Western Power
Asset Management System

Guideline for Transmission Connections to Western Power Grid

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Contact Western Power
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1. Introduction

This Guideline is intended to assist the customers in understanding the requirements for connecting a generator or load at transmission voltages to the Western Power Network.

This document is providing a simplified overview of the supported standard connection arrangements. There will be additional requirements that will be discussed with the customer over the specifics of their connection, once the Preliminary Assessment is completed. A Preliminary Assessment considers potential options for connection of the proposed load or generator to the Western Power Network and informs the decision to choose the preferred option which will be progressed through the connection process.

The Application and Queuing Policy (AQP[1]) sets out certain processes for customers that wish to:

(a) establish a new connection between their facility and Western Power Network; or

(b) materially modify facilities and equipment connected at an existing connection point.

For further information on the connection process please refer to Western Power's website or contact Western Power at network.access@westernpower.com.au.

1.1 Purpose and Scope

This guideline sets out the transmission connection to Western Power's network as below:

Document Section	Content
Part A	Provides a brief introduction and principles for augmenting the network
Part B	Provides various options for different segments of major customer connection works.

1.2 Definitions

Terms and definitions used in this document

Term	Definition
AIS	Air insulated switchgear – generally associated with outdoor busbars and circuits.
Augmentation	augmentation, in relation to a covered network, means an increase in the capability of the covered network to provide covered services.
Brownfield Substation	An existing substation
CBD Substation	A zone substation within a Central Business District
CMS	Customer Main Switch - The circuit breaker owned and operated by the customer
DC Component	The mean value of the top and bottom of the envelope of a short circuit current. This value decays from an initial value to zero in a very short period of time.
Distribution System	Any apparatus, *equipment*, plant or buildings used, or to be used, for, or in connection with, the transportation of electricity at nominal voltages of less than 66 kV
EHV	Extra high voltage is nominal voltages > 230 kV
Element	A single identifiable major component of a *transmission* system

[1] https://westernpower.com.au/media/1428/application-queuing-policy.pdf

Term	Definition
FOR	Forced Outage Rate
GIS	Metal enclosed gas insulated switchgear
Good Electricity Industry practice (Access code definition)	good electricity industry practice means the exercise of that degree of skill, diligence, prudence and foresight that a skilled and experienced person would reasonably and ordinarily exercise under comparable conditions and circumstances consistent with applicable written laws and statutory instruments and applicable recognised codes, standards and guidelines.
Greenfield Substation	A new substation on a previously unused site
HV	High voltage is nominal voltages > 35 kV and nominal voltages < 230 kV
Interleaving	Diversifying circuit locations on a busbar to ensure more than one similar circuit is not lost under fault or maintenance conditions. It is particularly relevant to mesh and ring busbar configurations.
MV	Medium Voltage
LV	Low voltage is nominal voltages < 1 kV
Major Primary *Equipment* items	Comprise a Transformer, *Transmission* Line or Busbar section
Mesh	A substation that has the same number of circuit breakers as the number of circuits, i.e. Ring Bus
Metropolitan Area	Refer to *Metropolitan Region Town Planning Scheme Act 1959* – Third Schedule
Perth CBD	(Network Quality and Reliability of Supply) Code 2005 – Part 1, clause 3
Planning Criteria	The criteria to which the *transmission* system must perform under a combination of operational and contingency events – defined by the Technical Rules. In general these criteria nominate how many *transmission* elements can be out of service without affecting the nominated performance of the associated part of the network.
PoC	Point of connection, also referred to as the "Connection Point". The point where Western Power asset connects onto the customers' network / assets
Primary Voltage	The high voltage side of a transformer and substation
Rated Normal Current	The R.M.S value of the current which the *equipment* shall be able to carry continuously under defined conditions. The values of rated normal current are selected from the R10 series of preferred numbers described later in the document.
Rated Short Circuit Duration	The intervals of time for which an item of *equipment* can carry a current equal to its rated short time withstand current.
Secondary Voltage	The low voltage side of a transformer and substation
Terminal Station	A substation that transforms electricity between two transmission system voltages and which supplies electricity to zone substations but which does not supply electricity to the distribution system.
***Transmission* Line**	A power line that is part of a *transmission* network
***Transmission* Network**	Any apparatus, equipment, plant or buildings used, or to be used, for, or in connection with, the transportation of electricity at nominal voltages of 66 kV or higher, and which forms part of the South West Interconnected Network. For the avoidance of doubt the transmission system includes equipment such as static reactive power compensators, which is operated at voltages below 66 kV, provided that the primary purpose of this equipment is to support the transportation of electricity at voltages of 66 kV or higher.
TX	Transformer

Zone Substation	A substation that transforms electricity from the specified Network Service Provider's *transmission* system voltages to the specified Network Service Provider's distribution system voltages.

2. Part A

2.1 Overview

This Guideline is designed for specific use by transmission connected customers.

The main purpose of this document is to:

- Simplify the customer connection arrangements, which will assist in –
  - minimising the time to achieve a connection
  - achieving a cost-effective connection;
- Reduce duplication of assets, both to the Customer and Western Power;
- Ensure Western Power sites are not sterilized by Customer assets; and
- Ensure the safety and integrity of Western Power assets and/or other Customers assets by minimising the need for customers to access Western Power sites.

2.2 Network Augmentation Principles

The acceptability of a network augmentation (for example, a new connection or the expansion of an existing connection to the South West Interconnected System (SWIS) shall be assessed against the requirements provided in sub-sections below. Detailed criteria are provided in Appendix A: General Connection Criteria.

2.2.1 Safety and Maintainability

1. The *augmentation* must be consistent with the safe and reliable operation of the *power system* and *good electricity industry practice*. This means the connection:
   a) Shall not adversely affect *power system* security or reliability; and
   b) Shall not adversely affect the quality or security of network services to other network *Users/Customers.*
2. All *augmentation*s shall be such that they are within the switching and isolation requirements of the network and do not have a materially negative impact on the time required to isolate, earth and maintain the network under planned or unplanned activities.

