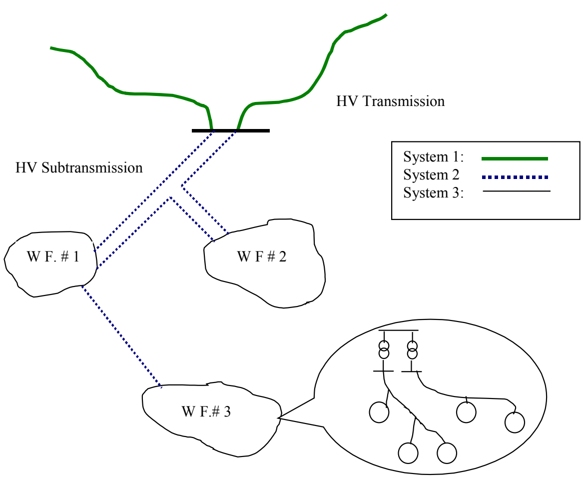
Wind Farm Electrical Design

In addition to the highly technical services relating to the electrical interconnection of a wind farm to the utility grid, ABB's consulting business unit can offer technical expertise for the design of the wind farm electrical collector system. Our team brings together a unique combination of skills and expertise that can help wind energy companies in performing the following two groups of analyses:

I) Optimal design of the subtransmission electrical system to connect several wind farms in the same area before the final interconnection with the transmission grid.
II) Optimal design of the wind farm collector system.

I) Optimal design of the subtransmission electrical system

Consider the case where several wind farms are connected at the distribution or subtransmission level, prior to being connected at a common interconnection point in the existing transmission grid. An example is shown in the figure below.

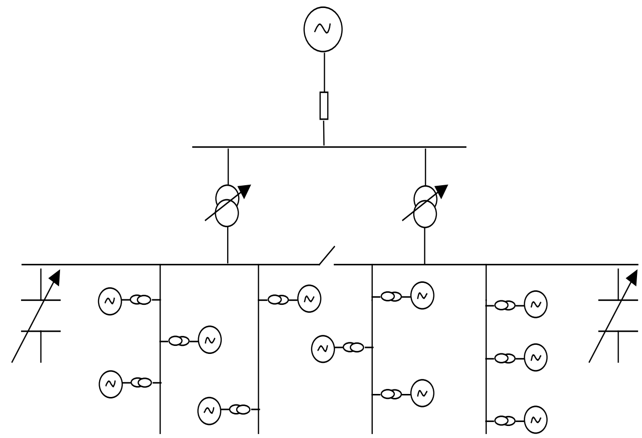


There are different subtransmission alternatives to connect the wind farms. The optimal choice is the one that fulfills all the technical requirements at the lowest cost.

The studies that ABB performs to define this system include:

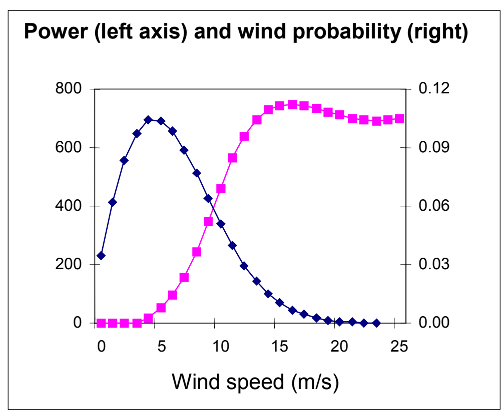
- Feasible topological layouts. In case of different alternatives, the optimal layout is chosen.
- Feasible voltage level system. Usually high voltage levels are chosen (66, 132 or 220 kV).
- Conductor sizes (after load flow, losses and voltage drop studies).
- Reliability studies related to two variables:
  - Reliability level required by the investor in the wind farm(s).
  - Reliability level required by the ISO.
- Economic studies that select the cheapest alternative when combining the different options of the last four points.

II) Optimal design of the wind farm collector system



All the studies of the collector system are performed taking into account both the **generator power curve** (kW versus wind speed) and the **wind-probability curve** (# of hours/year expected for every wind speed).

The following figure shows an example of these curves for a typical wind farm. The x-axis indicates the wind speed. The left and right y-axes indicate the kW generated by a single turbine (pink curve with squares) and the expected number of hours per wind speed in per unit (blue curve with diamonds), respectively.



a) Sizing of the medium and low voltage cables, switch gear and breakers.

