2EN renewable energy
services & applications

2EN Lattice 600 Triangular Tower

Lattice Meteorological Towers

The lattice tower design was implemented using CAD CAE technology.

Modelling design and assembly as well as finite element analysis techniques were integrated within NX platform provided by Siemens.

The software is equipped with NX - Nastran Solver which is widely used for the finite element analysis.

These techniques improve the design and optimize the strength of the components for the specific system development. All 2EN towers are certified for euro code compliance.

The lattice tower is designed to withstand wind velocities of more than 40m/sec with icing.

Optimum Reliability

Special study proposed

In high altitude areas, (> 1000) the heavy snowfall during the winter might build ice over the guy wires, which results in heavy loading of the anchors and the lattice structure. During the winter, the lattice tower should preventively be visited following extreme events to ensure its stability and operability.

Several other heights of aluminium lattice tower could also be manufactured.

Altitude (m)	600mm lateral length
0-600	Available up to 80m
600-1200	Available up to 65m
	Available up to 80m
1200-1500	Available up to 40m
	Available up to 60m
1500+	Available up to 48m

600mm Lattice tower design

Lattice sections

The 2en lattice 600 tower sections are built by three columns fixed with circular bars forming a collateral cross section of 600mm long. Each section is 3m long and weights approximately 55kg.

The new aluminum 2en lattice 600 model is a brand new design all from scratch.

This new tower features a new heavy duty column profile with round reinforced geometry and round geometry reinforced bars.

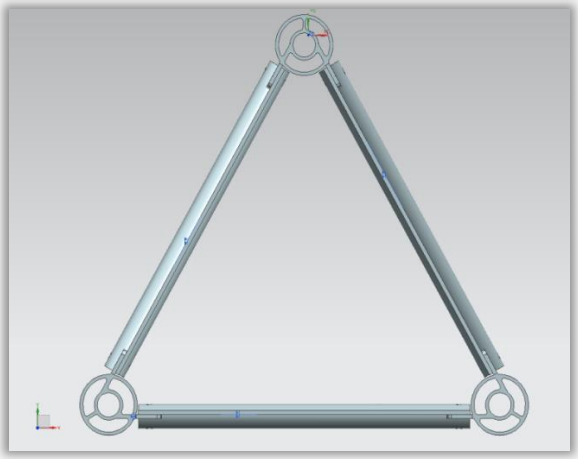
Profiles and machining

The whole structure is manufactured out of aluminium alloy 6005, aged with T6 heat treatment and electro-statically painted in red and white according to Civil aviation authority rules.

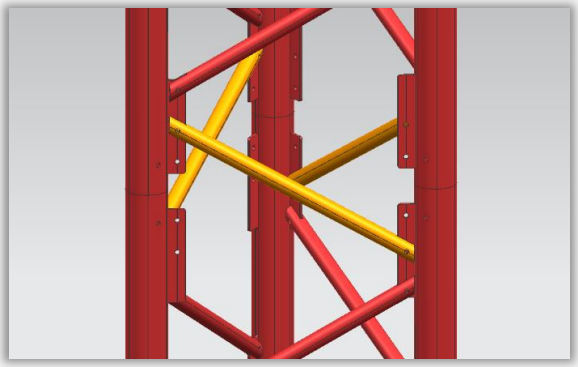
The column profile is made with extrusion moulding and is afterwards CNC machined in order to remove all unnecessary geometries that would increase the tower solidity and would affect the wind flow over the construction.

