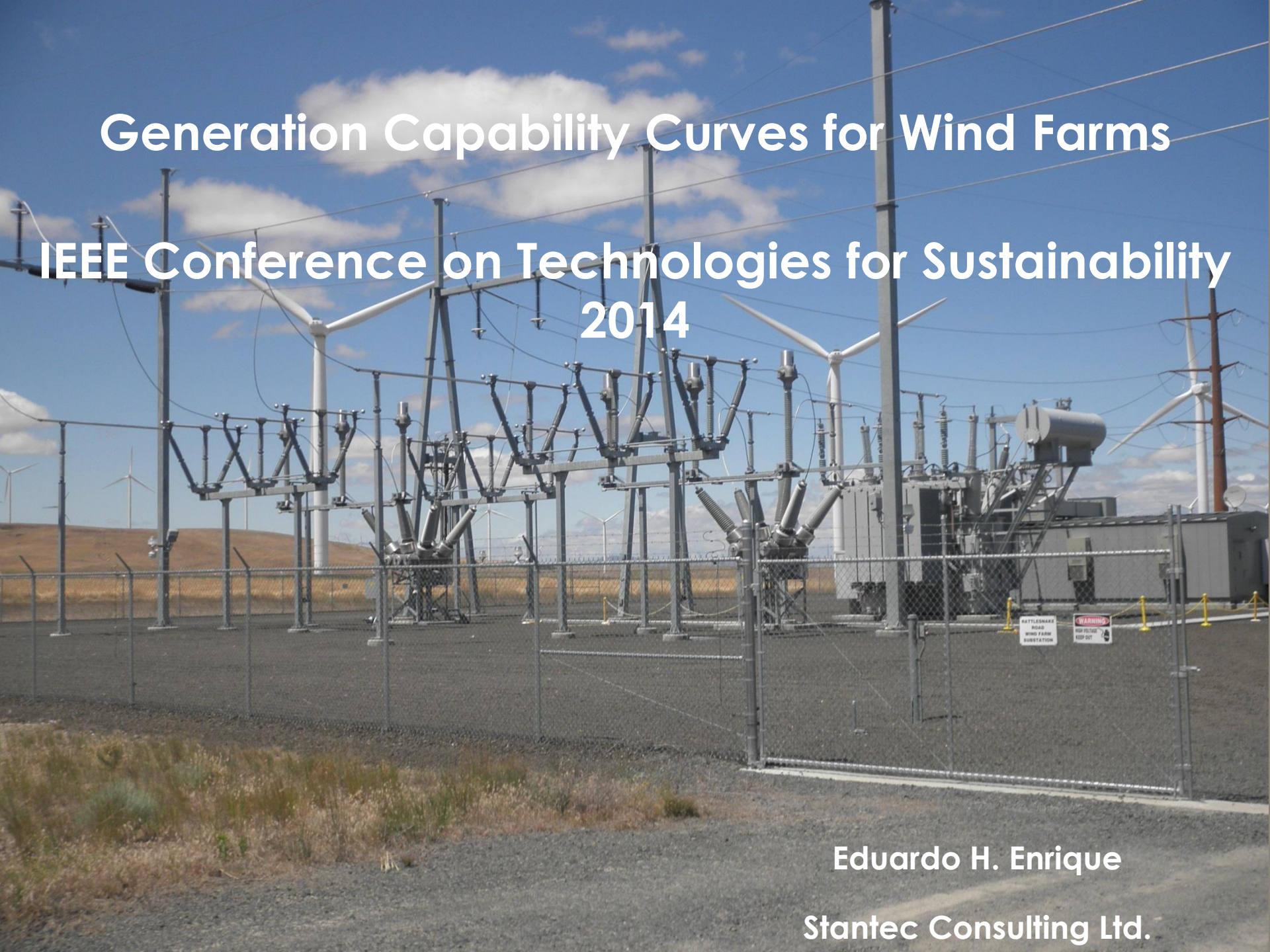
Generation Capability Curves for Wind Farms

IEEE Conference on Technologies for Sustainability 2014



Eduardo H. Enrique

Stantec Consulting Ltd.

Objective of this presentation

VERIFY COMPLIANCE WITH THE REQUIREMENTS FROM THE UTILITY AT THE POINT OF COMMON COUPLING:

REACTIVE POWER EQUAL TO ± "Q" (MVAr) AT ALL "P" (MW)

