Standards Alert

Subject: **Ratings Parameters and Assumptions for Large Renewable Connections**		**Control Ref No:**	StdsA421
		Date Issued:	02/10/2018
		Supersedes:	
For Policy/Procedure/Manual:	**Plant Rating Manual, Standard for Sub-Transmission Overhead Line Design, Substation Design Manual**	**Expiry Date:**	30/10/2020
Originating Dept:	**Asset Standards: Asset Capability & Utilisation**		

1. Objective

This Standards Alert is to communicate changes to the Energy Queensland distribution networks rating parameters in determining network capacity for large generator connections including renewables.

2. Introduction

From the Distribution Network Service Provider (DNSP) perspective, seasonal peak demand events have traditionally occurred for a few weeks of the year where prolonged extremes of temperatures are experienced. However, with the increase in large renewable generator connections, network power flows have changed, in many cases increasing the frequency in which constraints on primary assets are approached. Solar farms for example can push network assets to their thermal capacity daily, not seasonally.

This can result in a number of emerging risks of primary assets exceeding design temperatures and the potential for accelerated aging. The three main types of assets currently being impacted are overhead lines, underground cables and power transformers. The impacts and recommendations for these assets are discussed below. While other assets such as circuit breakers, current transformers and isolators have thermal limits, their operating environment is controlled and well understood.

3. Overhead Lines

Ground and inter-circuit statutory clearances are absolute and are maintained by operating an overhead conductor below its design temperature. Elevated line temperatures not only increase the risk of breaching clearances as the conductor elongates; but cumulative loss of tensile strength is also experienced in aluminium conductors as line temperatures rise above 100°C, reducing conductor life. Additional risks include localised hotspots in accessories such as terminations, deadends and joints. This is particularly pertinent where a line has been lightly loaded historically and a step change in utilisation levels is expected with the introduction of large distributed generation.

Given a line design temperature, the driving parameter in determining the rating of an overhead line is wind speed. Actual wind speed is also one of the most variable parameters and wind speeds below the assumed value can cause a temperature rise above the design temperature. Following zero and low wind studies, the following recommendations apply:

1. **Renewable generators connected to AAC, AAAC, HDBC and ACSR lines with design temperatures above 75°C will have their line rating limited to 75°C using standard network rating climate parameters. Higher design temperatures may be permitted after seeking advice from Asset Standards.**

2. **Ramp back schemes and ramp rates for overhead lines are to limit line temperatures to 100°C following activation of a scheme. Asset Standards has updated tools to facilitate this calculation to ensure compliance.**

CAUTION	**Generators connecting to existing overhead lines shall have the stated design temperature and statutory line clearances validated by detailed engineering assessment. (LIDAR data or recent line surveys may be available to inform this study)**

CAUTION	**Thermal scanning of overhead lines and accessories should be undertaken where a step change in utilisation levels is expected from renewable generation to determine hot spots.**

4. Underground Cables

The network connection of renewable generators is often facilitated by an underground cable to an existing zone substation switchboard. The primary underground cable design aspects which influence cable rating include depth of burial, mutual heating from nearby circuits, bonding arrangement and cyclic load factor.

Cable size is selected to ensure that under normal operation, the maximum conductor and insulation temperatures of 90°C for XLPE are not exceeded. To apply consistent methodology under all operating conditions, including periods of prolonged dry spells and drought, the following parameters are to be used for large renewable connections:

3. **An industrial load factor of 0.84 is to be used in design of cable systems for solar farms and a load factor of 1.0 used for wind farm or hybrid generator cable studies. Other types of generation including storage should be assessed on a case by case basis.**

4. **Consideration of impact to existing customer and network cable systems is to be investigated where mutual thermal coupling will occur. Where the proposed cable system will be located within 5m of existing circuits, either through a cable crossing or a parallel route, a cable study is to be performed to assess derating impact to existing circuits published in source systems.**

CAUTION	**Results from thermal resistivity (TR) testing should be used for design of the cable systems.**

5. Power Transformers

There are three scenarios under which large renewable generators can connect to the network through a power transformer. Firstly, the generator may procure and maintain ownership of power transformer assets beyond the connection point as part of their connection agreement. Secondly, the generator may procure the power transformer and transfer ownership to the network business to operate and maintain. The third scenario is where the generator is connecting to an existing network owned power transformer.

