Reasonableness Test RT 009/13

Bolivar to Virginia 66kV line overload

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GLOSSARY OF TERMS

Term	Meaning
Contingency Condition (N-1)	The term used to describe the state of the Distribution Network when any one piece of plant (N-1) is out of service, with the rest of the Network remaining intact.
Connection Point	A substation shared with ElectraNet, at which electrical power is injected from the ElectraNet Transmission Network into SA Power Networks' Distribution Network.
Distribution System	Shall have the meaning as defined within Chapter 10 of the National Electricity Rules.
Firm Delivery Capacity (N-1 Rating)	The maximum allowable load of a substation under single Contingency Conditions, including any short term overload capacity.
POE	Probability of Exceedance. The 50% POE forecast (1 in 2 year event) is compared against the substation's firm delivery capacity.
PV	Photovoltaic (also known as solar cells)
Transfer Capacity	The amount of load that can be transferred to an adjacent substation via the 11kV feeder while still providing adequate customer voltage levels.

GUIDELINE 12 REASONABLENESS TEST

Bolivar to Virginia 66kV Line Overload

1. CURRENT SUPPLY ARRANGEMENT

Virginia Substation is located at the northern end of the suburb of Virginia in Adelaide, on the corner of Angle Vale Road and Port Wakefield Highway and is supplied via a single 66kV sub-transmission line from Parafield Gardens West Connection Point, which is part of the Metro North sub-transmission network. Virginia Substation contains one 12.5MVA 66/11kV transformer and supplies 3 x 11kV feeders.

The substation has a total normal capacity of 14.9 MVA and a Firm Delivery Capacity of 0 MVA (due to it only having a single transformer). Its forecast load for summer 2013/14 under 10%POE conditions is 10.8 MVA. The substation currently supplies approximately 1,130 customers who are a mixture of rural, residential with some commercial and light industrial load.

As the substation has only one source of supply, the Firm Delivery Capacity of Virginia Substation following a sub-transmission line fault is 0 MVA (ie supply is lost to the entire load until either manual load transfers to other substations via 11kV feeder ties can be performed or the sub-transmission line is restored to service).

The existing 66kV sub-transmission line between Parafield Gardens West and Virginia Substations consists of two sections:

- Parafield Gardens West to Bolivar: consisting of 54/7/3.50 ACSR conductor designed to 100^{o}C. This section of line has a normal summer rating of 127MVA and an emergency rating of 142MVA.
- Bolivar to Virginia: consisting of 0.2 in^{2} Copper conductor designed to 50^{o}C. This section of line has a normal and emergency rating of 0MVA for ambient temperatures in excess of 40^{o}C.

For temperatures in excess of 40^{o}C, the Bolivar to Virginia section of this line will be overloaded unless all of the load supplied by Virginia Substation can be transferred and/or curtailed by customer owned generation.

Traditionally, all of SA Power Networks' 66kV lines were designed to 50^{o}C. These lines have been progressively up-rated to higher design temperatures over time based on a prioritised list which has considered amongst other things,

- Location;
- Load;
- Public accessibility;
- Cost; and
- Risk.

There are limited 11kV feeder ties to Angle Vale Substation; however transfers are limited due to both the capacity of the 11kV ties and voltage levels at the extremities of the feeders. In summer 2013/14, approximately 5.1 MVA can be transferred at peak times within 4 hours of a 66kV line fault occurring.

The area under consideration is shown in Figure 1.

