Advanced Validation Strategy for Nabrawind Self Erected Tower

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BREMEN
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www.nabrawind.com
www.cener.com

NABRAWIND

Advanced Wind Technologies

Drastic Cost Reduction

Modularity

Proven Technologies

Modular Blade Joint

Self Erected Tower

1 Introduction
XXL Tower Challenges

Cost Increase

$€_{HH140}=1.6 \cdot €_{HH100}$

Most Expensive Component HH>120

Logistics

Roads / Bridges Limiting Concepts

Assembly Cranes

Lack of Availability

Large Mobilization and Rental Costs

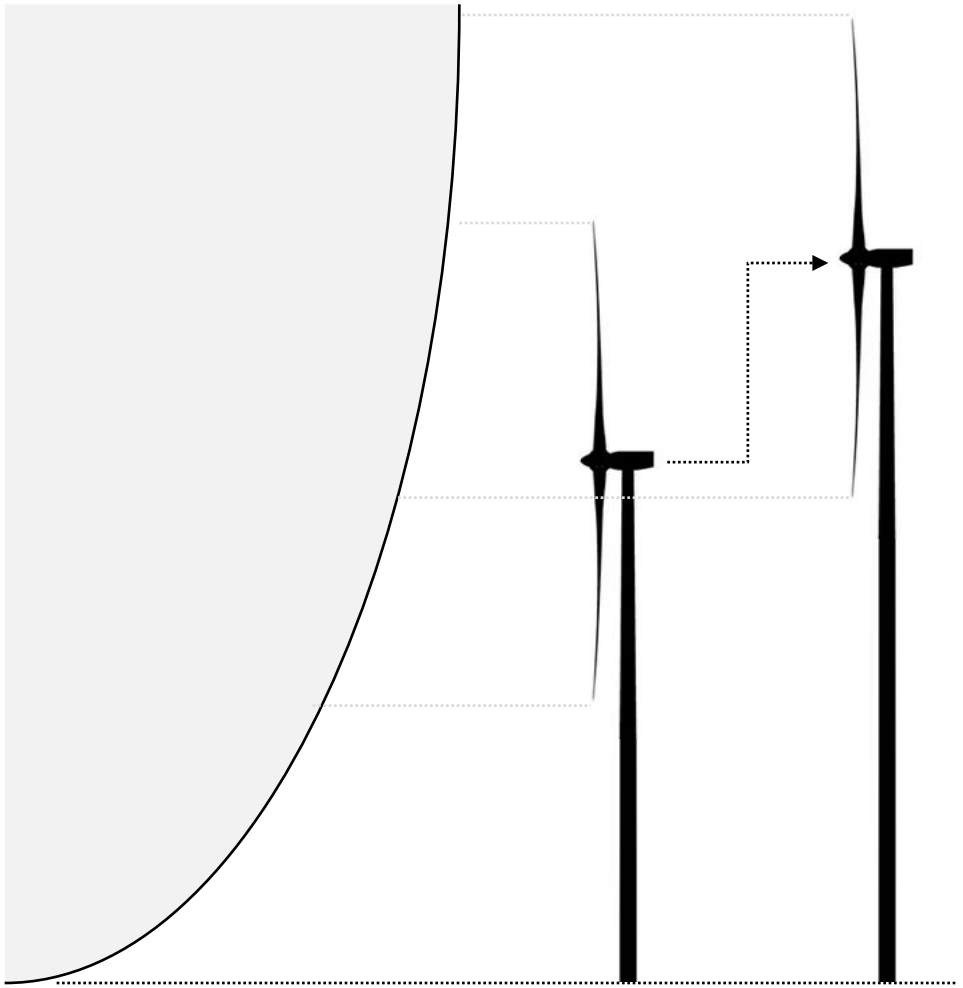
Installation Rate

New Concepts Delaying Wind Farm Installation Rates

WTG Integration

Control Challenges in Soft-Soft Towers

Soft-Stiff Unfeasible for XXL Steel Towers



2 XXL Tower Alternatives Evaluation

Tubular Steel

Segmented Steel

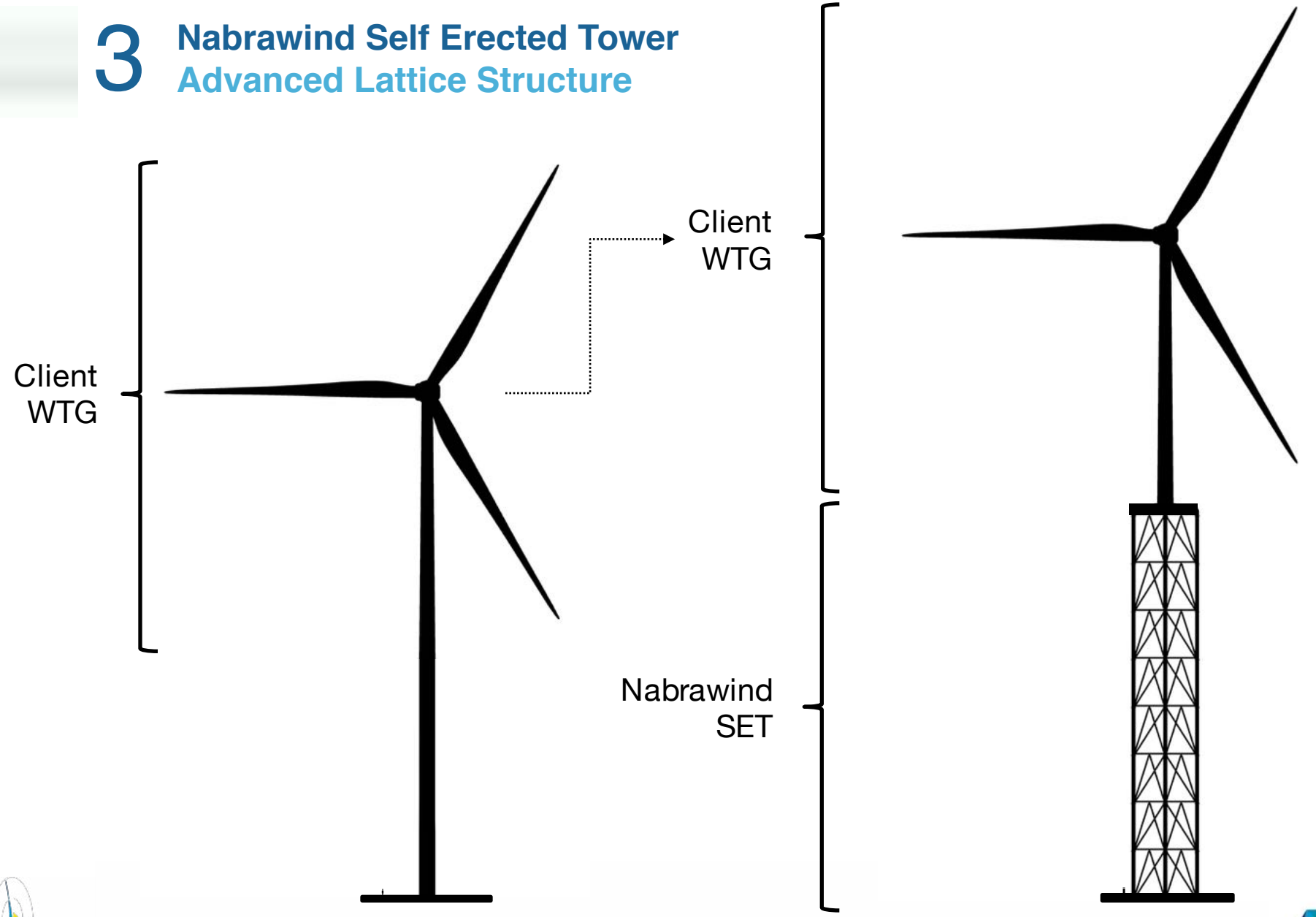
Precast Concrete or Hybrid

Lattice

	Tubular Steel	Segmented Steel	Precast Concrete or Hybrid	Lattice
Tower Cost	◔	◑	◕	◕
Logistics	○	◕	◔	●
Assembly & Erection	◑	◔	◔	◔
Modal Coupling	○	◔	●	◑
Operation Proven Life	●	◑	◑	◑

