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: Planning Support & Tariffs	**Category: Substations**
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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 default standard **Busbar** configuration is the **Enhanced Ring Busbar** for new transmission substations and, where feasible, existing and planned 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 and efficient transmission power system, delivered in an economic manner. 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, based on cost, reliability, operational flexibility and maintainability, the **Enhanced Ring Busbar** configuration is a more effective solution than a single **Busbar** configuration. When compared with a double **Busbar** configuration, the **Enhanced Ring Busbar** offers a greater level of reliability and flexibility for a similar cost. Furthermore, the ring topology of the **Enhanced Ring Busbar** offers the advantage of increased asset utilisation, in particular for circuits with high thermal ratings (e.g. HTLS), better substation through-flow capability and hence better overall system reliability.

The **Enhanced Ring Busbar** also supports modular development, as a **C-Type Busbar** can be constructed when four or less **HV Bays** are required. Depending on technology, the **C-Type Busbar** includes two **Sectionaliser Disconnectors** or two **Sectionaliser Bays** to minimise operational disruption and/or construction for expanding to an **Enhanced Ring Busbar** configuration.

Definitions	**Busbar**	Consisting of one or more **Busbar Sections** which are designated 'A' in single **Busbar** substations (Figure 1) and 'A' and 'B' in double **Busbar** substations (Figure 2).
	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 (Figures 3a and 3b) 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**.
		• One **Sectionaliser Bay** consisting of:
		  ○ Two **Sectionaliser Disconnectors** for AIS.
		  ○ Four **Sectionaliser Disconnectors** and two **Circuit Breakers** for GIS.
		• Provision that the technology used can be expanded to an **Enhanced Ring Busbar**.

	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 2 and 3) 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, e.g. a maximum of four **HV Bays** connected

		to the both A1 and B1 **Busbar Sections**. o Six **HV Bays** per **Busbar Section** for a radial substation. • An even distribution of circuit and transformer bays per **Busbar Section** where feasible.
	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 single bay substation may have a **HV Bay** but not a **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.
	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 Planning Criteria (TPC) 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**.**
	Skeleton Bay	An unequipped future bay i.e. space for a future bay with no 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 Bay** or couplers. **Standard Configurations** (currently single **Busbar**, double **Busbar**, **C-Type Busbar**, **Enhanced Ring Busbar** or breaker and a half substations) 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 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 3a, 3b, 4 and 5 or A2 to B2 in Figure 4).

