

## A. Introduction

1. **Title:** Verification and Data Reporting of Generator Gross and Net Reactive Power Capability
2. **Number:** MOD – 025 – RFC – 01
3. **Purpose:** To ensure that planning entities have accurate generator gross and net Reactive Power capability modeling data to use in system planning studies.
4. **Applicability:**
  - 4.1 **Functional Entities**
    - 4.1.1 Generator Owner
  - 4.2 **Facilities**
    - 4.2.1 Generators with maximum nameplate ratings greater than or equal to 85 MVA
    - 4.2.2 Generating plants/Facilities with maximum aggregate nameplate ratings greater than or equal to 85 MVA connected to the Bulk Electric System at a common bus
    - 4.2.3 All Blackstart Resources, regardless of their size
    - 4.2.4 Wind Generating Stations with maximum aggregate nameplate ratings greater than or equal to 85 MVA connected to the Bulk Electric System at a common bus
5. **Effective Date:** Upon ReliabilityFirst Board Approval, the standard will be mandatory and enforceable (without monetary penalties for non-compliance) to applicable ReliabilityFirst members and the enforcement mechanism will be as a “Term of Membership” under the ReliabilityFirst By-Laws.

Upon regulatory approval, the standard will be mandatory and enforceable (with monetary penalties for non-compliance) to all applicable NERC registered entities within the ReliabilityFirst footprint.

## B. Requirements

- R1** Each Generator Owner shall verify the operating range of Reactive Power capability for each of its applicable units by operational tracking or by test at least every five years, (with no more than 66 calendar months between verifications) in accordance with MOD-025-RFC-01 Attachment 1. [*Violation Risk Factor: Medium*][*Time Horizon: Long-term Planning*]
- R2** Each Generator Owner shall provide the following data from the most recent Reactive Power capability verification within 30 calendar days of a written request from its Transmission Planner, Transmission Operator, Reliability Coordinator or Planning Coordinator. [*Violation Risk Factor: Lower*][*Time Horizon: Long-term Planning*]

- 2.1** Gross and low side net Reactive Power generating capabilities and gross Real Power generating output<sup>1</sup> where low side net Reactive Power generating capability is calculated as follows:

Low side net Reactive Power capability = gross Reactive Power capability of unit (or units if multiple units are connected to one generator step-up transformer) - all plant related loads (aux transformers, generator step-up tertiary load, station service transformers and generator loads connected to other sources).

- 2.2** Reactive auxiliary loads and reactive resources.<sup>2</sup>
- 2.3** Method of verification, including date and conditions.

### C. Measures

- M1** Each Generator Owner shall have dated evidence that it performed the verification (such as completed MOD-025-RFC-01 Appendices A, B, C and/or D) in accordance with Requirement R1.
- M2** Each Generator Owner shall have evidence including a dated copy of the request for Reactive Power capability verification data and other evidence (such as dated electronic mail messages or mail receipts) to demonstrate that information specified in Requirement R2 has been supplied within 30 calendar days of a request from its Transmission Planner, Transmission Operator, Reliability Coordinator, or Planning Coordinator as required by Requirement R2.

### D. Compliance

#### 1. Compliance Monitoring Process

##### 1.1 Compliance Enforcement Authority

Compliance Monitor - Reliability *First* Corporation

##### 1.2 Data Retention

The Generator Owner shall retain information from the most current and prior verification.

If a Generator Owner is found non-compliant, it shall keep information related to the non-compliance until found compliant.

The Compliance Monitor shall retain any audit data for five years.

##### 1.3 Compliance Monitoring and Assessment Processes

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<sup>1</sup> Applicable reporting form is provided for non-wind units in Appendix A and for Wind Generating Stations in Appendix C

<sup>2</sup> Applicable reporting form is provided for non-wind units in Appendix B and for Wind Generating Stations in Appendix D

Compliance Audits  
 Self-Certifications  
 Spot Checking  
 Compliance Violation Investigations  
 Self-Reporting  
 Complaints