The objective of this analysis is to define the optimal selection of the medium voltage cables that minimize the economical investment while fulfilling the technical constraints (thermal capability and short circuit capability). In addition, the medium and low voltage switch gear and breakers are designed.

b) Design of the medium voltage neutral system.

Key aspects in this analysis are:

- Consideration of the neutral system of the network the wind farm is going to connect to.

- Detection capability of single-line to ground faults within the wind farm.
- Avoiding as much as possible overvoltages when clearing such faults.
- Avoiding stator damage when experiencing single-line to ground faults within the wind farm.

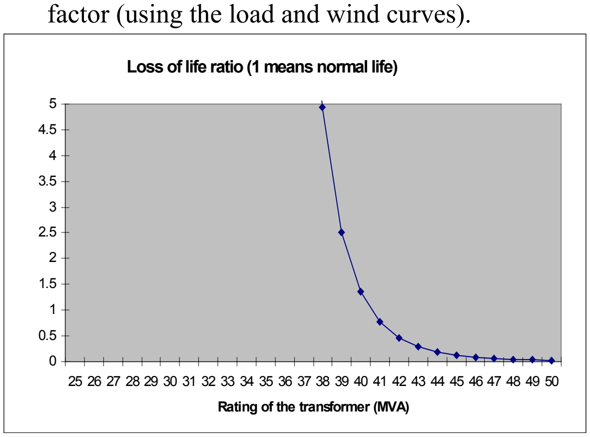
Possible solutions depending on the substation transformer winding configuration are:

- Use of grounding resistors on the neutral of the transformers.
- Connection of a three phase reactance when the transformer has a delta connection at the medium voltage side.
- Combination of the two solutions.

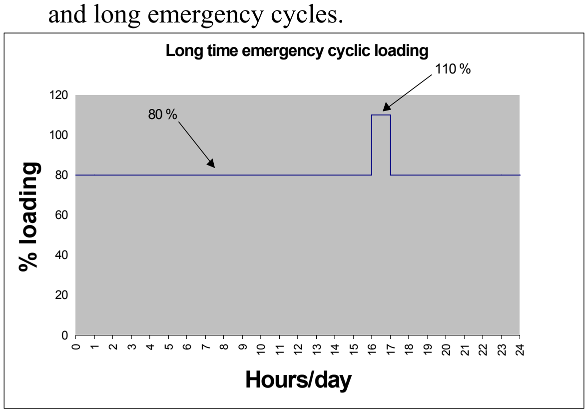
c) Specification of the substation transformer(s) of the wind farm.

- **Rating**: Since the typical operating condition of a wind farm is significantly lower than its peak load capability, the main substation transformer(s) may be selected accordingly with due consideration to relative loss of life. This means considerable cost savings by selecting the optimum transformer size. The following issues are taken into account when computing the optimal rating (both OA and FA/FOA ratings):

  - Relative loss of life based on the different load factors and number of hours per year of each load factor (using the load and wind curves).



  - Limitation of the hot spot temperature under short and long emergency cycles.



- **LTC range**: A voltage regulation system (LTC) is usually recommended at the main substation. ABB defines the range of the LTC taking into account the different load scenarios and the different voltage conditions of the external grid.

d) Design of the reactive compensating system.

The goal is to reduce the investment in capacitor banks and to define the number and connection of the different kVAR steps (depending on the load factor) that optimize the power factor in the interconnection with the utility grid. Once again power and wind curves are utilized for these studies.

e) Calculation and impact of the losses of the collector system design.

- Many wind farm developers limit the percentage of losses they can allow in their wind farm electrical system. Having higher percentage of losses may risk the return of investment.
- ABB calculates the percentage of losses relative to the overall energy produced per year. Different load scenarios and expected number of hours per year for each of them are utilized to compute the percentage of losses.
- This criterion can lead to designing higher sizes for the medium voltage cables than the sizes determined according to load flow and short-circuit criteria.

f) **Design of the grounding system of the wind farm.**

ABB designs the grounding of the substation as well as the grounds under the turbines. It also analyzes whether the different grounds should be connected or not, in order to keep the step and contact voltages within limits when experiencing single-line to ground faults at the main substation.

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