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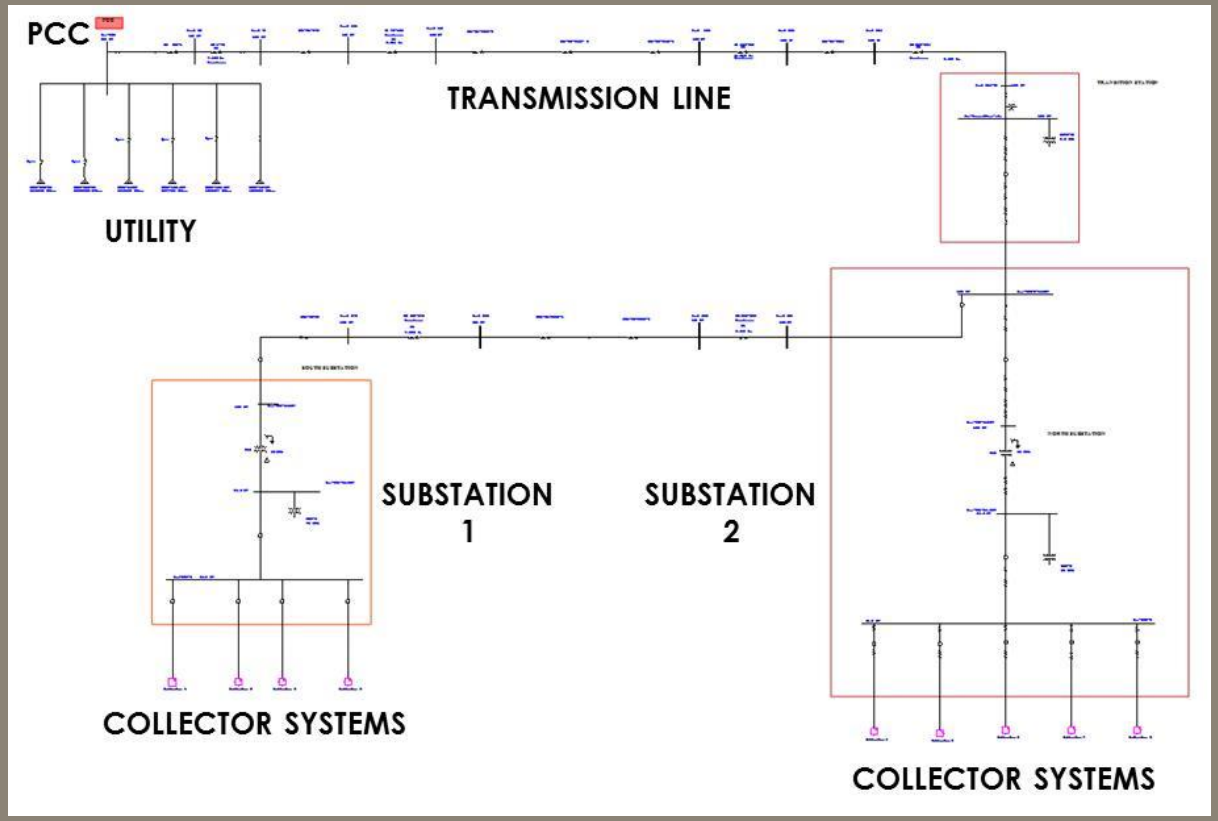
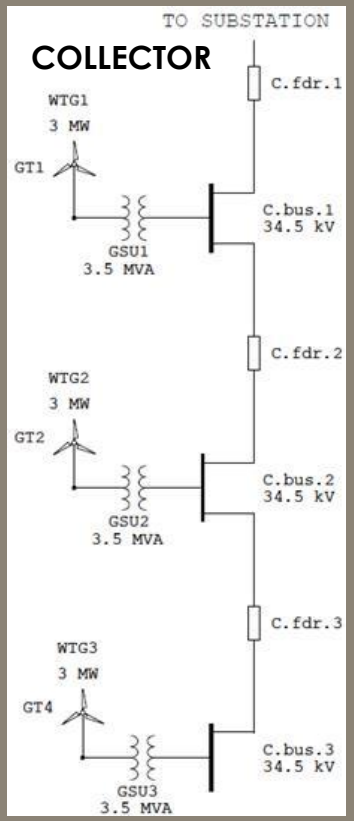
Objective of this presentation





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Agenda

1 Wind turbines performance

2 Collector system components

3 Wind farm load flow

4 Summary

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1 Wind turbines performance

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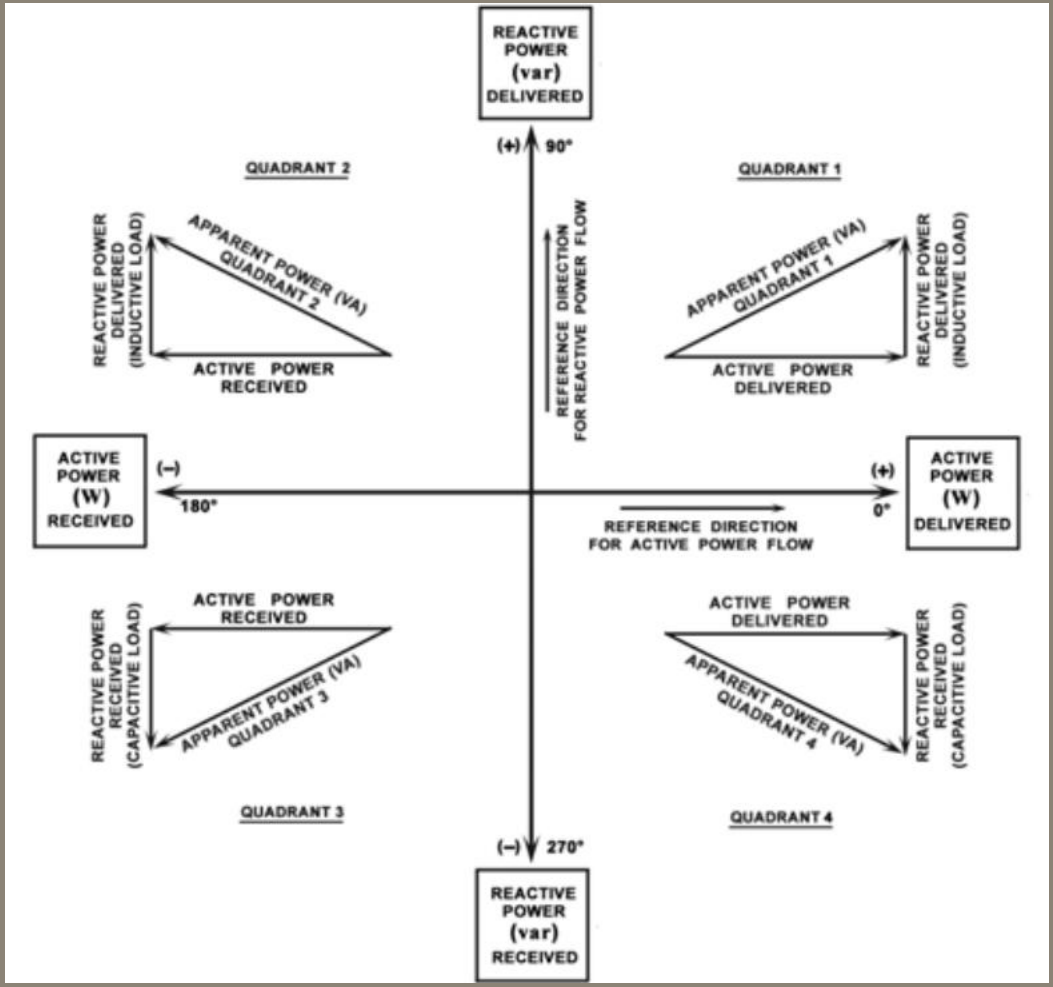

