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FEAC

ENGINEERING | REALIZE YOUR DIGITAL TWIN

Digital twins & numerical simulation of Wind turbines

www.feacomp.com

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Executable (real-time) Digital Twin

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Executable (real-time) Digital Twin

About Us

About Us



Consulting Projects

Delivering multi-physics simulation services covering the entire product development process.



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Smart Solution, Software & Technology Partner of SIEMENS DISW.



Training & Support

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Software Development

PITHIA, a unique simulation software



Engineering Expertise

Covering the entire product development process.



Aerospace/Aeronautics



Marine



Oil & Gas



Bioengineering



Construction



Renewable Energy



Accelerator Magnets

Realize your Digital Twin

Credit: Airbus Defence and Space
Source: ESA website ([link](#))
Collaboration with INASCO

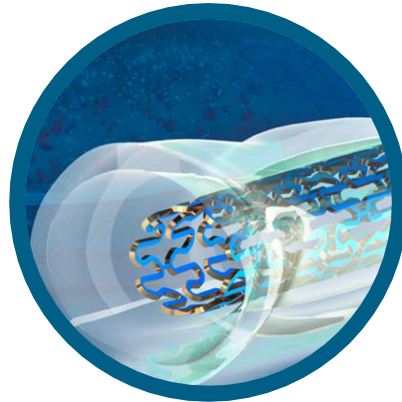
Some indicative projects



**CERN's
11T magnet**



**ESA's Juice
Mission**



**Coronary
Stent**



**Vessel's
Scrubber**

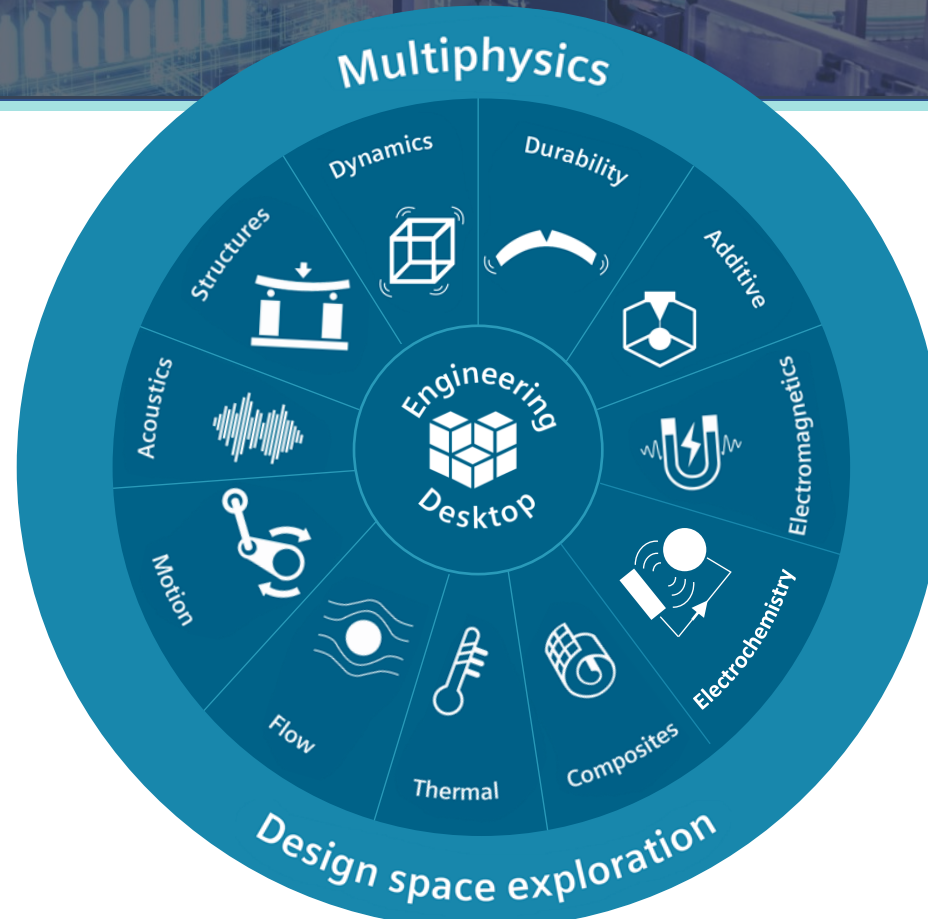


**Car's
Engine**

Some Of Our Partners And Clients



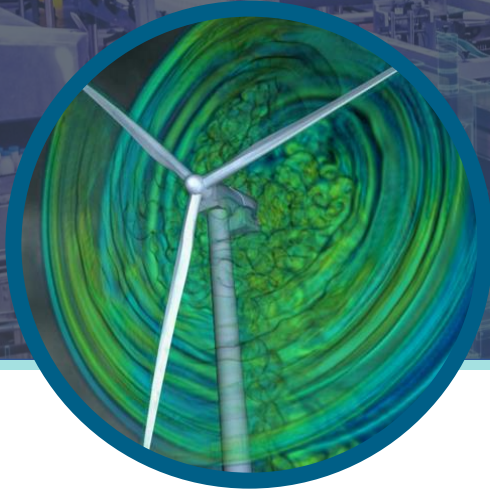
SIEMENS Simcenter





Simcenter 3D

Simcenter 3D is a fully integrated simulation platform for design, modeling, simulating and analyzing complex engineering products and Multiphysics simulations.



Star-CCM+

STAR-CCM+ software delivers accurate and efficient multidisciplinary technologies in the field of Computational Fluid Dynamics.



Amesim & gProms

Simcenter Amesim allows the virtual assesment and performance optimization of mechatronic systems.

gProms is a unified modelling and solution platform focusing on chemical reactions & operations.



Heeds

Modelling and simulation of various operating conditions. Design space exploration and design optimization.



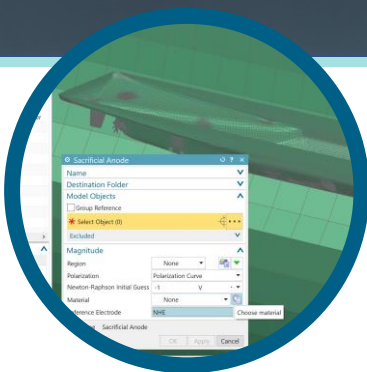
Pithia-CP

PITHIA-CP is FEAC's powerful and unique solution for Cathodic protection computer aided engineering, integrated and available as an addon module to the Siemens Simcenter 3D software.

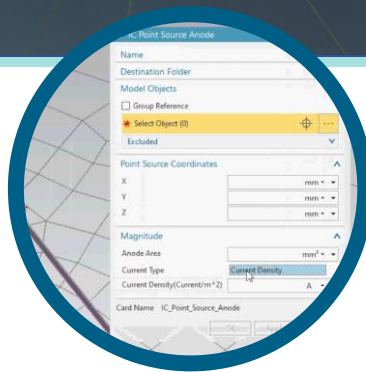
PITHIA-CP for Cathodic Protection



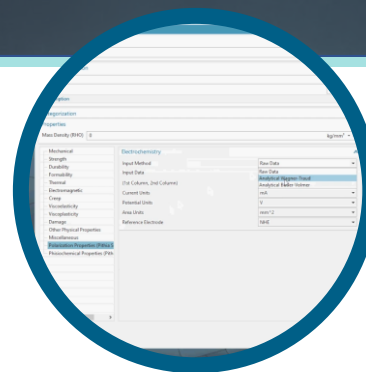
**Add-on module to
SIEMENS Simcenter 3D**



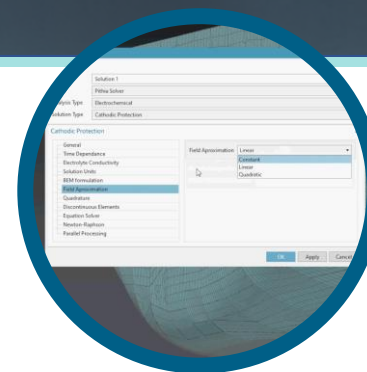
**Sacrificial Anode CP
(SACP)**



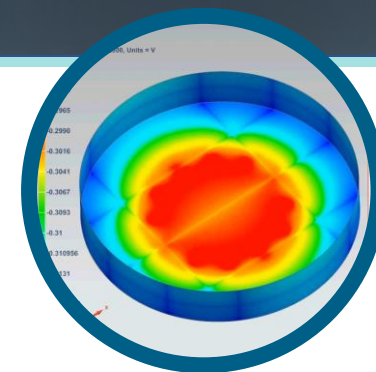
**Impressed Current CP
(SACP)**



**Material
Library**



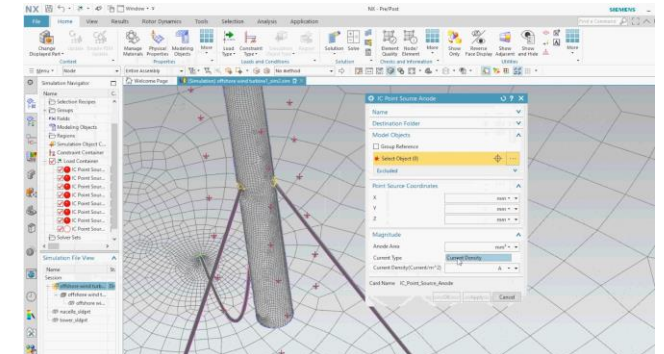
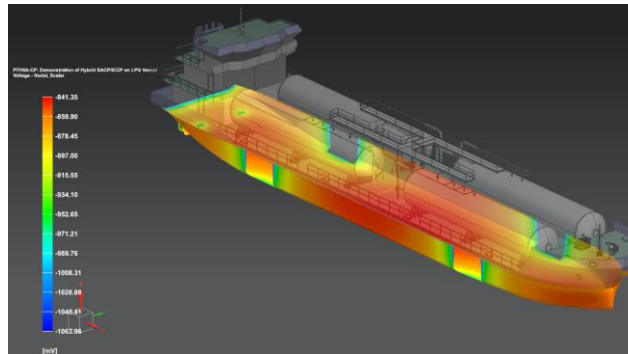
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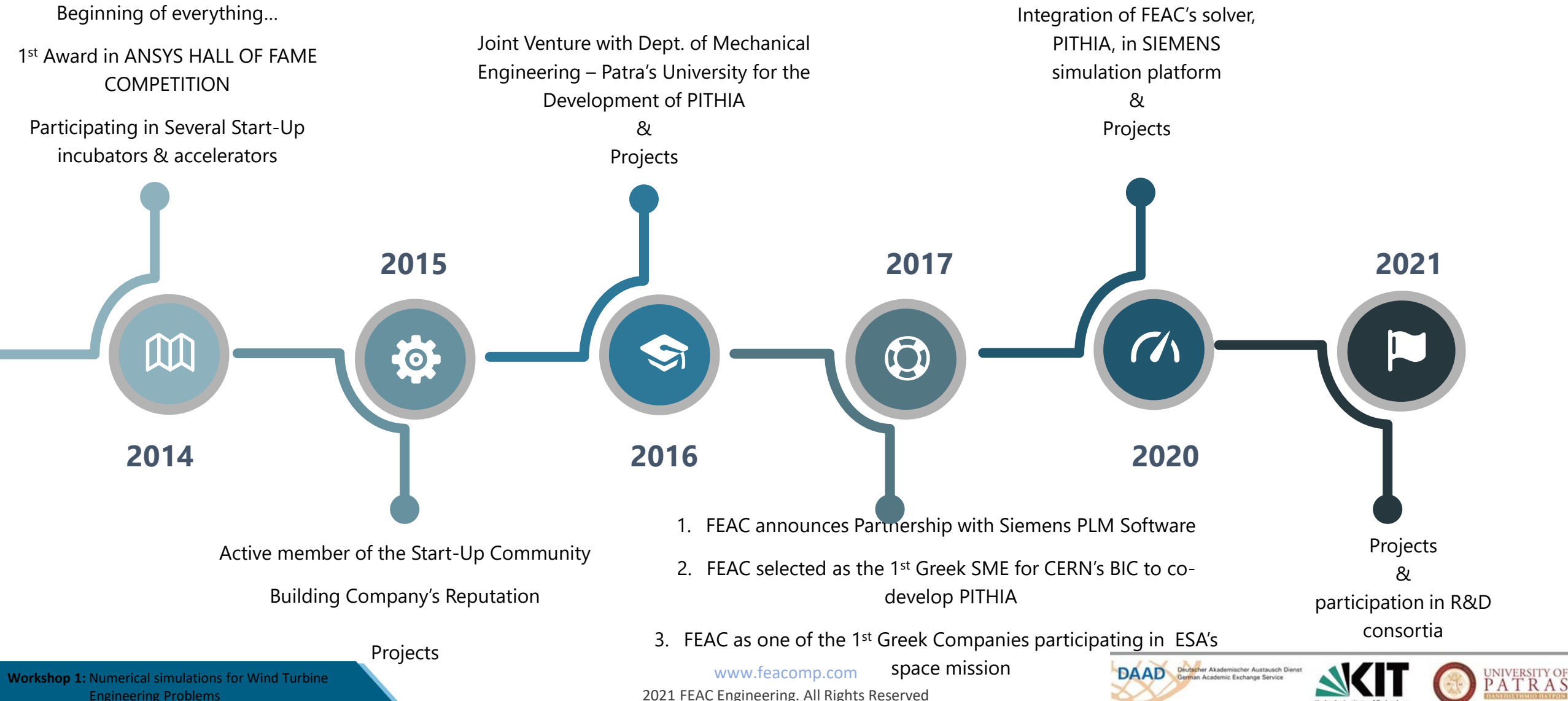


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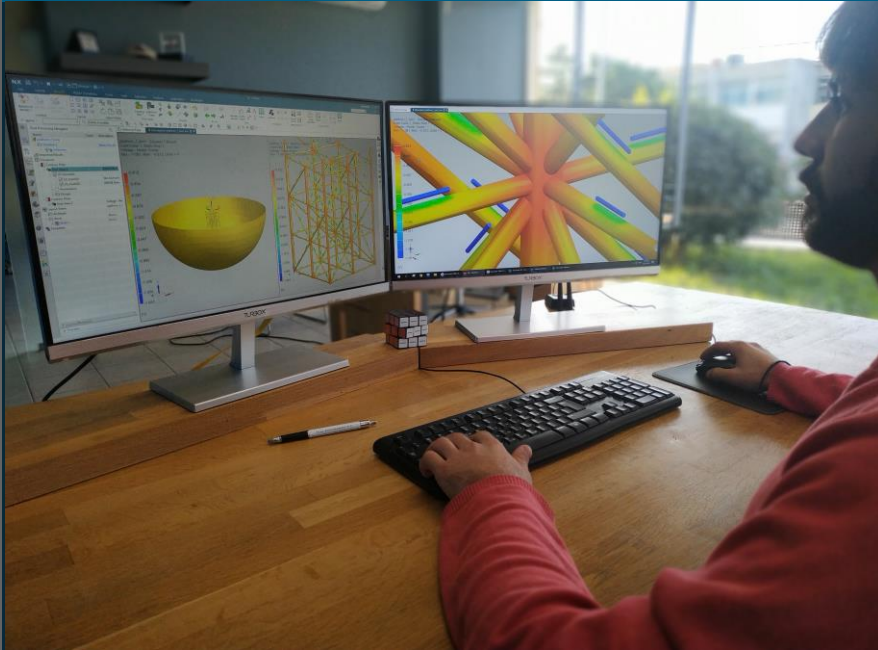


