EFFECTIVE USE OF DISTRIBUTED VARS FROM GRID FRIENDLY WIND POWER GENERATION

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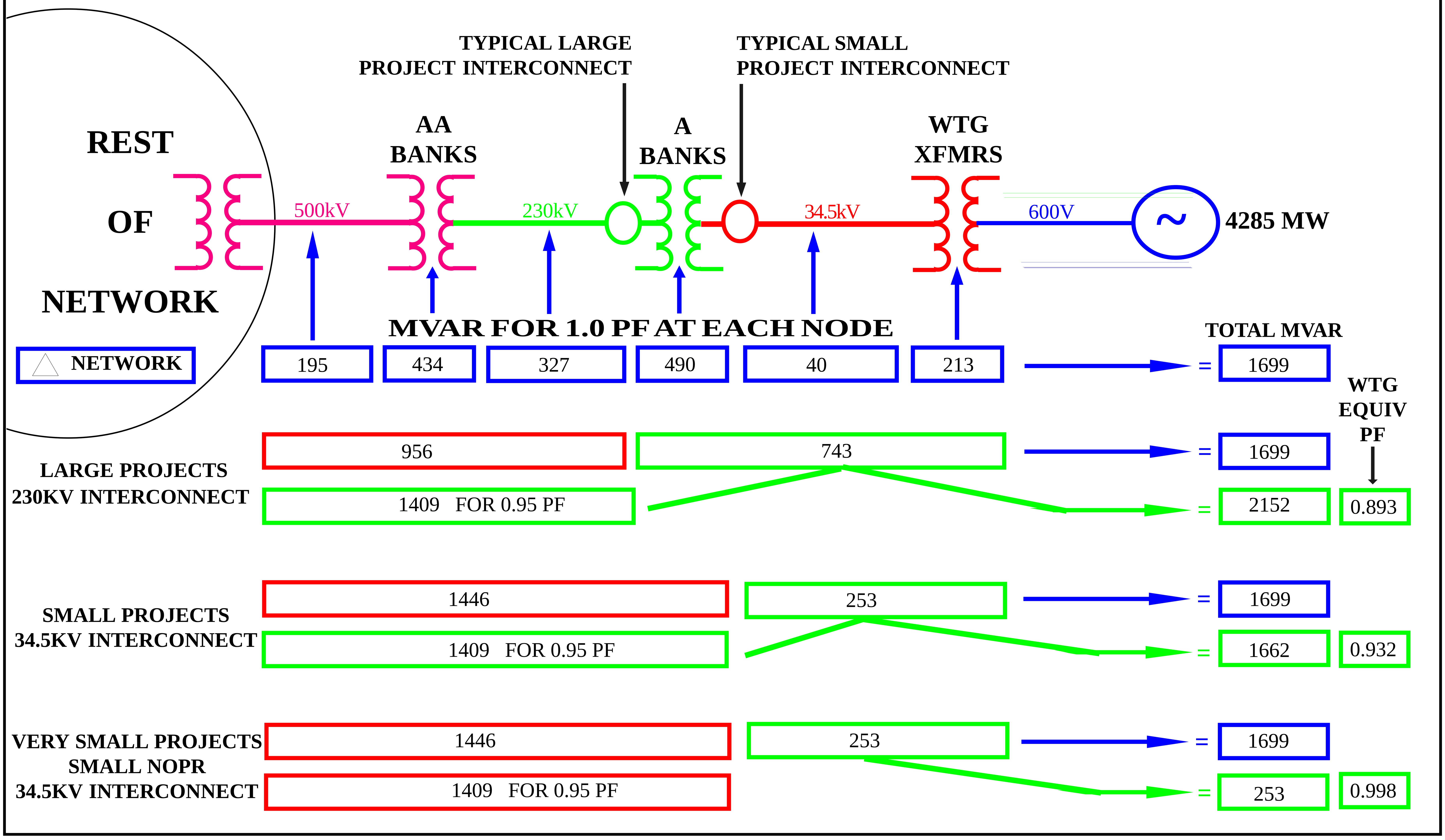
SIMPLIFIED DIAGRAM 4285 MW PLANNED TEHACHAPI SYSTEM



Overview

Substantial analysis has been done in the Tehachapi Collaborative Study Group to plan for 4,285 MW of new wind generation in the Tehachapi area. In this process, substantial analysis has been done on line configuration alternatives, and on the VAR requirements associated with different elements of the new system. The VAR planning has been based on these facilities initially being used only for the new wind generation, so the data is useful to help understand the needs for VARs through a network system, and where those needs occur. Three cases are provided, each assuming a different size or configuration of project, with each having substantially different implications concerning responsibility for the supply of the VARs, while the total VAR needs remain constant.