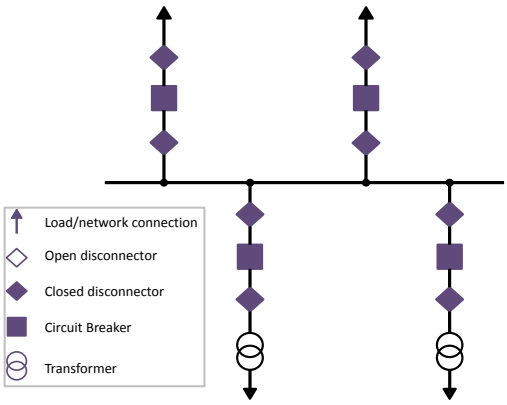

Figure 1: Single Busbar Configuration

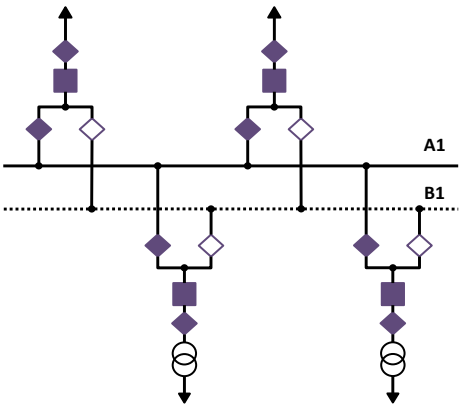

Figure 2: Double Busbar Configuration

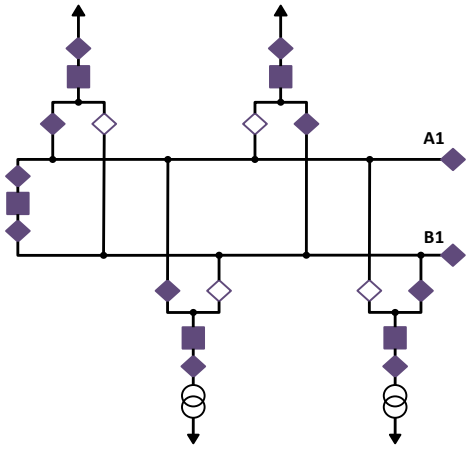

Figure 3a: Four Bay C-Type AIS Busbar Configuration

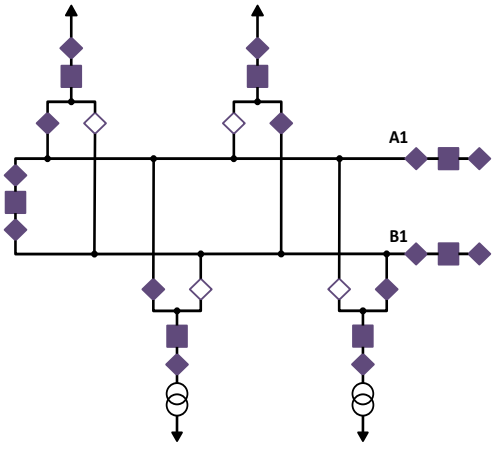

Figure 3b: Four Bay C-Type GIS Busbar Configuration

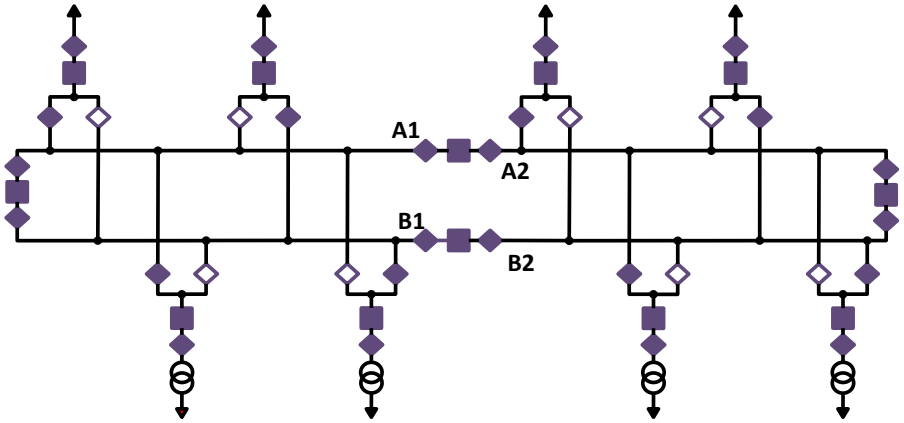

Figure 4: Eight Bay Enhanced Ring Busbar Configuration

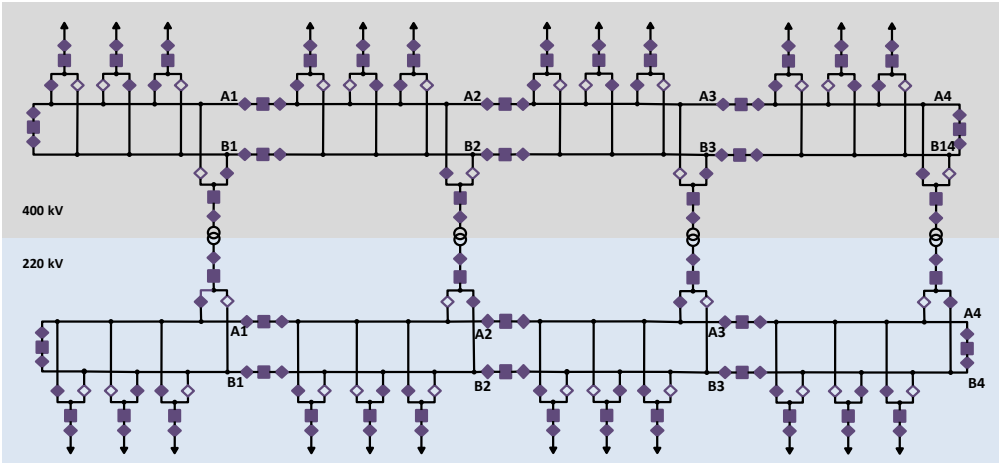

Figure 5: Sixteen Bay Enhanced Ring Busbar Configuration

Policy & Principles

There are two main categories of transmission substations defined in this policy:

1. New transmission substations, and
2. Existing and planned transmission substations.

Section 1 shall be considered for new transmission substation works and Section 2 shall be considered for existing and planned transmission substation works.

A substation can be defined as either existing or planned by meeting one or more of the following criteria:

i. A radial or meshed 110 kV, 220 kV or 400 kV substation that is already constructed and/or connected to the transmission system.
ii. Has a detailed **Busbar** configuration specified in a connection offer executed by both EirGrid and the customer
iii. Has a modification request to a connection offer (or a change to a related project) that does not result in a change to the **Busbar** configuration.

iv. Has a planning application submitted and currently being assessed by a planning authority which was reviewed and formally agreed to by EirGrid prior to submission.

v. Has planning permission/approval granted by a planning authority, the plans for which were reviewed and agreed to by EirGrid prior to submission.

The policy considers new, existing and planned **Busbar** configuration types to be typically single **Busbar**, double **Busbar**, **C-Type Busbar** or **Enhanced Ring Busbar**[1].

Substation connectivity to the transmission system is defined as being either radial (a single or tail connection) or meshed (at least two connections). A meshed substation has the same connectivity to the transmission system as a looped substation.