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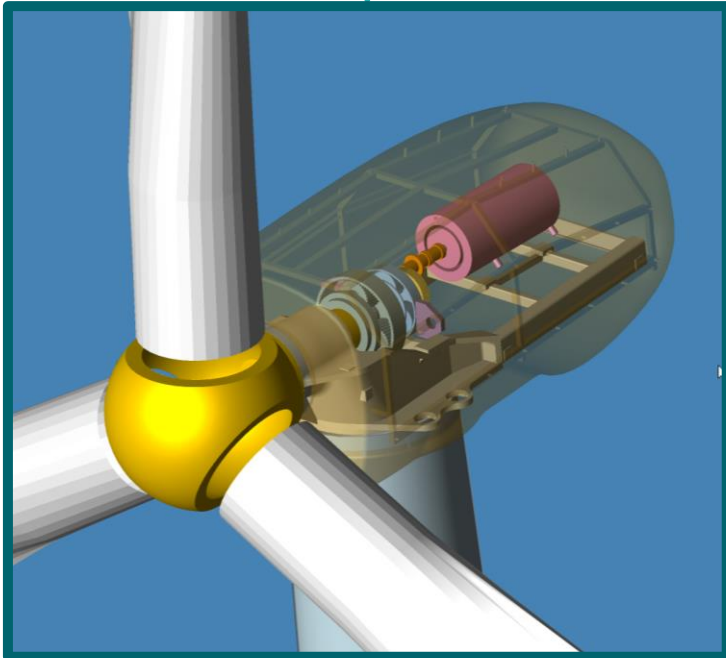


Holistic Digital twin

Ideation

Realization

Utilization



FEAC'S Expertise

Holistic Digital Twin Approach

Structural Performance:

Structural analysis



Computational Fluid Dynamics Performance:

Fluid dynamics analysis



NVH & Acoustic Performance:

e.g. Sound Vibration Analysis



Thermal Management:

Thermal Analysis



Electromagnetic Performance:

Electromagnetic Analysis



System Performance system:

e.g. 1D-3D co-simulation



Cathodic Protection:

Development of cathodic protection



Multiphysics Analysis:
Test-CAE correlation



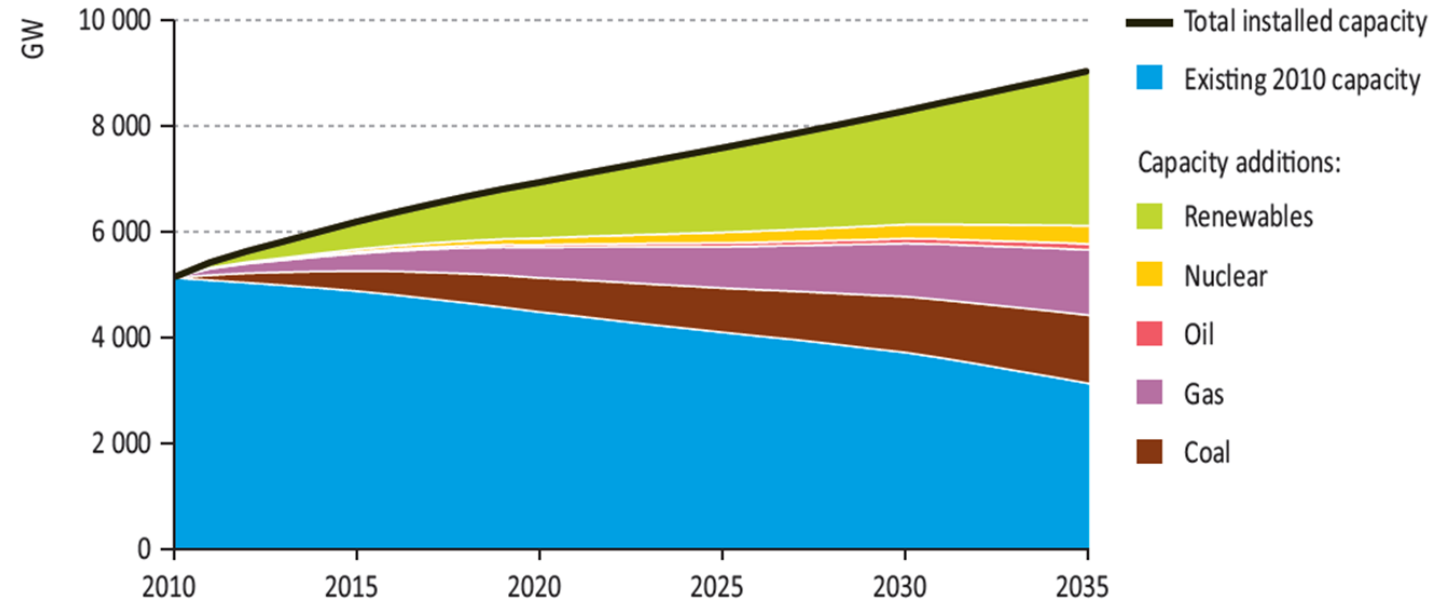
Verification & Certification

Wind Turbines

1. Introduction

General trends in the Energy Sector

- Increased environmental concerns
 - Environmental care
 - Lowering NOx and other pollutants
 - Decreasing noise levels
- Need for higher efficiency
- Keeping installations alive for a longer time and limit maintenance costs
- Peaks in energy demand and intermittent power generation demands energy storage



Gas & steam turbines



Wind turbines



Nuclear power plant



Electricity transformation & distribution



Power generation accessories (pumps, valves ...)

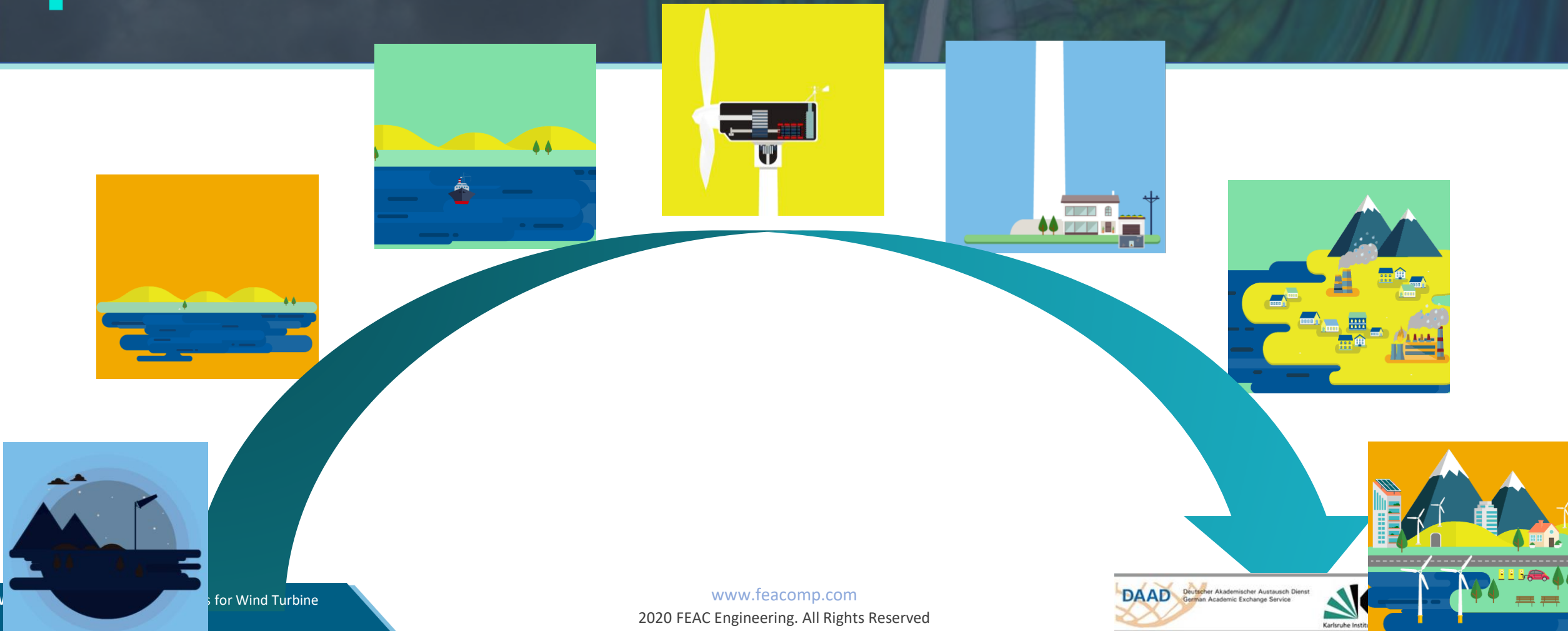


Electricity generating set (large diesel engines ...)

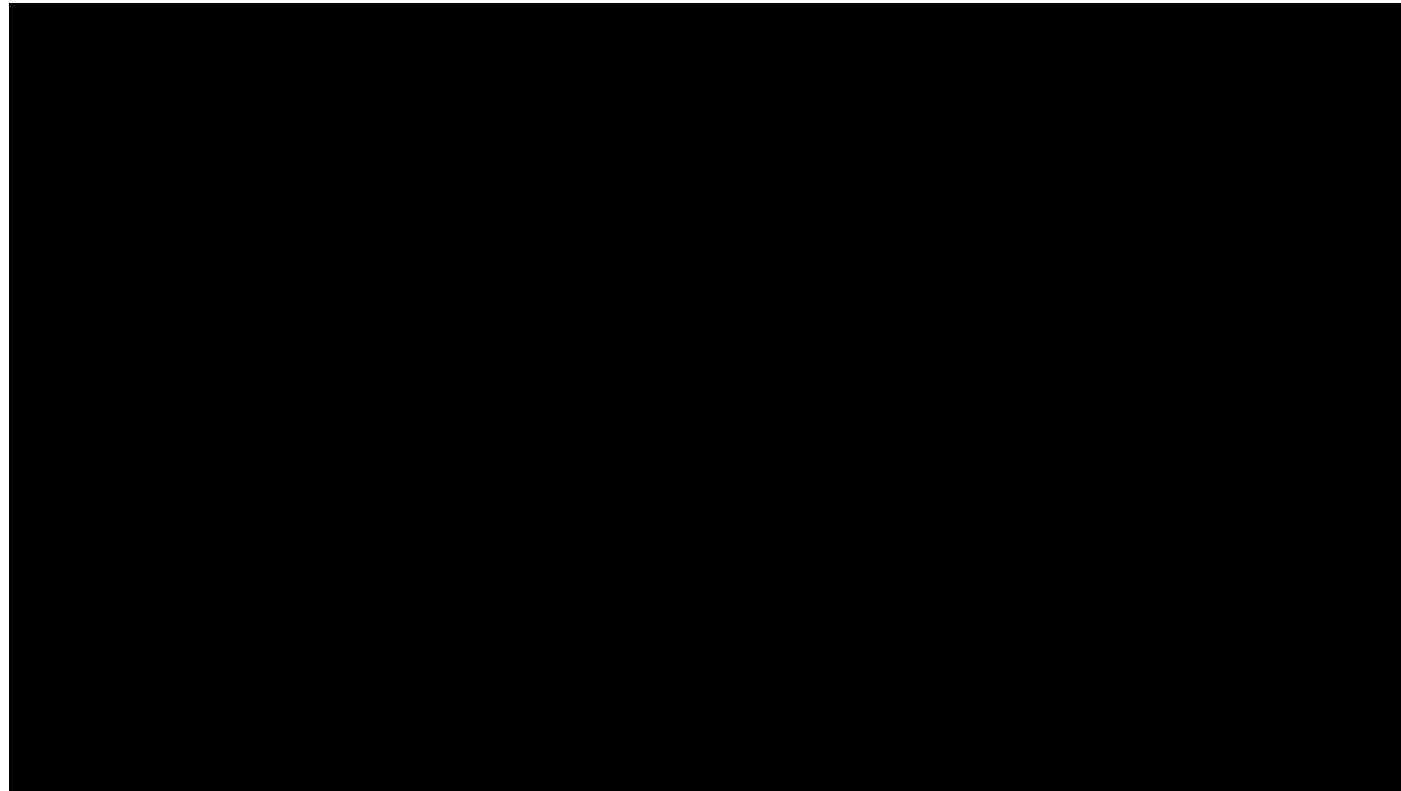


Oil & Gas

What is a WT?



| How does it work?



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Wind Turbines

2. Trends

The Changes in the Wind Energy Landscape

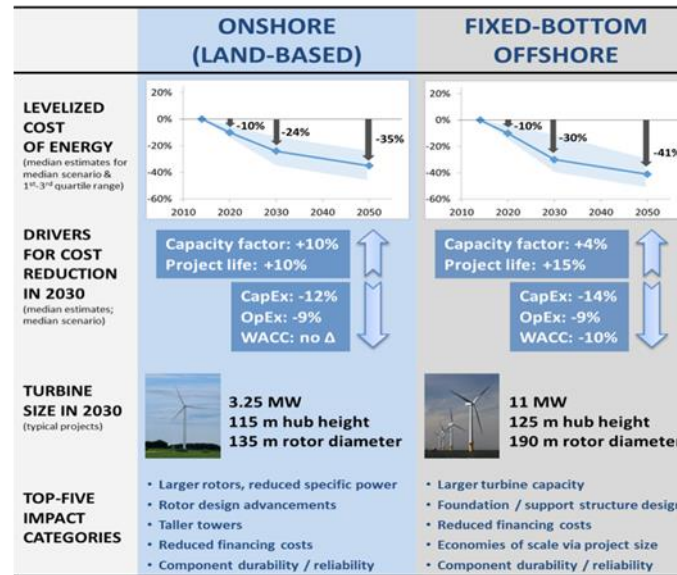
Shift to Offshore Wind Farms Logistical & technical challenges

The race to maximum energy harvesting leads to large offshore wind farms.



Wind Power Costs Reduced Rethink business model

The need to reduce the LCOE points to larger turbines, larger wind parks and longer lifetimes.