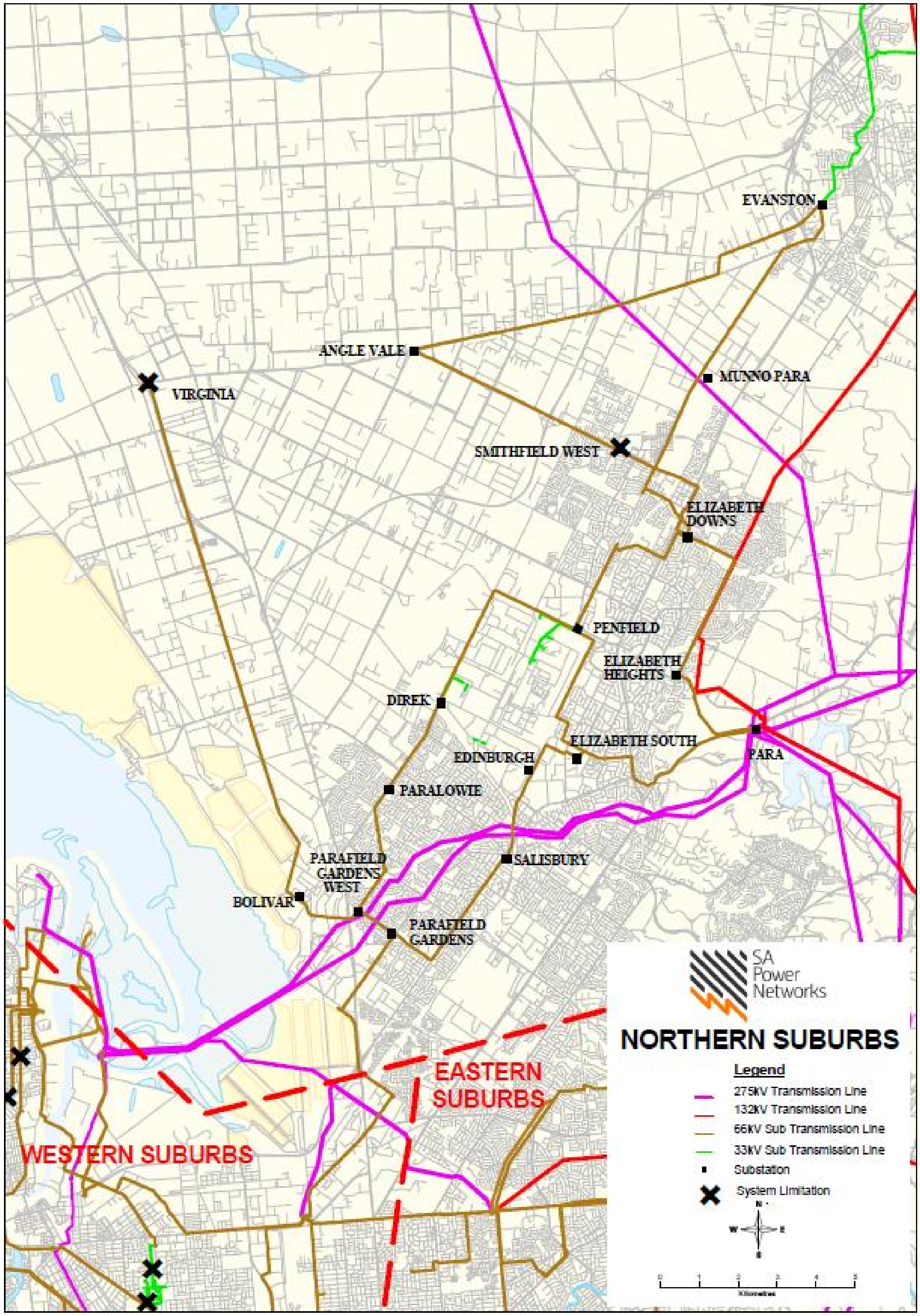

Figure 1 Metro North network including Virginia Substation

2. FORECAST LOAD AND CAPACITY

2.1 Load Forecast

The total load on Virginia Substation is forecast to grow at an average rate of 3.9% per annum, which sees the load increase from 10.8 MVA in 2013/14 to 19.3 MVA in 2028/29, as shown in Table 1. This growth represents the moderate 10% POE forecast which SA Power Networks uses for planning purposes of its sub-transmission assets. The forecast takes into account all known existing or committed demand management programmes and also takes into consideration the presence of any known embedded generation (eg PV). The Power Factor at peak times is 0.89.