● Good ○ Poor

3 Nabrawind Self Erected Tower
Advanced Lattice Structure

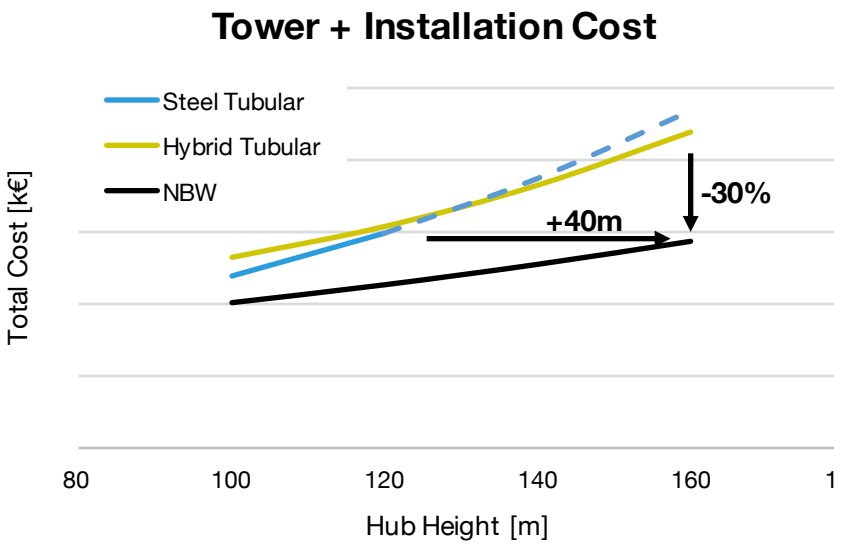


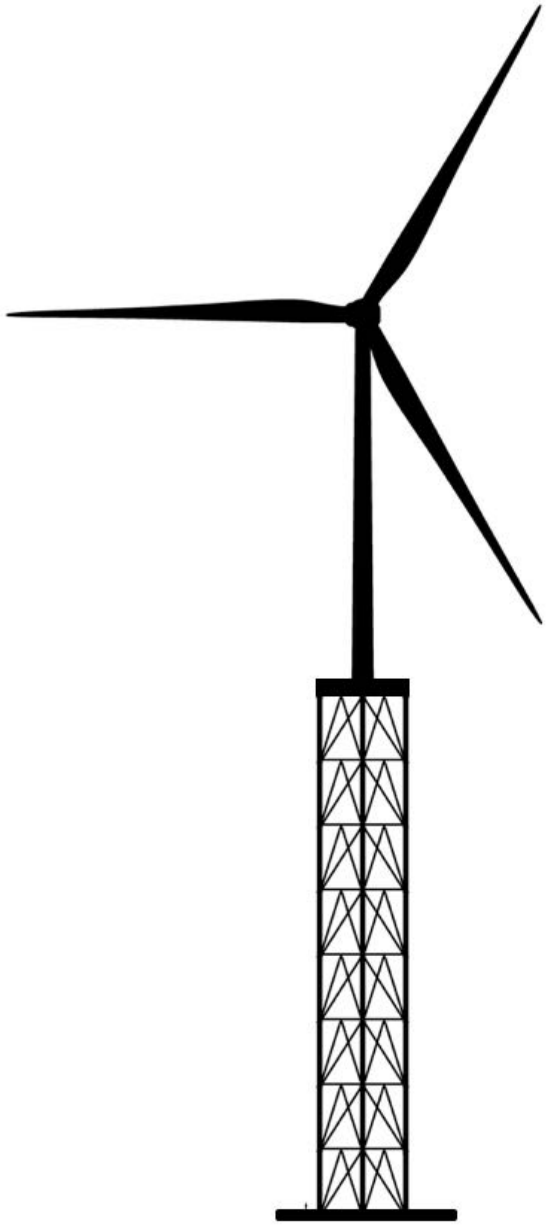
3 Nabrawind Self Erected Tower
Advanced Lattice Structure