ACTIVE POWER P AND REACTIVE POWER Q SIGN CONVENTIONS PER IEEE 1459

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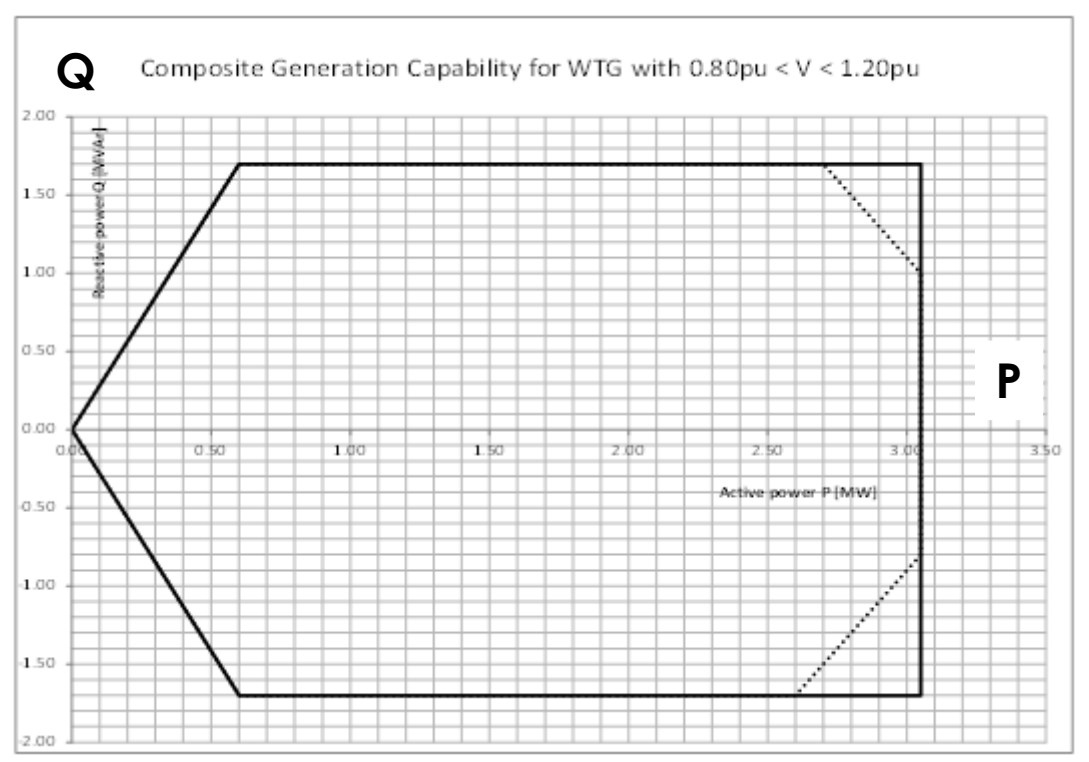
1 Wind turbines performance



TYPE 4 WIND TURBINE P-Q DIAGRAM

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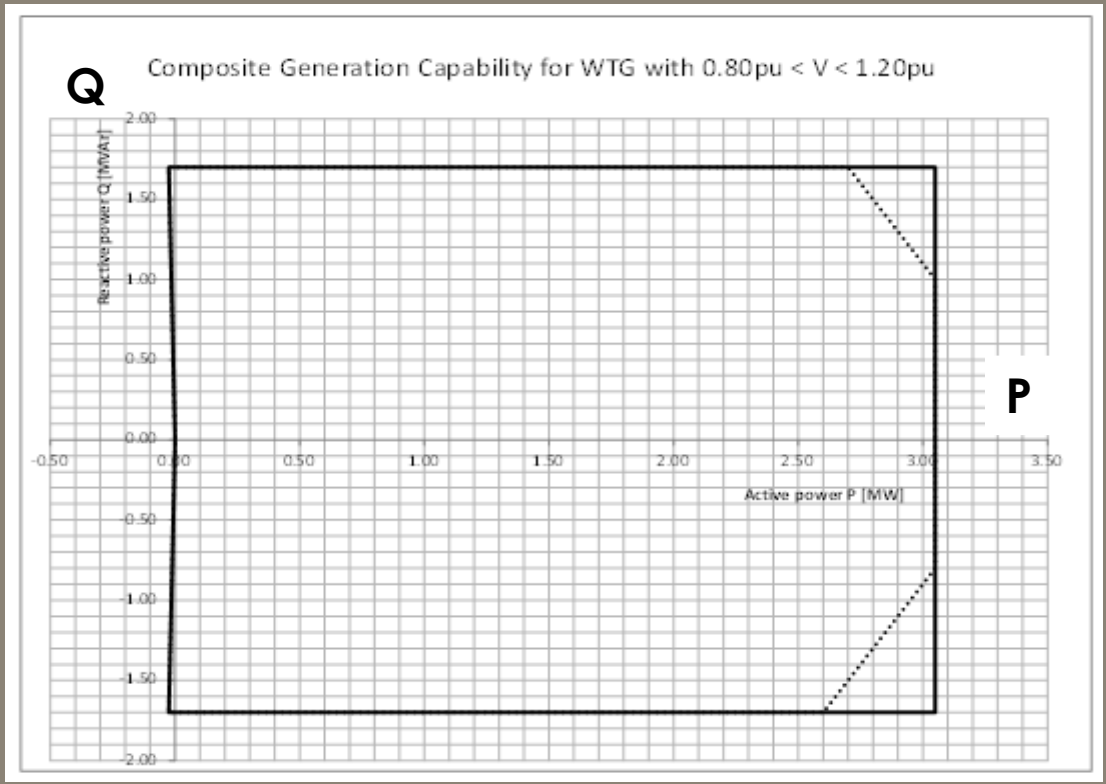
1 Wind turbines performance



