St_3_Busbar_Configuration	**Applicable to: Ireland**
Policy Owner: Future Networks	**Category: Substations**
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Revision No: 0	**Review Period: 2 Years**

Introduction	This policy provides a set of practical rules for **Busbar** configuration design for all new, existing and planned 110 kV, 220 kV and 400 kV transmission substations. The standard **Busbar** configuration is the **Enhanced Ring Busbar** for transmission substations. The **C-Type Busbar** configuration is the initial phase for the **Enhanced Ring Busbar** configuration. The objective is to deliver a consistent approach to the design and operation of transmission substations in Ireland while ensuring a safe, secure, reliable, economical, efficient and co-ordinated electricity transmission system. The policy must assist to ensure the long term ability of the transmission system to meet reasonable demands for electricity transmission. This is achieved by ensuring an adequate level of transmission substation reliability, and by extension consistent system-wide reliability, while ensuring that investment decisions maintain or improve reliability where required. Over the life-cycle of a transmission substation, the **Enhanced Ring Busbar** configuration is the most effective solution, based on cost, reliability, operational flexibility and capability to meet long-term system needs. The **Enhanced Ring Busbar** offers high levels of reliability and operational flexibility. Furthermore, the ring topology of the **Enhanced Ring Busbar** offers the advantage of increased asset utilisation, better substation through-flow capability and hence better overall system reliability. This policy supports modular substation development, as a **C-Type Busbar** can be constructed when three or four **HV Bays** are required as part of an initial substation development and can be extended to an **Enhanced Ring Busbar** at a later date when additional **HV Bays** are required.
Policy &	This policy applies to all substation development works. Substation development works are defined as works relating to connection offers executed after the effective policy date

Principles

and transmission projects receiving capital approval after the effective policy date.

The requirements of this policy vary depending on if the substation development works are carried out at new, existing or planned transmission substations.

New substations are defined as radial or meshed 110 kV, 220 kV or 400 kV substations that are not already constructed and/or connected to the transmission system or do not have a detailed **Busbar** configuration specified in a connection offer executed before the effective date of this policy. Section 1 in this policy outlines **Busbar** configuration rules for substation development works at new transmission substations.

Existing or planned substations are defined as radial or meshed 110 kV, 220 kV or 400 kV substations that are already constructed and/or connected to the transmission system or have a detailed **Busbar** configuration specified in a connection offer executed before the effective date of this policy. Section 2 in this policy outlines **Busbar** configuration rules for substation development works at existing and planned transmission substations.

Modification requests, received after the effective policy date, for connection offers executed before the effective policy date that result in significant and relevant changes to the **Busbar** configuration may result in a planned substation being reclassified as a new substation in the application of this policy, as determined by the Transmission System Operator (TSO).

Section 3 in this policy outlines general **Busbar** configuration rules for substation development works at new, existing and planned substations.

Requirements outlined in this policy apply to Air Insulated Switchgear (AIS) and Gas Insulated Switchgear (GIS) substations unless otherwise stated.

1. New Transmission Substations

This section of the policy outlines the minimum requirements for new 110 kV, 220 kV and 400 kV transmission substations.

1.1. A transmission substation with a single radial connection which requires:

- 1.1.1. A single **HV Bay** may be designed without a **Busbar**.
- 1.1.2. Between two and six **HV Bays** shall be designed with a **C-Type Busbar** configuration.
- 1.1.3. More than six **HV Bays** shall be designed with an **Enhanced Ring Busbar** configuration.

1.2. A transmission substation with a meshed connection with one voltage level that requires:

- 1.2.1. Up to four **HV Bays** shall be designed with a **C-Type Busbar** configuration.
- 1.2.2. More than four HV Bays shall be designed with an **Enhanced Ring Busbar**

configuration.