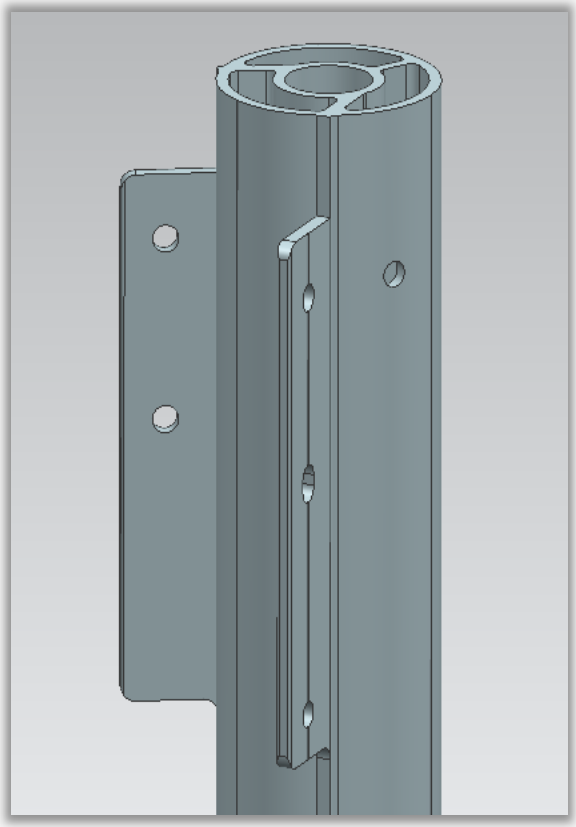
With this technology there is no need for welding and all the members are assembled using bolts.

Greek Industrial Property Organization
Patent Number:
1007941

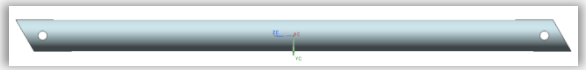


Lattice tower cross section





Column profile



Circular bars of the lattice structure

Mechanical properties and design limits of 2EN-LAT 600mm

All tower body is made of aluminum alloy 6005 / T6.
The mechanical properties of the alloy are shown at the table below.

Property	Value
Density	2.70 g/cm3
Melting Point	605
Modulus of Elasticity	70 GPa
Electrical Resistivity	0.034x10-6Ω.m
Thermal Conductivity	188 W/m.K
Thermal Expansion	24x10-6 /K

54m 2EN-LAT 600mm Design limits

Radial Ice (mm) at guys and body	Max allowed Wind speed* at 54m (m/sec)
0	75
10	62
40	50
60	45

65m 2EN-LAT 600mm Design limits

Radial Ice (mm) at guys and body	Max allowed Wind speed* at 65m (m/sec)
0	70
10	60
40	45
60	40

80m 2EN-LAT 600mm Design limits

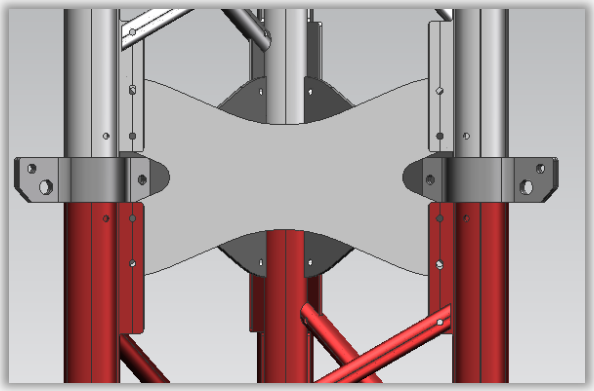
Radial Ice (mm) at guys and body	Max allowed Wind speed* at 80m (m/sec)
0	65
10	55
40	40
60	35

100m 2EN-LAT 600mm Design limits

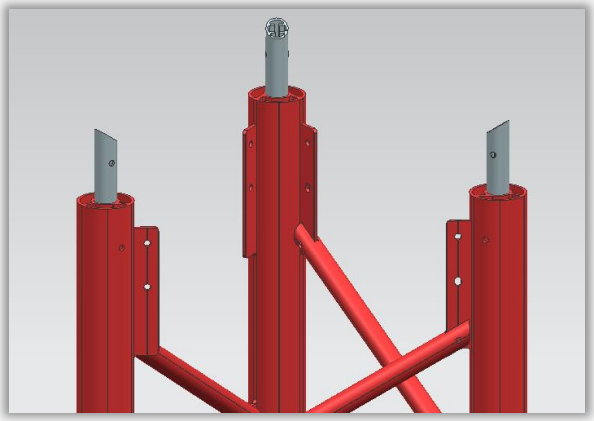
Radial Ice (mm) at guys and body	Max allowed Wind speed* at 100m (m/sec)
0	50
10	40
40	30
60	25

The design limits are calculated, taking into account several load conditions with different wind speed and direction, and different snow accumulation loads.