The intent of these requirements is to limit the potential for human error resulting from complex circuit arrangements.

2.2.2 Development at Point of Augmentation

1. Any augmentation must be consistent and compatible with the current network topology and future development of the network in accordance with good electricity industry practice.
2. Augmentation at existing stations is preferred wherever suitable, as it reduces network complexity by minimising plant and systems, thereby minimising the probability of failure of the system and the costs of operating and maintaining the system.
3. All augmentation not made at existing stations shall preferably be via one of the network configurations as described in Appendix B and will require suitable land to accommodate the ultimate station configuration as identified by the Western Power long term network development plan for the specific area.

4. The arrangement of *equipment* on the site must therefore allow for the ultimate station configuration to be built, if needed, without interruption or impact to the existing supplies in future and that the reliability of the connections to the site is not reduced.
5. The configuration of primary plant will not be the same for all *augmentations*, however, by applying good industry and standard practices, most *augmentations* will fit into one of several standard configurations, as given in Appendix B which collectively address most *augmentation* scenarios within the SWIS.

3. Part B

3.1 Configuration and Layout

Western Power has standard designs, plant and systems that are applied to maintain and improve *power system security*, network *reliability*, reduce long term costs and support *good electricity industry practice*. The merits in developing a network of substations which are as standardised as possible, include:

a) Efficient and repeatable estimating of costs;

b) Use of repeatable packages that enhance efficiencies in the design process;

c) Designs whose impact on the community and environment can be readily assessed and assist in streamlining the approvals process;

d) Standardised operations and maintenance methods, procedures, training and equipment that minimises whole-of-life cost, risk and optimises substation availability; and

e) Built-in flexibility to react confidently to faults in that common spares are more readily available, replacement methodologies are well recognised, all of which contribute to minimising downtime and safety risks.

Western Power has standardised substation configurations on three major types of high voltage- HV (35 kV or above) in its network to ensure it can meet the reliability and service requirements stipulated in the Technical Rules. These three types are defined based on their application in SWIN and the advantages and benefits each provide to support Western Power's strategic objectives (Safe, Reliable, Efficient and to support Growth, which includes the connection of customers).

These three standardised substation configurations are:

1. Single Busbar (with double busbar option on MV(<35 KV));
2. Double busbar
3. Breaker-and-a-Half; and
4. Ring Bus / Mesh[2].

These options were selected as they provide the best availability, reliability and lowest comparative cost.

Feeder circuits are considered equivalent to the distribution system (33 kV or below) from a performance point of view and as such do not need to exceed the HV distribution planning criteria, which is N-0. The substation layout is primarily dictated by the location of the busbar and circuits, which is typically governed by the approach direction of the *transmission* lines and exit requirements for distribution feeders.

Appendix B: Typical Arrangements provides diagrams to illustrate the various arrangements that are available and are not intended to define complete substation layouts[3]. Arrangements may differ because of a range of factors including topography, generation and load centres and the configuration of established surrounding network.

[2] Note that this is not common and only applies to 132kV GIS or partially developed breaker-and-a-half stations.

[3] Ring bus/Mesh arrangement not shown

3.1.1 Brownfield applications

There are existing substations with busbar configurations that are not included in this document. These Brownfield configurations are not supported options for future Greenfield substations.

In general, minor extensions to these substations will be based on their existing configurations without negatively impacting existing and future supplies. However, consideration of the long-term prospects of each site may dictate the need for a strategy other than just extending the existing arrangement. Augmentation should then be done in accordance with section 2.2.

Retention of existing busbar configurations will depend on space, cost, operational flexibility and reliability.

3.1.2 Tee Connections

Based on past experiences, Tee connections are generally <u>not</u> a preferred means of *augmentation*, especially due to the following reasons:

1. Negatively impacts system reliability, operability and increases operational complexity;
2. Creates additional complexities regarding protection schemes; and
3. Increases outage durations, which may result in adverse impacts to existing customers.

Tee connections are not preferred on non-radial N-0 and radial lines, as this arrangement leads to unnecessary interruptions to other parts of the network when work has to be done on the tee section.

Tee connections will only be considered in the option analysis, if the arrangement meets the detailed criteria in Appendix A 'General Connection Criteria'.

3.2 Line Ownership

The transmission line connecting the facility to the substation may be built, owned and operated by the customer or they may request WP to build, own and operate. (For clarity customer build and transfer (gifting) to Western Power is not a supported option). Western Power owned Zone / Terminal substation assets will be designed and constructed by Western Power in all cases.

3.2.1 Customer Owned

Where the transmission line between the customer's facility and the Western Power Network is Customer owned as shown in Figure 1, the preferred arrangement is for Western Power to own both the line circuit breaker (CB) and disconnector (DIS) at Western Power end. The Customer may use the Western Power CB instead of the CMS specified in TR clause 3.2.2, specifically for zone substations.

The definitions and interpretation of the TR stipulate to have duplicated plant, or a Customer owned DIS and CB will be required at the Western Power substation to allow for the de-*energisation* of *equipment* for both the Customer and Western Power (de-*energisation* of *transmission* lines). This configuration is onerous and at times not feasible due to:

- Sterilisation of Western Power sites:
- The additional cost incurred by the Customer, due to duplication of assets
- Impact to other Customer(s):

The Customer will make their own provision for protection and auxiliary *equipment* at the Point of Connection (PoC). All primary plant will be owned by the Customer at the Customer's substation. The protection and auxiliary *equipment* is to be located in a separate building/room that gives unobstructed 24/7 access to the Western Power. However, this will require amendment in the Technical Rules and temporary derogation/exemption until then. Metering primary plant will be owned by Western Power.

The obligation for the Customer to maintain/repair/replace equipment as required to meet Western Powers obligations and illustration of ownership boundaries will be captured in the Access Contract.