**1.4 Additional Compliance Information**

None

**2. Violation Severity Levels**

Req. Number	VIOLATION SEVERITY LEVEL			
	LOWER	MODERATE	HIGH	SEVERE
R1	The Generator Owner verified the Reactive Power capability for a specific generator in accordance with MOD-025-RFC-01 Attachment 1, and the verification was late by 60 calendar days or less and the Generator Owner has no evidence to support a delay in conducting the verification (per Attachment 1, Section 1.2.1 through 1.2.3).	The Generator Owner verified the Reactive Power capability for a specific generator in accordance with MOD-025-RFC-01 Attachment 1, and the verification was late by more than 60 calendar days but less than or equal to 70 calendar days late and the Generator Owner has no evidence to support a delay in conducting the verification (per Attachment 1, Section 1.2.1 through 1.2.3).  OR  The Generator Owner verified the Reactive Power capability for a non-wind unit but failed to include one (1) of the items as specified MOD-025-RFC-01 Attachment 1, Sections 1.1, 2.1,	The Generator Owner verified the Reactive Power capability for a specific generator in accordance with MOD-025-RFC-01 Attachment 1, and the verification was late by more than 70 calendar days but less than or equal to 80 calendar days late and the Generator Owner has no evidence to support a delay in conducting the verification (per Attachment 1, Sections 1.2.1 through 1.2.3).  OR  The Generator Owner verified the Reactive Power capability for a non-wind unit but failed to include two (2) of the items as specified MOD-025-RFC-01 Attachment 1, Sections 1.1, 2.1,	The Generator Owner verified the Reactive Power capability for a specific generator in accordance with MOD-025-RFC-01 Attachment 1, and the verification was late by more than 80 calendar days and the Generator Owner has no evidence to support a delay in conducting the verification (per Attachment 1, Sections 1.2.1 through 1.2.3).  OR  The Generator Owner verified the Reactive Power capability for a non-wind unit but failed to include three (3) or more of the items as specified MOD-025-RFC-01 Attachment 1, Sections 1.1, 2.1, 2.2 and 2.3

		2,2 and 2.3	2,2 and 2.3  OR  The Generator Owner verified the Reactive Power capability for a Wind Generating Station but failed to include one (1) of the items as specified MOD-025-RFC-01 Attachment 1, Sections 1.1, 3.1 and 3.2	OR  The Generator Owner verified the Reactive Power capability for a Wind Generating Station but failed to include two (2) or more of the items as specified MOD-025-RFC-01 Attachment 1, Sections 1.1, 3.1 and 3.2  OR  The Generator Owner failed to verify the Reactive Power capability for a specific generator as required in R1
R2	The Generator Owner provided the data (as specified in Requirement R2, Parts 2.1, 2.2 and 2.3) from the most recent Reactive Power capability verification but provided the data more than 30 calendar days but less than or equal to 40 calendar days following the request.	The Generator Owner provided the data (as specified in Requirement R2, Parts 2.1, 2.2 and 2.3) from the most recent Reactive Power capability verification but provided the data more than 40 calendar days but less than or equal to 50 calendar days following the request.	The Generator Owner provided the data (as specified in Requirement R2, Parts 2.1, 2.2 and 2.3) from the most recent Reactive Power capability verification but provided the data more than 50 calendar days but less than or equal to 60 calendar days following the request.  OR  The Generator Owner provided the data from the most recent Reactive Power capability verification within 30 calendar days of	The Generator Owner failed to provide the data (as specified in Requirement R2, Parts 2.1, 2.2 and 2.3) from the most recent Reactive Power capability verification more than 60 calendar days following the request.  OR  The Generator Owner provided the data from the most recent Reactive Power capability verification within 30 calendar days of the request but failed to include two (2) or more of

			the request but failed to include one (1) of the items as specified in Requirement R2, Parts 2.1, 2.2 and 2.3	the items as specified in Requirement R2, Parts 2.1, 2.2 and 2.3
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**E. Definitions**

The following are definitions of terms used in this Standard:

**Wind Generating Station** - A collection of wind turbines electrically connected together and injecting energy into the grid at one point, sometimes known as a “Wind Farm.”

**F. IntraRegional Differences**

None

**G. Notes**

None

**Version History**

Version	Date	Action	Change Tracking
1	March 3, 2011	Effective Date	
1	March 3, 2011	Removed “(Proposed)” from Effective Date section, updated “Approved and Effective Date” in header and footer	
1	November 3, 2011	Adopted by Board of Trustees	

**MOD-025-RFC-01 Attachment 1**  
**Verification of Generator Reactive Power Capability**

A commissioning test shall qualify as an acceptable initial test if the steps below are satisfied. If a unit is restricted from under-excited (leading) operation, then the unit should be verified as close as possible to unity power factor. Under-excited (leading) Reactive Power capability verification is not required of nuclear units.

