All ENERCON wind energy converters are designed and certified according to the latest international standards. Currently the basis for design are the internationally acknowledged IEC standards of the IEC-61400 series.

This implies several assumptions and conditions that are used to define the load cases which the wind turbine has to survive. In the following, the main design conditions are listed. For details it is hereby referred to the original IEC standards.

The safety system of the ENERCON wind turbines features various control sensors that protect the turbine and its components from damage. This includes - among other things - high and low temperatures, vibrations and oscillations, strain etc. In the case that one or more of these sensors detect conditions outside the design limits, the main control of the turbine will take the appropriate measures which range from small power limitations to complete stop of the turbine.

In case it is planned to install the turbines in complex terrain (included but not limited to steep hills, mountains, ridges, sites at more than 1000m above sea level, etc.), it is highly recommended to consult with ENERCON at an early stage of the project in order to carry out a detailed assessment of the site.

For sites with environmental conditions outside of the design conditions, ENERCON cannot be held responsible for any defects, including but not limited to damages and/or loss of energy yield.

IEC Design conditions: Wind classes

Wind turbine classes are defined in terms of wind speed and turbulence parameters. In case of the standard wind turbine classes, the mean value of the wind speed over a time period of 10 min is assumed to be **Rayleigh distributed** for the purposes of design load calculations.

The **E-70 E4** (turbine and 63m wind class I steel tower) is designed for sites with **IEC class IA** wind characteristics:

1. **Extreme wind speed (3 sec-average) in hub height** $v_E = 70.0$ m/s
2. **Extreme wind speed (10-min average) in hub height** $v = 50.0$ m/s
3. **Annual average wind speed and turbulence intensity**

The operational loads of wind energy converters depend on the combination of annual average wind speed and average turbulence intensity at the site. The E-70 E4 has been designed for

$v_m = 10$ m/s
(annual average wind speed in hub height)

with constant **turbulence intensity of 18%** at v = 15 m/s
(according to IEC turbulence class A)

For IEC wind class II sites, other towers are available (57m, 63m, 69m, 84m, 97m, 98m, 112m) which are designed and certified according to **IEC class IIA** with the following wind characteristics:

1. **Extreme wind speed (3 sec-average) in hub height** **v_E = 59.5 m/s**
2. **Extreme wind speed (10-min average) in hub height** **v = 42.5 m/s**
3. **Annual average wind speed and turbulence intensity**

v_m = 8,5 m/s
(annual average wind speed in hub height)

with constant **turbulence intensity of 18%** at v = 15 m/s
(according to IEC turbulence class A)

For the load calculations the following has been assumed:

- **safety factor** on the loads of **SF = 1.35** (normal and extreme loads)
- **inclination of mean flow** with respect to the horizontal plane of up to **8°** (invariant with height)
- **symmetrical icing** on all blades (see below)

<u>IEC Design conditions: Other environmental conditions</u>

According to IEC among others the following environmental conditions are taken into account for the design of the wind turbines:

- **normal system operation ambient temperature range** of **–10°C to +40°C**
- **extreme temperature range** of **–20°C to +50°C**
- **relative humidity** of up to **95%**
- **atmospheric content** equivalent to that of a **non-polluted inland atmosphere**
- **solar radiation intensity** of **1000 W/m^2**
- **air density** of **1.225 kg/m^3**

<u>Other Design conditions</u>

In order to protect the wind turbine from damages, ENERCON standard turbines are operated according to the following scheme (not taking into account power losses due to changes of aerodynamic behavior when icing occurs on the blades):

T = ambient temperature

T > -15°C	normal operation P_{max} = 100% P_{rated}
-15°C > T > -20°C	linear decrease with temperature of P_{max} from 100% P_{rated} at -15°C down to 25% P_{rated} at -20°C
-20°C > T > -25°C	linear decrease with temperature of P_{max} from 25% P_{rated} at -20°C down to 5% P_{rated} at -25°C
T < -25°C	operation with maximum 5% rated power

Below -25°C the turbine continues to operate with maximum 5% rated power in order to keep the rotating components moving and the turbine at a moderate temperature level.

Given this operational characteristics, the survival temperature for a standard E-70 is – 40°C.

For sites with lower temperature characteristics special material can be used for certain decisive turbine components which then will allow normal operation down to -30°C. A similar operational scheme as shown above will then be used for temperatures below -30°C.

According to the GL standard a “cold climate site” which will call for special requirements for the wind turbines is defined as follows:

Minimum temperatures of below -20°C have been observed during long term measurements (preferably ten years or more) on an average of more than nine days a year. The nine-day criteria is fulfilled, if the temperature at the site remains below -20°C for one hour or more on the respective days.

For sites with lower extreme temperatures, different materials will have to be used for various turbine components including but not limited to lubrication and steel material.

Icing on the blades:
The IEC standard requires that symmetrical icing (i.e. the same amount on each blade) has to be taken into account, but does not say how. Therefore ENERCON is calculating the ice loads as described in the GL standard:

The ice accumulates on the leading edge of the blades. There is zero ice at the blade root, the ice thickness increases linearly up to a value of µ at the middle of the blade and then remains constant up to the blade tip.

Unsymmetrical icing (different ice mass on the three blades) does not have to be taken into account, because the ENERCON turbines have a sensor for imbalance that will prevent the turbine from operation with unsymmetrical ice (imbalance of the rotor).

Wind farm layout (Micrositing)

Loading of wind turbines in a wind farm is determined by the above mentioned external wind conditions and additionally by the influence of neighboring wind turbines (so-called “wake effects”). Behind the turbines the incoming wind speed is being reduced, while the turbulence is increased. The effects of this on the operating loads have been assessed in so-called wake expertises and the allowed minimum distances of the turbines are defined accordingly, depending on the annual average wind speed and turbulence intensity at the site. These expertises are available on request.

In general ENERCON wind turbines can be placed in distances of 5 rotor diameters in prevailing wind direction and in distances of down to 3 rotor diameters in directions of less distinct wind without further calculations.

If smaller distances are planned, ENERCON has to approve the park layout. If this approval is not given or not being asked for, ENERCON cannot be held responsible for any defects, including but not limited to damages and/or loss of energy yield.

Smaller distances can be allowed if the site and layout conditions comply with the data mentioned in the wake expertises. If for any reason the conditions do not fit, there is the option to carry out a site specific calculation at the expense of the customer. In this case please contact your ENERCON sales representative at an early stage of the project.