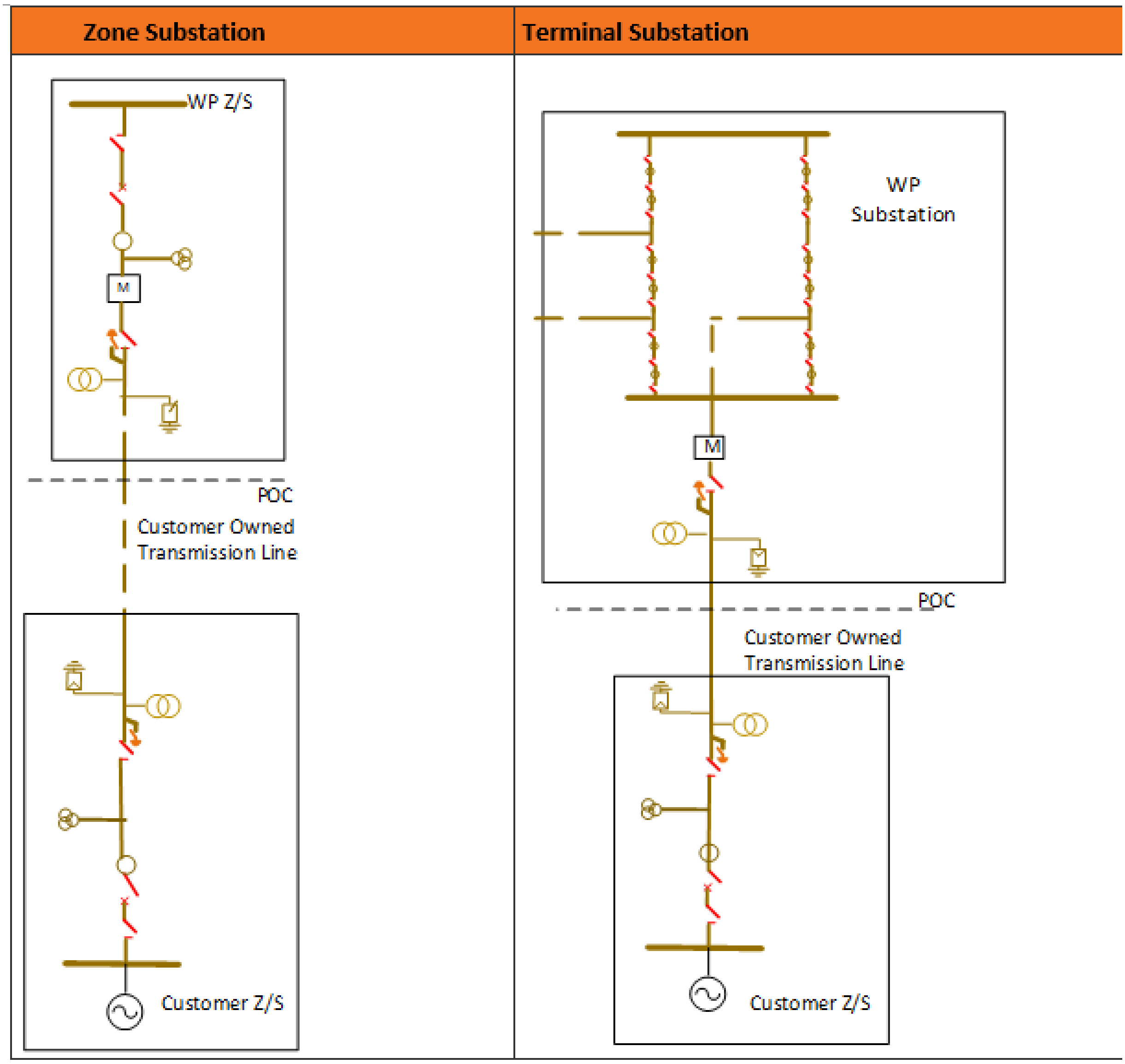


Figure 1: Ownership of equipment for Customer owned line to a customer substation.

3.2.2 Western Power Owned

As shown in Figure 2, the preferred arrangement when Western Power owns the line, is for the Customer to own both the breaker and disconnector at the Customer's substation and for Western Power to own the Breaker and disconnector at the Western Power end of the line.