TYPE 4 WIND TURBINE P-Q DIAGRAM WITH STATCOM CAPABILITIES

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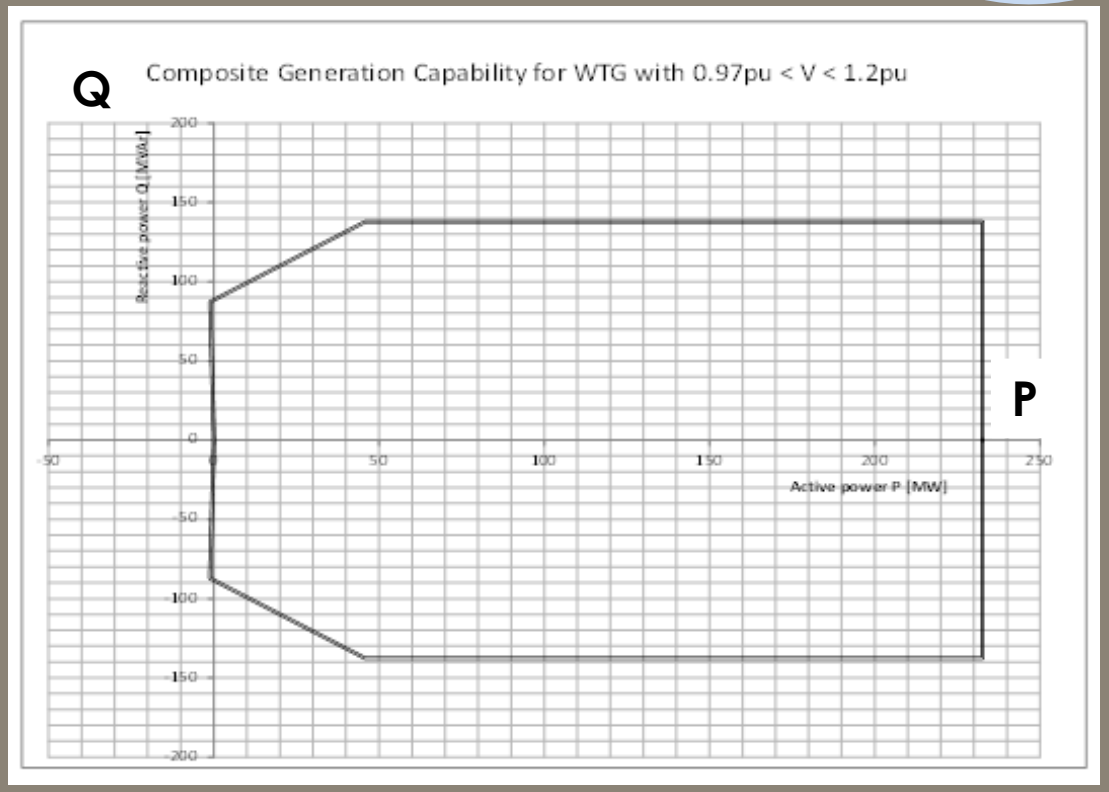
1 Wind turbines performance



WIND FARM TURBINES AGGREGATE P-Q DIAGRAM

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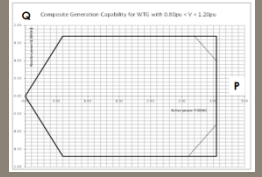
1 Wind turbines performance



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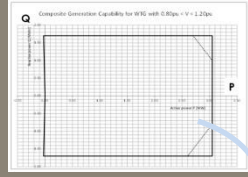

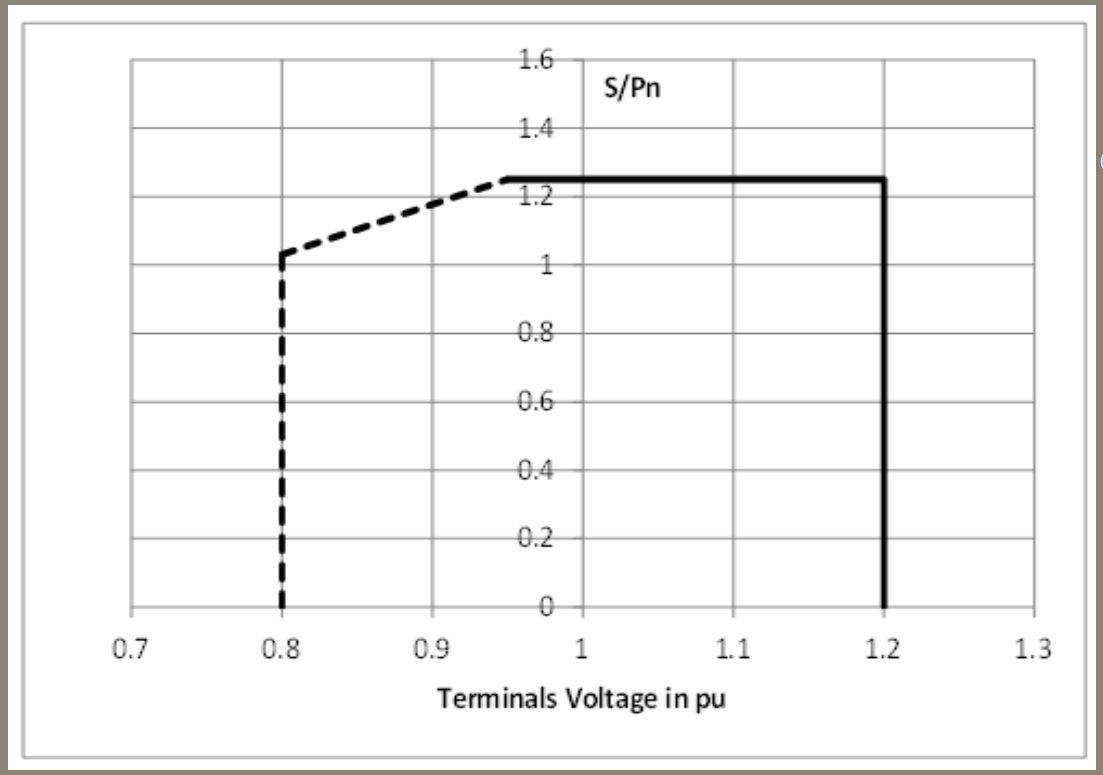

TYPE 4 WIND TURBINE POWER-VOLTAGE (P-V) OUTPUT

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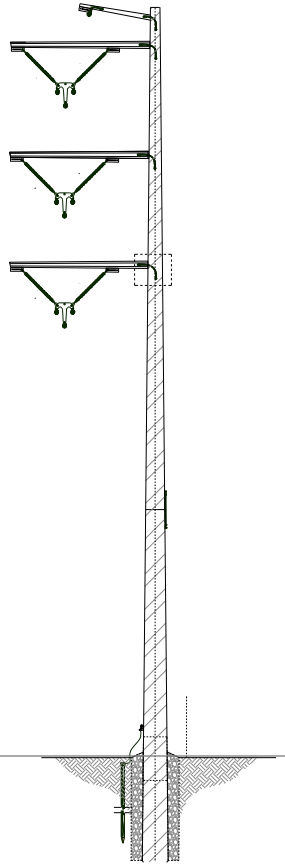
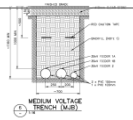
2 Collector system components