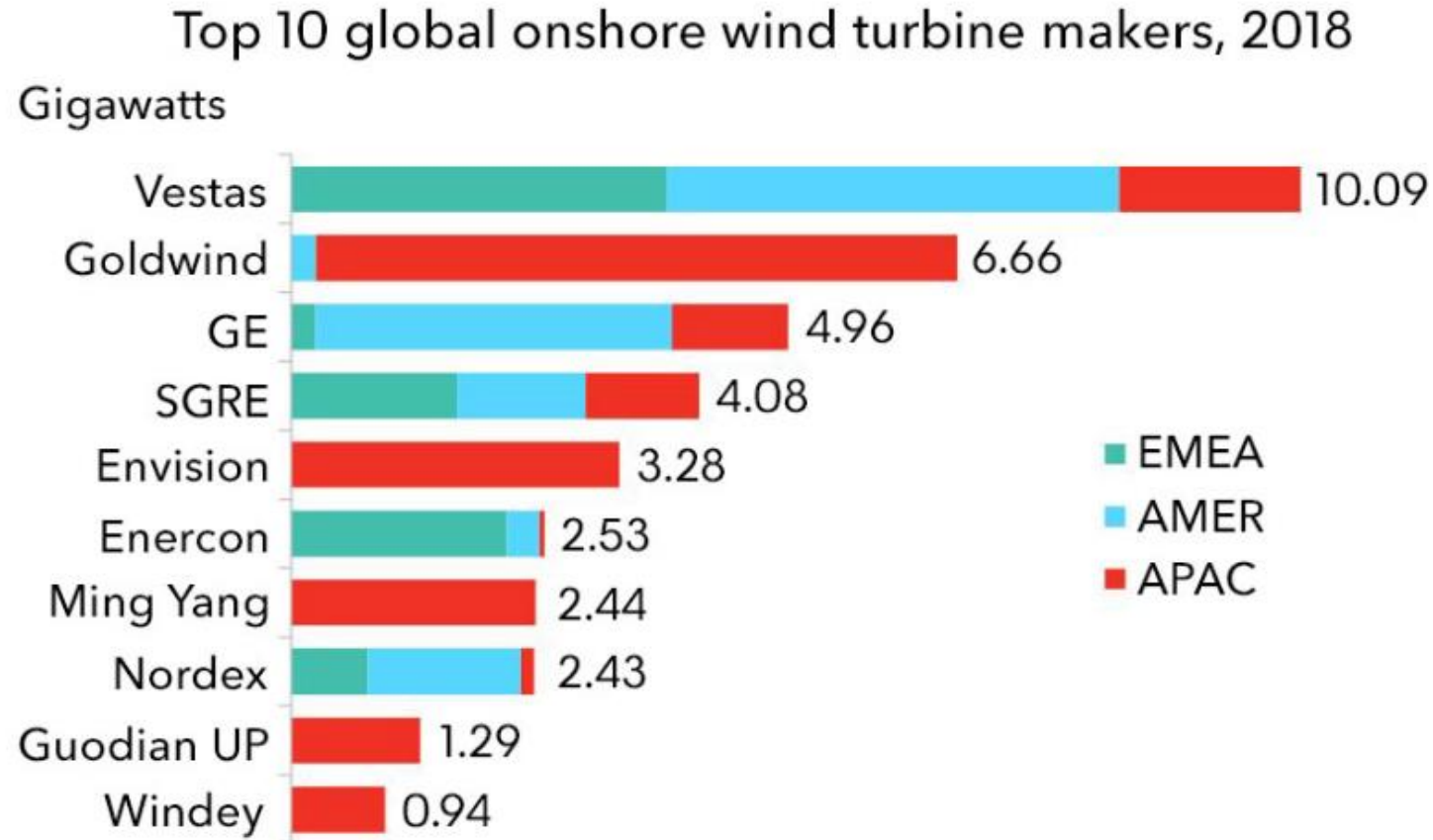
Source: Berkeley Lab, Energy Analysis and Environmental Impacts Division

Technology progresses Race towards bigger turbines

10MW (MHI-V), 12MW (GE), 14MW (SGRE), requires new and reliable technology. This leads to consolidation amongst the turbine makers. In 2019 the big 4 wind OEMs covered 55% of the market!



Stakeholders



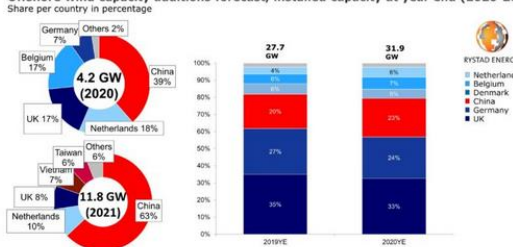
Source: BloombergNEF. Notes: Only includes onshore wind capacity. Total fully commissioned onshore wind capacity in 2018 was 45.4GW. SGRE is Siemens Gamesa Renewable Energy.

Rystad Energy: Global Installed Offshore Wind Capacity to Grow by 37% in 2021

February 4, 2021, by Adrijana Buljan

The world's installed offshore wind capacity rose by 15 per cent in 2020, despite the COVID-19 pandemic, and this year will see a 37 per cent growth in global installed offshore wind capacity, according to Rystad Energy.

Offshore wind capacity additions forecast, installed capacity at year end (2020-2021)



Source: Rystad Energy OffshoreWindCube

Source: Rystad Energy

Major contributor to both last year's and this year's growth is China. The country is expected to ramp up its offshore wind installation this year since after 2021 it will begin phasing out feed-in-tariffs, and many developers are therefore pushing to complete projects during the coming period.

Last year ended with 31.9 GW of installed offshore wind capacity, 15 per cent more compared to 27.7 GW at the end of 2019, with China accounting for 39 per cent of the additions, followed by the Netherlands (18 per cent) and the UK (17 per cent).

Rystad Energy expects the global installed offshore wind capacity to further increase by 11.8 GW in 2021, a 37 per cent increase compared to 2020, where China will continue to lead the new capacity additions, accounting for 63 per cent of the expected growth.

"China had a construction backlog of more than 10 GW going into 2020, and Chinese developers are racing to reach maximum commissioning by the end of the year in order to claim full feed-in-tariffs. This means 2021 is going to see major capacity additions, particularly since some projects initially scheduled for commissioning in 2020 ended up slipping into 2021", said **Alexander Fletre**, Rystad Energy's Product Manager for Offshore Wind.

Commitment Strong in Europe and U.S. Despite Delays

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UTM Consultants

Offshore Wind Business Development Manager EU
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Time for Offshore Wind to Wake Up to Full Benefits of Digitalisation

January 29, 2021, by Adrijana Buljan

The following article is a guest post by **Jonas Corné**, CEO at **Greenbyte**, a provider of asset management solutions. The article examines digitalisation in the offshore wind sector, the necessity of it and current challenges that hinder using digitalised solutions to advance offshore wind projects.

Despite the global disruption caused by the COVID pandemic, 2020 was a springboard for global offshore wind development. In Europe, the European Commission's 'offshore renewable energy strategy' targeted a 25-fold expansion of its offshore wind capacity by 2050, committing to significant investment in ports, grid connections and the wider supply chain to effectively support the sector's growth.

However, there is one key area in the EU's offshore strategy that, despite being crucial to the scaling up of green energy, is noticeably lacking in detail: digitalisation.

Too often, the development and implementation of advanced digital infrastructure and artificial intelligence (AI) has been seen as a 'nice-to-have' by the offshore wind sector, which means that some significant advances have gone under the radar. Indeed, AI algorithms are now capable of providing more than just a way to reduce operations and maintenance (O&M) costs, with new technologies able to stabilise central grids and increase electricity dispatch efficiency already available on the market.

In spite of its rapid growth, offshore wind has not managed to keep up with innovation in digital technologies, with many European offshore owners continuing to rely on outdated in-house data management systems.

This lack of understanding around digitalisation's potential benefits is also reflected at a company level. In a 2019 ORE Catapult survey, 94% of respondents agreed that the offshore wind industry was not extracting the full value of data and digital technologies as effectively as it could. In spite of its rapid growth, offshore wind has not managed to keep up with innovation in digital technologies, with many European offshore owners continuing to rely on outdated in-house data management systems.

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Biden Sets The Stage For An Offshore Wind Energy Boom

By [Tsvetana Paraskova](#) - Feb 14, 2021, 4:00 PM CST



The U-turn of the U.S. Administration's energy policies under President Joe Biden sets the stage for a flourishing U.S. offshore wind industry, as the federal government looks to speed up environmental reviews to make offshore wind a significant contributor to the new clean energy goals. In the United States, offshore wind hasn't really taken off, with just two small offshore wind farms in operation with less than 50 megawatts (MW) of combined capacity. To compare, Europe has 113 offshore wind farms in 12 countries installed, with [25 gigawatts \(GW\)](#) of total offshore wind capacity.

The U.S. [is smashing records](#) in onshore wind, solar, and storage installations, with records for each of those in 2020, according to the American Clean Power Association.

But offshore wind has been considerably lagging behind, also because of lengthy environmental reviews from federal agencies and the weighing of pros and cons of having offshore wind installations within sight of beaches or in areas of commercial fishing.

Near-future Opportunities all-around the globe

South Korea

South Korea unveils \$43 billion plan for world's largest offshore wind farm

By Myoung Seon

SEOUL (Reuters) - South Korea unveiled a 48.5 trillion won (\$43.2 billion) plan to build the world's largest wind power plant by 2030 as part of efforts to foster an environmentally-friendly recovery from the COVID-19 pandemic.



Ireland

Ireland Speeds Up Seven Offshore Wind Projects

May 18, 2021, by Nadia Dargatzis

The Irish government has designated seven offshore wind projects as relevant, meaning they will be fast-tracked through the new marine planning regime.

The selected projects include the **Orla**, **Imagery's Bray and Kish Banka**, **Costing (east)**, **Slend Rocka** and **North Irish Sea Array (NISAA)** wind farms.

The announcement means the projects are allowed to work and update a number of aspects as they can apply under the new marine planning regime which will be introduced by the Marine Planning and Development Management Bill 2020.

Minister for Housing and Urban Development Denis O'Brien said: "This is a great milestone for Ireland as it marks the first time that offshore wind projects have been fast-tracked through the new marine planning regime."

"I am pleased to announce a way forward for these offshore renewable energy projects which will now be determined under the planning regime to be introduced in the Marine Planning and Development Management Bill 2020," said Minister English.

"Under this new marine planning regime, these projects will apply for final development consent as one. This will provide further opportunities for public consultation on the individual projects."

To remind the Government's Climate Action Plan commits to having at least 3.5 GW of offshore wind in Ireland in the next ten years, which will help renewables account for 70% of electricity generation by 2030.

UK

UK Global Energy Group and Italian fabricator Rosetti join up for offshore wind and oil gigs

The tie-up will link Scotland's North Sea Nigg yard with manufacturing facilities in Ravenna harbour Sea to build towers, jackets, substations and floating platforms

The UK's Global Energy Group (GEG) has formed a joint venture (JV) with Italian oil & gas construction giant Rosetti Marino with an eye on the fast approaching market for offshore substations as North Sea wind fleet expands, along with oil & gas platform electrification projects, Recharge can reveal.

The tie-up, a five-year deal with extension options, expects to coordinate use of the GEG-owned Nigg fabrication yard in Scotland with Rosetti's construction facilities in Ravenna harbour on the Adriatic, to manufacture large

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UK

GBP 6.5 Billion East Anglia Hub to Feature 14+MW Siemens Gamesa Wind Turbines

February 2, 2021, by Adnan Durakovic

ScottishPower Renewables has selected Siemens Gamesa as the preferred bidder to supply and install 14-MW wind turbines for its GBP 6.5 billion East Anglia Hub programme offshore the UK.

More than 200 next-generation 14-MW turbines are planned for East Anglia ONE North, TWO, and THREE projects in the southern North Sea – collectively known as the East Anglia Hub, Iberdrola, the parent company of ScottishPower Renewables, said.

The two companies have agreed to work together ahead of the next Contracts for Difference auction – scheduled for later this year – to optimise the projects, with the ambition of then signing turbine supply and installation agreements.

Greece

Floating PV parks draw investments from Greek companies

3 companies are moving forward with new floating PV power parks in Greece. Terna Energy plans to expand into this new market, installing a floating PV park for a production certificate to develop 3 floating PV power parks totaling €170 million and with a total capacity of 265 MW. PPC Renewables – AEP Hellenic Energy, has also submitted applications to RAE for the advancement of a park in northern Greece with a total capacity of 50 MW, while Interphoton Group has applied for the installation of a 500 MW park in Lake Polyphytou. It appears as though a new chapter is unfolding in Greece's PV investment potential.

Sweden

Ørsted Probing Swedish Offshore Wind Sites

February 5, 2021, by Adnan Durakovic

Leading offshore wind developer Ørsted plans to start a consultation process on the offshore wind project in Sweden this spring.

The project is in an early development phase and the consultation is part of the permitting procedure, Ørsted said.

The wind farm covers an area of around 400 square kilometres located some 20 kilometres off Sweden's southernmost coast – Skåne.

The project will have the capacity of up to 1,500 MW.

Denmark

Denmark to construct artificial island as a wind energy hub

The construction project, believed to be the biggest in Danish history, will link hundreds of wind turbines to deliver enough electricity for millions of households.

Denmark approved plans on Thursday to construct an artificial island in the North Sea and use it as clean energy hub.

Vietnam

Siemens Gamesa Lands Its Largest Nearshore Project in Vietnam

February 5, 2021, by Adnan Durakovic

Siemens Gamesa has secured contracts to provide wind turbines and operations & maintenance services for a 100 MW nearshore wind farm in Vietnam.

The Tra Vinh Dong Hai 1 wind farm will feature 25 SG 5.5-145 turbines with a flexible power rating.

Additionally, Siemens Gamesa signed a 20-year long-term contract to provide O&M services for the project.

This is Siemens Gamesa's largest nearshore wind project in Vietnam to date.

Paula Soares, CEO of Siemens Gamesa's Onshore Business Unit in Asia Pacific, said: "We are investing to grow our assets and presence in Vietnam to ensure that we produce the best solutions available to long-term valued customers accelerate the development of wind energy in the country."

Located some 3.5 kilometres offshore the Tra Vinh province, the Tra Vinh Dong Hai 1 wind farm is the first nearshore project by Truongbinh Group as the company expands to the nearshore sector to complement its existing renewables portfolios for solar and onshore wind projects.

China

Offshore wind takes off in China

China's offshore wind sector, like solar and onshore wind before it, is soaring, boosted by government support and improved technology.