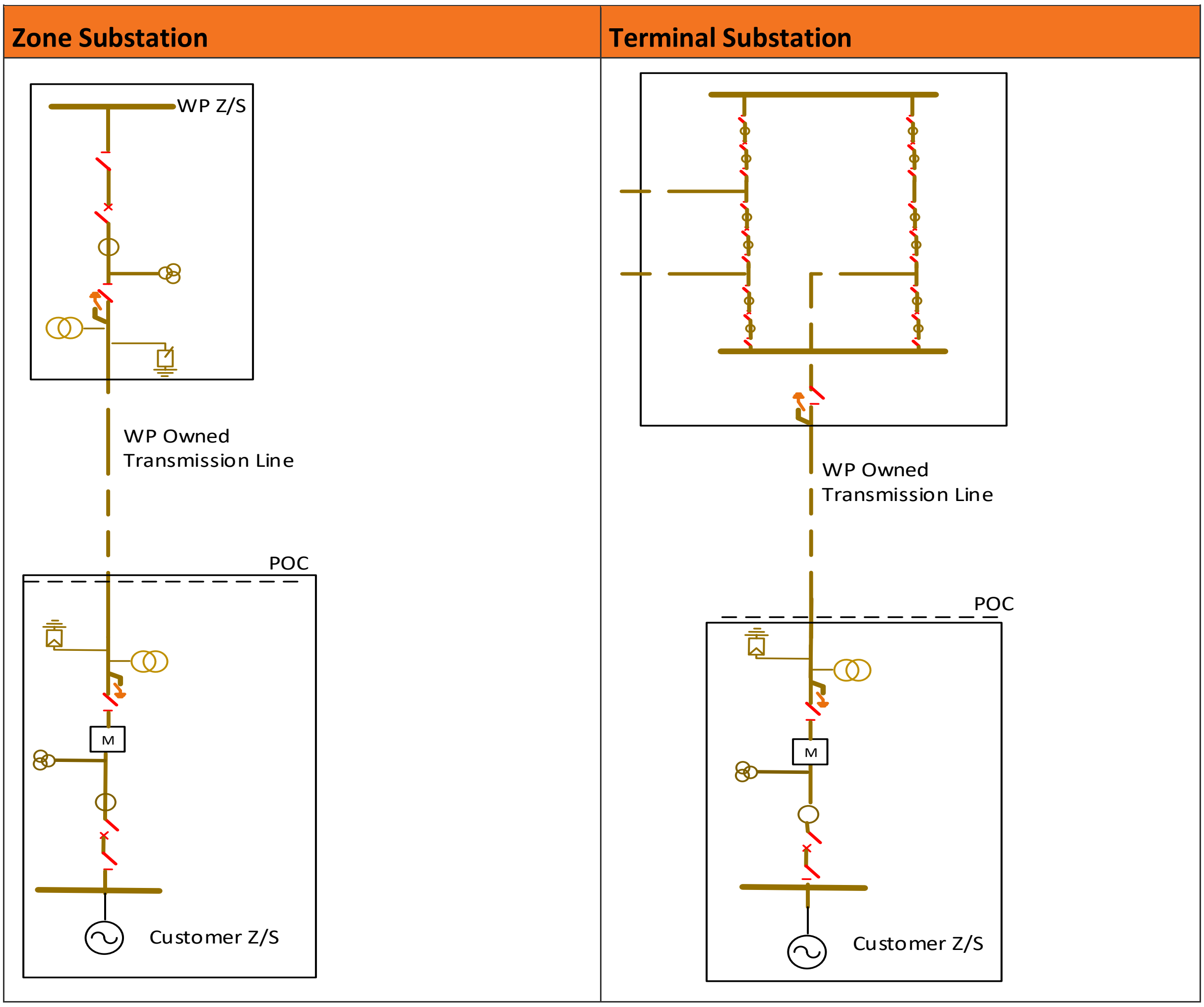


Figure 2: Ownership of equipment for Western Power owned line to a customer substation.

The definitions and interpretation of the TR stipulate to have duplicated plant or customer owned disconnector and circuit breaker will be required at the Customer substation to allow for the de-energisation of equipment for both the Customer and Western Power (de *energisation* of *transmission* lines). This configuration is onerous and at times not feasible due to

- Duplication of assets (which results in an increased time frame for project delivery)
- Increased Cost for Customer
- Space constraints at the customer site and / or limiting future expansion
- The site is a single customer substation without foreseeable extension or other customer requirements.
- Design complexity – Site space can be a premium which increases design complexities to ensure safe clearances with existing assets. Due to multiple variations of standard connection arrangements, this further increases costs and delays to project.

Customer to provide a room for metering panels, protection, SCADA and COMMS at the customer substation. Customer can own the metering equipment (CT/VTs). Western Power will own the communication equipment. The Western Power protection and auxiliary *equipment* shall be located in a separate building / room that gives unobstructed 24/7 access to Western Power personnel. No shared access to the building is allowed.

The obligation for the Customer to maintain/repair/replace equipment as required to meet NSP obligations and to illustrate ownership boundaries will be captured in the connection agreement. In this Connection Agreement, Western Power will require the Customer to indemnify the Western Power from and any and all liability for any direct or indirect damage caused to the Customer as a result of the Customer electing to use and Western Power circuit breaker to clear a fault.

4. Tariff/Revenue Metering

4.1 Location

Metering *equipment* must be located as close as practicable to the connection point and should be located on the Customer side of the PoC if Western Power is owning the line.

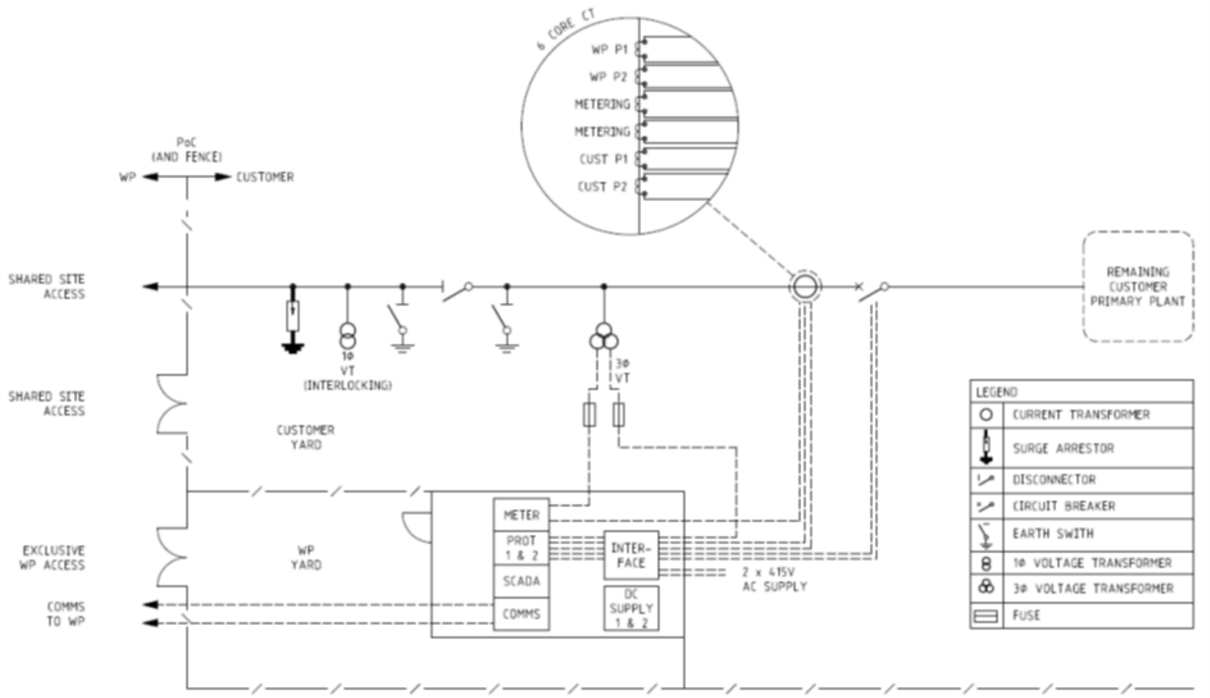


Figure 3: Protection & metering instrument transformers for Customer owned primary plant