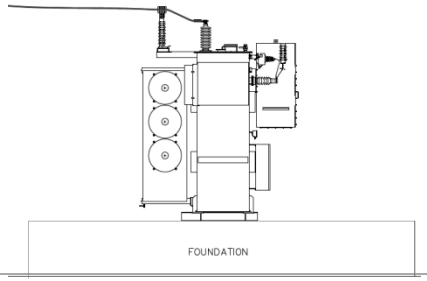
2 Collector system components



TRANSMISSION LINES



UNDERGROUND CABLES



TRANSFORMERS

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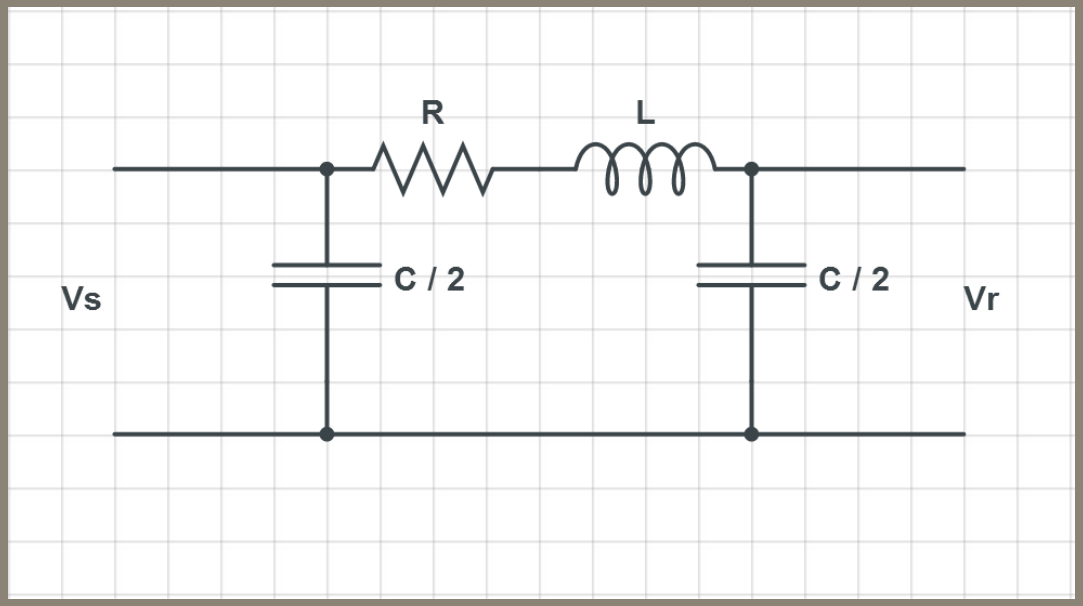
2 Collector system components



APPROXIMATED EQUIVALENT MODEL OF A TRANSMISSION LINE AND UNDERGROUND CABLE

$$Q_L \sim I^2 \; x_L$$

$$Q_C \sim V_r^2 \; / \; x_C$$

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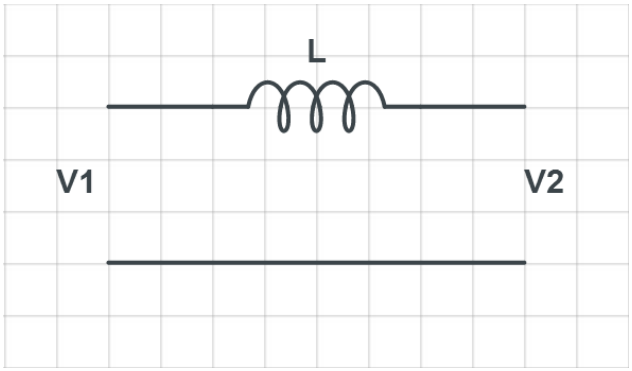
2 Collector system components



APPROXIMATED EQUIVALENT MODEL OF A TRANSFORMER

$$Q_L \sim I^2 \; x_L$$

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3 Wind farm load flow

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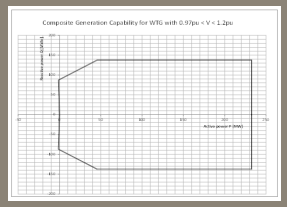
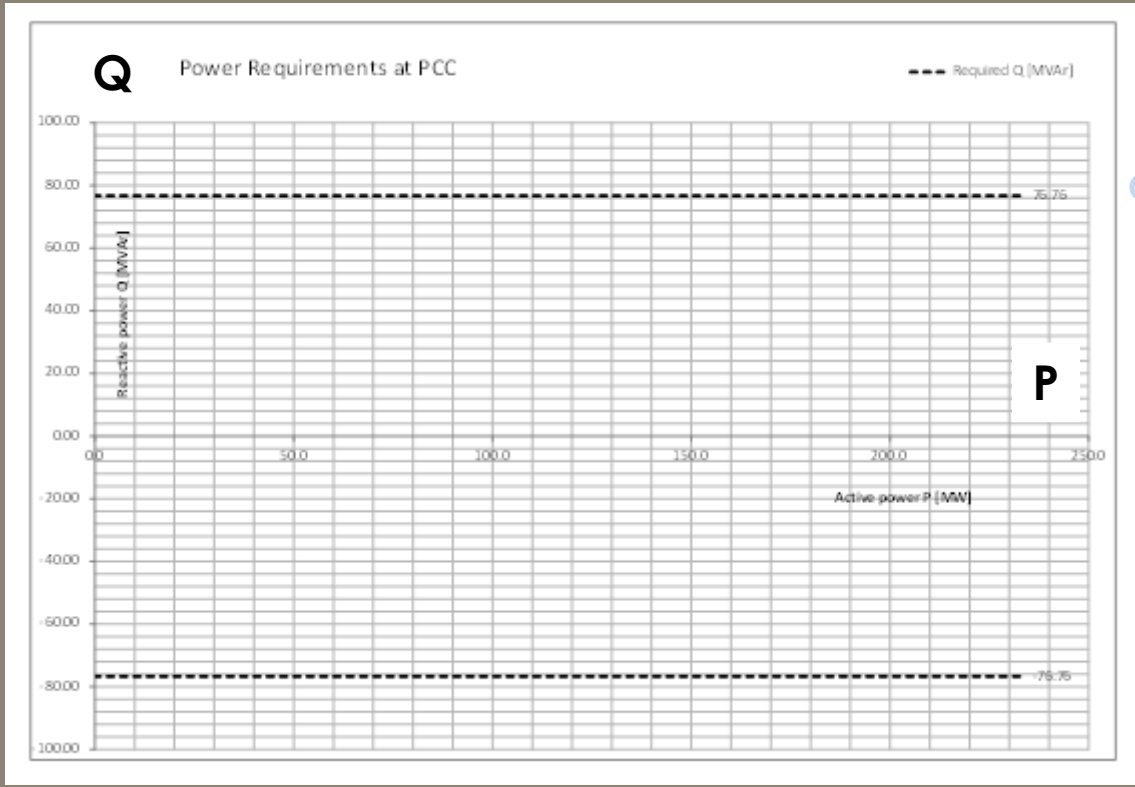
3 Wind farm load flow