It has been estimated that approximately 0.5 MW of roof top PV exists on the feeders serviced by Virginia Substation. This represents approximately 5% of the total load on the substation. The impact of this PV installation is included in Table 1.

Table 1 Forecast load growth at Virginia Substation

Summer Year	MVA	MW	MVAr
2013/14	10.8	9.6	4.9
2014/15	11.3	10.0	5.1
2015/16	11.7	10.4	5.3
2016/17	12.2	10.8	5.5
2017/18	12.6	11.3	5.8
2018/19	13.1	11.7	6.0
2019/20	13.7	12.2	6.2
2020/21	14.2	12.6	6.5
2021/22	14.7	13.1	6.7
2022/23	15.3	13.6	7.0
2023/24	15.9	14.2	7.3
2024/25	16.6	14.7	7.5
2025/26	17.2	15.3	7.8
2026/27	17.9	15.9	8.2
2027/28	18.6	16.5	8.5
2028/29	19.3	17.2	8.8

SA Power Networks is likely to commit to the construction of a new zone substation at Two Wells as described in RT007-13: Two Wells. This expansion will not however relieve the sub-transmission constraint which the augmentation proposed by this document is intended to address.

There is presently 3.5MW of non-export customer owned gas / diesel generation connected to Virginia Substation's 11kV feeders, used to support an existing customer's glasshouse agri-business. The use of this generation is insufficient to resolve the overload of the existing sub-transmission line and is not available for network support.

SA Power Networks is not aware of any other existing or committed embedded generation augmentations that could be used to positively address the sub-transmission constraint.

2.2 Pattern of Use

Peak electricity demand at Virginia Substation occurs during the summer months, predominantly as a result of air-conditioning load.

The summer load profile from the 17th January 2013 is typical of the load on the substation during peak periods. It shows some sign of PV penetration with a fairly sharp peak between 18:00 and 21:00 followed by a sharp decline in demand. In numbers, peak demand occurred for 2 ½ hours between 19:00 and 21:30 and was above 85% of peak for 5 ½ hours from 17:00 to 22:30.

Peak winter loads are dominated by early evening residential loads such as heating and cooking. It is worth noting that on many days due to the solar PV contribution, minimum load actually occurs around solar noon (ie between 11:30 and 14:30). Numerically, peak winter demand occurs for a smaller period than summer, with load exceeding 95% of peak for only 1 hour between 18:30 and 19:30 and exceeding 85% of peak for 3 hours between 18:00 and 21:00.