4.2 Ownership

Ownership of the metering *instrument transformers* will be defined depending on the location of the *equipment*. Should the metering *equipment* be located on the Customer side of the point of connection, this will be owned and maintained by the Customer to Western Power's specification and satisfaction. Metering Code requires Western Power to own the meter itself and the associated telecommunications systems. Where Western Power owns the instrument transformer, Western Power will maintain it.

This obligation on the Customer to maintain/repair/replace equipment as required to meet Western Power's Specification and satisfaction. Any change of ownership should ensure continued obligations on the Customer.

5. AC/DC Supply:

5.1 AC Supply

This refers to the 415 V station / AC auxiliary supply only. When Western Power deems that it is not possible to provide a 415 V AC auxiliary supply from the existing substation, i.e. Aux supply is underrated, the required supply is too big, cables are too long, inadequate earthing, etc. then customer need to provide the supply.

The AC auxiliary supply system shall provide adequate reliability and redundancy, e.g. no loss of AC supply in the event of a single component failure, in the power or auxiliary supply systems

a) Each AC supply shall be supplied by a separate source, preferably installed within the station, to reduce common mode failure.

Where it is not possible to have adequate supply and / or redundancy from within the station, e.g. staged design; single Zone or Terminal station transformer or Power VT, Customer site with Western Power relay room etc., the following option could be pursued for station supply:

- A standby generator (diesel / PV with Battery Storage) which will start automatically when the main AC supply fails. Supply from / to a customer site.

5.2 DC Supply

No DC supply will be shared between Western Power and any customer due to:

1. Criticality of DC supply to system integrity and restoration.

2. Additional standing load requirements on DC system.

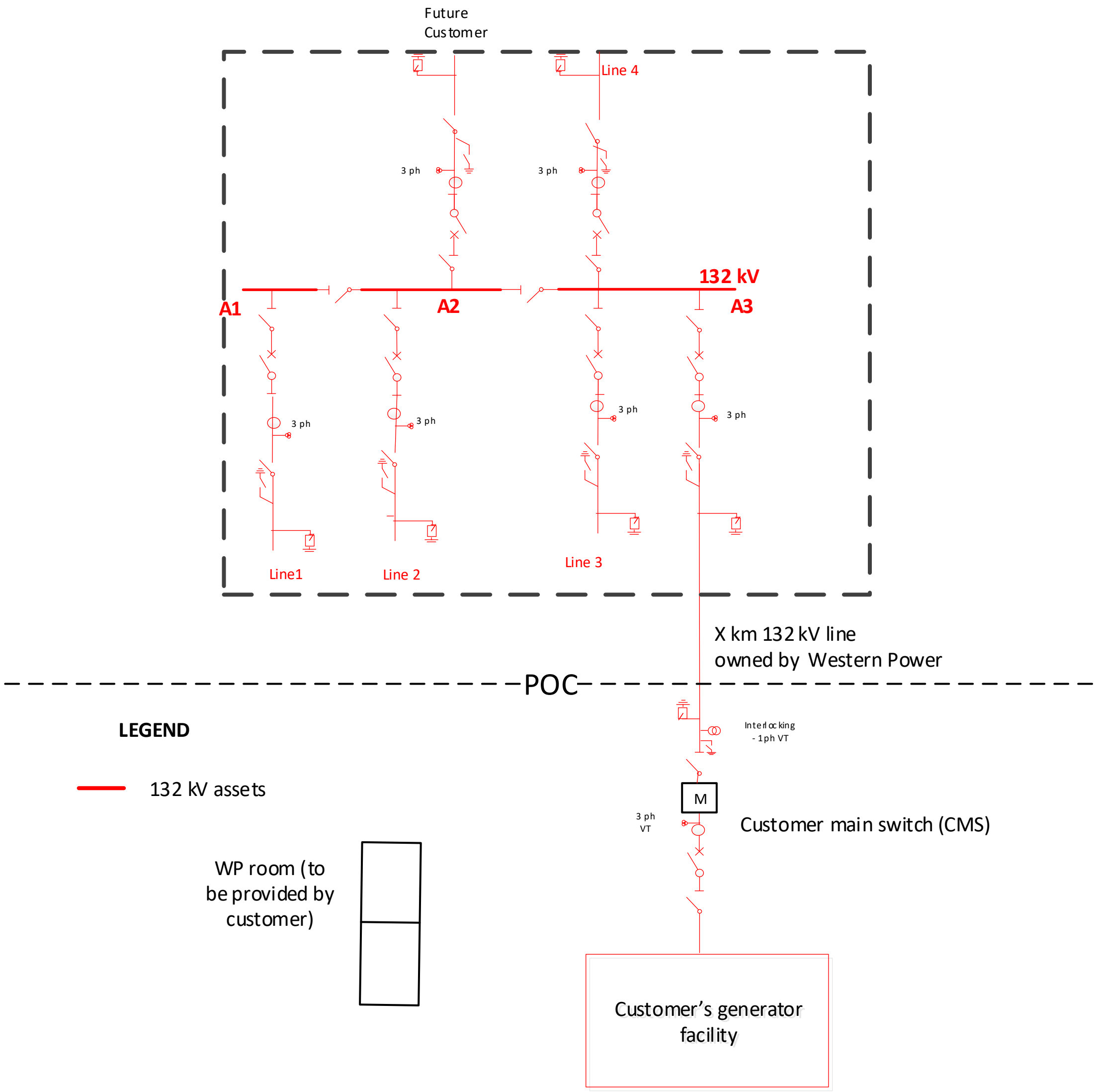
Appendix A: General Connection Criteria

Criteria	Consideration	Threshold
1	Impact on reliability	The connection should not have a materially adverse impact on the reliability of supply to other Customers/*Users* compared to a standard connection. Assessment of the impact on reliability must consider: a) The connection configuration. b) The *equipment* connected (e.g. load, generator, shunt device, etc.). c) If applicable, the percentage of time that device is connected (e.g. for shunt devices). d) The line length and line route (parallel or perpendicular to existing assets). e) The specification of *equipment* connected (see also item 3). f) The reliability of the existing assets and expected impact of planned and unplanned outages (FOR). g) Consequence of the outage. In assessing item f), impact of lightning, bushfires, fauna, etc. should be considered
2	Switching and protection complexity	The connection should not: a) adversely impact complexity, resulting in a material increase in risk of mal-operation, and b) should not cause the required number of switching operations to isolate the line to: • exceed 5 or • number of switching locations exceed 3 • the switching time should not be disproportionate to typical planned outage duration for the line if it did not include the new connection in the proposed arrangement.
3	Construction and maintenance	To mitigate adverse impact to forced outage rate (**FOR**), the assets connected must be designed to at least the same standard, reliability and maintenance requirements as the assets to which it connects).
4	Compliance with planning criteria	The connection should not result in new non-compliances to the system (where an exemption wouldn't otherwise be approved). (Note this includes power quality assessment e.g. voltage step change) The connection should not materially impact (increase risk associated with) existing non-compliances. In particular should not result in non-compliance with network security standards.
5	Least cost technically feasibility	The connection arrangement should be feasible and least overall lifecycle cost. This includes the cost associated with reliability impacts (which may include additional costs for running generation out of merit during planned and unplanned outages), additional protection costs, etc.
6	Interrupted load & generation	The sum of the load (or generation) interrupted by a single credible or non-credible contingency, as a result of connection in the proposed configuration, should not have a materially adverse impact on ancillary service requirements.
7	Impact on power transfer, system stability	The connection arrangement should not have a material adverse impact on power transfer limits or system stability.

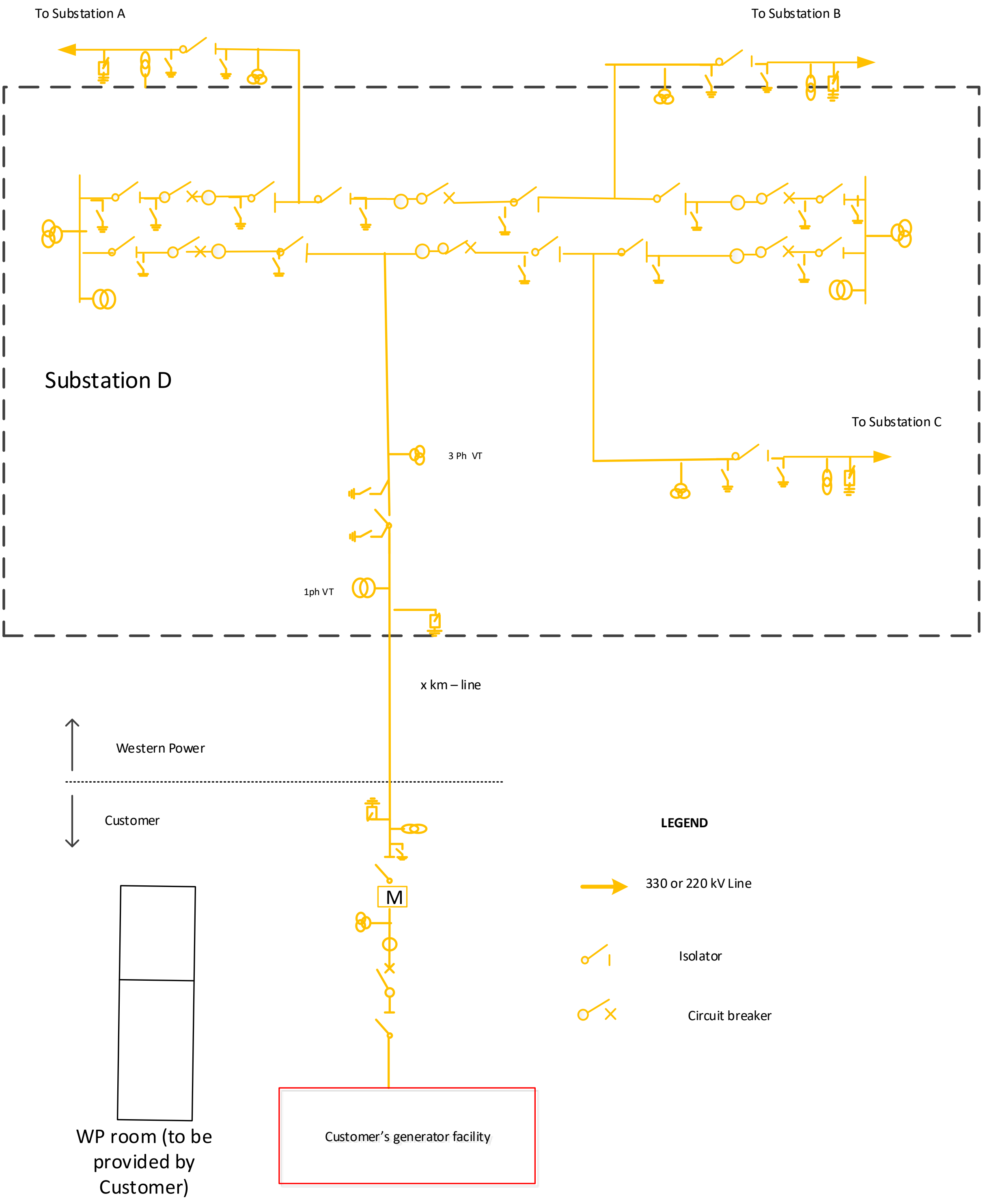
		Assessment must include the impact of any changes to protection clearing times which impact system stability and power transfer limits. For generator, shouldn't reduce maximum supportable demand (**MSD**) by any more than its output.
8	Proponent reliability	The configuration should meet the reliability requirements of the connecting plant / customer.
9	Consistency, expandability & alignment with long term development plans	The connection configuration should be compatible with network development plans. There must be sufficient connection *equipment* at initial stage to allow future expansion with minimal interruption to other *Users/Customers*.