Transformers have the capability of operating beyond nameplate under normal and contingency conditions without adverse effect. Under a cyclic load, with peak durations less than 4 hours, power transformers will typically age less than day for day. However, overloading transformers with a continuous load profile through the day will result in the rate of ageing to increase.

With renewable generators typically connecting to the LV bus of zone substations, studies are ongoing into the impact of this step change in utilisation on a power transformers life. Theory predicts that increases in weighted average temperatures of insulated paper windings can lead to accelerated aging when combined with high oxygen levels and normal water content of paper values. Increased frequency of oil sampling and monitoring will form part of the response strategy.

The following principles apply to specification and procurement of new power transformers for renewable generators and the rating of existing network power transformers connected to renewable generators:

5. **Where a renewable generator is specifying, procuring and transferring power transformer assets back to the network business, the Asset Standards power transformer building blocks are to be used. The specification of accessories being capable of 1.5p.u. may be lowered to between 1.0p.u. and 1.5p.u. depending on the likelihood of future network redeployment, network configuration and accessory standardisation.**

6. **Renewable generators exporting through an existing network power transformer capable of operating above 1.0p.u., are to have their cyclic loading limited to 1.0p.u. at the ONAN rating. The connection and subsequent operation of renewable generators at higher cooling modes such as ONAF/ODAF ratings is not permitted at this stage. Accelerated aging studies are ongoing in addition to increased oil sampling and monitoring where step changes in utilisation on power transformer assets are realised. The results of these studies will be reviewed annually to determine network impacts. The tertiary shall not be loaded beyond 1.0p.u. as per existing practice.**

7. **Ramp back schemes for renewable generators may be required following a contingency event to prevent overloading power transformers and other primary plant beyond thermal limits.**

CAUTION	**Reverse power flows through tap changers can be a constraint on single resistor tap changers. Currently only some Ferranti tap changer models appear to be impacted.**

6. National Electricity Rules (NER) Automatic Access Standard

The following reactive power and voltage clauses from the NER are applicable to the rating determination for overhead lines, underground cables, power transformers and other primary assets. Where a negotiated access agreement is entered into, refer to the generator performance standard of that connection agreement.

8. **The rating of equipment shall account for S5.2.5.1 Reactive power capability being capable of supplying or absorbing continuously at the connection point an amount of reactive power the product of 0.395 and real active power of the generating system, or a power factor of 0.93.**

9. **The rating of equipment shall account for S5.2.5.4 Generating system response to voltage disturbances where the generator is to be capable of continuous uninterrupted operation at 90% of the normal voltage.**

Example:

The line current expected on a 33kV feeder connected to a 30MW generator would therefore be:

$$\frac{30\text{MW}}{\left(0.93 \times 0.9 \times 33\text{kV} \times \sqrt{3}\right)} = 627\text{A}$$

Note: the NER defines 'large' generator connections as a nameplate rating greater than 30MW (5.18A.1). Ergon Energy Network and Energex consider all generators greater than 5MW as 'large' at distribution voltages. For example a 20MW generator would be considered large for a 22kV connection.

7. Update to Manuals

This Standards Alert will be incorporated into the following manuals as part of future releases. A new Energy Queensland Plant Rating Manual will be released as part of consolidation of the Ergon Energy and Energex legacy plant rating manuals.

NA000000R100	Plant Rating Guidelines (Ergon)
	Plant Rating Manual (Energex)
STNW3661	Standard for Distribution Line Design
STNW3355	Standard for Sub-Transmission Overhead Line Design
NI000401R121	Substation Design Manual

8. Further Information

For further information, please contact:

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