Load Calculation and Structural Design methods and assumptions of a two rotor Multirotor Wind Turbine Concept

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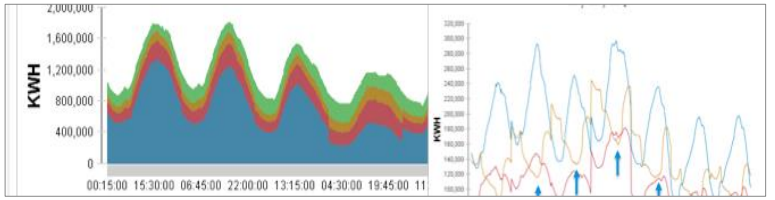
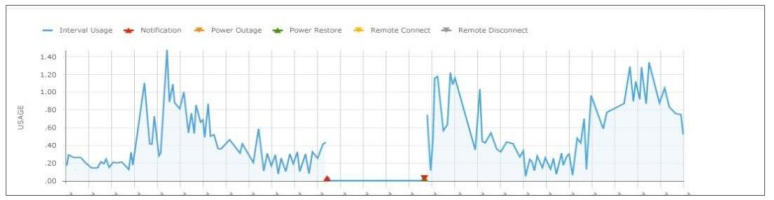
Size, Scaling and Industrialization

Energy System Integration

Digital Innovations





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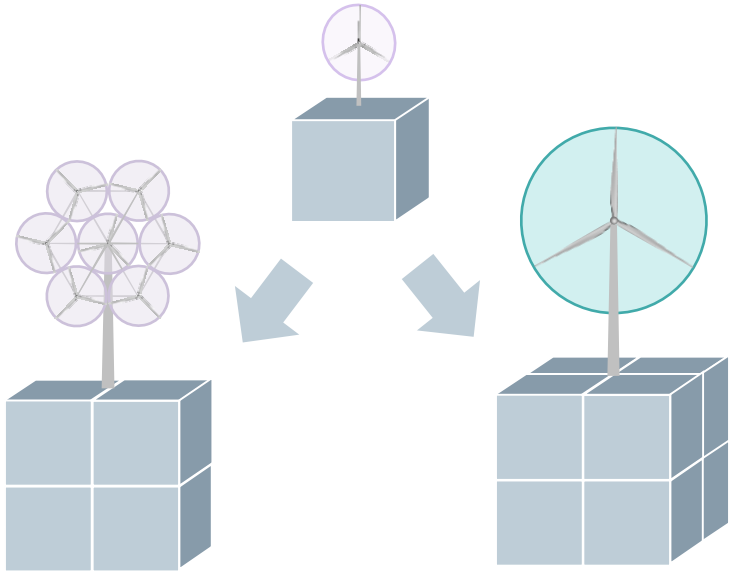
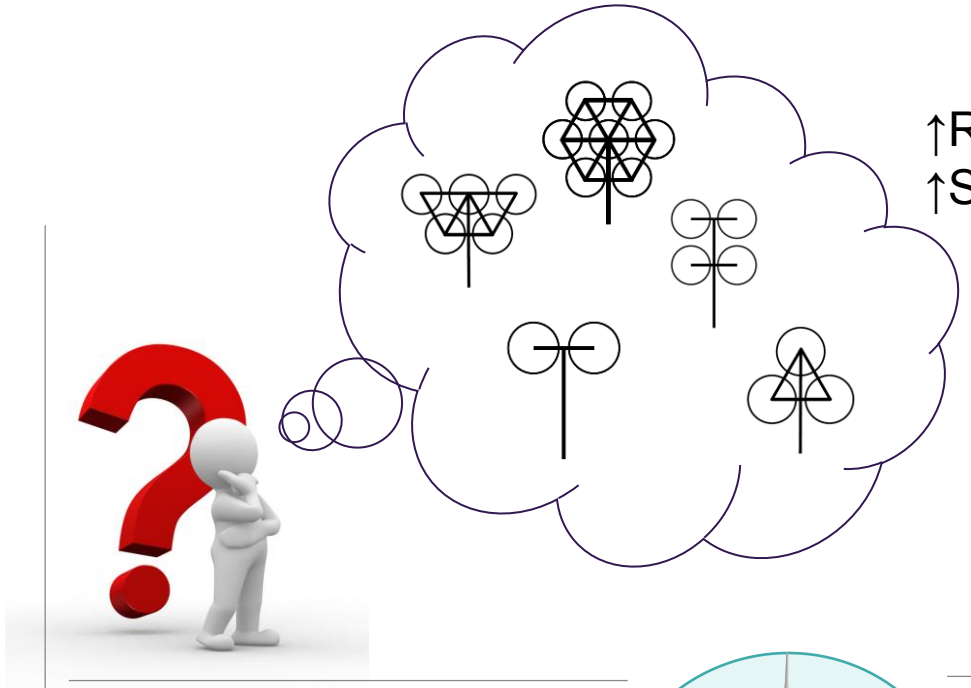
Conceptual Design