1. All applicable units shall be verified per the following:
  - 1.1 Units shall be verified with all applicable auxiliary equipment in service required for normal operation.
  - 1.2 If the Reactive Power capability is verified through test, the Generator Owner shall schedule the test with its Transmission Operator. The test shall be scheduled at a time advantageous for the unit being verified to demonstrate its Reactive Power capabilities while the Transmission Operator takes measures to maintain the plant's system bus voltage at the scheduled value or within acceptable tolerance of the scheduled value.
    - 1.2.1 If a verification test is scheduled in year five and cannot be started as determined by the Transmission Operator, the test shall be rescheduled as soon as possible but not to exceed one year from the originally scheduled test date. The five-year verification requirement shall be extended for up to a year for this unit until a successful test can be scheduled and performed.
    - 1.2.2 If a verification test is scheduled in year five and cannot be started because of a Generator Owner issue, the test shall be rescheduled within six months of the resolution of the issue. The five-year verification requirement shall be extended for up to six months following resolution of the issue (total extension equaling issue resolution period plus six months).
    - 1.2.3 If a verification test has been started and cannot be completed due to a transmission system limit or condition, this transmission system limit or condition shall be documented, and engineering analysis taking into account known limitations (as specified in Attachment 1, Section 2.2 for non-wind units) shall be used to determine the verified capabilities.
2. Applicable non-wind units shall be verified per the following:
  - 2.1 Begin the verification at or above the normalized gross verified summer Real Power capability as reported under MOD-024-RFC-01.
  - 2.2 The over-excited (lagging) and under-excited (leading) Reactive Power capabilities (MVAR) shall be verified with reference to the manufacture's generator Reactive Power capability curve (D-curve) with any protection system limitations to the reactive capability superimposed on the D-curve.

- 2.2.1** For hydrogen-cooled generators, the hydrogen pressure should be at the normal operating pressure and shall be documented. If the normal operating hydrogen pressure is not the maximum pressure shown on the appropriate generator Reactive Power capability curves (D-curves), the reason for this condition shall be documented and the appropriate generator Reactive Power capability curve (D-curve) shall be used.
- 2.2.2** For air cooled generators, the inlet air or ambient temperature shall be documented.
- 2.2.3** The reason(s) for any verified Reactive Power capabilities that, due to plant equipment, are more constraining than the appropriate generator Reactive Power capability curve (D-curve) shall be documented. (For example, exciter or generator field current limitations, generator terminal voltage, auxiliary or safety-related bus voltage limitations, volts per Hz alarms, excessive generator vibration, generator temperature limits, hydrogen coolers restrictions, shorted rotor turns, safety, other protection, etc.)
- 2.2.4** The reason(s) for any verified Reactive Power capabilities that, due to operational measures, are more constraining than the appropriate generator Reactive Power capability curve (D-curve) shall be documented. (for example, stability limits, station operating procedures, substation voltage limits, etc.)
- 2.2.5** The scheduled voltage at the system bus or generator terminals shall be documented
- 2.2.6** The generator step-up transformer existing tap setting shall be documented
- 2.3** The over-excited (lagging) Reactive Power capability verification shall be preceded by a minimum one-hour temperature stabilization period during which the average Reactive Power output shall have been maintained within  $\pm 5\%$  of the reported verified capability. The over-excited (lagging) Reactive Power capability shall be recorded after this one-hour period. Data for under-excited (leading) Reactive Power capability verification (or minimum over-excited (lagging) Reactive Power capability per Attachment 1, Section 2.2) shall be recorded as soon as a limit is encountered.

  - 2.3.1** The actual voltages at the system bus and generator terminals shall be recorded.
  - 2.3.2** The Reactive Power load, at the time of each verification, shall be recorded on a simplified key one-line diagram showing all auxiliary Reactive Power loads and resources. This simplified key one-line diagram shall include all existing generator step-up

(GSU) transformers, unit auxiliaries transformers and station service transformers. If metering does not exist, engineering analysis can be used. The Generator Owner shall include Reactive Power consumed by common service equipment (for example, coal-handling or lighting) that shall be prorated among the appropriate units in the plant.

**3** Applicable Wind Generating Stations shall be verified per the following:

**3.1** The operating range (the over-excited (lagging) and under-excited (leading) reactive limits) of Reactive Power capability, exclusive of Reactive Power compensation devices, at each collector station (*i.e.* 34.5 kV bus) of Type 3 (doubly-fed asynchronous) and Type 4 (full converter interface) Wind Generating Stations shall be verified. Wind Generating Stations shall be verified at 50 percent or greater of their verified Real Power capability.