UTILITY REQUIREMENTS OF REACTIVE POWER AT THE PCC

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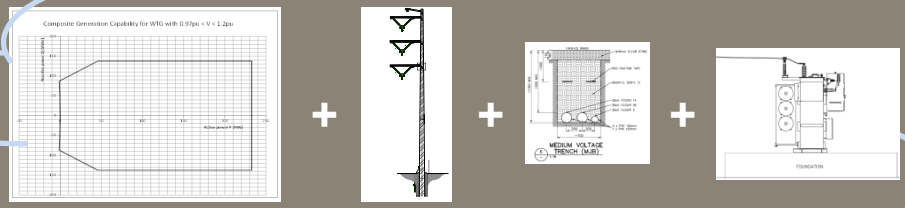
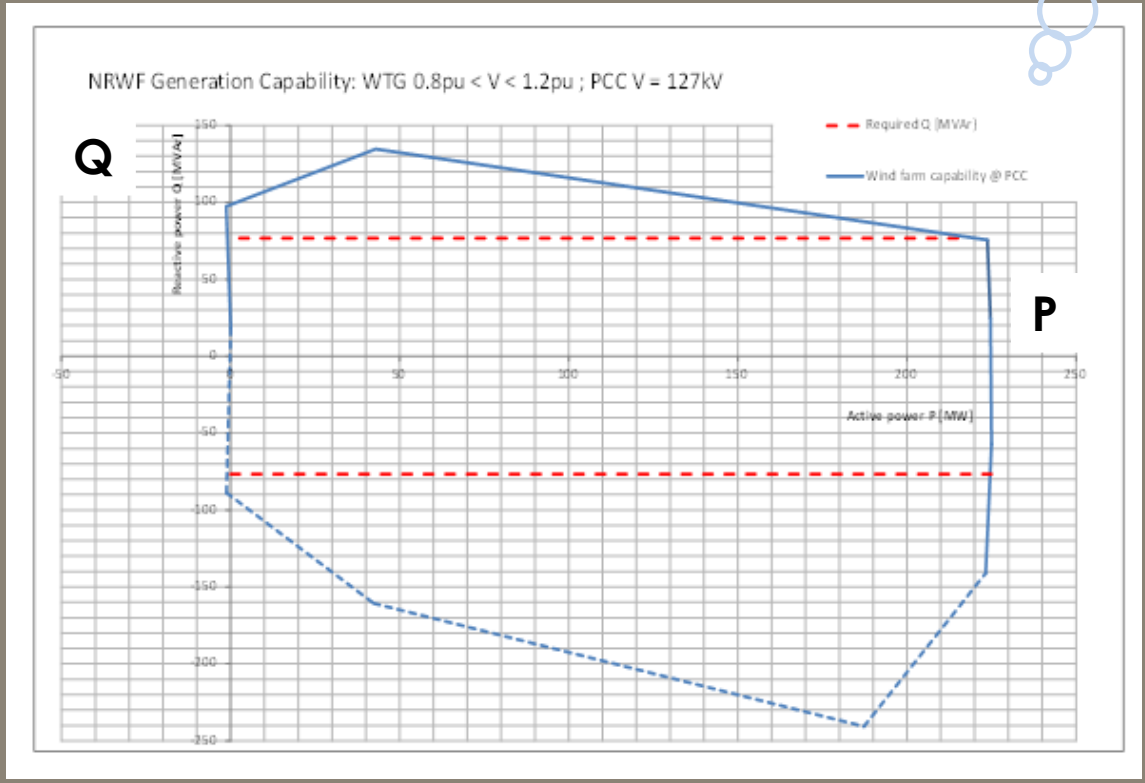
3 Wind farm load flow





WIND FARM GENERATION CAPABILITY CURVE FOR MINIMUM VOLTAGE AT THE PCC

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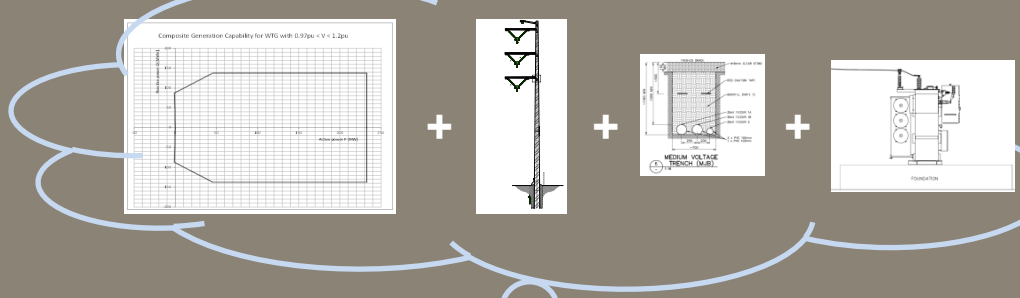
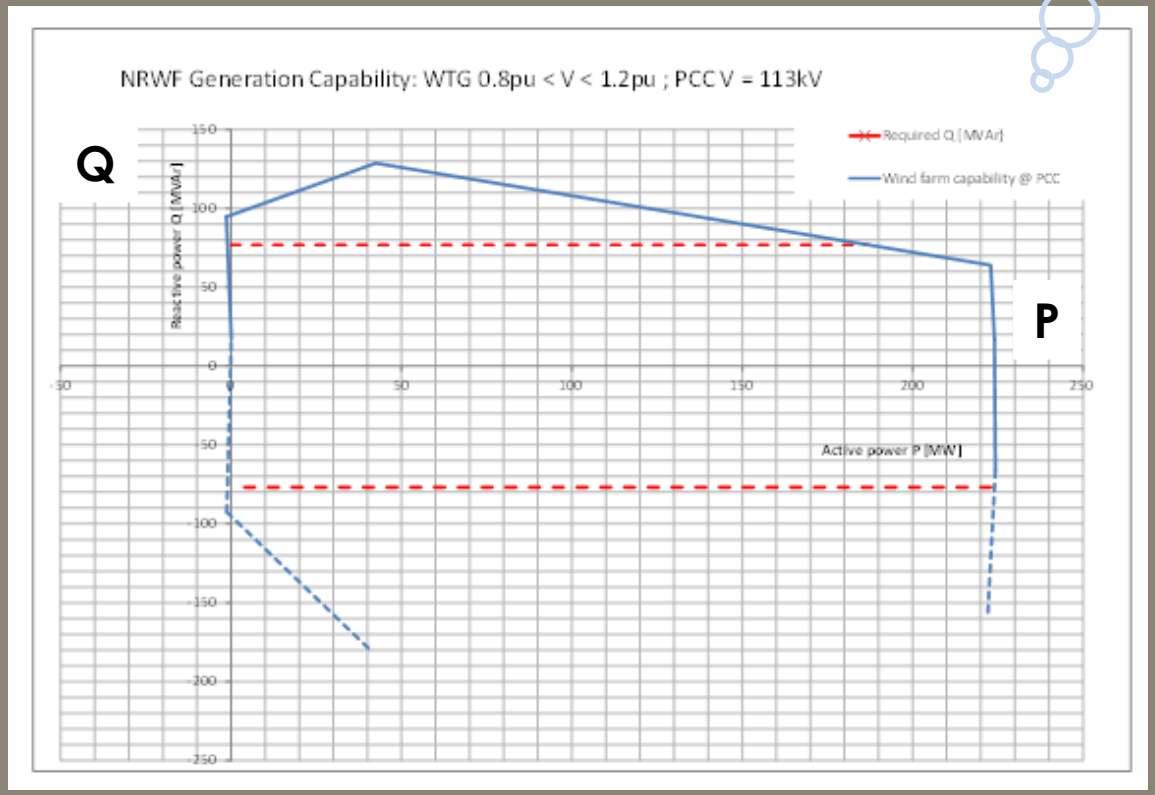
3 Wind farm load flow





