Wind Turbine Towers for Greater Hub Heights

Why higher wind turbine tower can contribute to increase energy output?

- Energy output is proportional to the cube of wind velocity, 100m towers (versus 80m) would produce about 12% more power per installed turbine (NREL)

Expanded Area of Potential Wind Energy Deployment Resulting from Increasing Hub Height from 96m to 140m

Land-based Annual Average Wind Speed at 200m Resolution

Source: NREL Report No. TP-5000-61063.
Source: NREL and AWS Truepower
wind towers represent 26% of the total WTG (Wind Turbine Generator) cost
Why concrete tower is an alternative for higher wind turbine tower?

Steel towers:
- Limited environmental impact
- Transport as complete tubes
- Speedy construction

- Limitation in tower base diameter;
- Deeper foundation;
- More volatility in price than concrete
Concrete towers:
• Easy transportation with small modules;
• Allow for mobile factories;
• Deflection (3”-3’/300ft tower);
• Increase steel’s 20 year tower life.

Two designs:
• Full concrete designs
  Enercon;
  Acciona;
  Inneo Terro;
  Precast Concrete Tower Inc.
• Hybrid system
  Advanced Tower System;
  Tindall

Sample of current offering of turbine-tower combinations

Source: Turbine manufacturers, TUV, X&Y Partners analysis
Acciona Windpower Concrete Tower

- Prestressed concrete shells (precasted in the mobile factory and transported to site)—20m
Acciona Windpower Concrete Tower

• Joined through vertical patented joins on site configuring 20 meters tower sections

Source: Acciona Windpower
• Great interior space at the base of the tower thanks to its larger diameter, which promotes the assembly of equipment within the tower on one level without space constraints.
• Very easy to anchor on the walls of the tower interior elements and equipment needed.
• Not conditioned by transport limitations and therefore provides freedom in the choice of the geometry of the tower.

Source: Peñablanca Wind Farm, featuring a tower of 100 m
• Functionality
Larger door that allows the passage of the complete equipment, which greatly facilitates installation or repair possible and, in some cases, avoids the need for additional booths for processing equipment.

Source: Peñablanca Wind Farm, featuring a tower of 100 m
Advanced Tower System (ATS hybrid tower)

- combines a pre-cast concrete segmented tower with tubular steel sections on top.
- consists of three or more 15 meters long, slender segments and corner elements.

Advanced Tower Systems BV
• The lower tower sections, which require a diameter bigger than the 4.3m transport limit, are vertically divided into three or more slender segments made of high-quality pre-cast concrete. The segments can be easily transported via ordinary trucks.
• The installation of the entire tower takes less than a week and can be done under most weather conditions.
Tindall - Altas Concrete Tower Base

- Accommodates 100-140 meter class hub heights
- No bolts – post-tensioned tendons only
- Components can be factory manufactured or site cast
- Employ prefabricated concrete rings bolted together on-site and post-tensioned using external tendons.
Tindall-Altas CTB

- A pair of Atlas CTB staves are easily transportable by rail within a 3-m Width x 4.5-m Height conventional rail transportation footprint.

- One size stave with multiple base diameters makes easily transportable in pairs by rail;

- As the number of staves increases, so does the base diameter, making this design concept able to accommodate the loads presented by higher towers and larger output turbines.
Technique challenges in tower design

Short-term loads:
• **Seismic/earthquake loads:** Tower may not be capable of resisting the local seismic demands.
• **E-stop:** The short/hard stop creates a shock load spectrum on the structure and results in a drastic dynamic impulse load to the system, resulting in large lateral deflections.

Long-term sustained loads:
• The most unique aspect of wind tower structural design is the dynamic characteristics and fatigue-related issues. Long-term loads are the normal operational wind loads that include dead, live, static wind pressure and standard operational overturning moments, shears and axial loads. The frequency of these long-term sustained loads may reach over 20,000,000 cycles in 20 years. Therefore, every aspect of the tower-foundation design must consider these provisions.
Questions

Thank you!