1.3. A meshed transmission substation with two or more transmission voltage levels[1] that requires:

1.3.1. Four **HV Bays** or less per transmission voltage level shall be designed with a **C-Type Busbar** or **Enhanced Ring Busbar** configuration at each voltage level with a maximum of two **System Transformers** permitted to connect the transmission voltage levels.

1.3.2. More than four **HV Bays** per voltage level shall be designed with an **Enhanced Ring Busbar** configuration for each voltage level with a maximum of four **System Transformers** permitted to connect two transmission voltage levels.

1.4. A radial or meshed transmission substation with two or more transmission voltage levels may have a combination of **C-Type Busbar** and **Enhanced Ring Busbar** configurations assuming **HV Bay** requirements in Sections 1.1 and 1.2 are met.

2. Existing and Planned Transmission Substations

This section of the policy outlines the rules for the **Busbar** configuration at existing and planned transmission substations.

2.1. A transmission substation without a **Busbar**, that requires the connection of additional **HV Bay(s),** shall be designed as a **C-Type Busbar** or **Enhanced Ring Busbar** depending on the rules outlined in Sections 1.1 and 1.2.

2.2. An AIS transmission substation with a **C-Type Busbar** configuration with less than four **HV Bays**, that requires one additional **HV Bay**, may remain as a **C-Type Busbar** transmission substation.

2.3. A transmission substation with a **C-Type Busbar** configuration and four **HV Bays,** which requires an additional **HV Bay**, may be extended incrementally[2][3] if a system needs assessment suggests that no additional **HV Bays** are required, and shall be designed so that the station ultimately meets the standard **Enhanced Ring Busbar** configuration with four **HV Bays** per **Busbar Section**.

2.4. The Busbar Configuration Guide shall be used to determine if an additional **HV Bay**, a replacement **HV Bay,** a **Busbar** uprate**,** or a substation refurbishment drives the

[1] E.g. 400/220 kV, 400/110 kV, 220/110 kV or 400/220/110 kV
[2] Incremental expansion may significantly impact the service continuity of the Busbar section being extended.
[3] Changes to GIS standard designs present risks associated with extensions of GIS substations.

requirement for migration to a **C-Type Busbar** or **Enhanced Ring Busbar** configuration at an existing or planned transmission substation.

3. General Substation Considerations

This section of the policy outlines additional considerations, irrespective of the substation being classified as new, existing or planned.

3.1. Section 4.1 and Section 4.2 of the *Transmission System Security and Planning Standards*[4] (TSSPS) shall be complied with when considering a substation **Busbar** configuration.

3.2. A **Busbar Section** shall have no more than:
- 3.2.1. Four **HV Bays** for a meshed substation, and
- 3.2.2. Six **HV Bays** for a radial substation.

3.3. A minimum of three **HV Bays** are required in an initial **C-Type Busbar** configuration. Once fully extended each **Busbar Section** in both **C-Type Busbar** and **Enhanced Ring Busbar** configurations shall contain four **HV Bays**.

3.4. For GIS, four fully equipped **HV Bays** shall be provided as standard in a **C-Type Busbar** configuration[5] where only three **HV Bays** are required in the initial build.

3.5. The design of a substation with a **C-Type Busbar** configuration shall facilitate expansion, with minimal operational disruption, to an **Enhanced Ring Busbar** configuration:
- 3.5.1. A GIS transmission substation shall be laid out in a manner which includes a full **Sectionaliser Bay** (Figure 2) on each **Busbar**.

3.6. GIS **Wing Coupler** and **Sectionaliser Bays** shall be installed in their final location[6]. Service continuity implications do not permit relocation of these two bay types.

3.7. The design of a substation with an **Enhanced Ring Busbar** configuration shall facilitate expansion with minimal operational interruption[7] where extension is foreseeable e.g. extension of 8 bay **Enhanced Ring Busbar** configuration to 12 bay **Enhanced Ring**

[4] EirGrid, Transmission System Security and Planning Standards
[5] Provision of four HV Bays as part of initial development ensures that significant service continuity impacts are avoided for GIS substations.
[6] Outcome of joint EirGrid, ESB Networks and ESB International Working Group 2018
[7] Short duration outages of Busbar sections and outages to secondary systems such as Busbar protection and interlocking are anticipated to incorporate new bays.