In the past two years, China's offshore wind power has increased more than any other nation.

A Global Wind Energy Council report on offshore wind in 2019 described the year as the best yet for the sector – and the biggest ever for China's offshore wind capacity. China and the Asia-Pacific region look set to drive growth in the sector for the coming decade.

UK

Bidding Starts on UK Offshore Wind Seabed Rights

CONTRACTS & TENDERS

January 28, 2021, by Adnan Durakovic

UK seabed manager The Crown Estate has launched the third and final stage in the tender process to award up to 8.5 GW of new offshore wind projects.

The Offshore Wind Leasing Round 4 has now entered the multi-cycle bidding process under Invitation to Tender (ITT) Stage 2.

Once all bidding cycles have concluded, The Crown Estate will share the details of the outcome, including the identity of successful bidders, and the location and capacity of their proposed projects.

At this stage, using option fees bid by eligible bidders to determine the award, one project is awarded per daily bidding cycle, with bidding cycles continuing until the 7 GW minimum capacity limit has been awarded or exceeded.

Near-future Opportunities all-around the globe


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USA

BP Officially Enters Offshore Wind

February 1, 2021, by Adrijana Buljan

BP and Equinor have closed the transaction for BP's acquisition of a 50 per cent interest in the Empire Wind and Beacon Wind projects off the U.S. east coast.

The closing of the transaction marks BP's official entry into offshore wind.

"We see significant opportunities by rapidly growing bp's offshore wind business, making a major contribution to our strategic goals and developing assets that will provide long-term, stable returns", said **Ben Sengul**, BP's executive vice president of gas and low carbon energy.

The British oil & gas giant has bought the stakes in the two projects for a total cash consideration of around USD 1.1 billion, excluding customary purchase price adjustments.

Equinor and BP announced in September 2020 that BP was buying 50 per cent non-operated interests in Empire Wind and Beacon Wind and that they were establishing a strategic partnership, which would see the two companies together pursuing further growth in the U.S. offshore wind market.

"This transaction is the first step in the strategic partnership in offshore wind where Equinor and bp are combining strengths to enable profitable growth in offshore wind in the U.S. Equinor will remain the operator of the projects in these areas through the development, construction and operations phases, and the wind farms will be equally staffed in operation", Equinor said.

On 13 January, the New York State Energy Research and Development Authority (NYSERDA) selected the partnership between Equinor and BP as the winner of the state's second offshore wind solicitation. Under the award, the companies will develop the 1,260 MW Empire Wind 2 and the 1,230 MW Beacon Wind 1 offshore wind projects and will also partner with the State of New York to transform the South Brooklyn Marine Terminal (SBMT) and the Port of Albany into large-scale offshore wind working industrial facilities.

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BP

Equinor

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Location

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Poland

Breaking: Polish Parliament Passes Offshore Wind Act

January 13, 2021, by Adnan Durakovic

Poland's Senate has unanimously passed the Offshore Act regulating the development of offshore wind farms in the Polish Baltic Sea.

The bill has now cleared both chambers of the Polish Parliament, the Sejm and the Senate, marking the end of the legislative process in this institution.

The bill is expected to be signed into law by Poland's President Andrzej Duda shortly and come into force in late January or early February, the Polish Wind Energy Association (PWEA) said.

The Senate approved the Offshore Act without adding any amendments.

"This is a historic moment and a key act not only for our energy, mostly based on fossil fuels, but also for our economy," said **Kamila Tarnacka**, vice president of PWEA.

"The regulations contained in the so-called Offshore Act, which is the basis for the development of wind farms in the Polish part of the Baltic Sea, will support the process of transformation of Poland towards low-emission for the next decades. Launching investments worth around PLN 130 billion will help to reduce the negative effects of the slowdown caused by the pandemic."

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Taiwan

Boskalis and MENCK Team Up Offshore Taiwan

January 25, 2021, by Adnan Durakovic

Pile-driving specialist MENCK has won a contract to support Boskalis with the foundation piling activities on the Changfang and Xidao offshore wind farm in Taiwan.

This involves the piling of 186 pin piles for the 62 three-legged jacket foundations being installed over two campaigns in 2021 and 2022 in water depths of up to 40 metres, Aecton, MENCK's parent company, said.

MENCK will be providing a piling hammer spread including two 1200 KJ hammers with associated powerpicks and winches for the project.

"Providing services on this project is a significant achievement within the Taiwanese region where we are continuously increasing our presence through equipment development, strategic partnerships and deployment of localised personnel," **TJ Pan**, Taiwan country manager at Aecton, said.

"Our track-record is growing and is enhanced by Aecton's partnership with DWTEK in Taiwan. DWTEK will assist us with local suppliers, importation/customs and personnel work permits and Visas."

Back in 2019, Boskalis established a joint venture to transport and install the jacket foundations and the accompanying pin piles at the 589 MW Changfang and Xidao project.

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France

French Offshore Wind Tender Enters Competitive Dialogue Stage

January 25, 2021, by Adnan Durakovic

France's Commission de régulation de l'énergie (CRE) has opened a competitive dialogue process towards selecting the developer of an offshore wind farm off the Cotentin Peninsula, Normandy.

The process will be carried out in three phases: the selection of applications, competitive dialogue, and tender submissions and the selection of a winner.

The procedure is scheduled to be completed and the winner announced in 2022.

The deadline for the submission of applications is 12 March at 12 noon local time. Questions can be submitted by 12 February, CRE said.

The area selected for the development of the wind farm, France's eighth, is located more than 32 kilometres off the coast of Normandy.

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USA

US Hits Pause Button on Oil & Gas Leasing, Doubles 2030 Offshore Wind Target

January 28, 2021, by Adrijana Buljan

U.S. President Joe Biden signed a new Executive Order on 27 January, directing the Department of the Interior to identify steps that can be taken to double offshore wind energy production by 2030 and to pause entering into new oil and natural gas leases on public lands and in federal waters.

The Executive Order comes a week after Biden's statement of acceptance of the Paris Agreement on 20 January, following the U.S. exiting the Paris Agreement under the previous Administration. With the new order, Biden-Harris Administration aims to achieve a carbon pollution-free power sector by 2035 and put the U.S. on an irreversible path to a net-zero economy by 2050.

"The order affirms that, in implementing – and building on – the Paris Agreement's objectives, the United States will exercise its leadership to promote a significant increase in global ambition. It makes clear that both significant short-term global emission reductions and net zero global emissions by mid-century – or before – are required to avoid setting the world on a dangerous, potentially catastrophic, climate trajectory," the White House states in a press release.

The federal agencies are also directed to eliminate fossil fuel subsidies and identify new opportunities in clean energy technologies and infrastructure. The Department of Interior said that it would immediately begin a review of processes and procedures to date as it re-invests in a rigorous renewable energy program.

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Greece

Greece Opens Public Consultation on Offshore Wind Legislative Framework

January 22, 2021, by Adrijana Buljan

The Greek wind energy association ELETEN has launched public consultation for a legislative framework for the development of offshore wind in Greece.

The consultation period will run until 1 February and is part of the implementation of the project "Necessary legislative adjustments to promote offshore wind energy in Greece", funded by the EEA Financial Mechanism 2014-2021 programme.

Feedback will be provided on the basic documents and draft regulations for the new institutional framework for offshore wind energy in Greece and these, together with the results of the consultation, will be submitted to the governing bodies of ELETEN to take the relevant decision to submit a final proposal to the Greek government.

According to WindEurope, the Greek government announced that it was considering a new legislative framework for offshore wind last summer.

"For the new framework to be most effective it should consider defining an ambitious pipeline of projects and a schedule of actions, ensuring stable revenues for projects via Contracts for Difference, investigating and allocating sites efficiently and offering financing for new infrastructure", WindEurope said.

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Croatia

Croatian Oil & Gas Company Eyeing Offshore Wind in Adriatic Sea

January 27, 2021, by Adrijana Buljan

Croatian oil and gas company INA-INDUSTRIJA NAFTE, d.d. (INA) plans to diversify into renewable energy and is specifically considering offshore wind and solar energy developments in the country.

At an energy conference held on 26 January, INA's Director of Strategic Operations and Public Affairs, Hrvoje Glavaš, said that INA would first start with solar energy and the installation of pilot solar projects at its own industrial facilities.

The company is considering offshore wind projects in the Adriatic Sea and sees great potential for using this technology off the Croatian coast, where it already operates gas fields, according to Glavaš.

In 2018, when the Italian oil and gas company Eni announced it was leaving the upstream sector in Croatia with the sale of Eni Croatia b.v. to INA, the Croatian company became the owner and operator of the Northern Adriatic and Marica gas fields.

One of the renewable energy sources INA is now also looking into is geothermal energy.

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UAE

Lamprell Setting Up Renewables Unit

January 14, 2021, by Nadja Skopjak

The UAE-based Lamprell is setting up a new business unit dedicated to the renewable energy sector as part of its wider strategic reorganization.

Lamprell stated that this comes as part of the group's goal to increase its focus on renewables and the energy transition.

The Renewables unit will explore opportunities of collaborating with others to increase the company's execution capacity and support the local content objectives of clients, as well as to move up the renewables value chain, consistent with the group's strategic focus on EPC/CI.

According to Lamprell, renewables opportunities currently make up USD 2.5 billion, circa 40% of the group's bid pipeline, with the increase attributable to U.S. renewables entering the pipeline.

The company also announced a reorganization into the Digital and Oil & Gas units, stating that the aim is to maximize opportunities across its core markets.

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Italy

Italy on pole in race for first Mediterranean offshore wind

28 February 2018 11:11 GMT - UPDATED 27 February 2018 8:44 GMT
By Bernd Reinhardt in Munich

Italy – and likely the Mediterranean – first offshore wind project, a 30MW nearshore array off the southern Italian town of Taranto, has reached financial close, consultancy Mott MacDonald said.

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South Korea

South Korean Pair to Develop Offshore Wind Substation

GRID CONNECTION
January 20, 2021, by Nadja Skopjak

Daewoo Shipbuilding & Marine Engineering (DSME) and Korea Electric Power Corporation Engineering & Construction (KEPCO E&C) have signed a Memorandum of Understanding (MoU) to develop an offshore wind substation.

해상풍력 발전설비시장 진출을 위한 양해각서 체결
2021. 01. 19. (수) : 09:30 (KST)

DSME Issues Green Quarter Back Lamprell's Green Quarter Contract
13 days ago

Lamprell Cuts Into Sangre
4 months ago

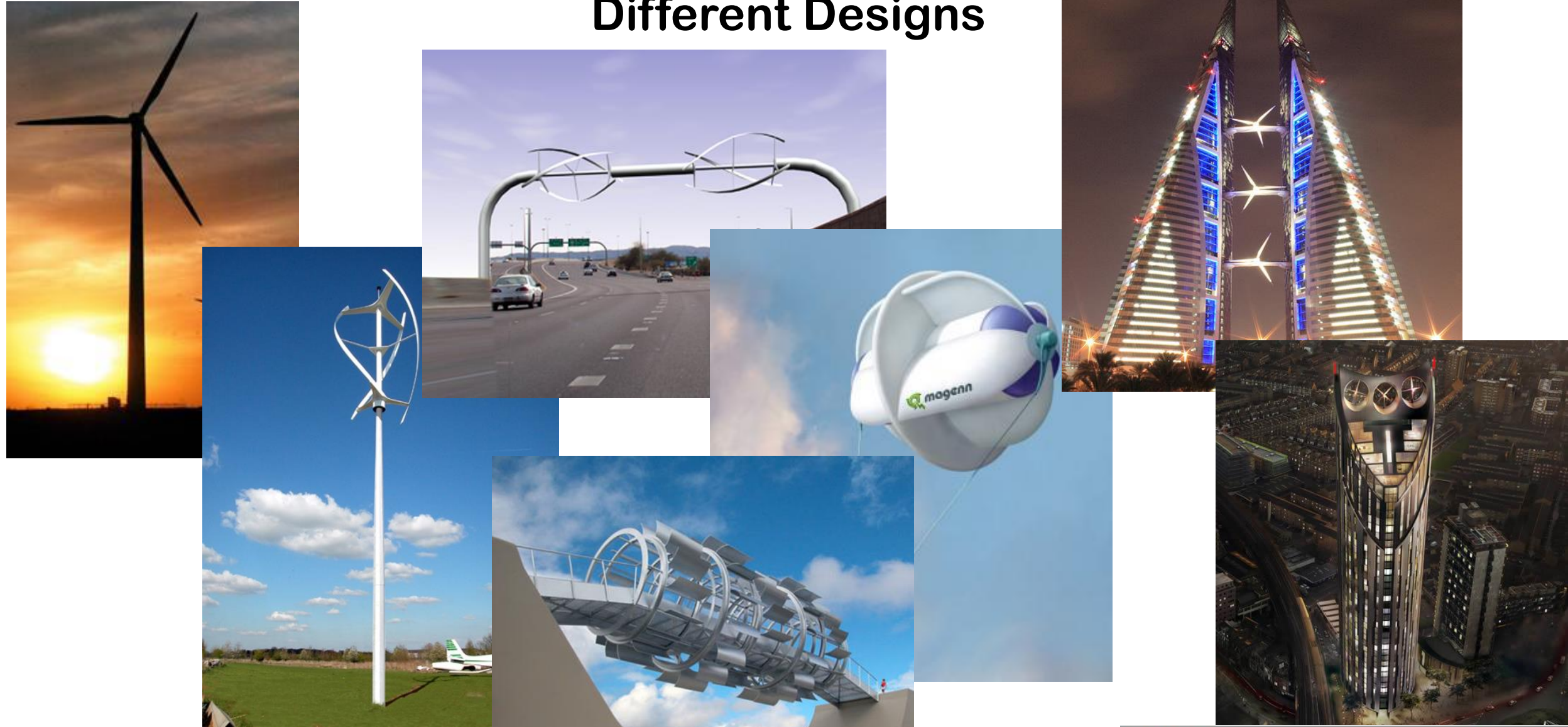
Japan's MOI Sets Up Offshore Wind Division
2 months ago