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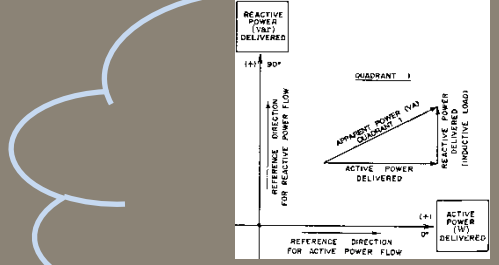
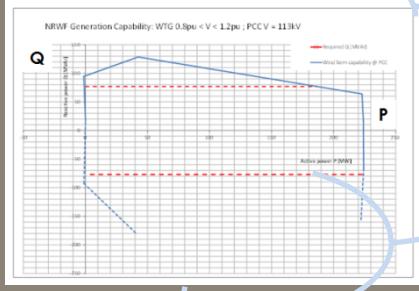
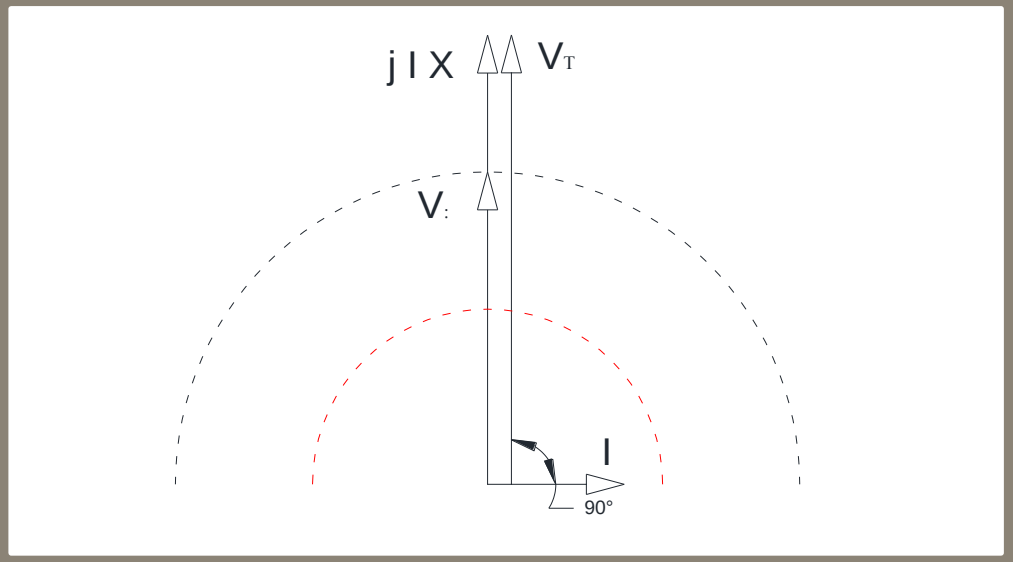
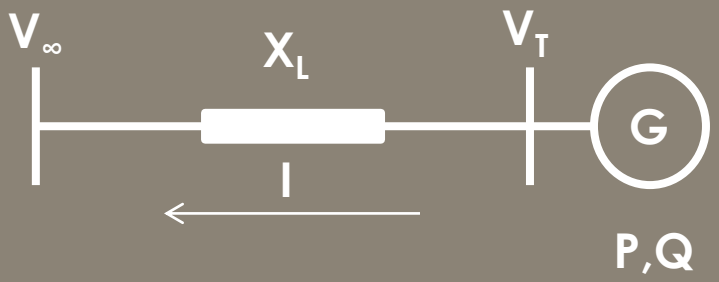




REFERENCE CAPABILITY CURVE



VOLTAGE LIMITATIONS ON THE P-Q DIAGRAM
P = 0MW, Q ≠ 0MVAr



ONE-LINE EQUIVALENT MODEL OF THE WIND FARM

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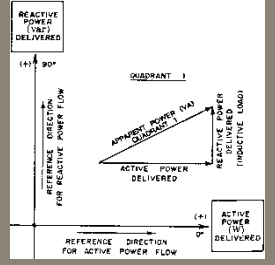
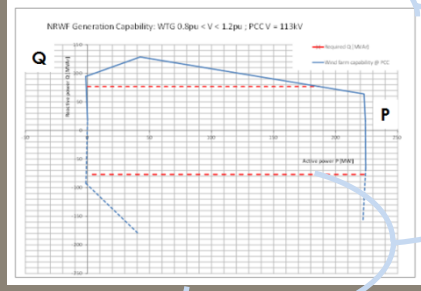
3 Wind farm load flow