Busbar configuration. In the case of GIS substations, this may be achieved where practicable by **Busbar** coupling of two sectionaliser bays, as shown in Figure 4, or by installing a fully functioning coupler bay to join two sectionaliser bays or by some other acceptable means.

3.8. Regarding unequipped **Future HV Bays**:

3.8.1. They are not permitted in GIS substations.

3.8.2. They are permitted in AIS substations. Post insulators and spans of **HV Bay** conductors shall be installed between **Busbar Sections** on all **Future HV Bays**.

3.9. The number of **Spare Bays** required should be based on:

3.9.1. An assessment of transmission system needs at the substation; or

3.9.2. Plans outlined in strategic publications such as the latest national Transmission Development Plan or European Ten Year Network Development Plan.

3.10. GIS building sizes shall consider station extendibility on a project-by-project basis. Service continuity requirements are captured in the latest version of the EirGrid GIS functional specification, XDS-GFS-25-001-R4[8].

3.11. 110 kV, 220 kV and 400 kV transmission substation **Busbars** shall not use XLPE cable. Solid tubular **Busbar** or stranded conductor shall be used for AIS **Busbar**. Gas insulated bus duct shall be used for GIS stations.

3.12. The loss of any 110 kV transmission **Busbar Coupler** or **Sectionalising Bay** (e.g. two **Busbar Sections**) shall not directly or indirectly result in the loss of more than 500 MW of **System Load** or the equivalent MW quantity of **System Generation**.

3.13. The loss of any 110 kV transmission **Busbar Section** operated in **Standard Configuration** shall not directly or indirectly result in the loss of more than 250 MW of **System Load** or the equivalent MW quantity of **System Generation**.

3.14. The loss of any 220 kV or 400 kV **Busbar Section** or **HV Bay** in **Standard Configuration** shall not result in the cascade tripping of any other part of the transmission system.

3.15. The loss of any 220 kV or 400 kV **Busbar Disconnector**, **Coupler** or **Sectionaliser Bay** shall not directly or indirectly result in the loss of more than 375 MW of **System Load** or **System Generation** exceeding twice the rating of the single **Largest Credible**

[8] EirGrid, Function specification 110/220/400 kV Substation General Requirements.

Generation Infeed permissible on the system.

3.16. Regarding **Busbar Disconnectors, Couplers** or **Sectionaliser Bays**, the loss of any 220 kV or 400 kV section of **Busbar** operated in **Non-Standard Configuration** shall not directly or indirectly result in the loss of more than 375 MW of **System Load** or **System Generation** exceeding the rating of the single **Largest Credible Generation Infeed** permissible on the system.

Application

This policy applies to all substation development works at new, planned and existing 110 kV, 220 kV and 400 kV transmission substations in Ireland effective from the approval date in the revision history section.

Derogation

Exception from the minimum requirements outlined in this policy can only be achieved by applying the ***Derogation Policy***.

Revision History

Version	Date	Summary of Changes/Reasons	Authors	Approved By
v1.0	2009	Original Busbar Policy	Jon O'Sullivan Mark Norton	Andrew Cooke Fintan Slye
V2.1	2013	Updated to, based on legal review, to reflect the EirGrid busbar position paper	Mario Duarte Jeff Kelliher	Andrew Cooke John Fitzgerald
V3.0	2015	Updated to address high number of derogations for existing substations	Yvonne Coughlan Jeff Kelliher John Leahy	Transmission Investment Committee (TIC)
V4.0	15/10/20	Restructuring of document and text edits throughout. Updates to reflect recommendations of joint working group of EirGrid, ESB Networks and ESB International on GIS substations. Changes to switchgear requirements for AIS C-Type Busbar configurations. Changes to text clarifying the minimum standard for C-Type Busbar configurations.	Jeff Kelliher Ciarán Rabbitt	Transmission Investment Committee (TIC)

Definitions

Busbar	Consisting of one or more **Busbar Sections** which are designated with the letters 'A' and 'B' in **C-Type Busbar** (Figure 1 and 2) and **Enhanced Ring Busbar** substations (Figure 3).