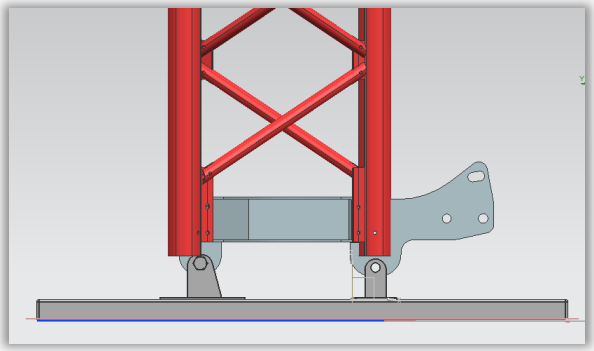
*10m average wind speed



Lattice tower section Layout



Section connection patterns



Base Hinge

The sections, where a guy wire level is attached, are connected to each other with three aluminium plates (one per side).

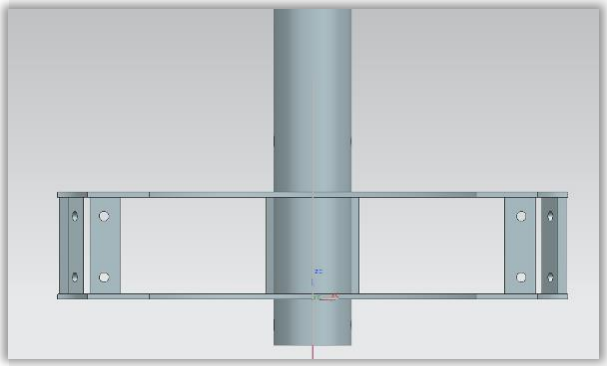
All the other sections are connected using internal connecting rods, which are used for reinforcing the section connection.

Although all the sections have the same geometry, two of them are different.

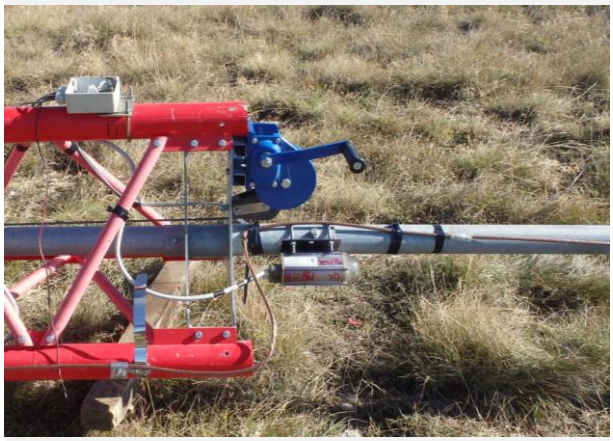
The one is equipped with the gin pole hinge, which is obviously the one that has to be mounted on the base plate.

The other section is equipped with an adaptor for Φ70 tube and is mounted as the top section.

For compliance with the new ISO 61400 -12 -1 edition 2.0/2017 standard, the top adaptor is telescopic.



Top Adaptor



Guy Wires

The guy wires are made of galvanized steel of a cross-section of 8 - 10 mm and a steel core (type 1X7) of ultimate tensile strength 1770 MPa.