Appendix B: Typical Arrangements

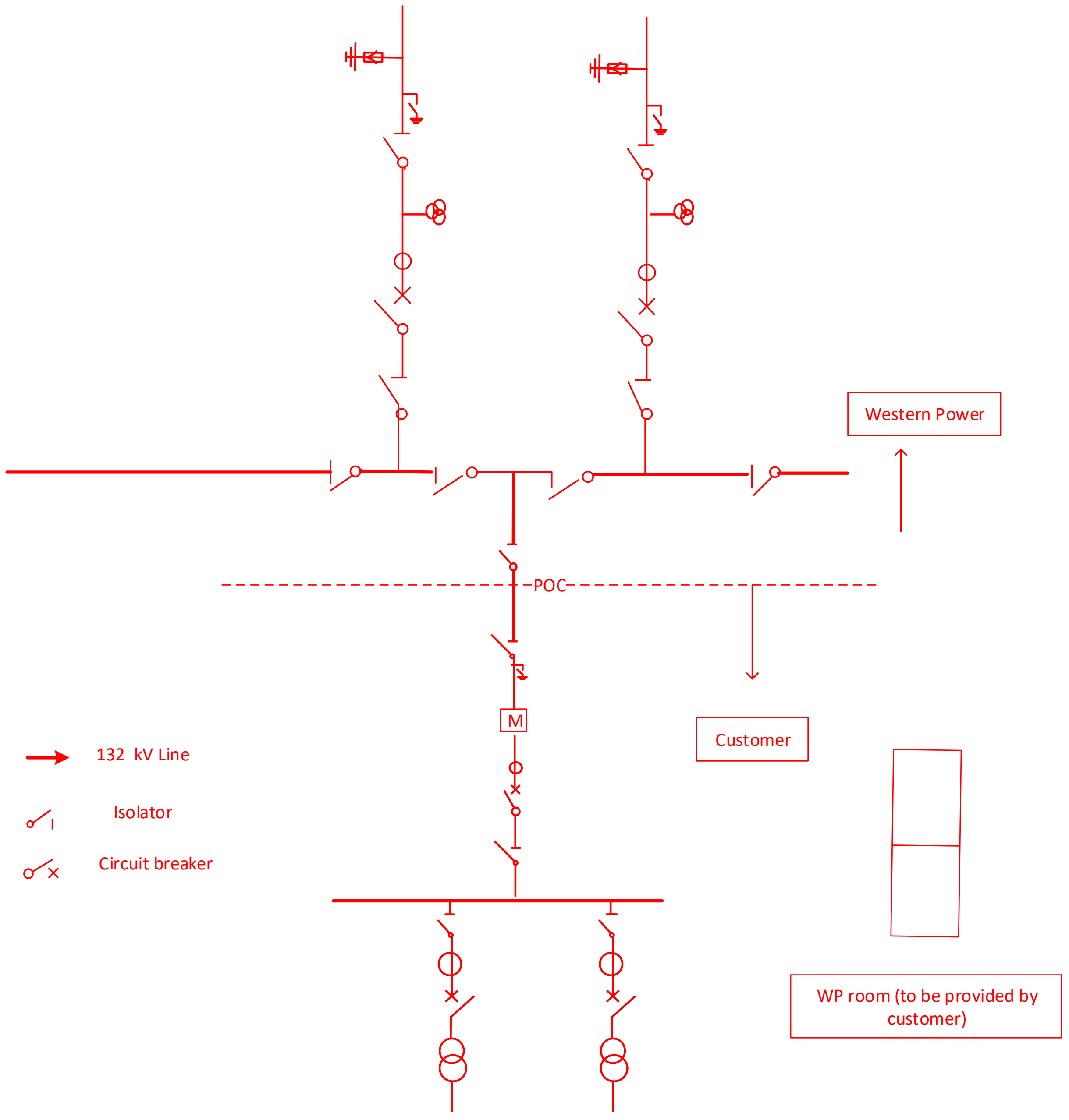
Arrangement 1: Radial connection:



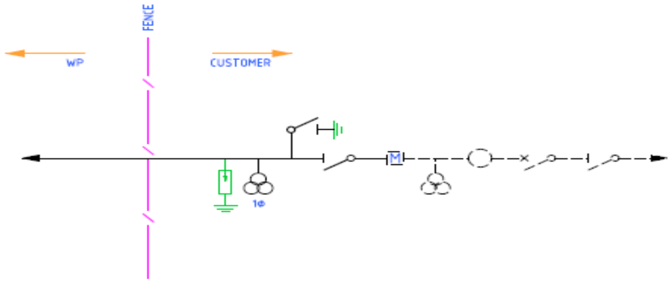
Arrangement 2: Breaker and half Configuration:



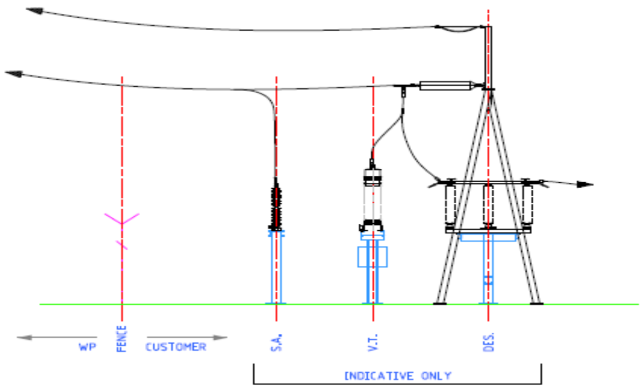
Arrangement 3: WESTERN POWER Cut in Cut out switchyard with adjoining Customer substation