	Busbar Section	A **Busbar** consists of one or more **Busbar Sections** which are connected together, e.g. with a **Sectionaliser Bay** or **Sectionaliser Disconnector**. For example a **C-Type Busbar** configuration consists of two **Busbars** (A and B) with one **Busbar Section** (A1 and B1) on each **Busbar**.

	C-Type Busbar	A **C-Type Busbar** configuration (Figure 1 and 2) is the initial phase of an **Enhanced Ring Busbar** configuration which includes:
		• Two **Busbars**, each with one **Busbar Section**.
		• Up to:
		  ○ Four **HV Bays** for a meshed substation, and
		  ○ Six **HV Bays** for a radial substation, and
		• One **Wing Coupler**.
		• Two **Sectionaliser Bays** for GIS substations.

	Circuit Breaker	A mechanical switching device capable of making, carrying, and breaking current under intact and contingency operating conditions.
	Coupler	A **Coupler** is used in a substation (typically double **Busbar** substations) to couple the A and B **Busbars**. A **Coupler** consists of a **Circuit Breaker** and a combination of **Busbar Disconnectors** and **Sectionaliser Disconnectors**. **Couplers** can vary in design and can have varying numbers of **Busbar** and **Sectionaliser Disconnectors**.
	Busbar Disconnector	A switch that connects or disconnects a **HV Bay** to the A and B **Busbars**.
	Enhanced Ring Busbar	A **Busbar** configuration (examples in Figures 3, 4 and 5) that includes: • A double **Busbar** configuration formed as a closed loop with **Sectionaliser Bays** and **Wing Couplers** in series. • A minimum of four (e.g. A1, B1, A2 and B2) **Busbar Sections**. • Two **Wing Couplers**. • A minimum of two **Sectionaliser Bays**. • A maximum of four **HV Bays** per **Busbar Section** for a meshed substation or six **HV Bays** per **Busbar Section** for a radial substation. • An even distribution of circuit and transformer bays per **Busbar Section** where feasible.
	Future HV Bay	An unequipped **Future HV Bay**, i.e. a **Future HV Bay** with no switchgear installed that provides space for a **Future HV Bay**.

	HV Bay	Any bay (e.g. for a transformer, overhead line, underground cable, capacitor bank etc.) that is directly connected to the substation **Busbar.** A **HV Bay** does not include a bay used for equipment that couples **Busbars** or **Busbar Sections** such as **Couplers**, **Wing Couplers** or **Sectionaliser Bays**.
	Largest Credible Generation Infeed	Defined as the single largest generation unit or interconnector connected to Ireland's transmission system as defined in the most recent All-Island Transmission Forecast Statement.
	Meshed Substation	A transmission substation with two or more connections to the transmission system.
	Non-Standard Configuration	The exception to **Standard Configuration** is where the **Non-Standard Configuration** is employed to facilitate the connection and testing of new infrastructure or plant. The **Non-Standard Configuration** shall only be considered for planned or forced outages permissible under the EirGrid Transmission System Security Planning Standards (TSSPS) to permit maintenance, or following a forced outage, of one item of plant and equipment rather than for unusual generator patterns.
	Sectionaliser Bay	Consisting of a **Circuit Breaker** with two **Sectionaliser Disconnectors** connecting two **Busbar Sections** on the same **Busbar** (e.g. connecting A1 to A2).
	Sectionaliser Disconnector	A switch that connects or disconnects two **Busbar Sections**, e.g. A1 and A2**.**
	Radial Substation	A transmission substation with one connection to the transmission system.
	Spare Bay	An equipped **HV Bay**, i.e. a future **HV Bay** with switchgear provided.
	Standard Configuration	The **Standard Configuration** of all 110 kV, 220 kV and 400 kV substations shall permit all **HV Bays** and equipment to be maintained. The **Standard Configuration** shall have **Busbar Sections** connected using either **Sectionaliser Bays** or **Couplers**. **Standard Configurations** shall be the same for all 110 kV, 220 kV and 400 kV substations to reduce the possibility of operator error.