Ultra Low Cost

Foundation / Tower Components

Logistics / Assembly





3 Nabrawind Self Erected Tower
Advanced Lattice Structure

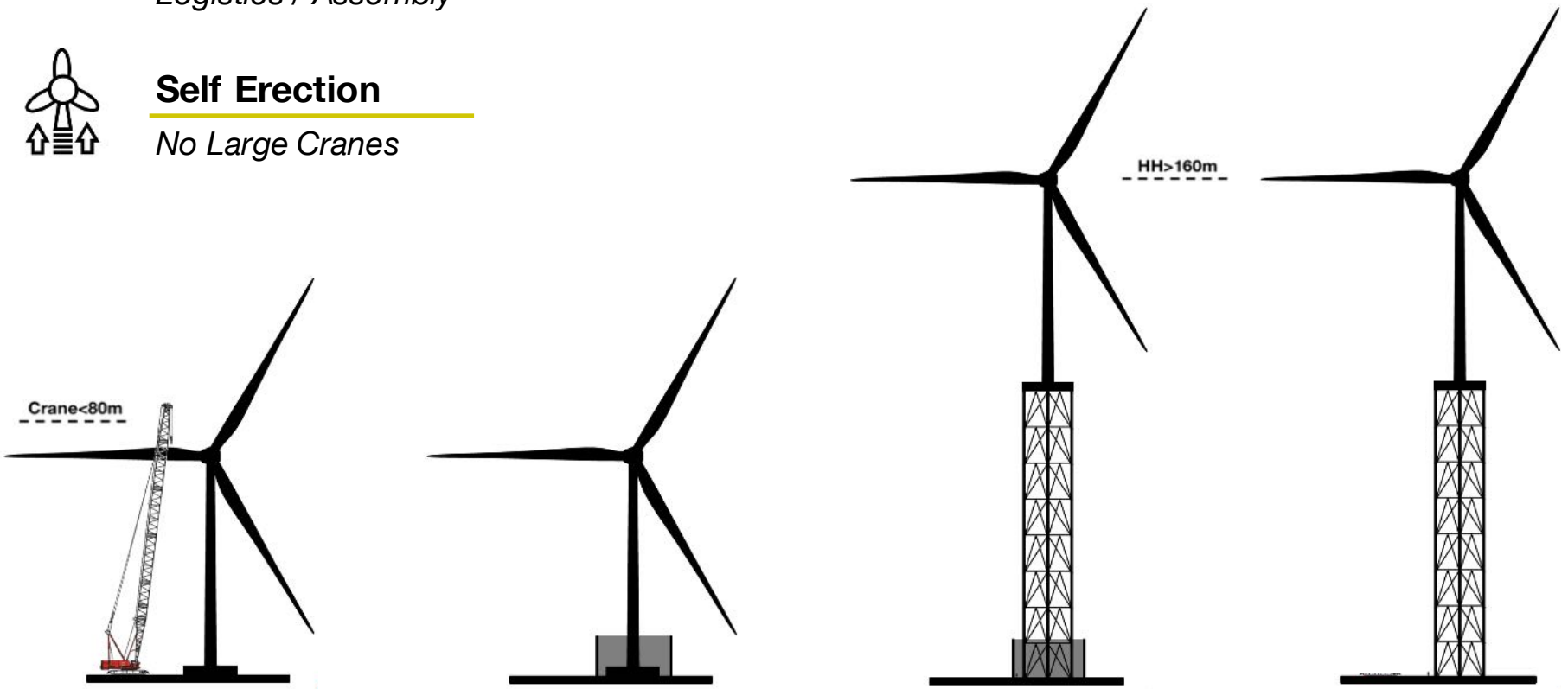
Ultra Low Cost

Foundation / Tower Components

Logistics / Assembly

Self Erection

No Large Cranes



3 Nabrawind Self Erected Tower
Advanced Lattice Structure

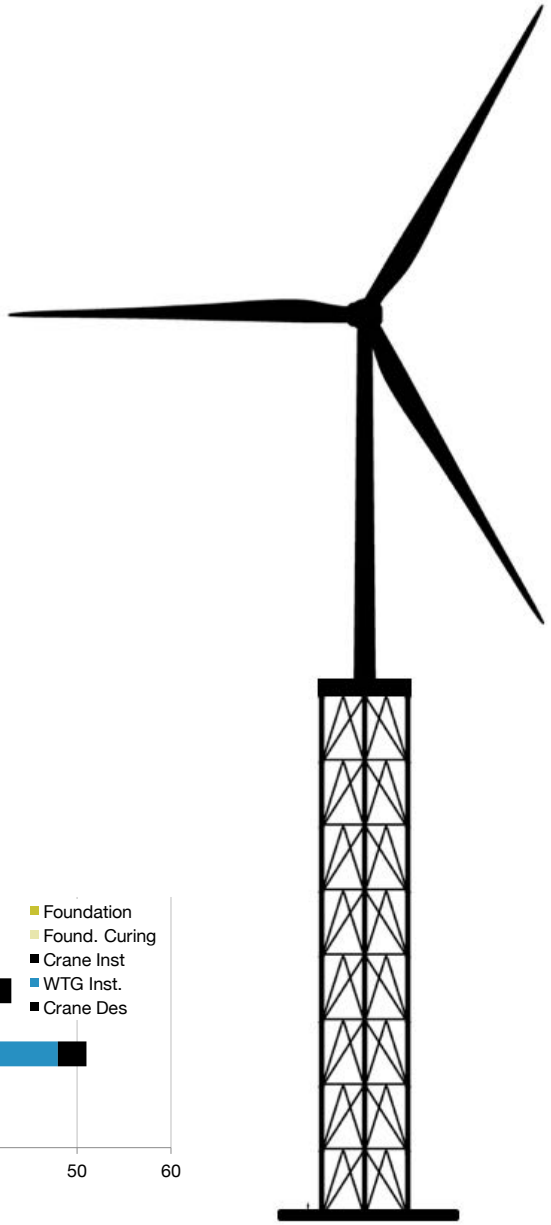
Ultra Low Cost
Foundation / Tower Components

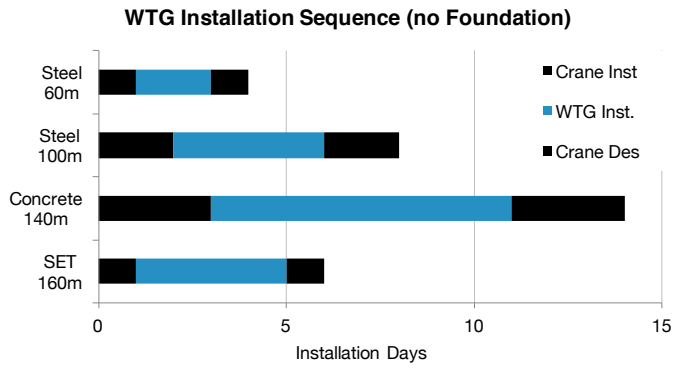
Logistics / Assembly

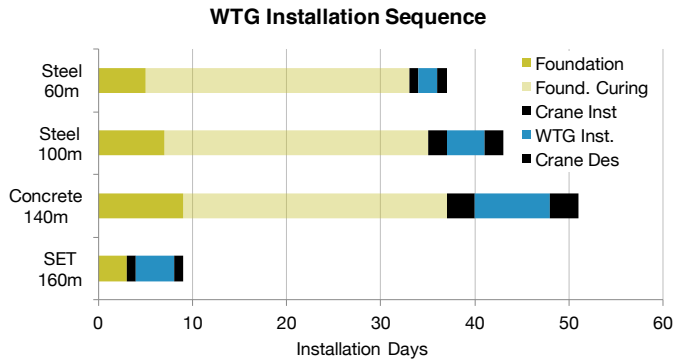
Self Erection
No Large Cranes

Fast Assembly
2-Days WTG Erection (Wind >15m/s)

Prefab Foundation (T<0ºC)