Source: DSME

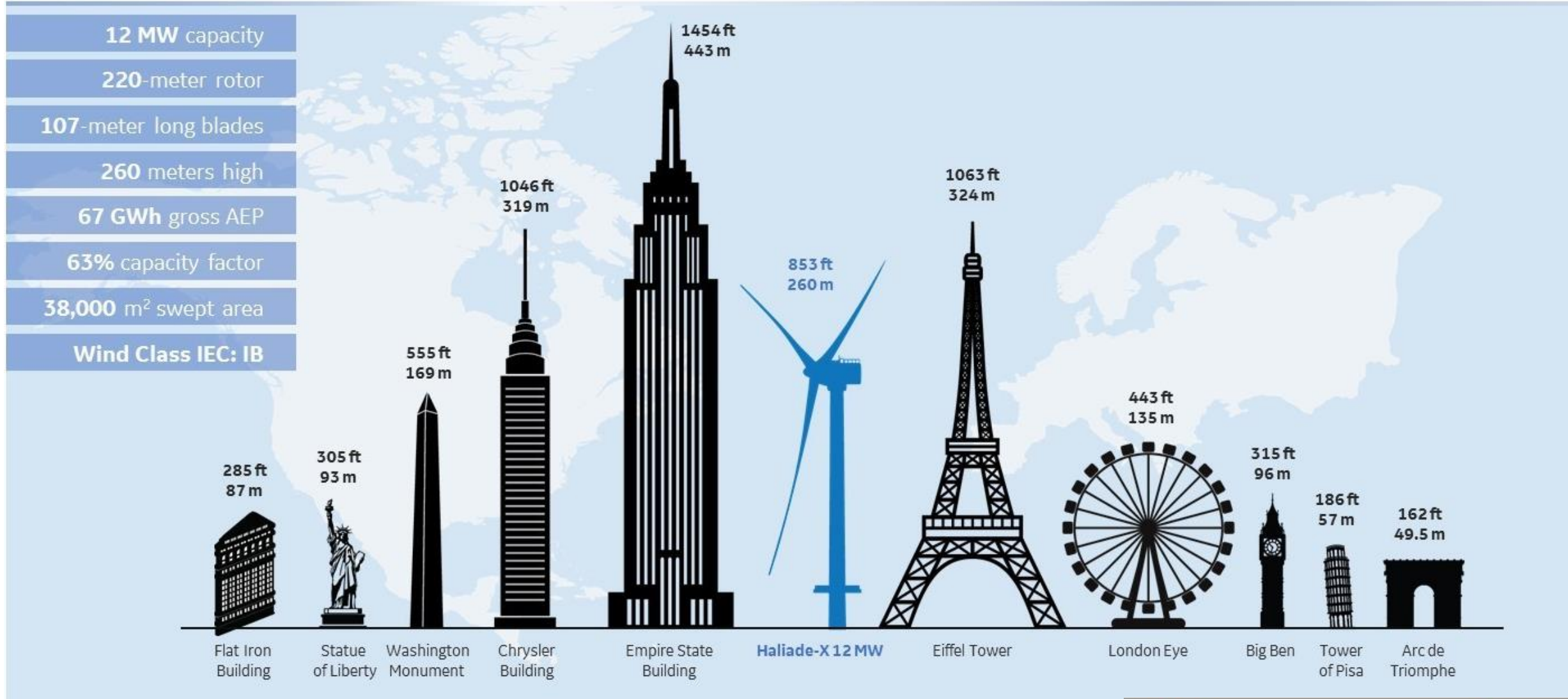
The South Korean companies plan to jointly research and develop the offshore substation both for the shallow and deep waters, as well as further expand their business targets to the overseas market.

[link](#)

Different Designs



Size is constantly increasing



Biggest Wind Turbine

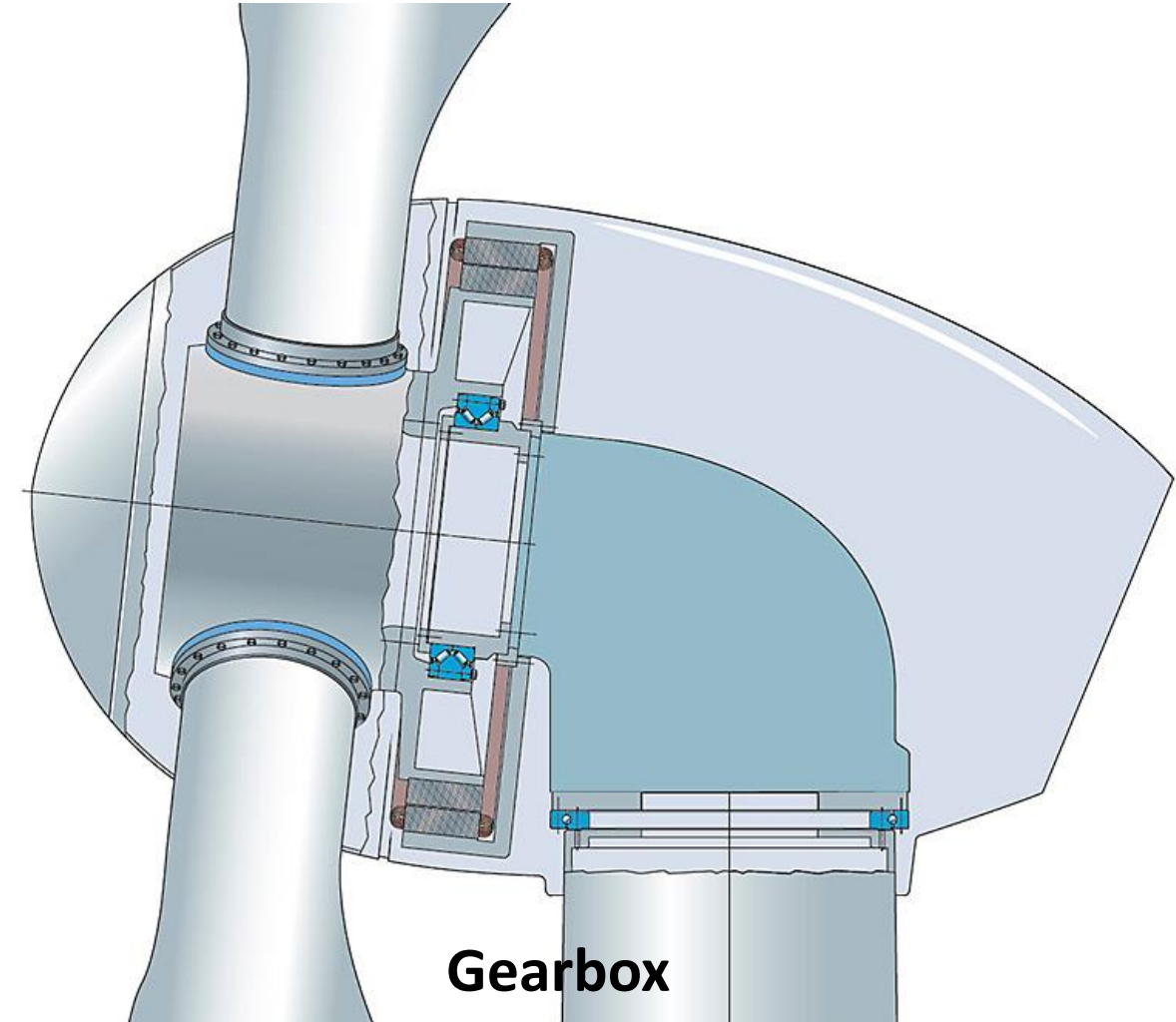
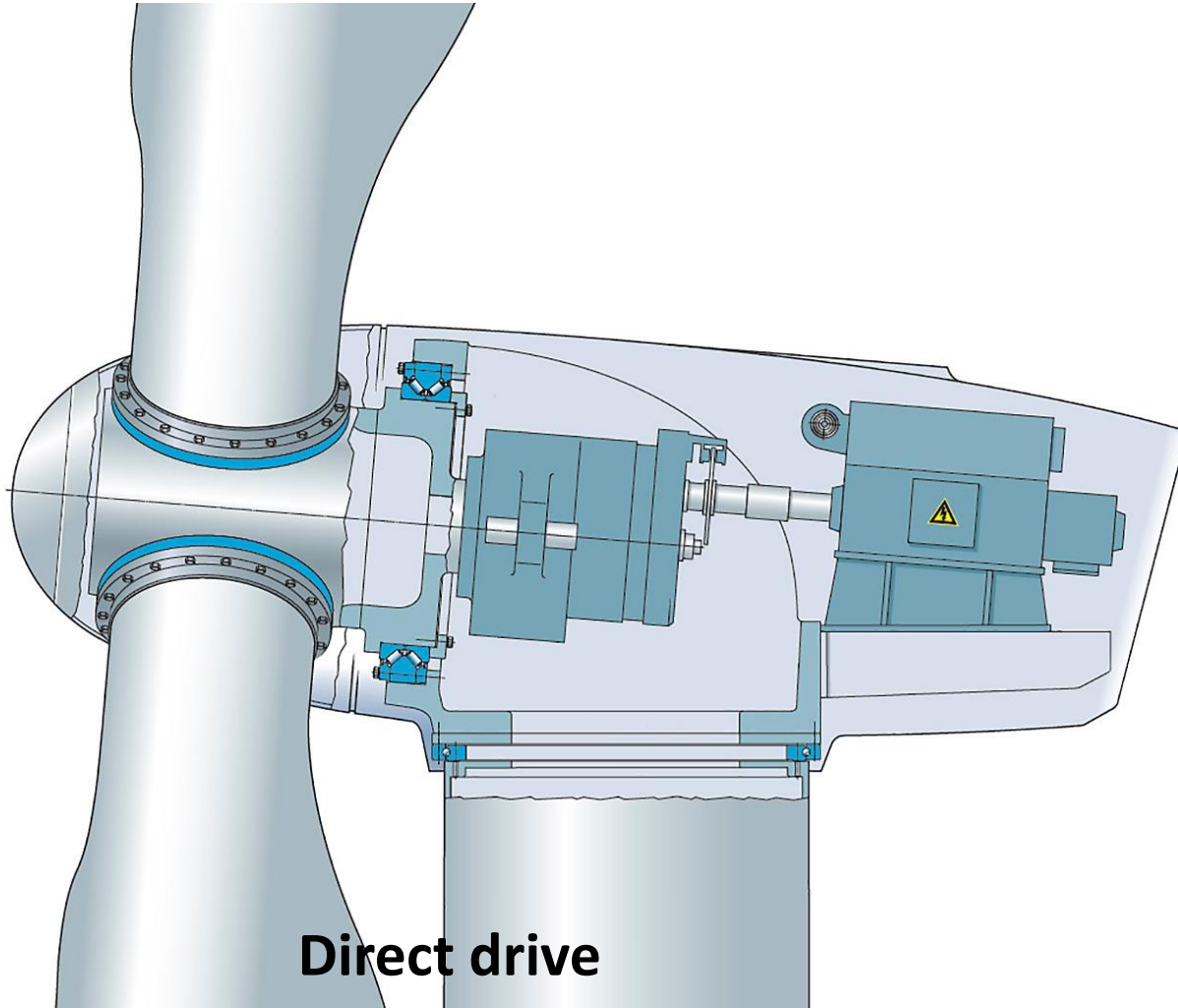


2021 – GE Haliade-X (12-13MW)



2022 – SIEMENS Gamesa SG 14- 222DD (14-15 MW)

Transmission



Onshore vs. Offshore

- Onshore Wind Turbines
 - withstand higher turbulence (landscape)
 - limited tip speed (Noise regulation)



- Offshore Wind Turbine
 - Different type of foundations
 - Very expensive to install
 - Expensive to maintain



Onshore vs. Offshore installation

- Onshore Wind Turbines



- Offshore Wind Turbine

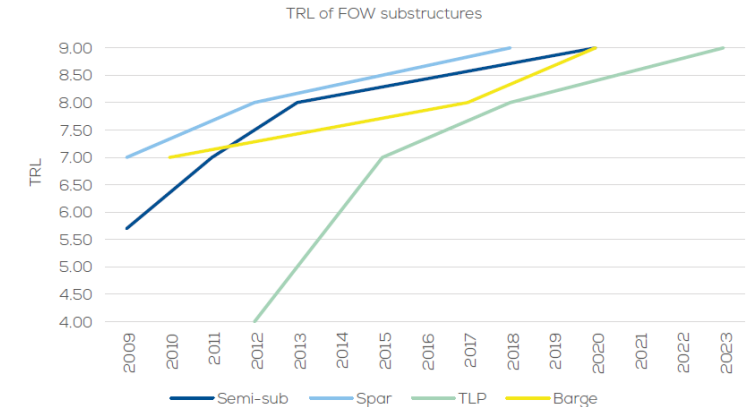
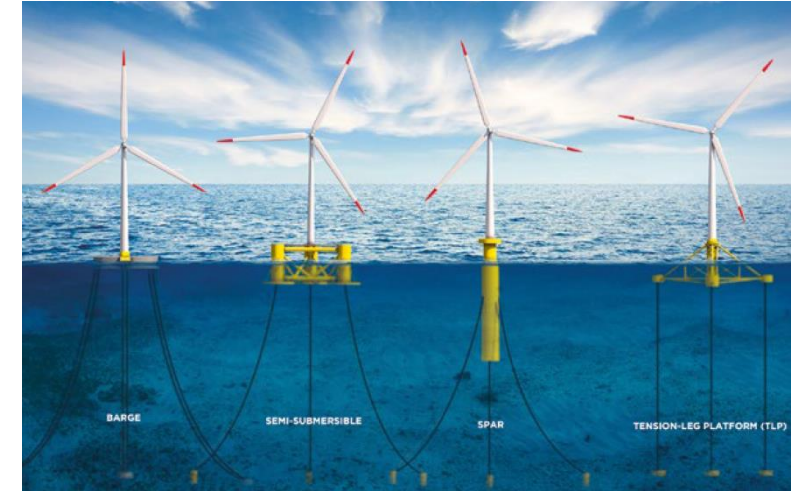


Onshore vs. Offshore installation

- Onshore Wind Turbines



- Offshore Wind Turbine



Source: The Crown Estate¹ and WindEurope

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Why Simulation? Simcenter Portfolio

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Today's Technology & Digital Twin Applications in WT

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Executable (real-time) Digital Twin