System Generation	Defined as the generation required to balance the **System Load**.
System Load	Defined as Ireland's forecasted transmission system peak load corresponding to the final year as detailed in the most recent All-Island Generation Capacity Statement.
System Transformers	Transformers used to connect transmission voltage levels (e.g. 400/220 kV, 400/110 kV, 220/110 kV or 220/275 kV).
Wing Coupler	Consisting of a **Circuit Breaker** with two **Sectionaliser Disconnectors** connecting two **Busbars Sections** on different **Busbars** (e.g. connecting A1 to B1 in Figures 1, 2 and 3 or A2 to B2 in Figure 3).

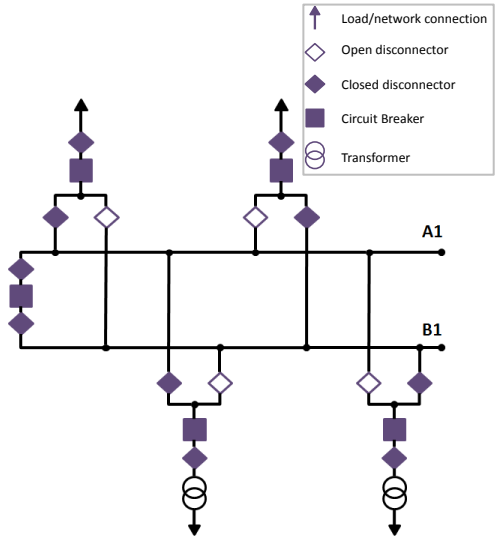

Figure 1: Four Bay C-Type AIS Busbar Configuration

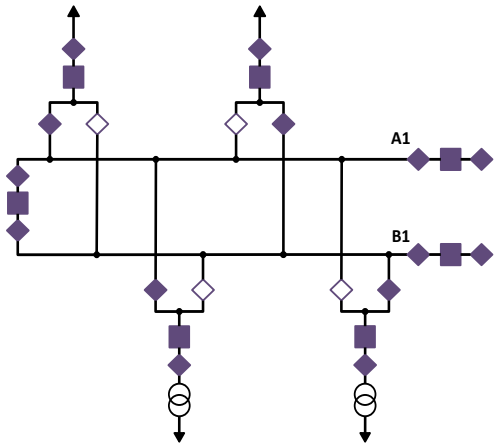

Figure 2: Four Bay C-Type GIS Busbar Configuration

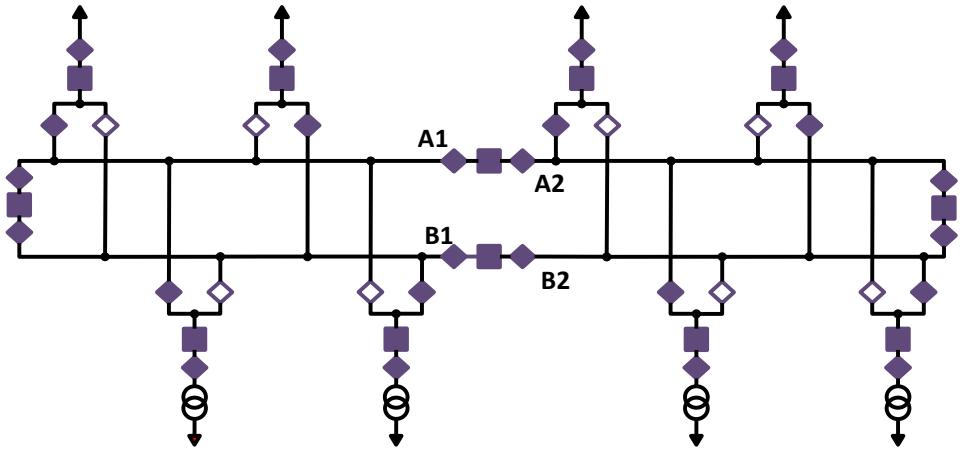

Figure 3: Eight Bay Enhanced Ring Busbar Configuration

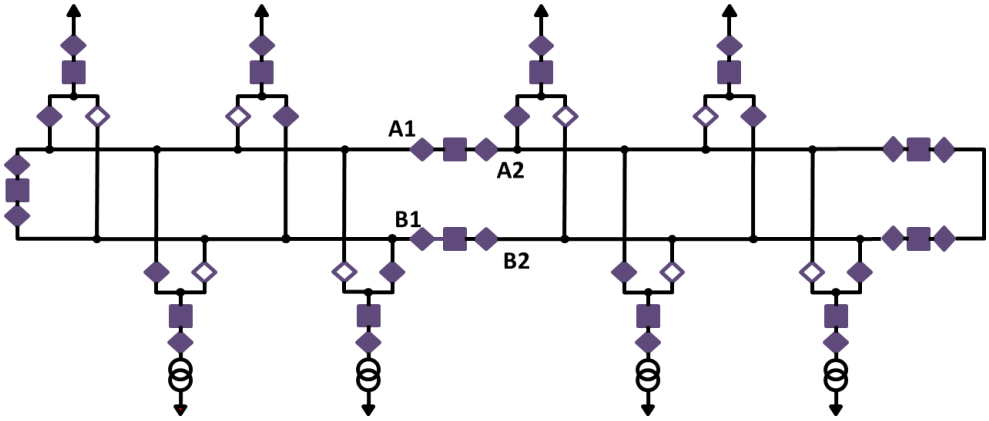

Figure 4: Eight Bay Enhanced Ring Busbar Configuration with Busbar coupling of two sectionaliser bays.

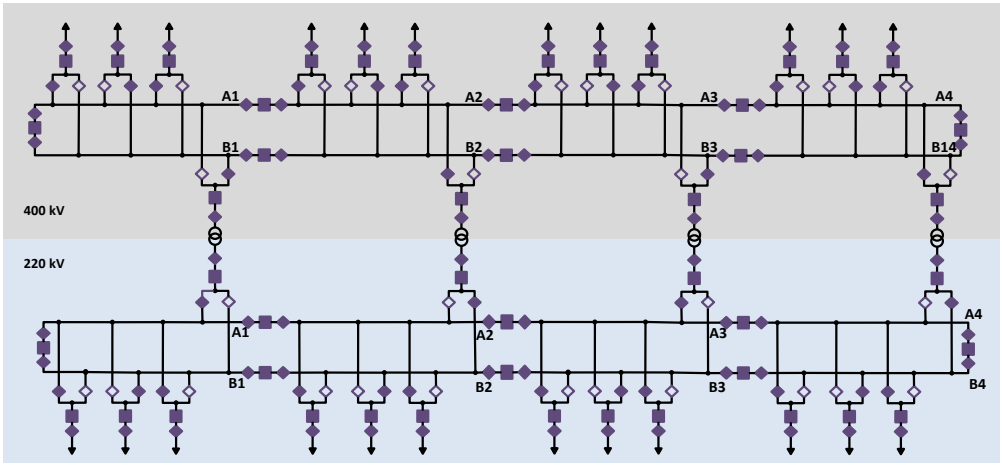

Figure 5: Sixteen Bay Enhanced Ring Busbar Configuration