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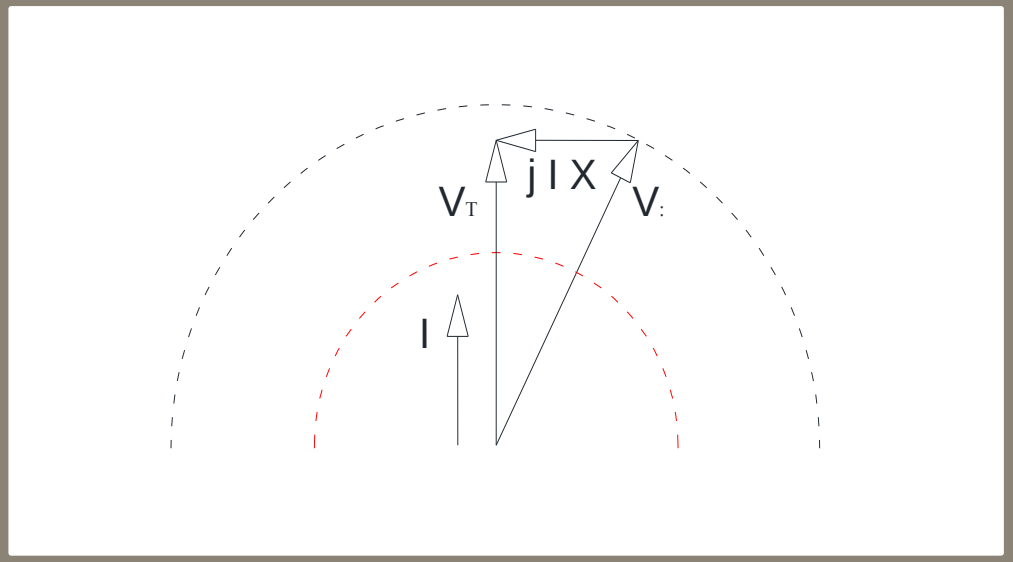
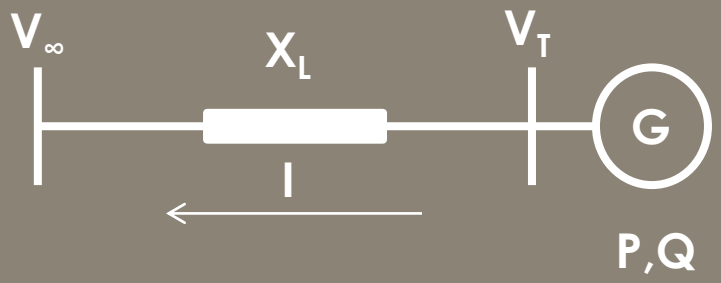


VOLTAGE LIMITATIONS ON THE P-Q DIAGRAM
P ≠ 0MW, Q = 0MVAr



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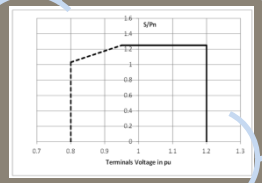

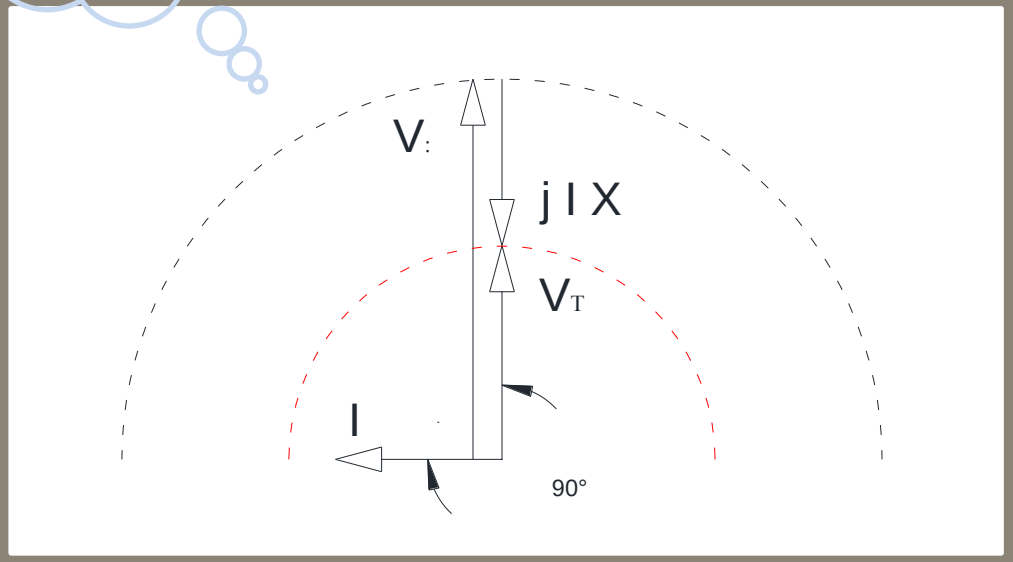

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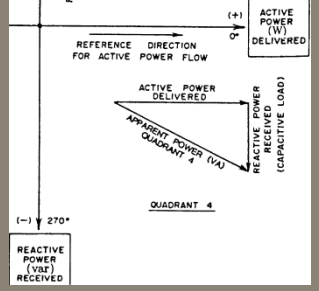
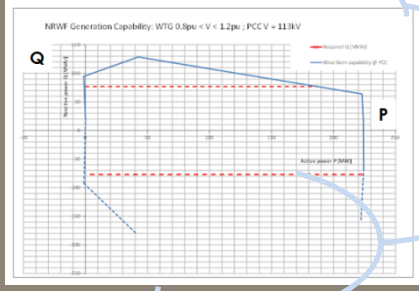
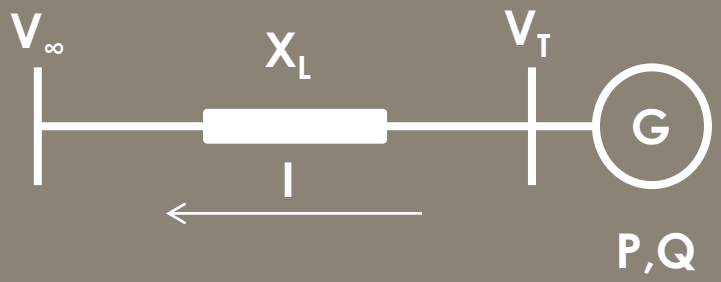




REFERENCE CAPABILITY CURVE



ONE-LINE EQUIVALENT MODEL OF THE WIND FARM

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4 Summary

1. The capability curves are an effective tool to evaluate compliance with the requirements of the utility at the PCC

2. These curves provide a view of the effects of the electrical components in the collector system and substation

3. The need for additional reactive power can be visualized without having to resolve the system load flow each time

4. They show the limitations of the wind farm in the event of changing conditions in the transmission system.

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Questions?

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