Technology is the key to success

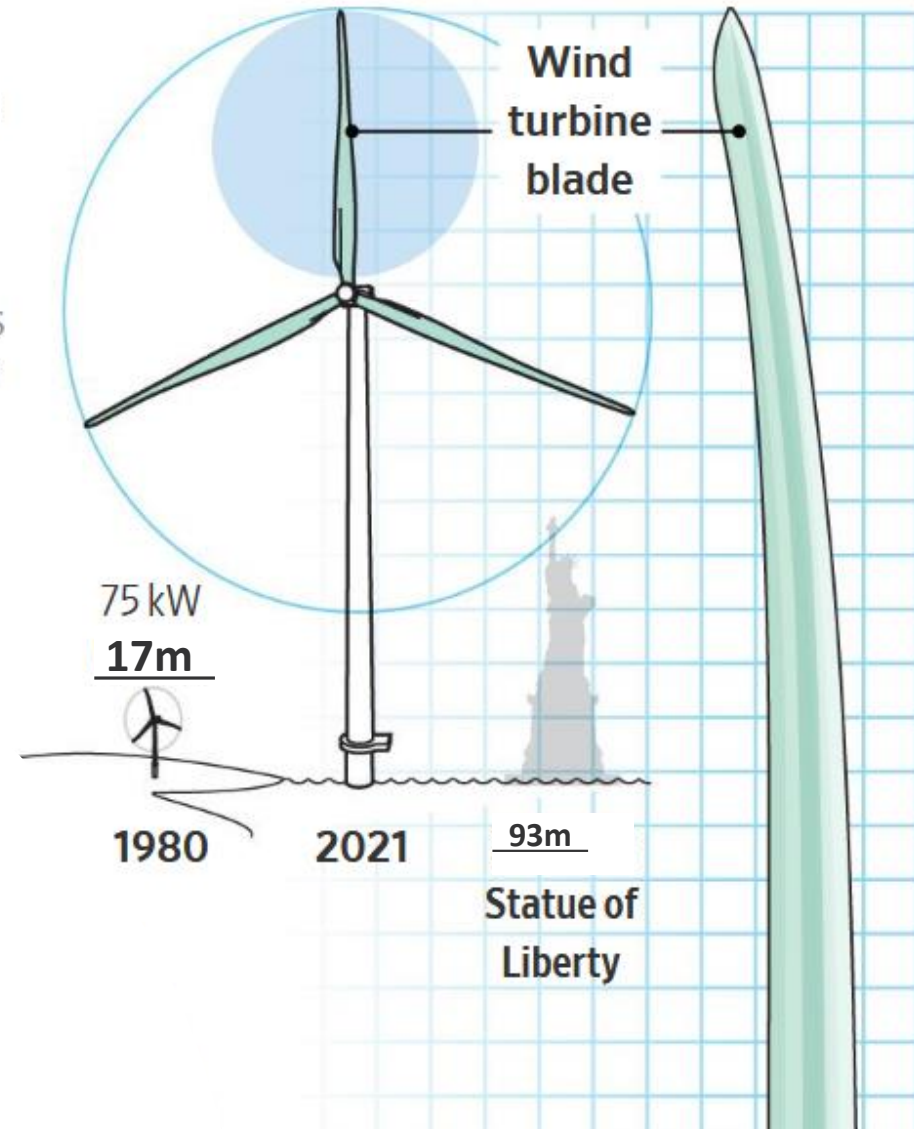
3. Tools

The size

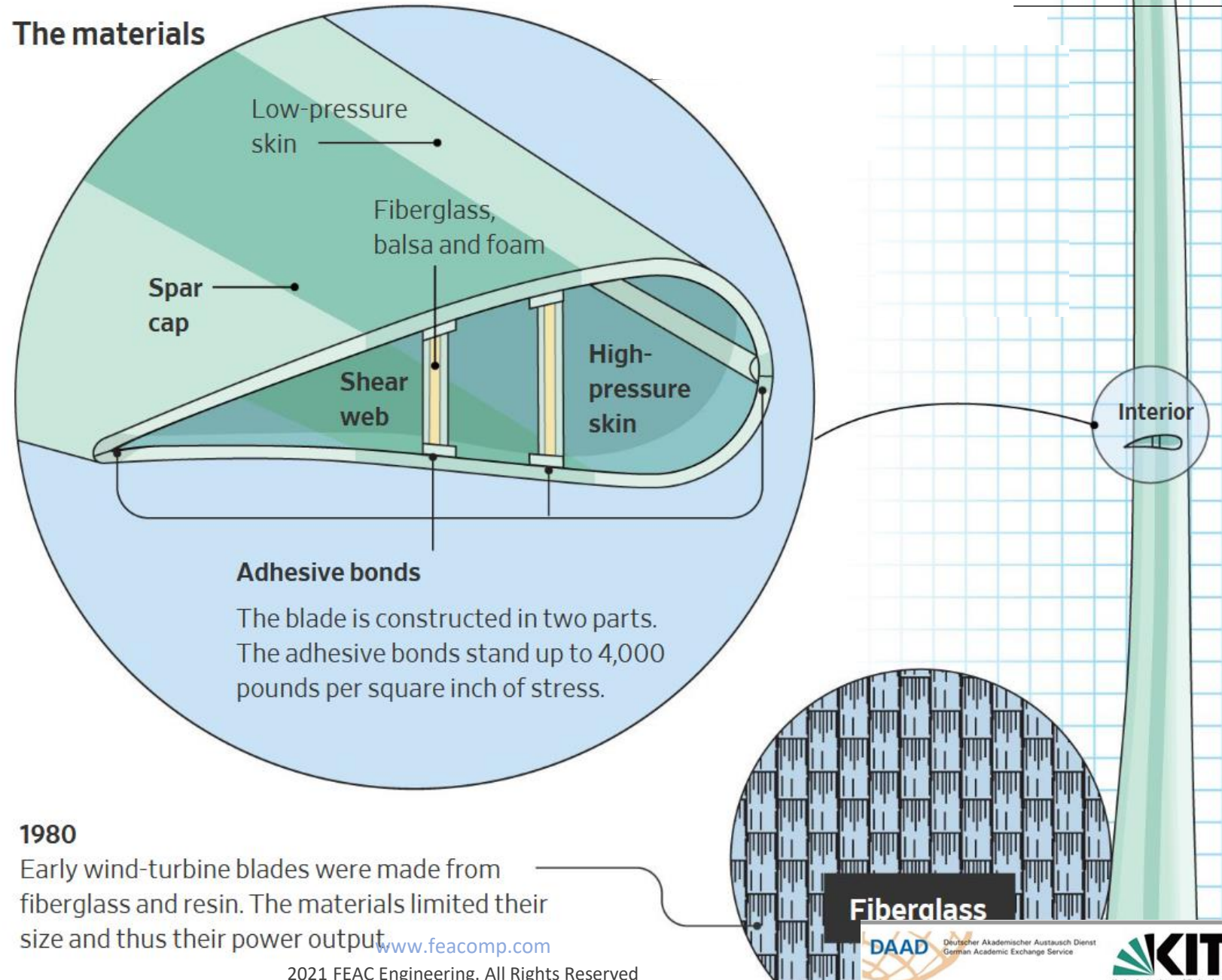
Forty years ago typical wind-turbine blades were around **8m long**. Today, with lighter materials, the blades have reached **107m**, longer than the Statue of Liberty is tall, and are packed with new technology.

263m
height

15,000
kilowatts
of power



The materials



www.feacomp.com

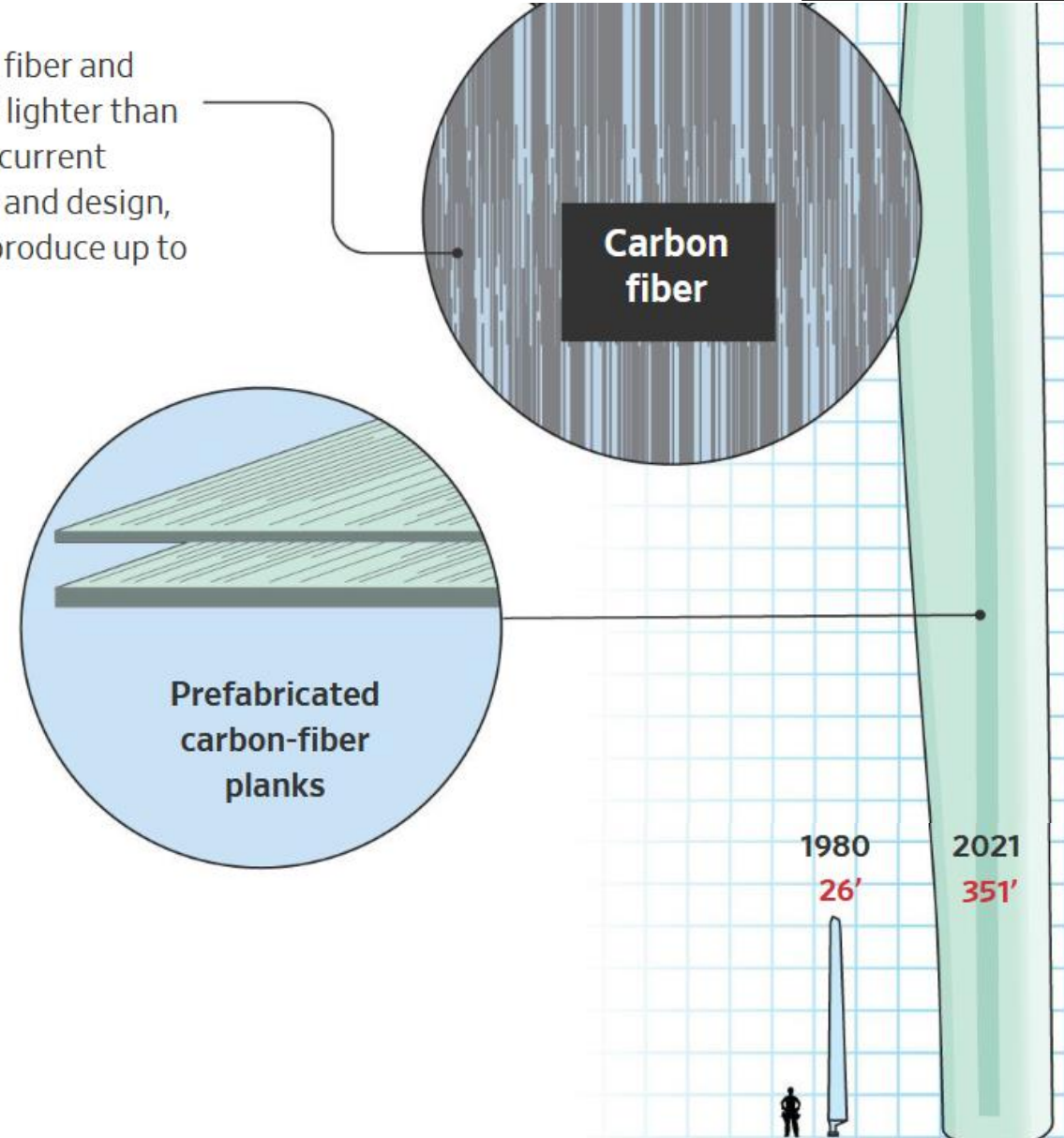
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2021

Modern blades, made from carbon fiber and other advanced materials, are 90% lighter than 1980s blades would be if scaled to current turbine sizes. Because of their size and design, turbines with the new blades can produce up to 15,000 kW of energy.

Spar cap

This section of the blade takes an enormous amount of stress. It is now reinforced with a carbon-fiber strip the entire length of the span for strength. Sometimes the strip is made with carbon-fiber planks instead of cloth.



The shape

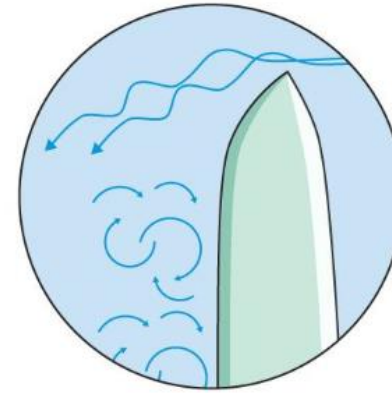
Innovations for the modern wind-turbine blades include higher strength that can withstand more stress, bend-twist coupling to reduce loads, and aerodynamic improvements to the blade tip for noise mitigation.

1980



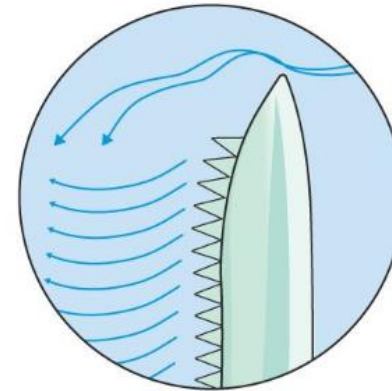
Blade tip

Since the blade tip moves faster than the blade nearest the hub, more noise is generated on the tip.



Tip shape

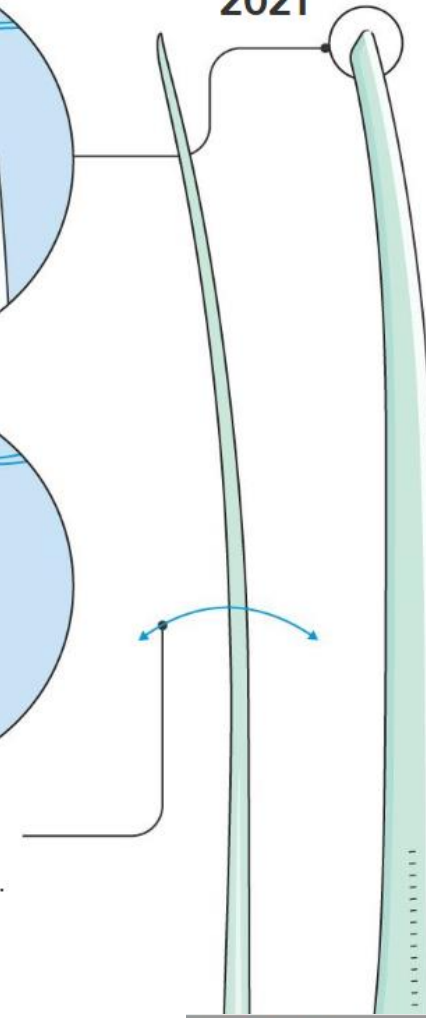
Rounded tips and serrated edges make blades quieter.

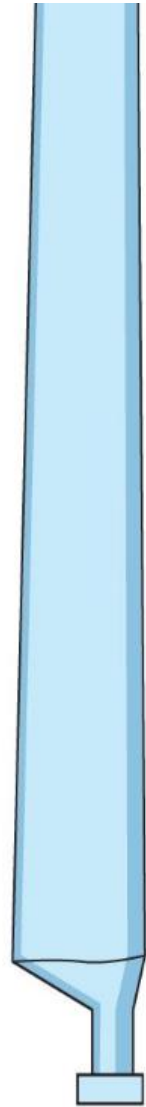


Bend

Greater swept area captures more wind, but requires longer blades that are more slender and flexible in bending. Manufacturing in a bend in the blade (known as a pre-bend) allows more room to deflect while avoiding contact with the tower.