3 Nabrawind Self Erected Tower
Advanced Lattice Structure

Ultra Low Cost
Foundation / Tower Components

Logistics / Assembly

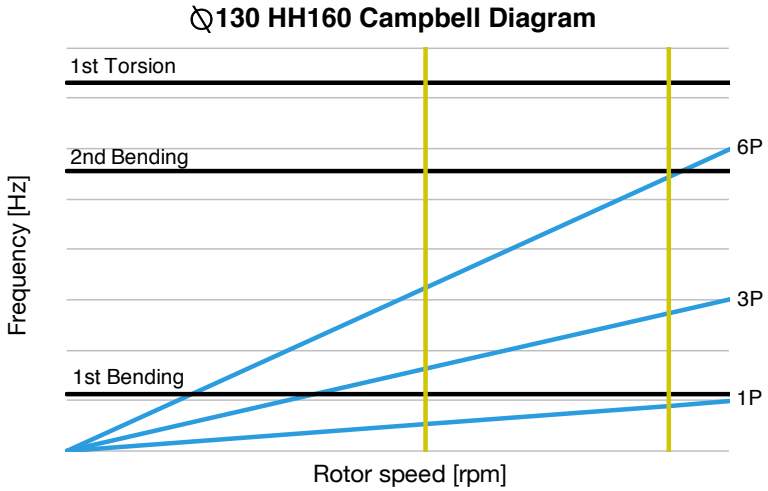
Self Erection
No Large Cranes

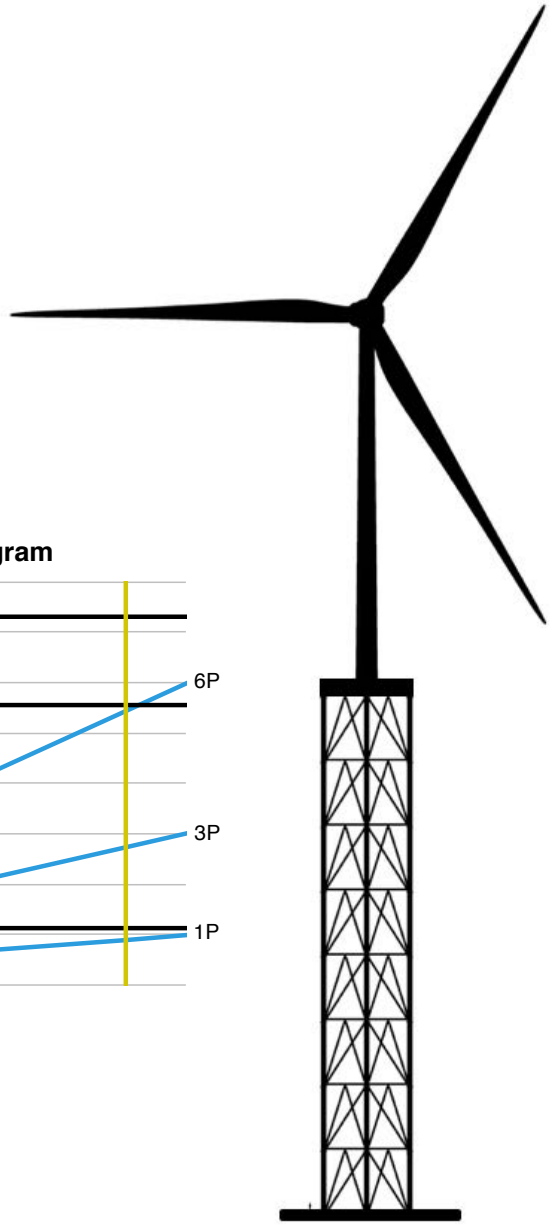
Fast Assembly
2-Days WTG Erection

Prefab Foundation

Easy WTG Integration
Soft-Stiff Tower H>180

No Functional Affection





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Advanced Lattice Structure

Ultra Low Cost
Foundation / Tower Components

Logistics / Assembly

Self Erection
No Large Cranes

Fast Assembly
2-Days WTG Erection

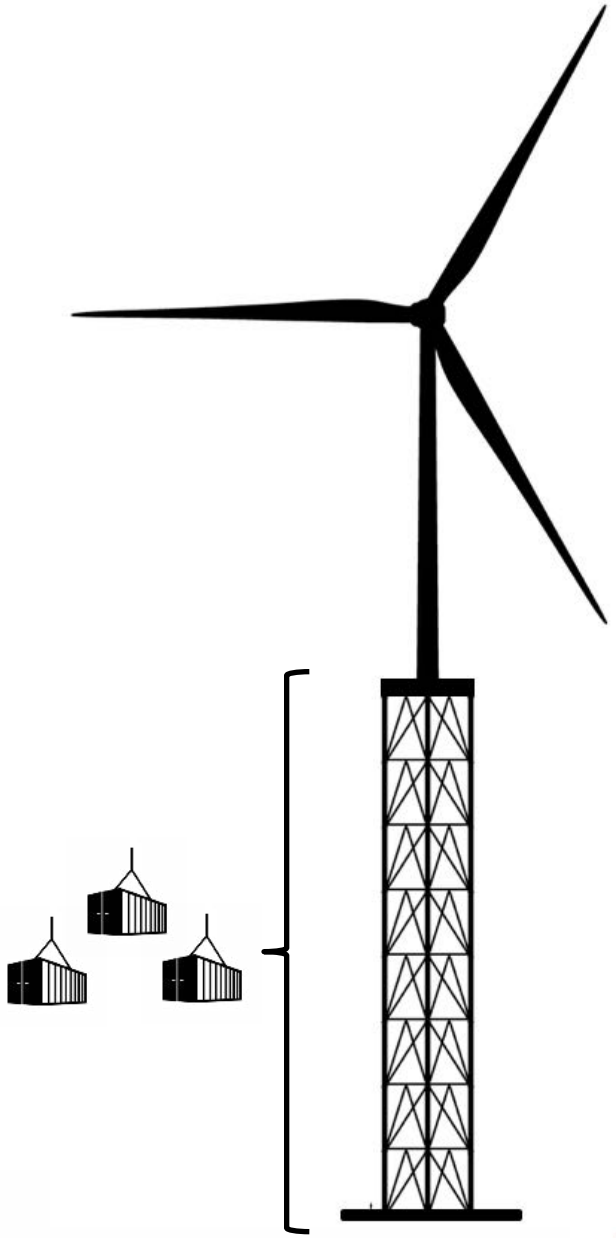
Prefab Foundation

Easy WTG Integration
Soft-Stiff Tower H>180

No Functional Affection

Simple Logistics and Operation
Packable in Standard 40ft Containers

Maintenance Free Structure and Connections



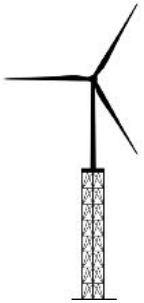
3 Nabrawind Self Erected Tower
Tower Alternatives Comparison