Evaluation of new turbine architectures

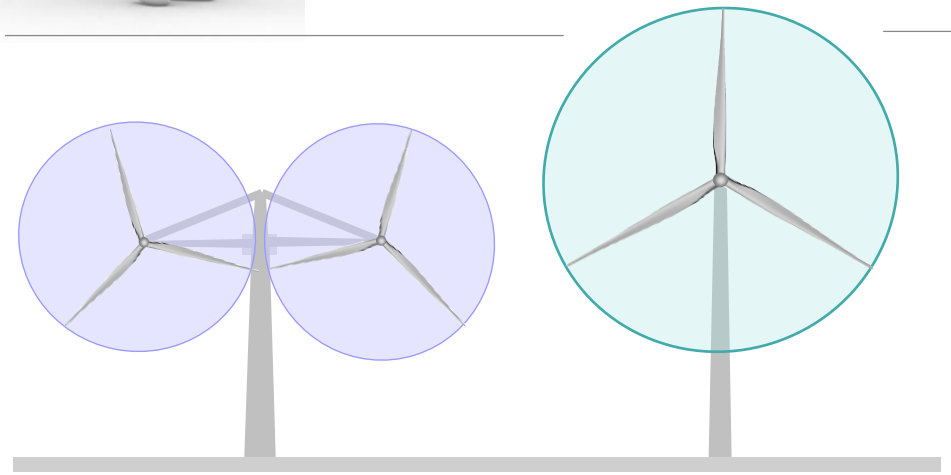
Conceptual Design. Multirotor





↑Rotors ↓RNA Weight
↑Support Weight

1evolutionary step → 2Rotors → Concept Optimization



Comparison of two wind energy devices with similar AEP (P_{NOM} and A_{ROTOR})

Physical Scaling Laws

- Wind Power ~ Rotor Area (D^2)
- Total Mass ~ Machine Volume (D^3)

Therefore scaling up the RNA *size* costs more in mass than scaling the *number of rotors*

Conceptual Design → **Load Calculation** → **Structural Optimization**

Convergence Loads-Structure

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Methods & Tools

Sequential Approach

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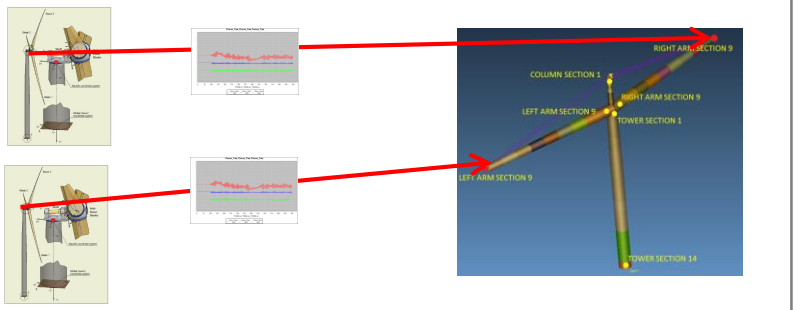
Method & Tools. Method Validation

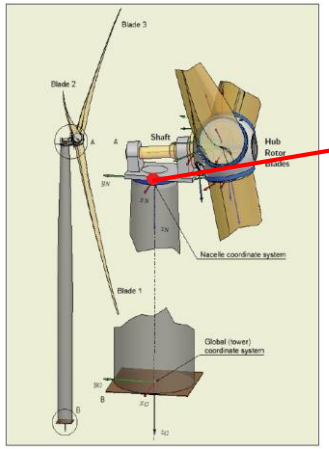


Sequential Approach: 2 independent ext. load calc.