2021





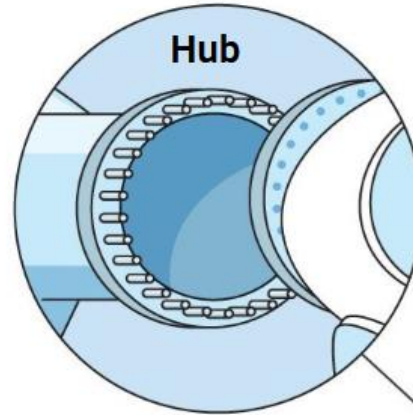
Front view

Twist

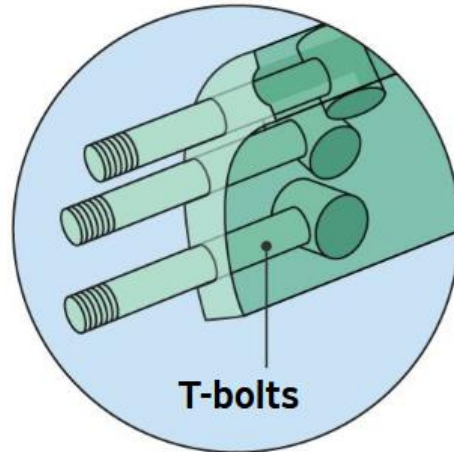
Passive bend-twist coupling reduces the sensitivity to natural turbulence in the wind and allows even longer blades without increasing the weight.

New attachments

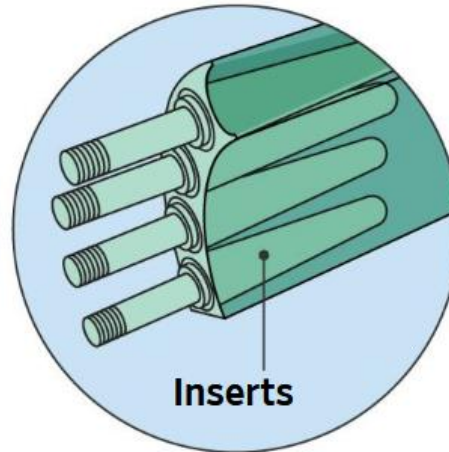
Blades were attached to the hub first with bolted flanges, then using heavy T-bolts. Inserts are a lighter alternative that is even stronger.



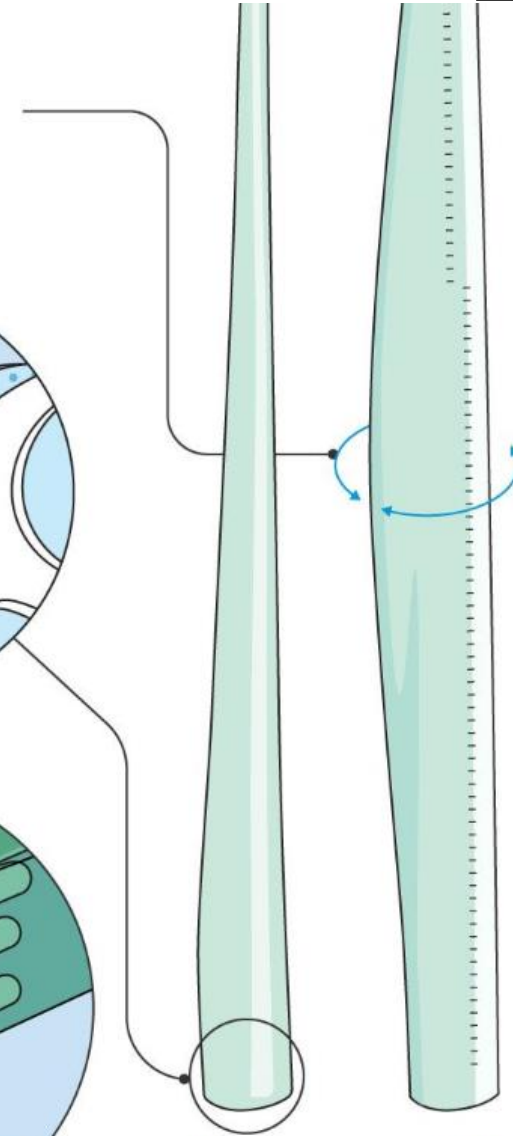
Hub



T-bolts



Inserts

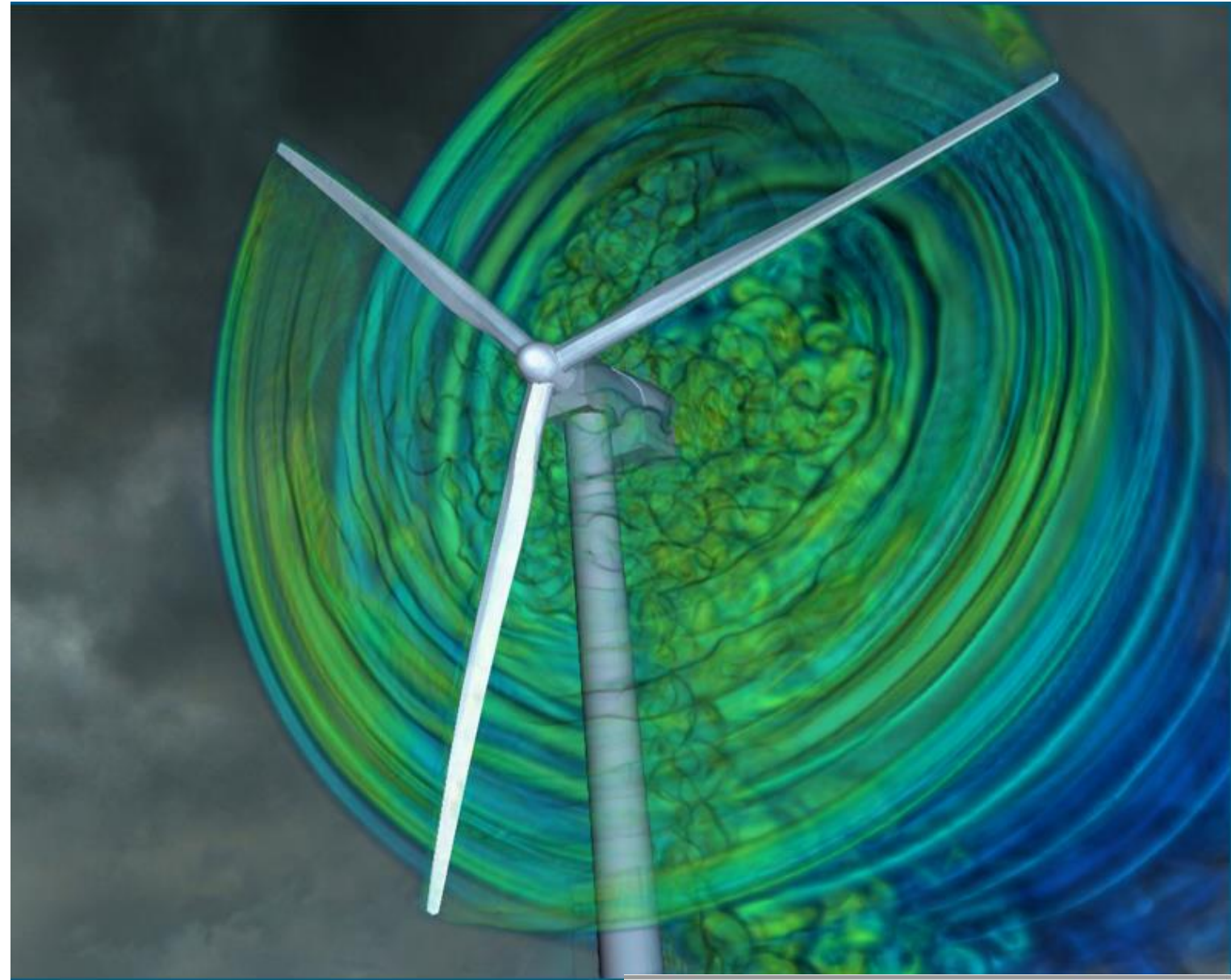


Edge view

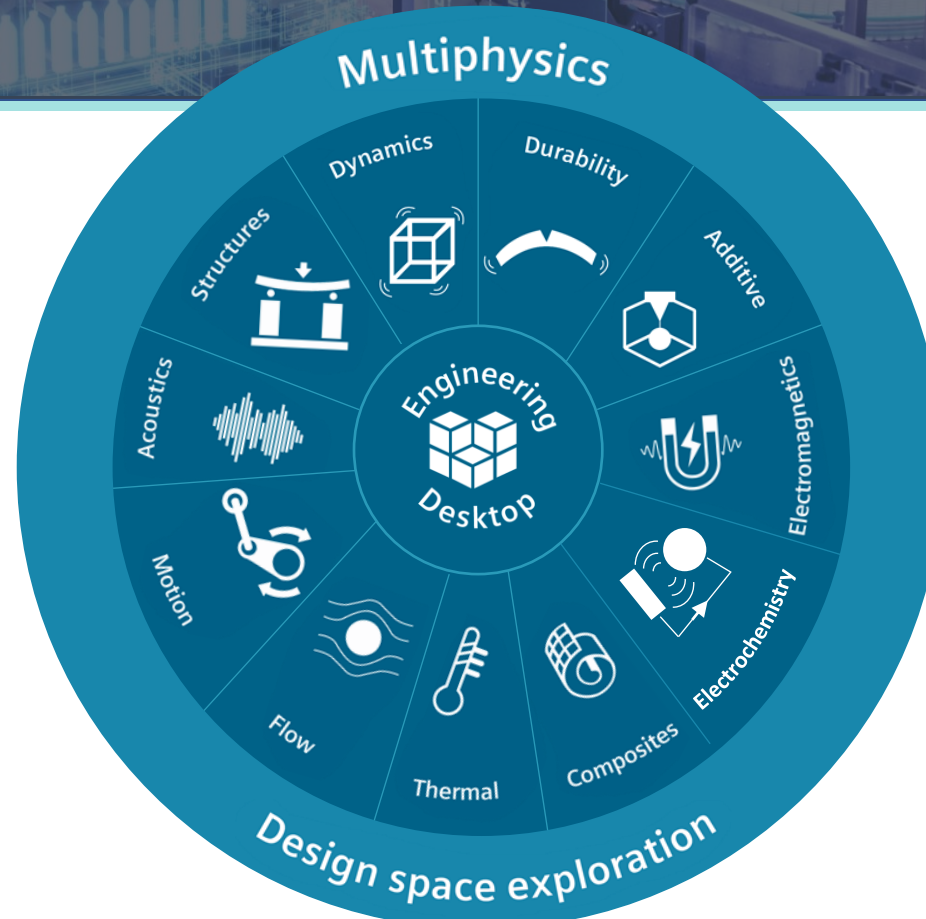
Front view

+

the right tools



SIEMENS Simcenter



Wind Turbines

4. Digital Twins

TWINS

100% Identical
100% Different



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TWINS



Only their
mother can
tell them
apart.

Value of
Digital Twin?

...not really
...huge

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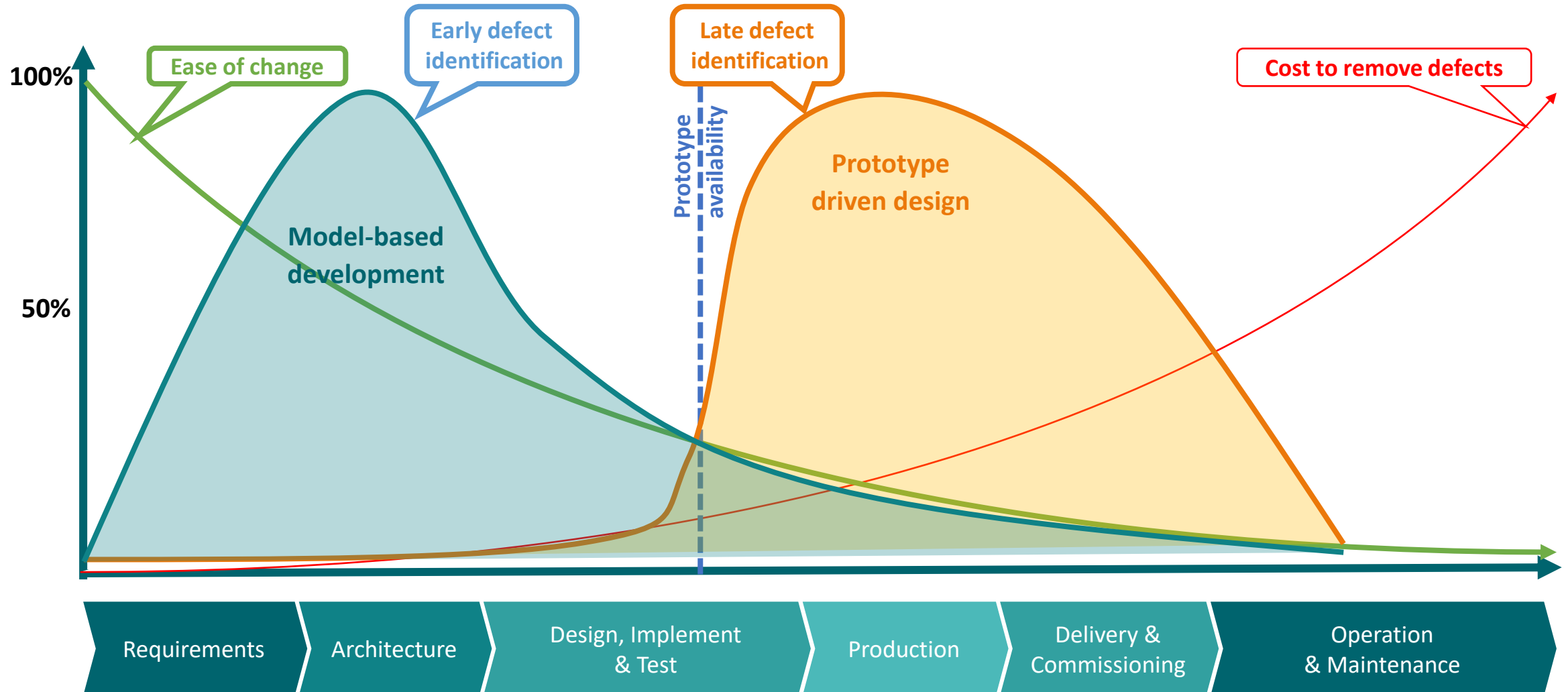
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Digital Twins are the future