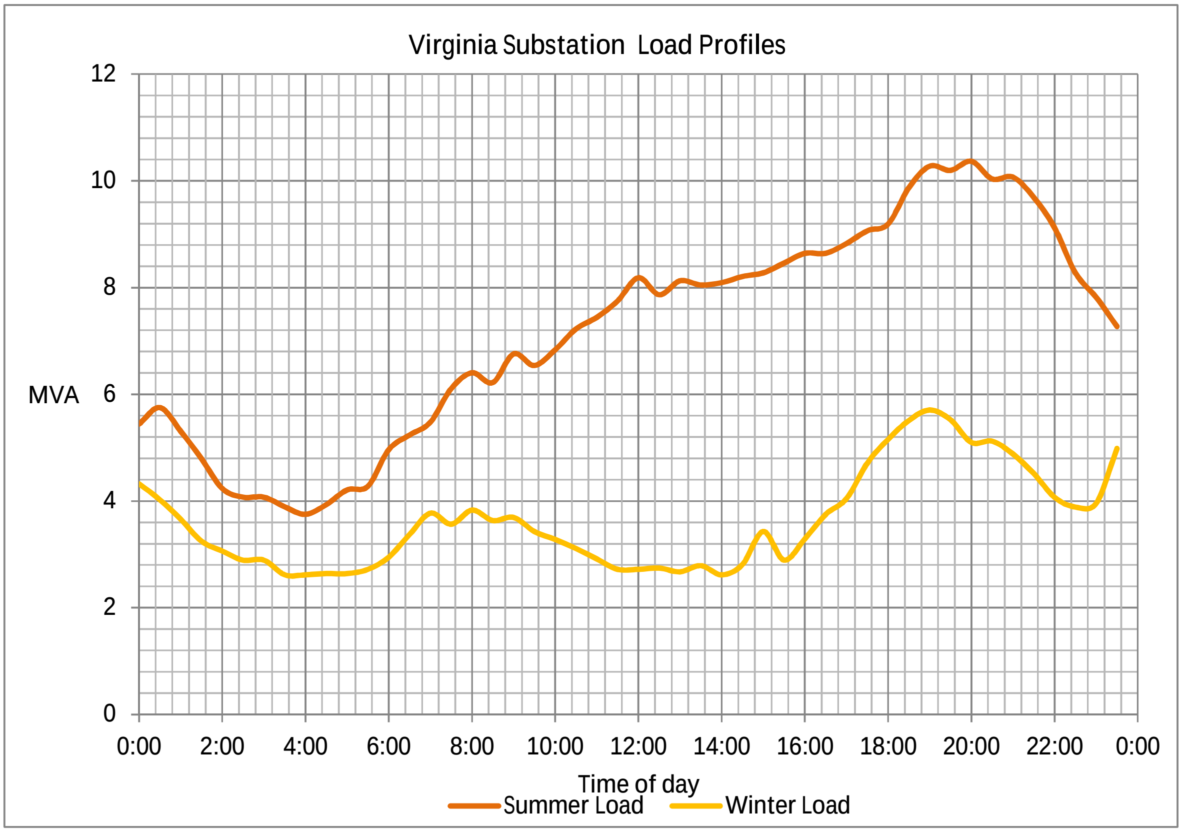

Figure 2 Load profile Virginia

In terms of the annual load spread, loads in the Virginia area are fairly typical of those substations supplying predominately residential loads, exhibiting a sharp peak on a few hot days a year and a low average for the rest of the time. The loads exceed 95% of peak for approximately 6 hours a year and are in excess of 85% of peak demand for approximately 42 hours a year. The average load is approximately 38% of the peak demand (see Figure 3).