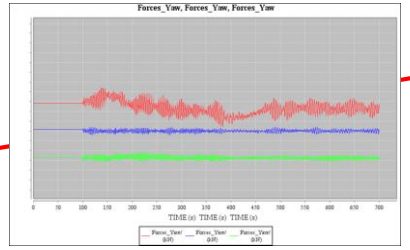
Method Validation:

Loads are introduced as external loading in Tower Top and are measured at tower bottom.

Responses must be similar to validate method.



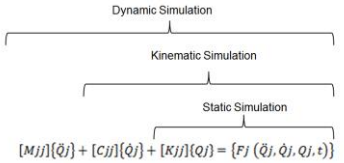
Introduced as external loads* at Tower Top in Samcef.

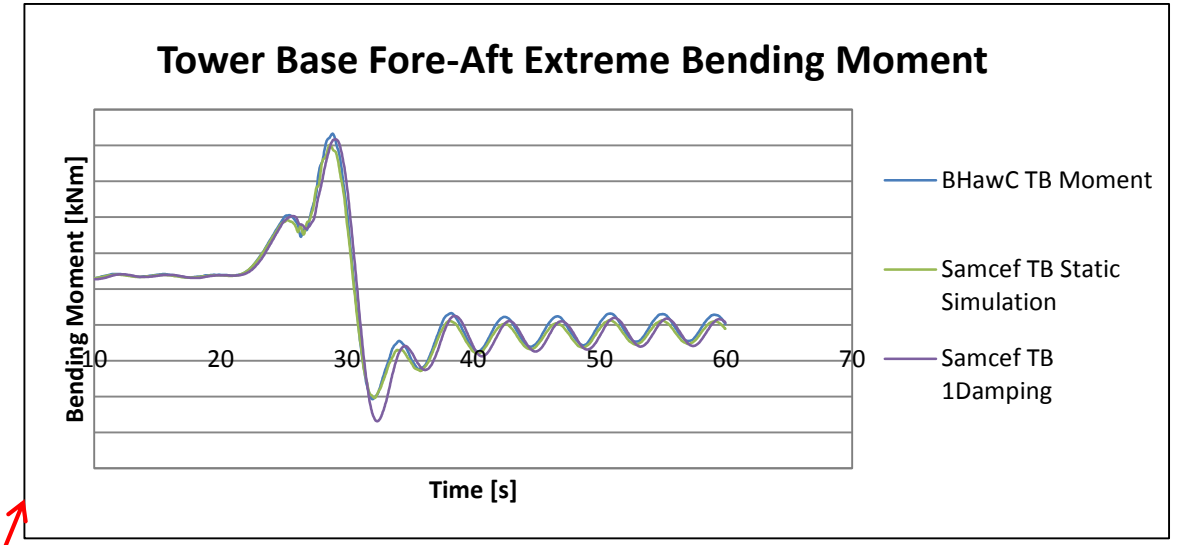


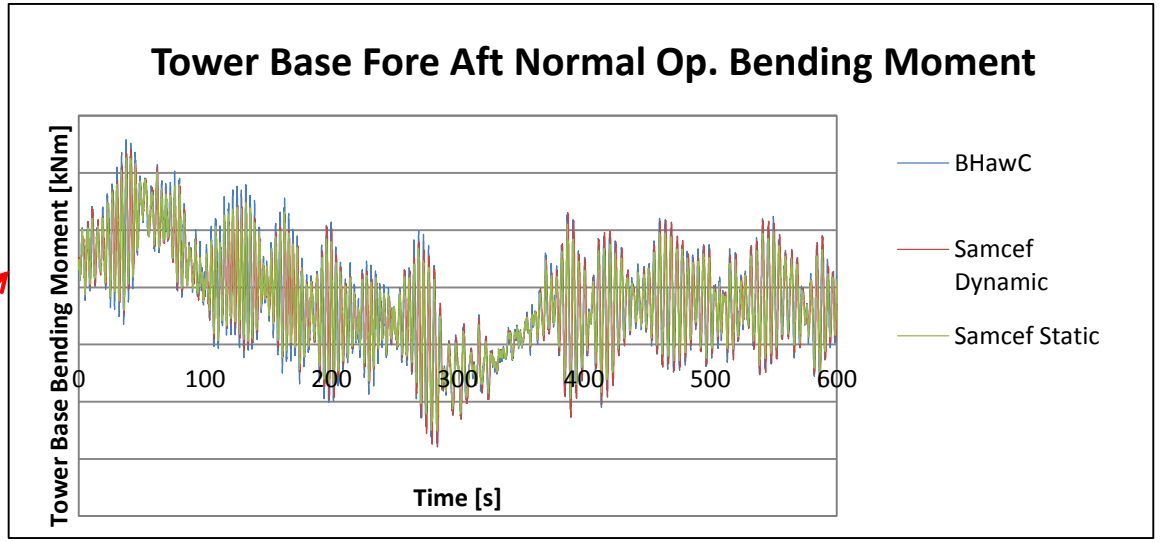
Internal loads → fully coupled dynamic simulation (BHawC)