The planned new Tehachapi grid when completed is to be supplied from existing major substations at 500 KV. The distance of the new 500 KV Tehachapi Substation #1 is approximately 35 miles distant from the Antelope Substation and an additional 20 miles to the Vincent Substation, and 25 miles from Antelope to the Pardee Substation. These are not great distances for transmission lines of 500 KV, and it is important to adjust the line losses presented here when trying to evaluate situations with longer distances.

The local Tehachapi area collection grid is to be supplied from Tehachapi Substation #1 at 230 KV and is currently planned as a loop, with a number of substations distributed on the loop, either to interconnect a major project, or to supply a number of smaller projects, or both. Larger projects are expected to internally collect at 34.5 KV and smaller projects are expected to interconnect at 34.5 KV. Some very small projects may interconnect at 13.8 KV, as that voltage is available on the standard SCE transformer that is planned for common use.

Unity VAR Planning, Base Case

The design of the system VAR needs is based on unity Power Factor at each node on the planned system, with all facilities in service and operating normally. The distribution of these VARs then show how the VARs are consumed throughout the system

VARs associated with the Greater Network, beyond the major substations have not been computed, and generally will be consistent with the VAR needs along the network, depending upon the amount of load that is served. As energy is delivered at greater distances across the network, the VAR needs will rise, and the planner must ultimately take into consideration the quantity of VARs needed for delivery into the load center. Such VAR needs will be offset by any reduction in VARs consumed by energy currently being delivered from other generators, and being displaced by Tehachapi wind.