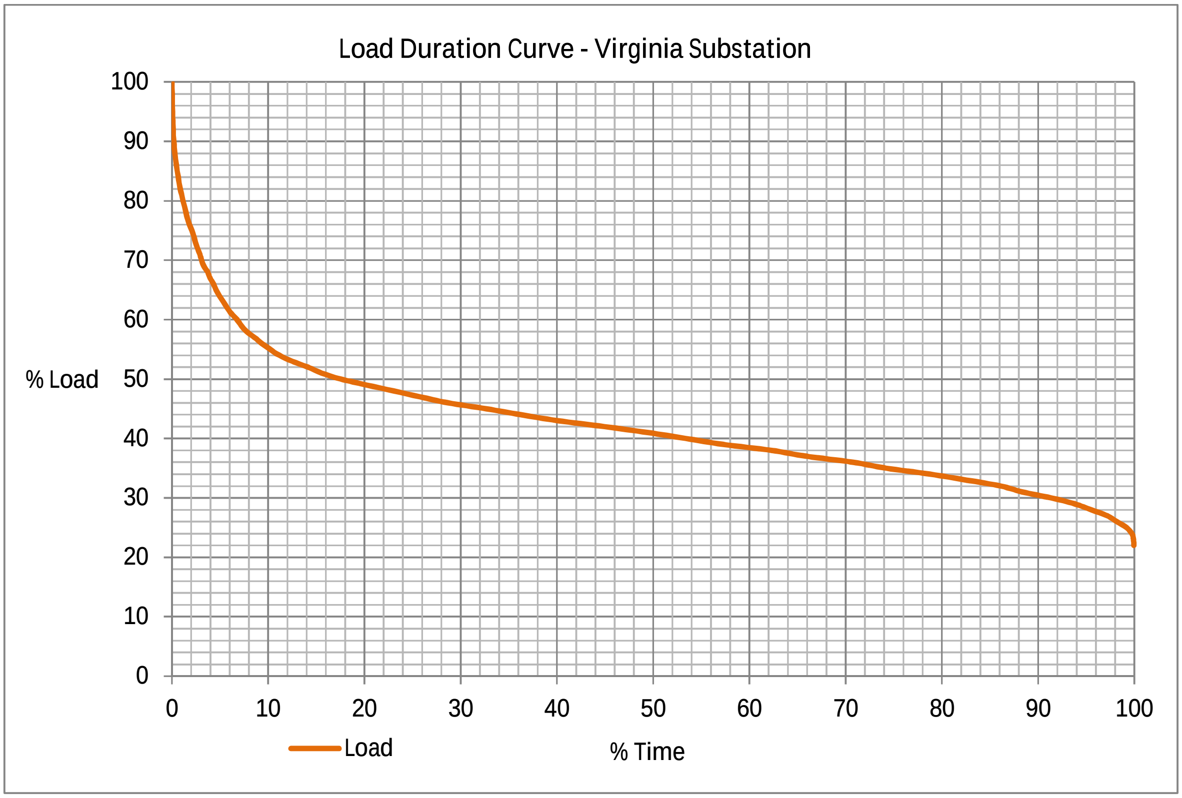

Figure 3 Load duration curve – Virginia Substation

2.3 System Limitations

The system limitation identified is the breach of statutory clearances on the section of 66kV line between Bolivar and Virginia at high ambient temperatures.

As load on the line and ambient temperature increases, the temperature of the line conductor also increases and therefore sags more. At a high enough ambient temperatures this increased sag infringes the statutory clearance to ground.

The identified need is the requirement increase the design rating of the 66kV line in order to maintain statutory clearances under forecast peak demand conditions.

3. NETWORK UPGRADE

The preferred network option to address the identified need is to upgrade the line from a design temperature of 50°C (T50) to a design temperature of 80°C (T80). This will increase the capacity of the line to approximately 60MVA. Given the radial nature of the 66kV supply to Virginia Substation, whilst the line is out of service and the substation is offloaded, SA Power Networks proposes to take this opportunity to perform other reconfiguration works at Virginia Substation to facilitate the future expansion of the network to Two Wells (refer RT07-13) and thereby minimise future disruption of this line. The total cost of this option is expected to be in the order of $6 million.

Two network alternatives were also considered:

- Rebuilding the line with a larger capacity conductor. This option offers a substantial increase in capacity and would see the replacement of the existing 60 year old conductor.
- Building a new 66kV line to Virginia from Angle Vale Substation (a distance of approximately 7 km). Whilst this option would see the construction of a new 66kV line, this option would not provide a second source of supply to Virginia Substation under all conditions, unless the existing line's rating were also increased.

In both cases, the alternative options are significantly more expensive than the proposed line up-rate option.

4. DEMAND MANAGEMENT ANALYSIS

4.1 Required Demand Management Characteristics

For a demand management option to be credible, it must be capable of reducing the load at Virginia Substation to below the rating of the 66kV line. As the line is rated for 0 MVA on days in excess of 40°C, this implies that any Demand Managment (DM) option must be capable of supplying the full load at Virginia Substation, now and into the future. The table below assumes that reactive support is also installed to reduce the load on the line to its absolute minimum.

Table 2 DM Load Reduction Required (MW)

Year	MW
2014	10.0
2015	10.4
2016	10.8
2017	11.3
2018	11.7
2019	12.2
2020	12.6
2021	13.1
2022	13.6

In addition, it is likely that some form of dynamic rating of the line may also be required in order to minimise the number of hours such support would be required.