Base Plate

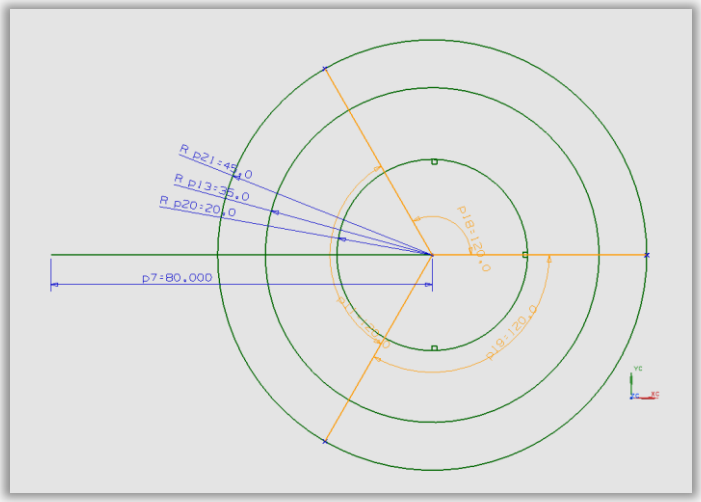
The tower base plate is welded made of st37 steel rectangular profiles 100x50mm with 5mm wall thickness. At the corners of the base plate there are holes for anchoring

Tilt up erection and Anchors layout

The anchors are placed in three concentric circles of 20, 35 and 45 m radius where the center of each circle is the base of the lattice tower.

Adjacent anchors form 120^{O} angle and should not exceed a ± 1.5^{O} orientation tolerance.

One of the main characteristic of this new tower, due to the lightweight of the aluminum profiles, is the tilt up erection method.



2EN LAT600-80 Anchor mounting

The tower can be erected using a gin pole and handheld tools without the need of a crane or trained climbers.

The maximum erection force needed, does not exceed 60KN. This erection force can be handled either by two parallel handheld tirfors (32kN each), or hydraulic tirfors or other special winch with a suitable capability.

The lift anchors, where the gin pole is mounted, are placed 20m ± 0.2m from the tower base, opposite the spread out lattice mast as shown in the schematic.

Tilt up erection with tirfors

2EN recommends double anchors per tirfor for safety reasons.

All installation component (D links, tensioning devices, etc) must be provided by 2en in order to have the right specifications.

Optionally the tower could be erected by climbers.

600mm Lattice tower design

Tilt up Lattice tower during erection

Certification

2EN is ISO 9001 certified for the design & manufacture of lattice towers and holds a certificate of conformity of the factory production control.

The tower construction has been studied and verified using finite element analysis (FEA).

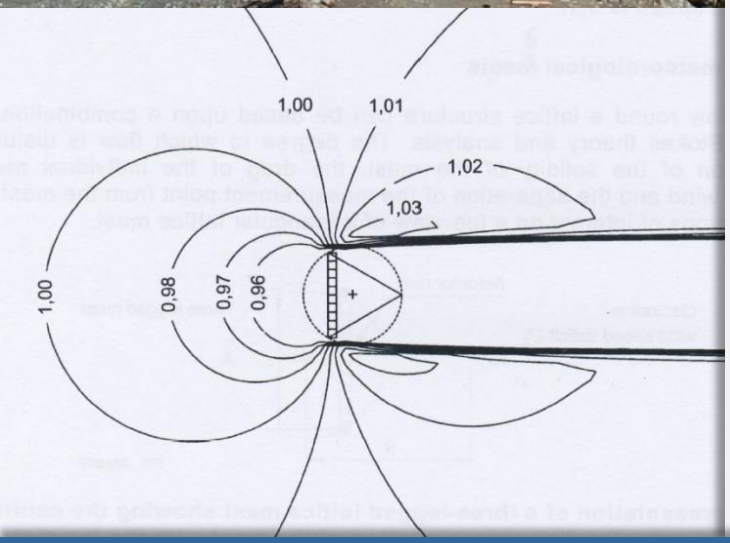
Every part is verified and checked separately and the whole structure has been certified for euro code compliance.