(*) Note that gravity loading has been subtracted and added as a point mass

TBFA STD	Margin = (STD-ref)/ref	
	S. Static	S. Dynamic
	9%	2%







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Assumptions & Results

Innovative assumptions for new WT architecture with limited resources

Assumptions

Some of the assumptions to perform a simplified load calculation with appropriate accuracy for provided resources:

- Limited number of realizations per wind speed (lower statistical content). No wind misalignment & No distributed turbulence.
- 96% Availability per rotor → 2 Approaches (96% Combined Availability –Asymmetric Production–; 92% Combined Availability –No asymmetric Production–)
- DLC1.3 ETM combined with maximum difference of wind speed between rotors (~3m/s).
- Combination of events: External conditions events → 3 events (2 individual events and 1 collective)

  Internal/Control faults → 2 events (no collective event)
- Ultimate Loads: Dimensioning Loads for tower of baseline with max/min. DLC1.3 → Average Maxima/Minima. Additional ULS SF 1.05
- The overall philosophy was to compare systems with as similar as possible probability of failure

Results

Comparison SRS vs 2xMRS

Taking into account uncertainty, results can be interpreted:

Decrease Fatigue Tower Loading ~9-10%(TB-h)* ~27%(TB) ~26%(TT)

Increase Ultimate Tower Loading ~5%(TB-h)* ~(-)13%(TB) ~100%(TT)**

Decrease of RNA Mass ~20%

Decrease Tower Mass ~20%

Additional structure, arms (~1tower), frames, column, strands.

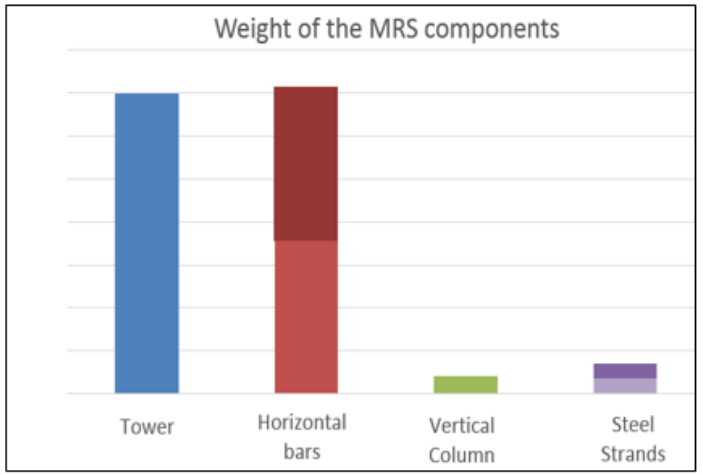
(*) at same vertical distance to yaw system