Tubular Steel


Segmented Steel


Precast Concrete or Hybrid


Lattice


Nabrawind SET

	Tubular Steel	Segmented Steel	Precast Concrete or Hybrid	Lattice	Nabrawind SET
Tower Cost	◔	◑	◕	◕	●
Logistics	○	◕	◔	●	◕
Assembly & Erection	◑	◔	◔	◔	◕
Modal Coupling	○	◔	●	◑	●
Operation Proven Life	●	◑	◑	◑	○

4 CENER Introduction

AREAS

- **Wind Power**
- Photovoltaic
- Solar thermal
- Biomas
- Grid integration
- Bioclimatic architecture

NUMBERS:

21 M€	In 2016 the annual budget is 20,5€ million. 70% self-financing
190	190 employees
100 M€	Total investments (2002-2016): ~ 101€ million

INFRASTRUCTURES

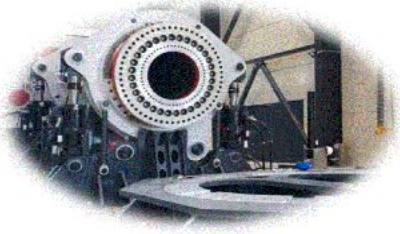
Headquarters
Sarriguren, Navarra - Spain

Wind Test Laboratory
Sangüesa, Navarra - Spain

Biofuels Plant
Aoiz, Navarra - Spain

Blade Test Bench
(70m)

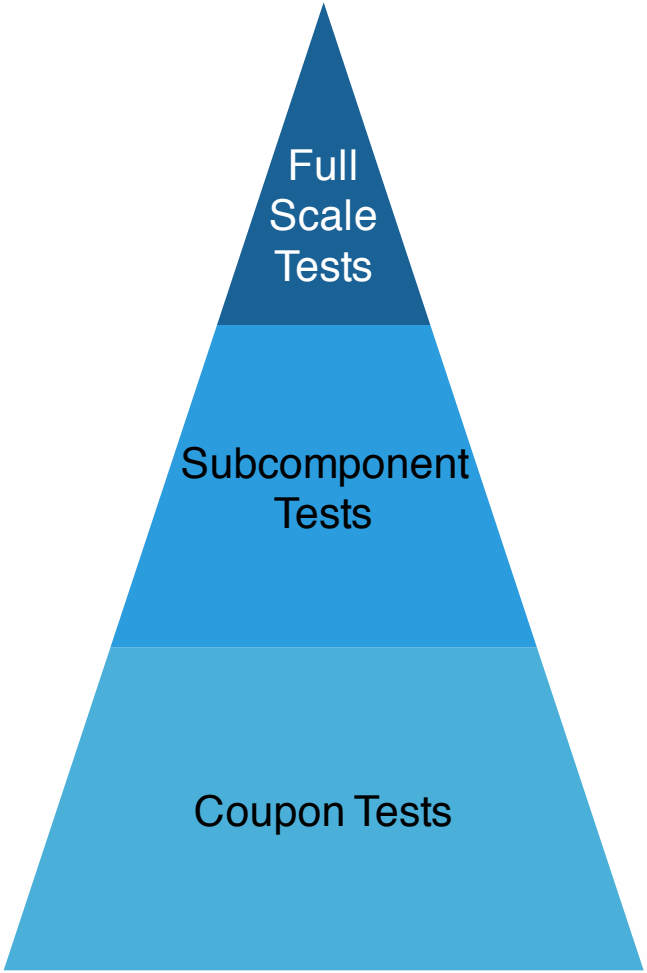
Powertrain Test Bench
(8 MW)

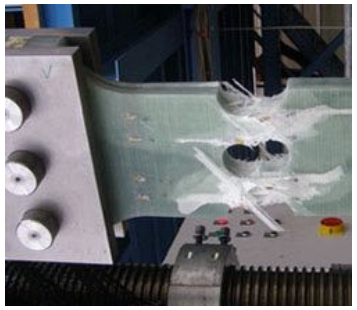


Generator / G. box Test Bench

Experimental Wind Farm (6x5 MW)

5 Advanced Tower Validation
WTG Blades vs Towers Validation Strategy Comparison



	WTG Blades	
Component Verification	√	
Design Details Validation	√	
Material Allowables Definition	√	