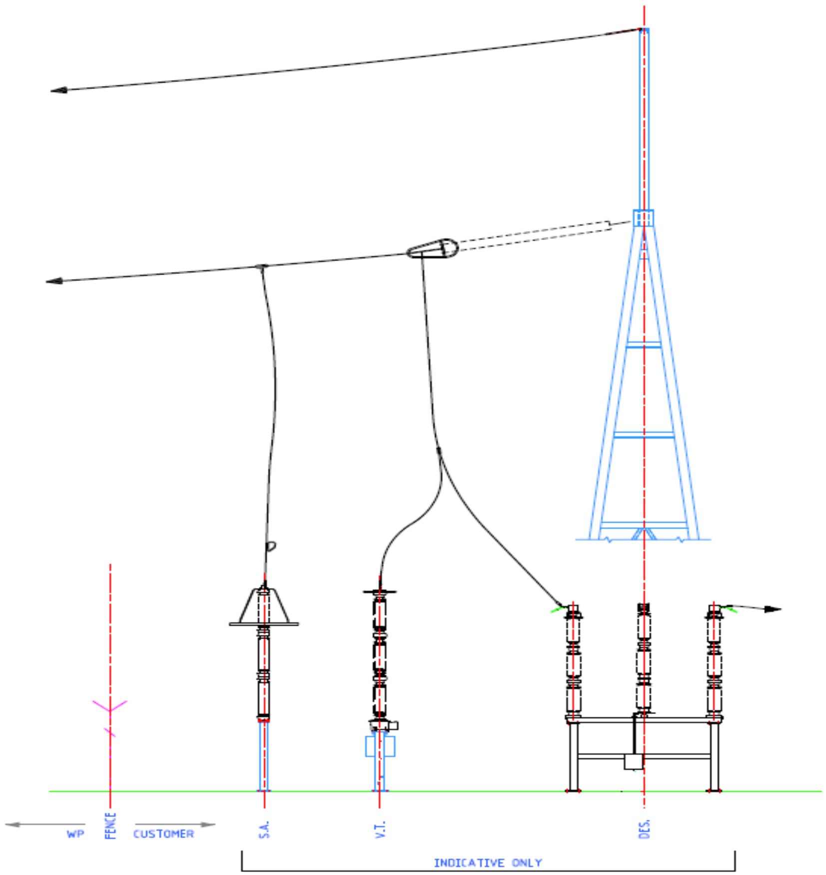
Line circuit Connection for Arrangement 1 and 2



SINGLE LINE DIAGRAM

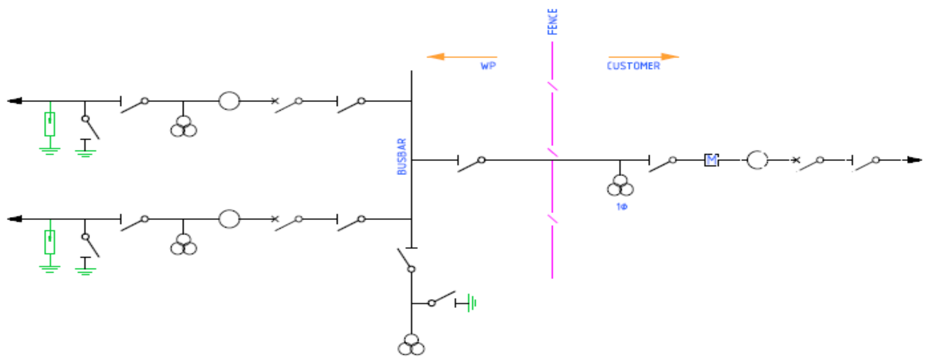


132kV LINE CONNECTION

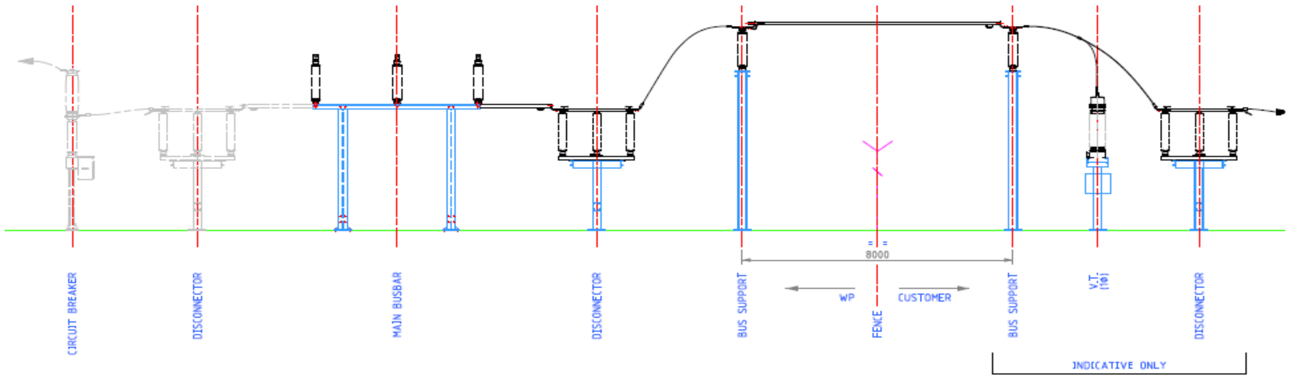


330kV LINE CONNECTION

Cut in Cut out –Primary plant Layout



SINGLE LINE DIAGRAM



TYPICAL SECTION

NOTES:

1. DIMENSIONS ARE INDICATIVE ONLY AND ARE TO BE CONFIRMED IN EXECUTION PHASE.