**3.1.1** The mode of normal Wind Generating Station operation, whether automatic voltage regulation control, constant power factor control, or constant VAR control, shall be maintained and documented during the test with allowance for appropriate adjustment of voltage, power factor or VAR set points.

**3.1.2** If the verification test is performed at less than 100 percent of a Wind Generating Station's verified Real Power capability, the range of Reactive Power capability of each collector station with all installed wind turbines running at 100 percent of verified Real Power capability shall be extrapolated from the verified Reactive Power capability range.

**3.1.3** Documentation correlating the range of Reactive Power capability to the Wind Generating Station's Real Power dispatch level shall be available.

**3.2** The following data shall be recorded:

**3.2.1** The actual collector bus voltages

**3.2.2** The scheduled voltage (if applicable) and location (generator terminals, collector bus, etc.).

**3.2.3** The main transformer tap setting

**3.2.4** The Reactive Power load at the time of each verification shall be recorded on a simplified key one-line diagram showing all auxiliary Reactive Power loads and resources. This simplified key one-line diagram shall include the main transformer(s), unit auxiliary transformers and station service transformers. If metering does not exist, engineering analysis can be used. The Generator Owner shall include Reactive Power consumed by common service equipment (for example, lighting) that shall be

prorated among the appropriate units in the Wind Generating Station.

**MOD-025-RFC-01 Appendix A**  
**Gross and Net Reactive Capability Verification Data Form**

NOTE: If the data form is not suitable for the Generator Owner, Transmission Planner, Transmission Operator, Reliability Coordinator or Planning Coordinator a modified data form can be used, in accordance with a predetermined agreed upon format, consisting of the information listed in the data form and specified within the requirements.

Company \_\_\_\_\_ Reported By (name) \_\_\_\_\_

Plant \_\_\_\_\_ Unit No \_\_\_\_\_

Unit Type:       Nuclear                       Blackstart Resource       Non-Nuclear

**Stabilization Periods:**

The over-excited (lagging) Reactive Power capability verification shall be preceded by a minimum one hour temperature stabilization period during which the average Reactive Power output shall have been maintained within  $\pm 5\%$  of the reported verified capability.

Data for under-excited (leading) Reactive Power capability verification (or minimum over-excited (lagging) Reactive Power capability per Attachment 1, Section 2) shall be recorded as soon as a limit is encountered.

	<u>Gross (MW)</u>	<u>Gross Capability (MVAR)</u>	<u>Aux Power*** (MVAR)</u>	<u>Low Side Net Capability (MVAR)</u>	<u>Actual Terminal Voltage (kV)</u>	<u>Actual Substation Bus Voltage (kV)</u>	<u>Scheduled Substation or Terminal Voltage (kV)</u>	<u>Date and time</u>	<u>H2 Pressure (PSIG), Inlet Air or Ambient Temperature</u>
<b>Over- Excited*</b>									
<b>Minimum Over Excited*</b>									
<b>Under- Excited*++</b>									

\*Verifications can be performed at different dates and times

++ Applicable for under-excited (leading) test only

\*\*\* Total Reactive aux Power specified in Appendix B

GSU Tap Setting: \_\_\_\_\_

Summary of Verification

Prior verified net Reactive Power capability: \_\_\_\_\_ MVAR (over-excited)  
 \_\_\_\_\_ MVAR (minimum over- excited)  
 \_\_\_\_\_ MVAR (under-excited)

Reasons for not meeting generator Reactive Power capability curve (D-curve), if any:

\_\_\_\_\_

\_\_\_\_\_

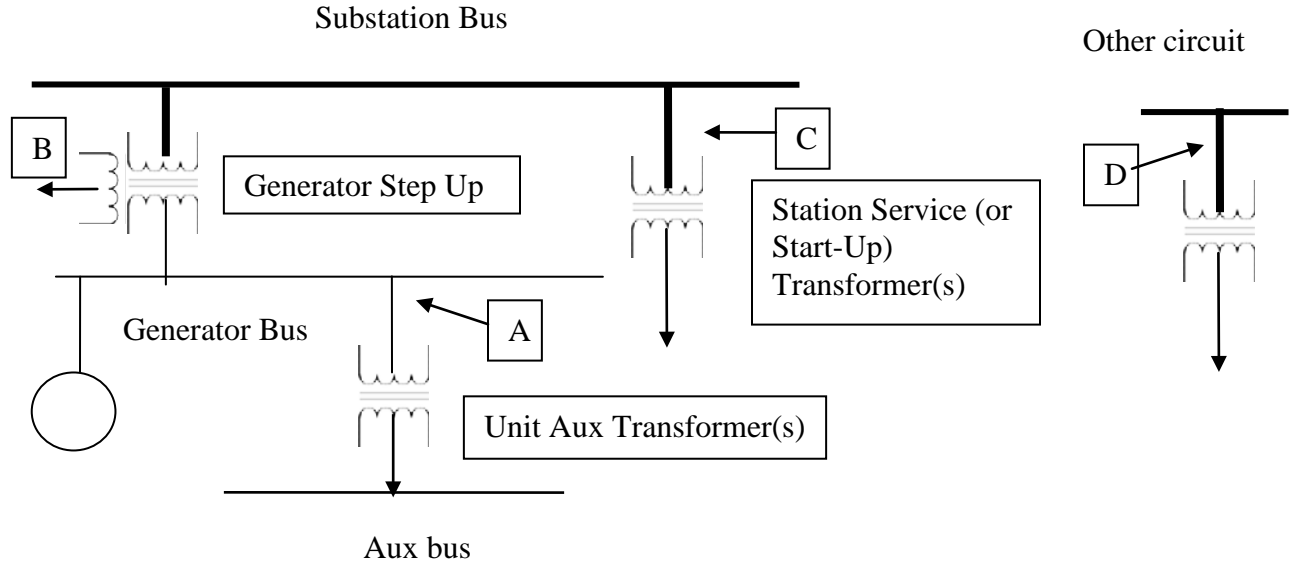
Remarks:

\_\_\_\_\_

\_\_\_\_\_

**MOD-025-RFC-01 Appendix B  
Key One-Line Diagram Data Form**

NOTE: If the data form is not suitable for the Generator Owner, Transmission Planner, Transmission Operator, Reliability Coordinator or Planning Coordinator a modified data form can be used, in accordance with a predetermined agreed upon format, consisting of the information listed in the data form and specified within the requirements.



- A: \_\_\_\_ kV \_\_\_\_ MVAR (multiple Aux Transformers should be summed)  
 Metered       Calculated
- B: \_\_\_\_ kV \_\_\_\_ MVAR (tertiary load, if any)  
 Metered       Calculated
- C: \_\_\_\_ kV \_\_\_\_ MVAR (multiple Station Service Transformers should be summed)  
 Metered       Calculated
- D: \_\_\_\_ kV \_\_\_\_ MVAR (locations must be described so that they can be modeled)(multiple locations should be individually reported)  
 Metered       Calculated

Total aux Power: \_\_\_\_\_ MVAR (A + B + C +D)

All values need not be filled in. More complicated auxiliary load systems may require specialized diagrams.

Plant common service load should be distributed among the units and summed into the values listed above.

**MOD-025-RFC-01 Appendix C**  
**Gross and Net Reactive Capability Verification Data Form**  
**for a Wind Generating Station**

NOTE: If the data form is not suitable for the Generator Owner, Transmission Planner, Transmission Operator, Reliability Coordinator or Planning Coordinator a modified data form can be used, in accordance with a predetermined agreed upon format, consisting of the information listed in the data form and specified within the requirements

NOTE: A Wind Generating Station can be made up of multiple turbine groups. All turbines within any one turbine group should be identical, in one control mode and Reactive Power resource capability is controlled by one master controller.

Company: \_\_\_\_\_ Reported By (name): \_\_\_\_\_  
 Plant name: \_\_\_\_\_

Turbine groups (this section can be repeated)

Turbine group identifier: \_\_\_\_\_  
 Number of turbines: \_\_\_\_\_ Capability of an individual turbine (MW): \_\_\_\_\_

Total Wind Generating Station capability (MW): \_\_\_\_\_

Unit Type:  Type 3     Type 4     Other (please explain) \_\_\_\_\_

Control mode (Attachment 1, Section 3.1.1):  Automatic Voltage Regulation     Constant Power Factor  
 Constant VAR Control     Other (please explain) \_\_\_\_\_

NOTE: Wind Generating Stations shall be verified at 50 % or greater of their verified Real Power capability.