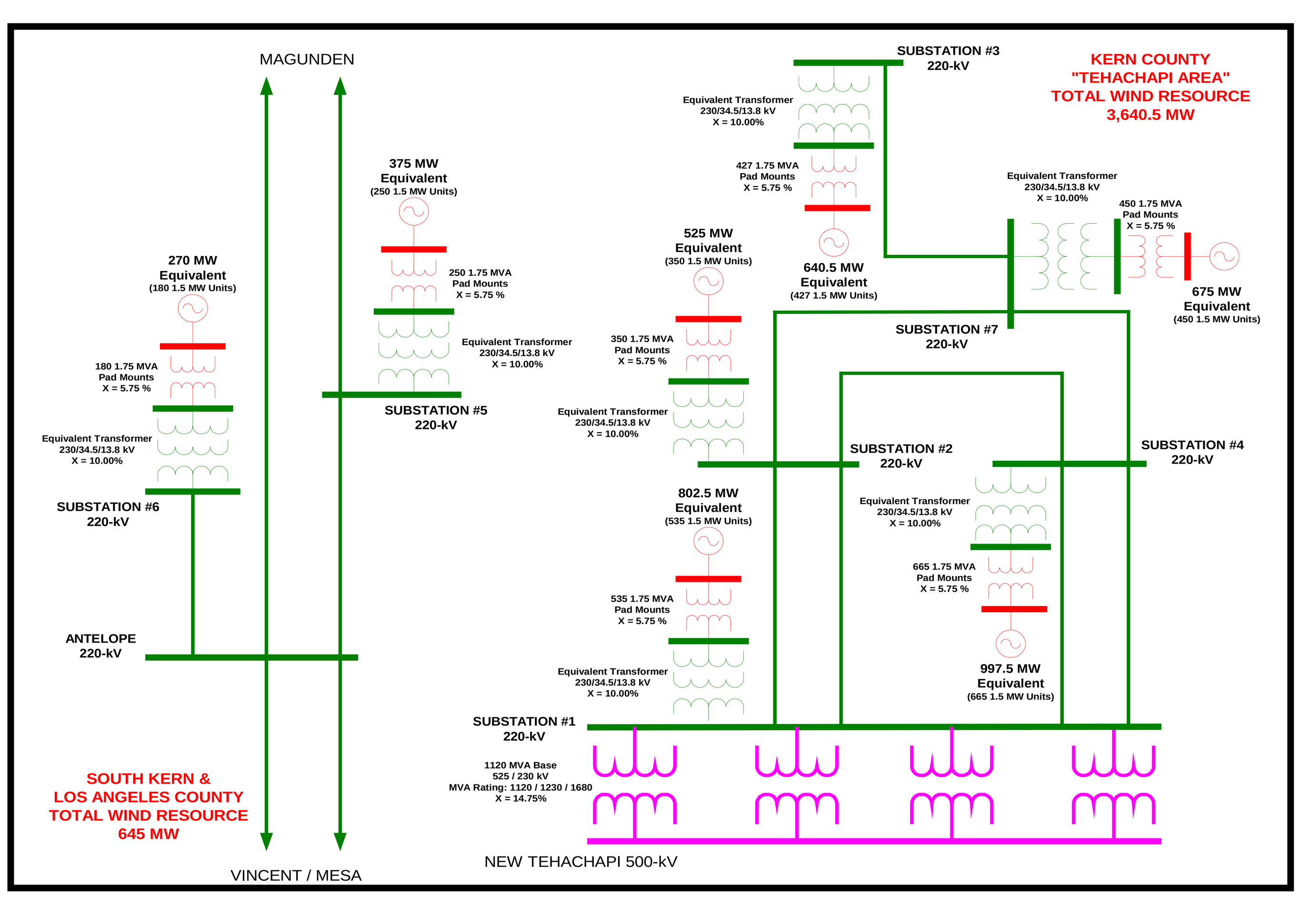
Responsibility for VAR Supply

The rules for VAR supply are currently undergoing revision, along with wind turbine performance criteria for increase reliability of supply. The allocation of responsibility shown here is generally consistent with practical projects in the Western Interconnect, and is anticipated to be the national standard with completion of Large and Small NOPR by FERC.

Large Projects are shown to interconnect at 230 KV and include in the project the A Bank substation transformer for converting the 230 KV to 34.5 KV. The responsibility for VAR supply is with the project up to the point of interconnect, which is assumed to be the high side of the substation transformer. In some cases, the point of interconnect will be remote from the A Bank transformer, and the VAR responsibility will need to be adjusted accordingly. Some projects will be more remote, or less dense than occurs in the Tehachapi area, and VAR consumption needs should be adjusted accordingly.

The total VAR responsibility for Large Projects includes the A Bank Substation, and all of the 34.5 KV collection system, including the wind turbine transformers.

In the case of the project conditions here, and adding the VARs needed to supply 0.95 PF to the grid, the total VAR responsibility of the large project is equivalent to a 0.893 PF at the wind turbine. These numbers do not include wind turbine VAR needs, and assume a unity PF at the wind turbine main breaker.



Small Projects, associated with the FERC Large NOPR, or any projects required to supply 0.95 PF to the grid, are shown as the Small Projects below. The significant difference from the large projects above, is that the point of interconnection is on the low side of the A Bank transformer, and as such the responsibility for VARs at that transformer passes from the project to the utility.

The total VAR responsibility for Small Projects includes all of the 34.5 KV collection system, including the wind turbine transformers. In the case of the project conditions here, and adding the VARs needed to supply 0.95 PF to the grid, the total VAR responsibility of the small project is equivalent to a 0.932 PF at the wind turbine. These numbers do not include wind turbine VAR needs, and assume a unity PF at the wind turbine main breaker.

Very Small Projects differ from Small Projects only in size, such that they are associated with the Small NOPR, and are assumed, consistent with the current draft NOPR, to not be required to supply any VARs to the system, but to perform to a standard of unity power factor at the point of interconnection.

The total VAR responsibility for Very Small Projects includes all of the 34.5 KV collection system, including the wind turbine transformers. In the case of the project conditions here, with no need to supply 0.95 PF to the grid, the total VAR responsibility of the very small project is equivalent to a 0.998 PF at the wind turbine. These numbers do not include wind turbine VAR needs, and assume a unity PF at the wind turbine main breaker.

The VARs not shown above as being the responsibility of the wind projects, are the responsibility of the utility to supply.