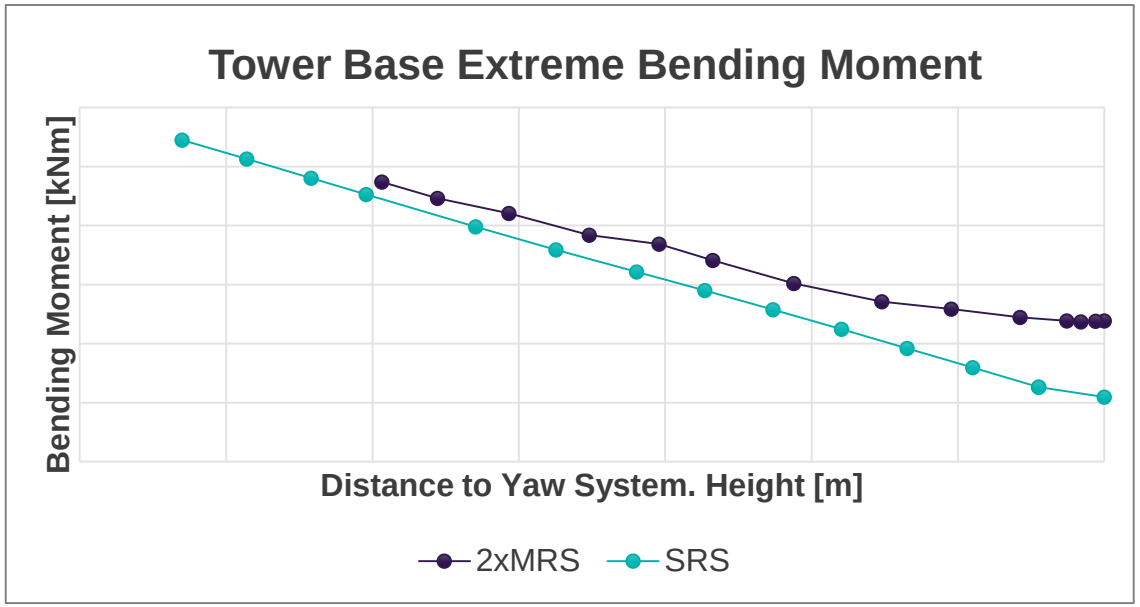
(**) 20% at same height above ground

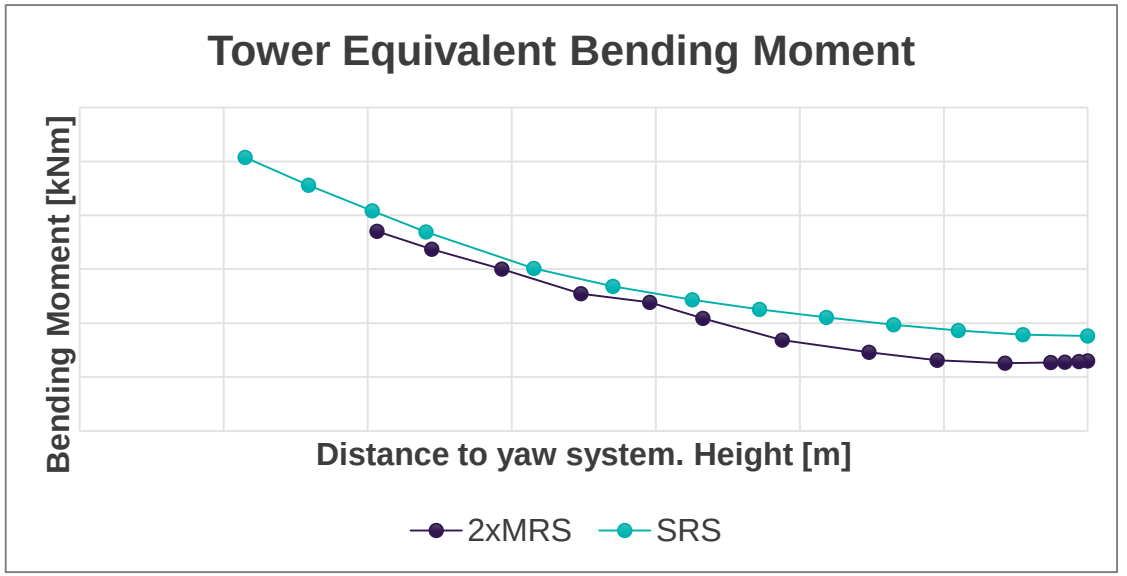
<u>Other remarks:</u>

Huge Torsion loading (no collective controller)

No increase of Power and Thrust taken into account due to wake interaction







Thank you!

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