4.2 Demand Management Value

The following table provides an indication how much can be spent in year 1 to achieve a 1, 2 or 3 year deferral expressed both as an overall cost and in terms of $ per kVA of load reduction. The minimum and maximum amounts specified have been derived using different assumptions regarding the cost of capital from a minimum of 8.98% to 12.5%. The stated benefits also include an allowance of $50k per annum to cover administrative costs. Note: these figures are indicative only and any credible DM solution proposed will be evaluated against the preferred network solution by a full RIT-D evaluation. Details of how this is performed are contained within the Demand Side Engagement Document available from our website.

Table 3 $ per kVA available for Demand Management

Deferral Period	Total Available Benefit $,000's (min)	Total Available benefit $,000's (max)	$ available per kVA (min)	$ available per kVA (max)
1 year deferral	$481	$652	$43	$58
2 year deferral	$968	$1,276	$83	$109
3 year deferral	$1,416	$1,831	$116	$150

4.3 Demand Management Options Considered

Various Demand Management (DM) technologies were considered to determine their viability in reducing the demand in the constrained area. These DM options were evaluated for both technical feasibility as well as cost effectiveness.

4.3.a Standby diesel generators

Establish contracts with customers who have existing standby diesel generators on their premises and utilise the generators at peak load times or install peak lopping generators to reduce load at peak times. This option is not viable as there are not enough customers with standby generators within the region to make this option feasible. Note that the existing installed customer generation previously discussed is not a standby unit.

4.3.b Install new diesel generation

Recent experience indicates that the $ per kVA value available is too small to support a medium sized (5MVA -15MVA) peaking plant in the Virginia area.

4.3.c Install power factor correction

This option is not technically feasible as there are not enough large customers supplied out Virginia to make individual power factor correction viable. Substation based correction would help reduce the load at risk but not eliminate it, consequently without additional viable options this is not in itself sufficient.

4.3.d Retrofit commercial lighting with efficient lighting.

This option relies upon the ability to upgrade existing commercial fluorescent lighting to T5 lighting. Based on the upgrade of an existing 400W fluorescent bank with a 2x 80W efficient bank to provide the equivalent lumen output, the demand saving per bank is 240W.

The estimated cost for this option is $2,500/kVA. Significant disruption to the customer while the retrofit is carried out can be expected, which may influence the number of willing participants. It is highly unlikely that sufficient volume could be achieved to make a significant difference, particularly given the time of the substation's peak demand.

4.3.e Peak load control – direct load control

Direct load control technology may be available where tripping multiple small air conditioning units supplied from a single distribution transformer can be performed. Recent experiences have shown the costs of such solutions to range from $300 to $800/kVA. Given the constraint requires the entire offload of the substation, it is highly unlikely that sufficient volume and subsequent load reduction would be available to make a significant difference to the size of constraint.

4.3.f Peak load control – curtailable load

This involves establishing a contract with one or more large customer's requiring them to reduce their load by either turning off the power supply to part of their business or shifting load to "off peak" times. Practically, there are no suitable customers with a load large enough to individually have a material impact on the network load for this option to be viable.

4.3.g Residential compact fluorescent lamp (CFL) program

This option was deemed not relevant due to peak load conditions occurring in daylight hours. Load contribution from residential housing lighting during daylight hours is believed to be minimal.

4.3.h Thermal storage systems

Installation of this form of storage system at a suitable site in a previous trial revealed a saving in load in the order of 150kVA. Smaller scale installations have also been trialled and are still very much in the development stage. However, the expected cost of this size of installation ranges from $1,000-1,600/kVA, which is much more expensive than the $ per kVA available.

4.3.i Energy Storage

Use of energy storage technology such as flow batteries is typically in the order of $6000 per kVA, which is significantly more than the available amount.

5. CONCLUSION

Based on the Demand Management options considered when compared to the preferred network solution, it is not possible that sufficient Demand Management measures could be implemented to achieve the demand reduction required to make project deferral technically and economically viable.

The constraint on the sub-transmission line capacity into Virginia Substation has therefore failed the Reasonableness Test and a Request for Proposal (RFP) will not be issued.