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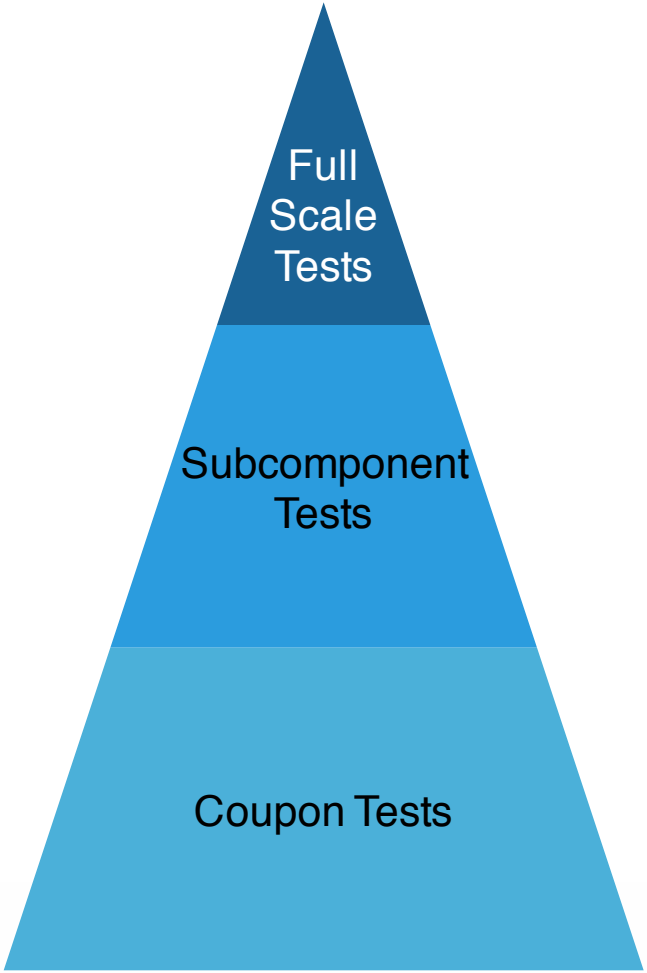
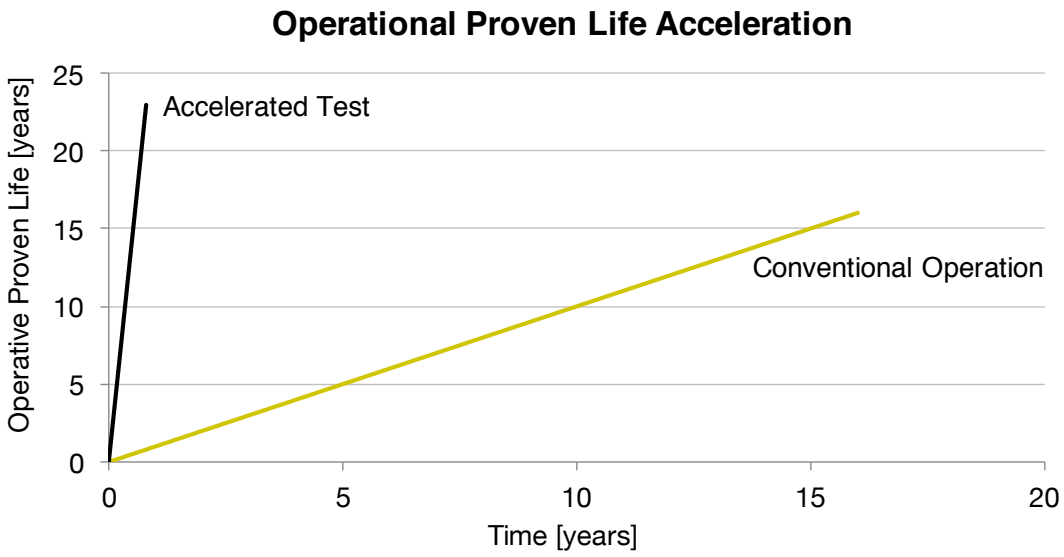
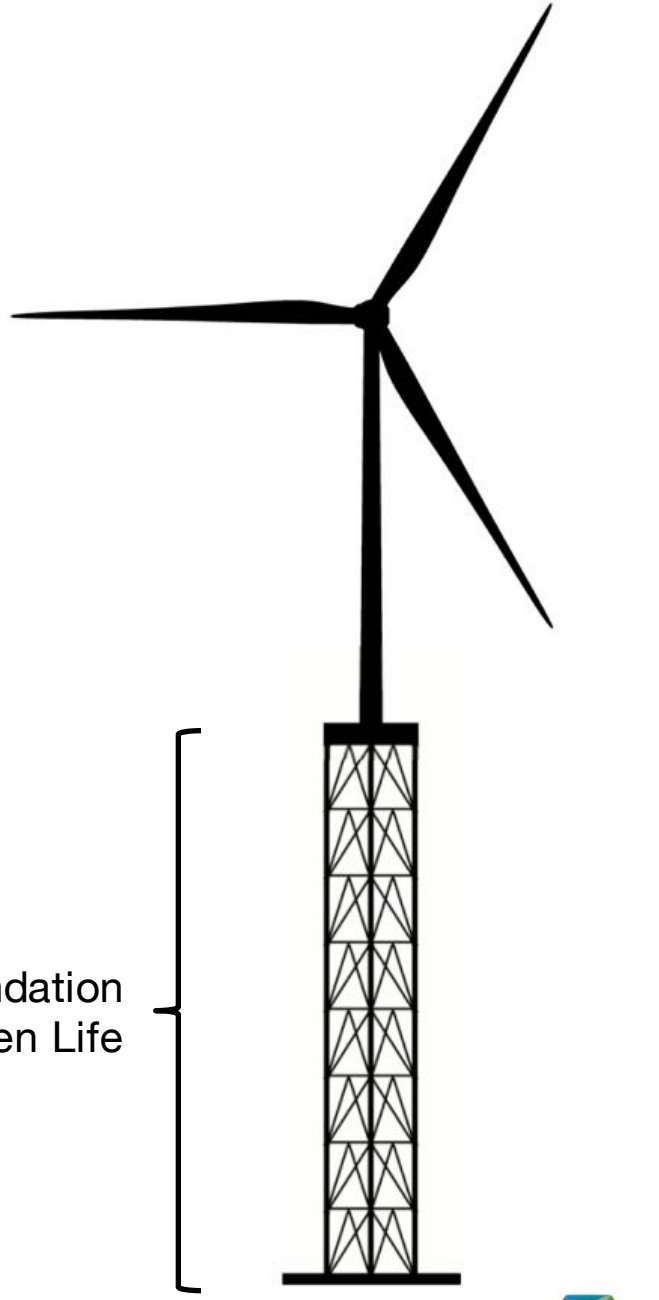