	<u>Gross (MW)</u>	<u>Gross Capability (MVAR)</u>	<u>Aux Power*** (MVAR)</u>	<u>34.5 kV Collector Bus Net Capability (MVAR)</u>	<u>34.5 kV Collector Bus Voltage (kV)</u>	<u>Transmission Station Voltage (kV)</u>	<u>Voltage Schedule (if any) and Location (kV)</u>	<u>Date and Time</u>	<u>Supplemental Reactive Output/Compensation (MVAR)</u>
Over-Excited*									
Under-Excited*									

\*Verifications can be performed at different dates and times  
 \*\*\* Total Reactive aux Power specified in Appendix D

Main transformer tap setting: \_\_\_\_\_

Extrapolation of Verification

Net Reactive Power capability at 100 percent Real Power output  
 \_\_\_\_\_ MVAR (over-excited)  
 \_\_\_\_\_ MVAR (under-excited)

As per Attachment 1, Section 3; documentation correlating the range of Reactive Power capability to the Wind Generating Station’s Real Power dispatch level shall be submitted with this form.

Describe additional Reactive Power resources and their use, if any:

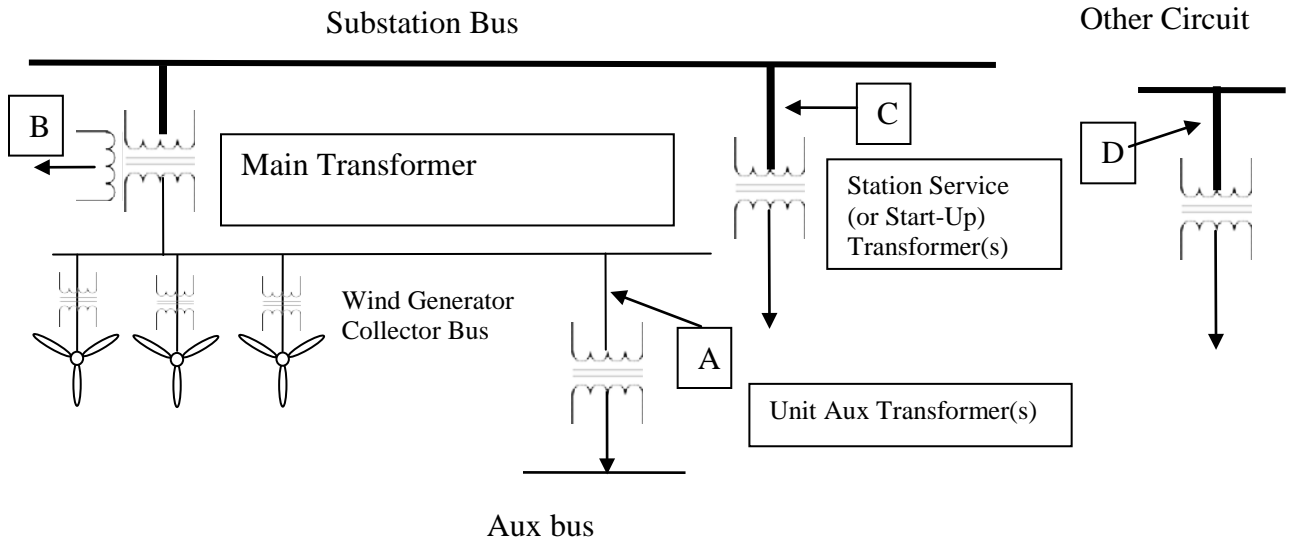
\_\_\_\_\_

Remarks:

\_\_\_\_\_

**MOD-025-RFC-01 Appendix D**  
**Key One-Line Diagram Data Form for Wind Generating Station**

NOTE: If the data form is not suitable for the Generator Owner, Transmission Planner, Transmission Operator, Reliability Coordinator or Planning Coordinator, the Generator Owner may submit a modified data form, in accordance with a predetermined agreed upon format, consisting of the information listed in the data form and specified within the requirements



- A: \_\_\_\_ kV \_\_\_\_ MVAR (multiple auxiliary transformers should be summed)  
 Metered       Calculated
- B: \_\_\_\_ kV \_\_\_\_ MVAR (tertiary load, if any)  
 Metered       Calculated
- C: \_\_\_\_ kV \_\_\_\_ MVAR (multiple Station Service Transformers should be summed)  
 Metered       Calculated
- D: \_\_\_\_ kV \_\_\_\_ MVAR (locations must be described so that they can be modeled)  
 (multiple locations should be individually reported)  
 Metered       Calculated

Total aux Power: \_\_\_\_\_ MVAR (A + B + C + D)

Only those values that apply to the particular application are required to be filled in. More complicated auxiliary load systems may require specialized diagrams. Wind Generating Plants with multiple collector buses may require duplication of this diagram.

Plant common service load should be distributed among the units and summed into the values listed above.