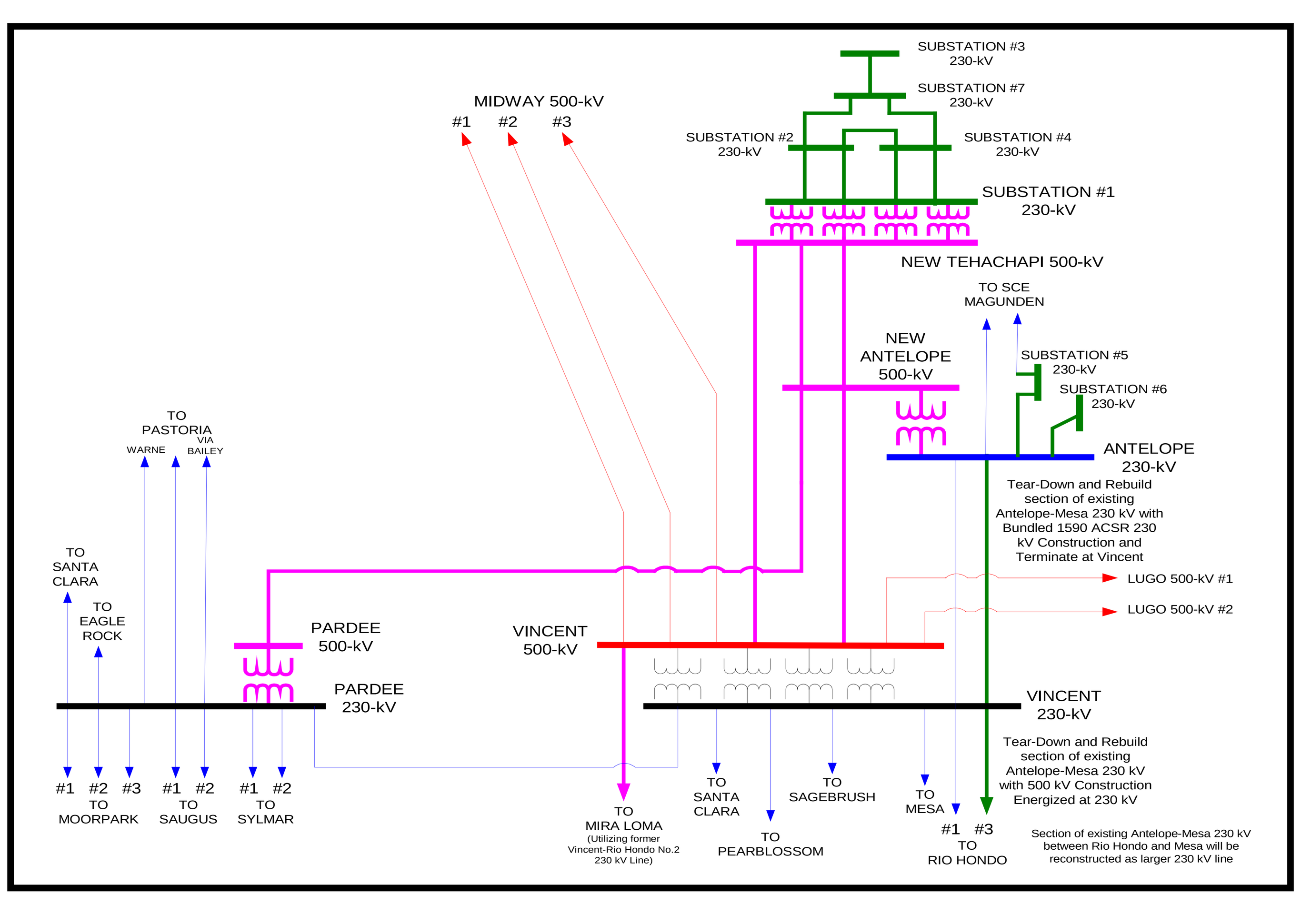
VARs for Contingency Conditions

It is necessary to plan the network system for N-1 and N-2 conditions, where the worst case facility outages are assumed to occur. When such conditions exist, the remaining facilities in the network are loaded to higher levels, and generally VAR consumption rises dramatically with increased loading. As a result, it is necessary to plan for such contingencies, and to have available adequate VARs to meet the need of maintaining the system operation reliable under these contingencies.

The VAR supply associated with the 0.95 Power Factor supply is initially considered to be reserved for these contingencies, and for other contingency conditions, including the factors that cause need for ride through capability. The actual needs for these conditions here have not been calculated, and are more fully analyzed as the complete details of the system develops.

Dynamic or Static VARs

In general, for a well designed and adequate system, such as is planned here, the VARs associated with normal Base Conditions grid needs can be static VARs, switched in and out as needed, under normal control. However, the VARs associated with Contingency Conditions must be of very fast response to be effective in many conditions, and as such need generally to be dynamic.



Dynamic VARs are usually voltage responsive, and very fast acting, and can produce their effect quickly to maintain grid conditions within limits. Dynamic VARs can be supplied from SVC, Statcom, or D-VAR systems. They can also be supplied from the wind projects, from the inherent capability of some wind turbines, generally equipped with inverters, or from wind turbines equipped with the equivalent of SVC capability. Voltage responsive Dynamic VARs are generally quite effective in stabilizing the grid and maintaining high quality voltage conditions.

Where wind projects do not supply adequate Dynamic VARs for the overall needs of the network, they will have to be supplied by the utility. In general, it is economically more efficient to provide the needed dynamic VARs from wind projects than as added system facilities, to the extent that required VAR needs can be met with Dynamic capability.

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