	WTG Blades	WTG Towers	SET
Component Verification	√	X	√
Design Details Validation	√	~	√
Material Allowables Definition	√	~	√

6 Fatigue Full Scale Tower Test
Test Objectives

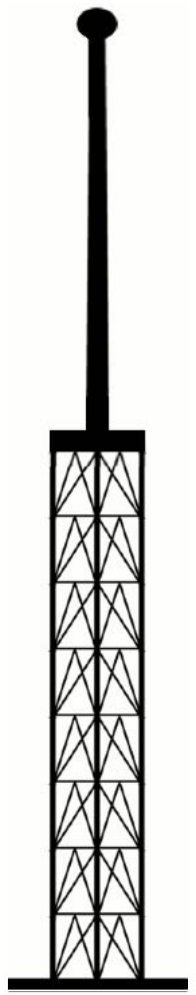




Tower & Foundation
Accelerated Proven Life

6 Fatigue Full Scale Tower Test
Test Setup

Tower Head Mass
Tower Head Exciter



Strain Gauges
LVDT
LVDT
Bolt Load Sensors

Hot Spots
Lattice Members
Foundation Settlement
Bolt Preload Control

6 Fatigue Full Scale Tower Test
Test Design

Tower Design Fatigue Loads 20/25 years

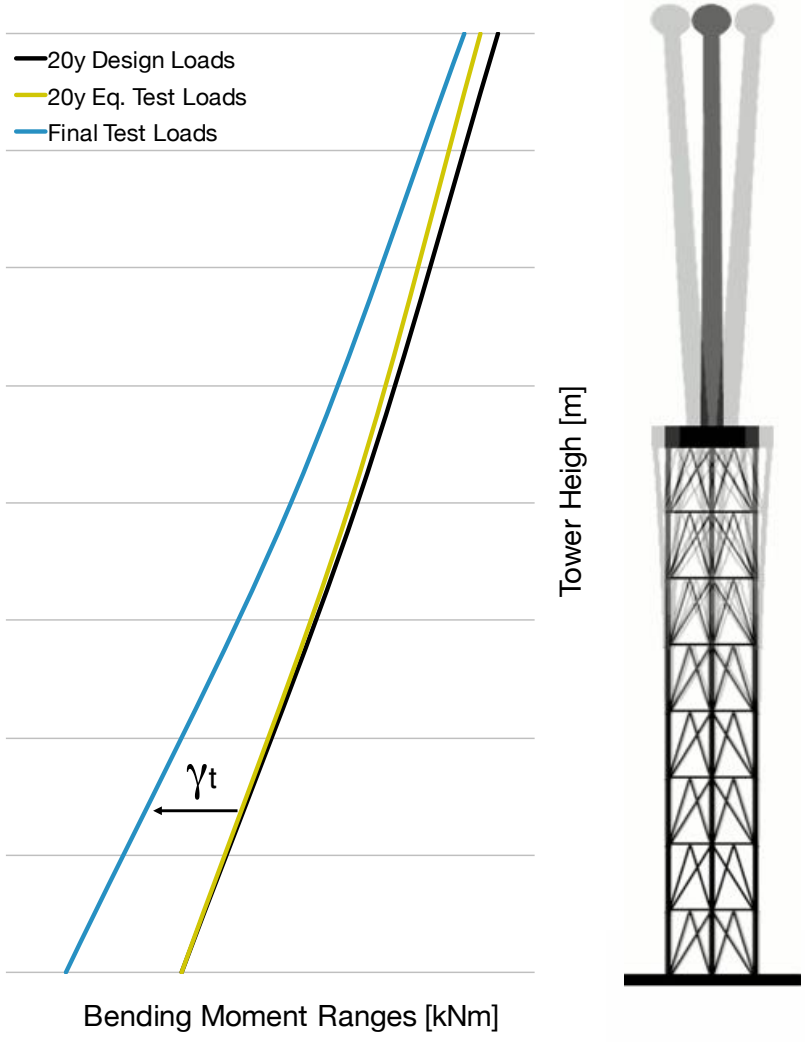
Damage-Equivalent Ranges Analysis

Test Equivalent Loads >20/25 years

IEC61400-23 based Test Factor (γ_t):
- Conseq. Failure
- Tower Variation
- Fatigue Formulation

Test Loads

Full Scale Test Load Distribution



7 XXL Tower Alternatives Evaluation
After SET Full-Scale Test


Tubular Steel


Segmented Steel


Precast Concrete or Hybrid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Nabrawind SET

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Tower Cost	◔	◑	◕	◕	●
Logistics	○	◕	◔	●	◕
Assembly & Erection	◑	◔	◔	◔	◕
Modal Coupling	○	◔	●	◑	●
Operation Proven Life	●	◑	◑	◑	◔

8 Nabrawind Self Erected Tower Project
Project Summary

2015	2016	2017	2018

Company / Project Funding

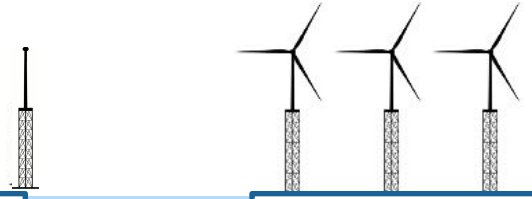
SET Technology Development

HH160 Tower Detailed Design

HH160 Tower Prototype Manuf. & Erection

Tower Tests

Tower Preserials



Design Certificate

Tower Certificate

Thanks for your Attention

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