INTRODUCTION

A structural tower or some other support structure is needed to raise the nacelle assembly that could weigh several metric tonnes up into the air, away from the slower and more turbulent winds near the ground. It elevates the rotor to a height where the wind velocity is significantly larger and less perturbed than near the ground level. Some towers can reach 50 meters in height, necessitating that their structures are capable of withstanding significant loads due to gravity, rotation and wind thrust loads.

The structural tower must be capable of resisting environmental impacts such as corrosion from sea water for the design life of the turbine of 20-30 years.

A wind turbine must be positioned at least 10 meters higher than any obstructions in the surroundings such as trees, buildings, fence rows or shrubs.

The tower of a modern wind turbine carries the rotor blades and the nacelle. Large wind turbines use tubular steel, lattice truss or concrete towers.

Poles supported by guy wires which are cables attached to the tower and anchored in the ground so that the tower will not move or vibrate under the influence of the wind are used for small wind machines for water pumping or battery charging.

The structural towers must be designed to resist the full thrust produced by an operating windmill or a stationary wind machine in a storm. Special consideration must be given to the possibility of destructive vibrations caused by a mismatch of wind machine and tower which could eventually cause fatigue failure.

Figure 1. Truss and conical pole structural towers.
Figure 2. Base of structural tower, Fenner wind farm, New York State.

Figure 3. Dimensions of 2 MW Ecotèchnia E80 wind turbine. The structural tower is composed of three conical sections.
CONICAL TUBULAR POLE TOWERS

Most modern wind generators use tubular cylindrical pole towers. They are manufactured in 20-30 meters long welded sections. Each section has flange at each end. They are bolted together on site.

The towers have a conical shape with a base wider than the top. Such design increases their strength, as well as saves materials.

They can be manufactured from tapered steel or concrete. The steel towers could be welded or pressed together in sections in a factory or on the site.

Spun concrete towers are less flexible than tubular steel towers and thus they do not transmit nor amplify rotationally induced vibrations offering a sound suppression capability.
LATTICE TRUSS TOWERS

Lattice truss towers are constructed using connected steel beams and are relatively cheap to construct. They offer a cost advantage over conical pole towers since less steel is used in their construction. They also allow the wind to flow through them offering less resistance to its flow. A lattice truss tower requires half the material as a freely standing conical pole tower of the same stiffness.

Lattice towers require less volume in their foundation than tubular towers since they spread the structure’s loads over a wider area. They also give less of a tower shadow effect than tubular designs.

At some time they were used for large and medium size machines. However, lattice truss towers have a lower visual and aesthetic appeal than conical towers. In spite of their lower cost, they are not used in large modern wind machines, particularly in the European Union.

Figure 6. Lattice truss tower construction at Altamont Pass California.
Fig. 7. Structural truss towers at San Gorgonio Pass, Palm Springs, California, 1985.

**GUY WIRE ERECTABLE POLES**

Small wind turbines use narrow poles supported by guy wires. Guy wires are cables attached to the tower and anchored into the ground so that the tower will not move or vibrate under the influence of the wind. Some designs can be lowered to the ground using a gin pole without the need for a heavy crane. They are then raised after repair or maintenance operations. This makes ground rotor and nacelle maintenance possible.

The poles may be made of steel pipe or tube for small machines that can be assembled on the ground and then raised upright with a gin pole. The diameter of the guyed towers is less than that for fixed towers.

Their basic advantage is their low cost. They also give less of a tower shadow than tubular designs.

Their disadvantage is that they occupy a large area and their wires make access around the wire difficult where farm equipment may need to maneuver for cultivation of the ground around the wind turbine bases. Animal grazing is less affected.

Overall safety is also reduced due to their propensity to vandalism acts.

Fig. 8. Guy wire tower construction.
Some designs use combinations of the basic tower construction techniques. As an example is the 95 kW Bonus tower which uses a combination guyed and lattice tower.

![Image of wind turbine and tower](image)

Figure 9. Hybrid lattice guy wire tower construction.

**TOWER DESIGN CONSIDERATIONS**

**TOWERS COSTS**

Structural towers account for about 20 percent of the price of a turbine installation. For a conical pole tower 50 m in height, an extra 10 m of height would require an additional cost of $15,000, necessitating careful optimization of the tower/s height.

Lattice truss are the cheaper to manufacture since they use less structural steel for the same stiffness level.

**TOWER HEIGHT**

The optimal height of a wind structural tower is a function of:
1. The tower cost per meter of height.
2. The wind local variation of the wind speed above ground level. A higher roughness necessitates a taller tower.
3. The price obtained for the extra energy produced by the wind generator for the extra energy produced by a higher tower.

Manufacturers tend to deliver towers that have a height almost equal to their rotor diameter, which is more aesthetically appealing than higher tower.

**AERODYNAMICS**
It is generally advantageous to construct tall towers in areas possessing high terrain roughness, since the wind speed increases with height above the ground. Truss lattice and guyed pole towers have an advantage of resulting in less of a wind shade than a conical pole tower.

STRUCTURAL DYNAMICS

The rotors on short towers will be subject to different wind speeds and consequently lower bending moments when a rotor blade passes through its top and bottom position. This results in higher fatigue loads on the turbine than a rotors positioned on a high tower where the variation between wind speeds between the bottom and top of the rotor path is smaller.

ERECTION OF WIND GENERATORS

The steps involved in the erection of a wind generator are shown in Figs. 10-18. Since the components are standardized and manufactured in factory environment, the erection process takes a short time from experienced crews.

Figure 10. Pouring of the reinforced concrete foundation of a wind generator at Delabole, Cornwall, UK.
Figure 11. Welding of steel structural towers sections.

Figure 12. Transportation and delivery of rotor blade.

Figure 13. Hoisting of structural tower sections.
Figure 14. Raising and welding of the tower sections.

Figure 15. Assembly of rotor blades.
Figure 16. Raising the blades onto the tower.

Figure 17. Attachment of rotors to wind generator’s nacelle atop the structural tower.
Figure 18. Rotor tips finishing.

Figure 19. Interior ladder in conical steel structural tower.