This construction is made to withstand very high winds with 10minute average higher than 50m/sec which leads to gusts over 80m/sec at the top of the mast.

The ultimate load strength diagram expressed by the mean Wind speed vs. radial ice on the cables and tower body has been certified by TUV NORD.

The tower is certified according to the following standards and their Greek annexes where applicable.

- **Eurocode 1.**
  EC1PART1.4En1991-1-4 Wind Actions,
  EC1 PART1.3 En 1991-1-3 Snow Loads.
- **Eurocode 3.**
  EC3 PART3.1 1993-3-1 Towers and Masts,
  EC3 PART3.11 1993-1-11 Design of structures with tension elements.
- **Eurocode 8.**
  EC8 1998.06 - Design of structures for earthquake resistance - Part 6: Towers, masts and chimneys.
- **Eurocode 9.**
  EC9 Aluminium structures.
- **BS EN 795** - Protection against falls from a height - Anchor devices - Requirements and testing.



Booms

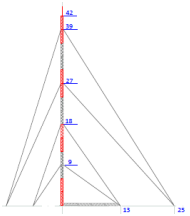
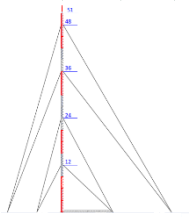
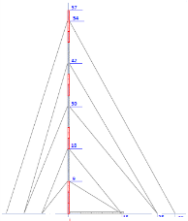
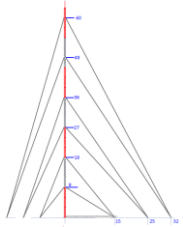
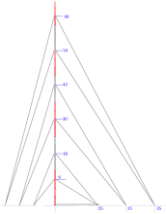
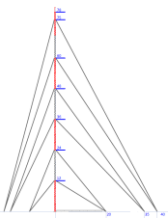
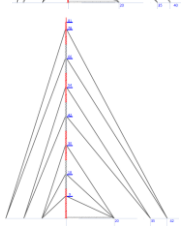
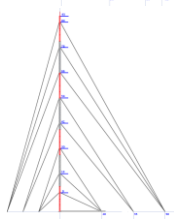
According to IEC 61400-12 Annex G iso-speed plot, with local speed normalised by free - field wind speed, of flow round triangular lattice masts analysis by two dimensional Navier-Stokes computations, a wind speed deficit of 99% for a lattice tower of Ct:0,5 will reduce the distance R to 3,7 times the mast leg distance.

For a 99,5% centre line wind speed deficit and Ct=0,5, a boom mounted anemometer should be no closer than 5.7 tower leg from the centre of the tower.

At the same time, the boom must remain stable, so that it does not oscillate. With analytical computation taking into account the solidity of the tower the thrust coefficient is Ct=0.44.

So for a sensor distance to the centre of the tower over 3150mm, the centre-line wind speed deficit Ud is below 0.5%. Alternatively with a 2,7m long boom the centre-line wind speed deficit Ud is below 0.7%.

Available models

Models	3m sections	3m section incl. adapter for 3m tube (70mm)	Levels of guy wires	Gin pole type	Total structure weight	Schema
2EN-LAT600 44m	14	1	4	12m Lattice (500mm)	1200 Kg	
2EN-LAT600 53m	17	1	4	12m Lattice (500mm)	1450 Kg	
2EN-LAT600 59m	19	1	5	15m Lattice (500mm)	1620 Kg	
2EN-LAT600 65m	21	1	6	15m Lattice (500mm)	1780 Kg	
2EN-LAT600 71m	23	1	6	15m Lattice (500mm)	1950 Kg	
2EN-LAT600 80m	26	1	6	18m Lattice (500mm)	2200 Kg	
2EN-LAT600 83m	27	1	7	18m Lattice (500mm)	2300 Kg	
2EN-LAT600 95m	31	1	8	21m Lattice (500mm)	2700 Kg	

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