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 radial transmission substation which requires:

1.1.1. A single **HV Bay** may be designed without a **Busbar**.[2]

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 meshed transmission substation 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[3] 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

[1] There are other busbar configurations on the system such as the reduced ring **Busbar** in the Galway 110 kV substation and the breaker-and-a-half **Busbar** in the Shellybanks 220 kV substation. This policy considers the Galway **Busbar** to be a single **Busbar** and the Shellybanks **Busbar** to be a double **Busbar**.

[2] This may be impractical and not possible for GIS substations.

[3] E.g. 400/220 kV, 400/110 kV, 220/110 kV or 400/220/110 kV

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.

1.5. For a **C-Type Busbar** configuration, the technology used shall facilitate the safe expansion, with minimal operational disruption, to an **Enhanced Ring Busbar** configuration:

1.5.1. An AIS transmission substation shall be laid out in a manner which includes two **Sectionaliser Disconnectors** (Figure 3a) on each **Busbar**.

1.5.2. A GIS transmission substation shall be laid out in a manner which includes a full **Sectionaliser Bay** (Figure 3b) on each **Busbar**.

2. Existing and Planned Transmission Substations

This section of the policy outlines the rules for the busbar configuration at existing and planned transmission substations. Where stated, the *Busbar Configuration Guide*[4] may be used as a case-by-case busbar configuration assessment methodology.

2.1. The replacement or refurbishment of a transformer (or associated transformer bay equipment) at an existing or planned transmission substation, with an equal or higher MVA rating and does not drive the need to uprate the **Busbar**, may not drive a change from the **Busbar** configuration at the substation.

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

2.3. A 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.

2.4. If technically viable[5], a transmission substation with a **C-Type Busbar**

[4] http://gridshare/sites/FG/A_P/Policies/TI%20Policies/Substations/Busbar%20Configuration/Pol_St_3_Busbar_Configuration/Issue%203%20-%202015_v3.0/Busbar_Configuration_Policy_Guide_v1.docx

[5] This refers specifically to GIS technology which, due to the age of the equipment, may not be expandable.

configuration and four **HV Bays,** which requires an additional **HV Bay**, shall be expanded and designed as an **Enhanced Ring Busbar** configuration. Otherwise the *Busbar Configuration Guide* shall be used to determine the **Busbar** configuration.

2.5. 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 requirement for migration to a **C-Type Busbar** or **Enhanced Ring Busbar** configuration at a transmission substation with four or more **HV Bays**.

2.6. For a transmission substation with a single **Busbar** configuration, a new **HV Bay** may connect temporarily to the existing **Busbar** in advance of the associated **C-Type Busbar** or **Enhanced Ring Busbar** being constructed.

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. A **Busbar Section** shall have no more than:

3.1.1. Four **HV Bays** for a meshed substation, and

3.1.2. Six **HV Bays** for a radial substation.

3.2. Sections 4.1 and 4.2 of the Transmission Planning Criteria[6] shall be complied with when considering substation **Busbar** configuration works.

3.3. New GIS **meshed** transmission substations shall not be designed as single **Busbar** configurations.

3.4. GIS technology, by its nature, does not lend itself to **Skeleton Bays**. However GIS substations can be extended, e.g. a **C-Type Busbar** substation can be converted into an **Enhanced Ring Busbar** configuration, even by a different switchgear manufacturer.

3.5. Future GIS bays can be added via **Busbar** extension and not via provision of skeleton bays. **Wing Couplers** shall be relocated where required. 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.

3.6. GIS spare bays should only be fully equipped where it is envisioned that they will be required based on plans outlined in the latest national Transmission

[6] http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf

	Development Plan or European Ten Year Network Development Plan. 3.7. 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. 3.8. 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**. 3.9. 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**. 3.10. The loss of any 220 kV or 400 kV **Busbar Section** operated in **Standard Configuration** shall not directly or indirectly result in the loss of 250 MW of **System Load** or **System Generation** exceeding the rating of the single **Largest Credible Generation Infeed** permissible on the system. 3.11. 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. 3.12. 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 500 MW of **System Load** or **System Generation** exceeding twice the rating of the single **Largest Credible Generation Infeed** permissible on the system. 3.13. With the exception of Section 3.11, 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 new, existing and planned 110 kV, 220 kV and 400 kV transmission substations in Ireland. With regards to existing transmission substations, this policy acknowledges the historical development of each substation and the present **Busbar** configurations are therefore deemed to satisfy performance requirements to date. Should the needs of an existing substation change or the substation be redeveloped (including

	expansion and the replacement of equipment) this policy shall therefore apply.
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 [1]	Mario Duarte Jeff Kelliher	Andrew Cooke John Fitzgerald
V3.0	2015	Udpated to address high number of derogations for existing substations	Yvonne Coughlan Jeff Kelliher John Leahy	Transmission Investment Committee (TIC)

References	[1] Position Paper – Proposed Move from Existing Double Busbar Station Philosophy to a New Enhanced Ring Station Philosophy [2010] [2] Substation Reliability Analysis for Transmission Substations in Ireland [2015]