Model Based Development

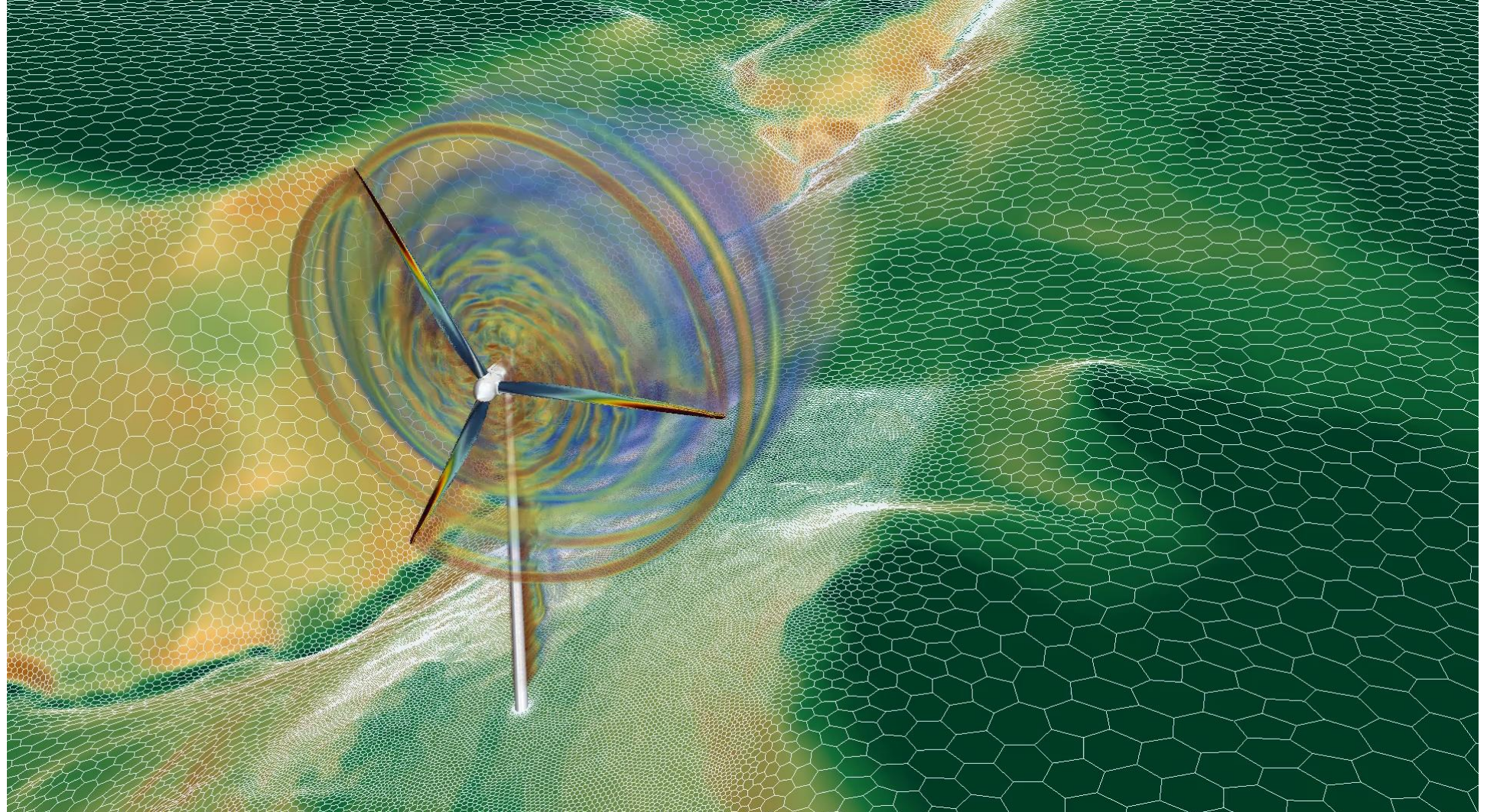
Reducing the development costs, time and risks via simulation



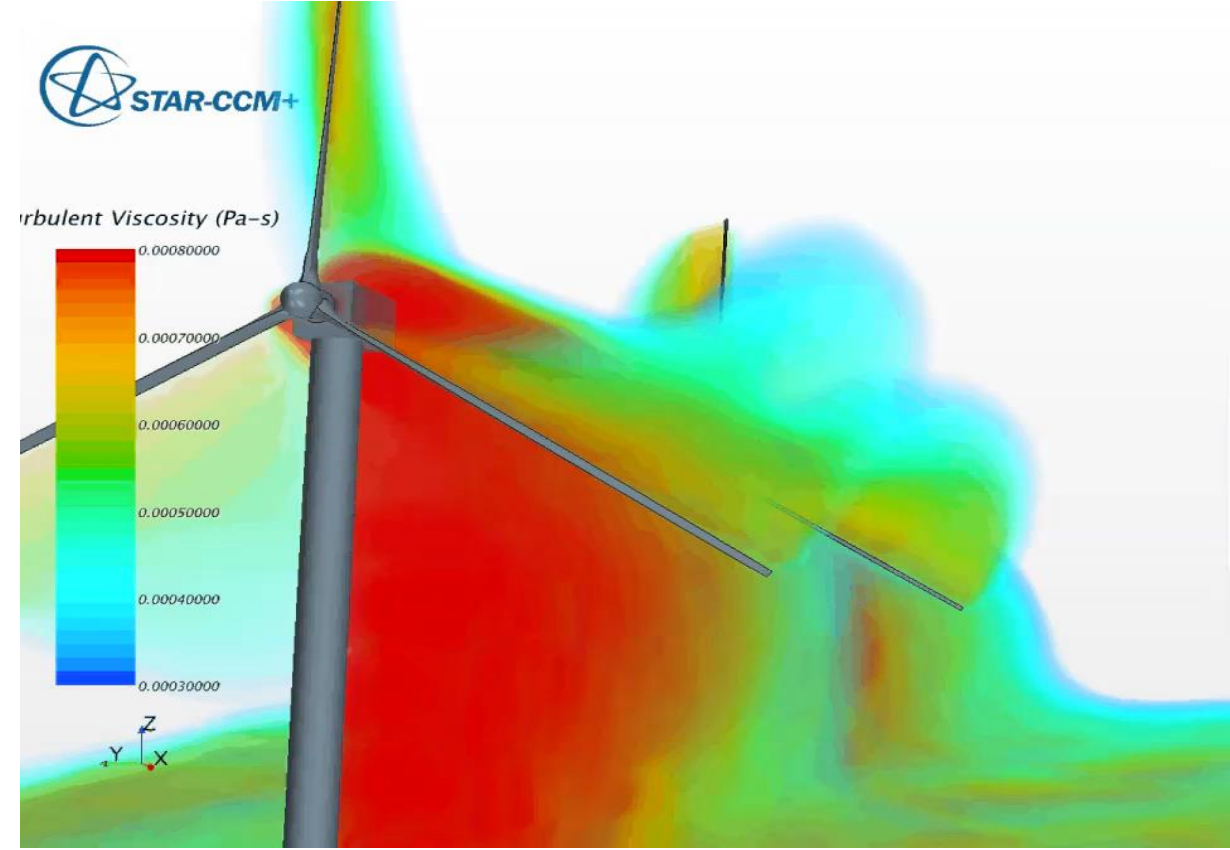
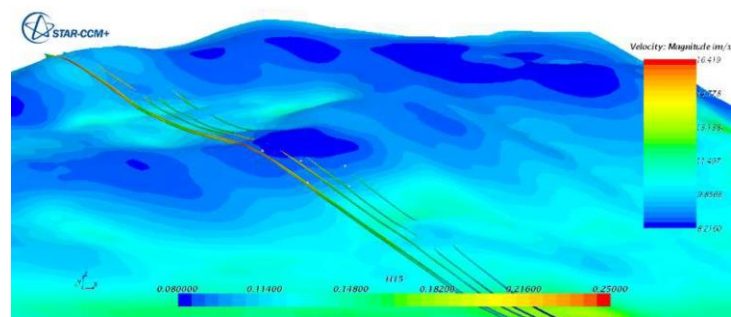
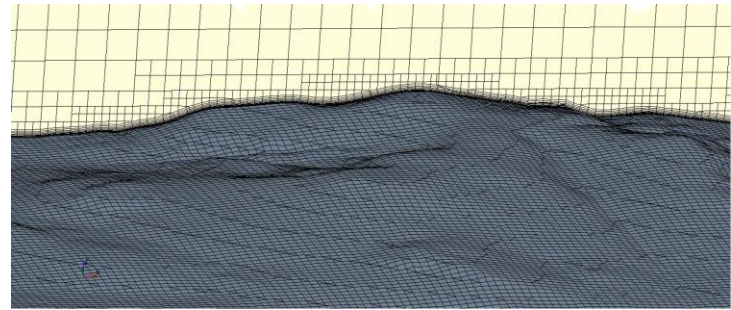
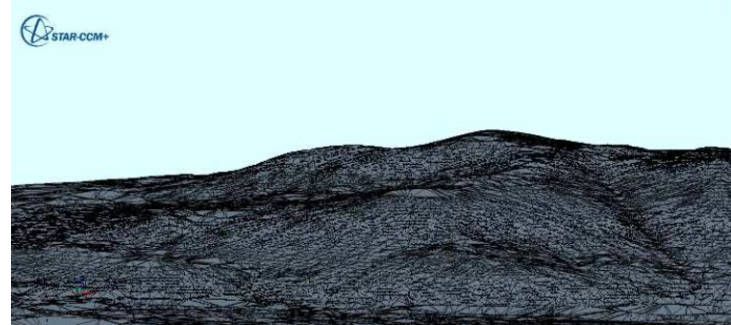
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....Siemens Portfolio Tool...

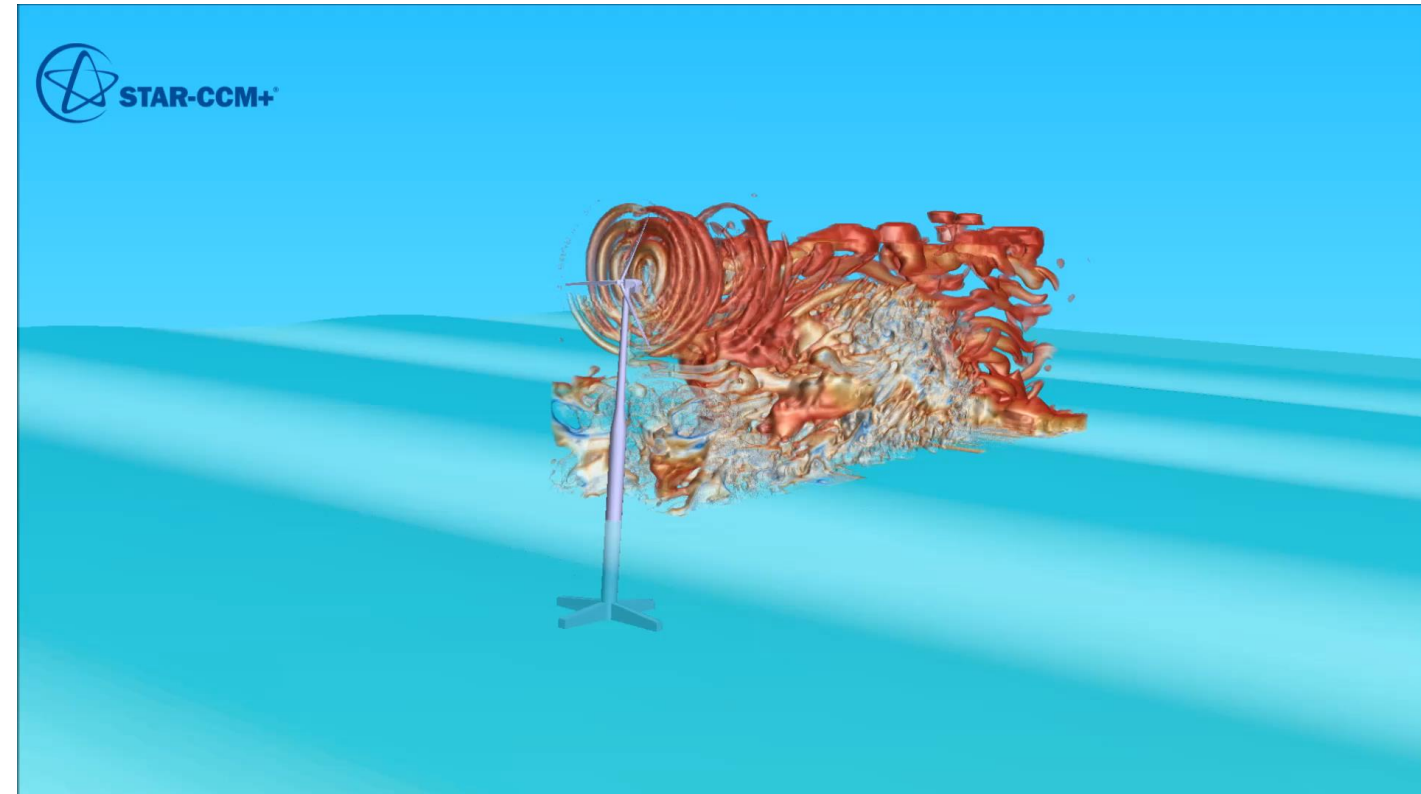
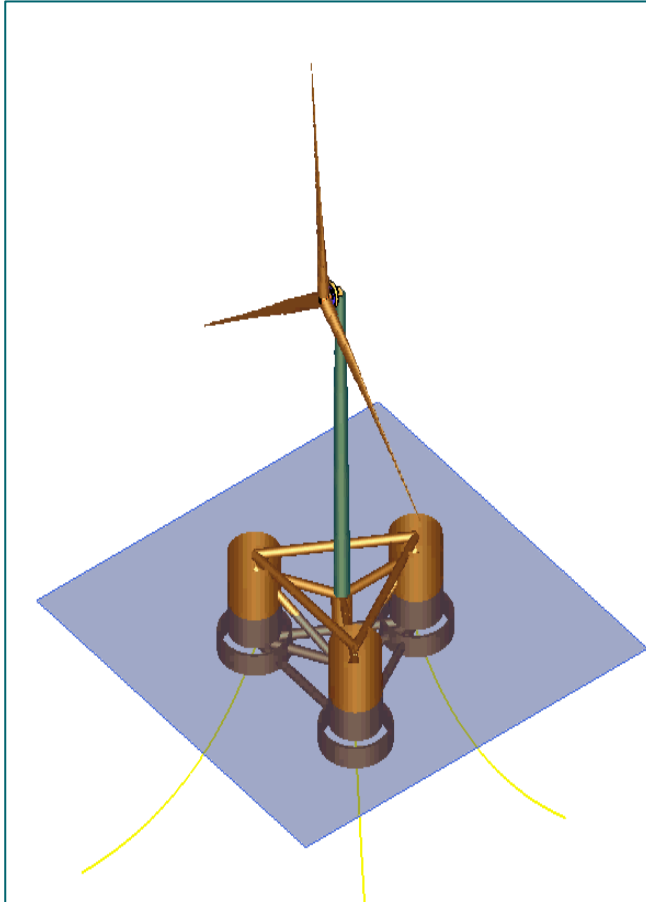
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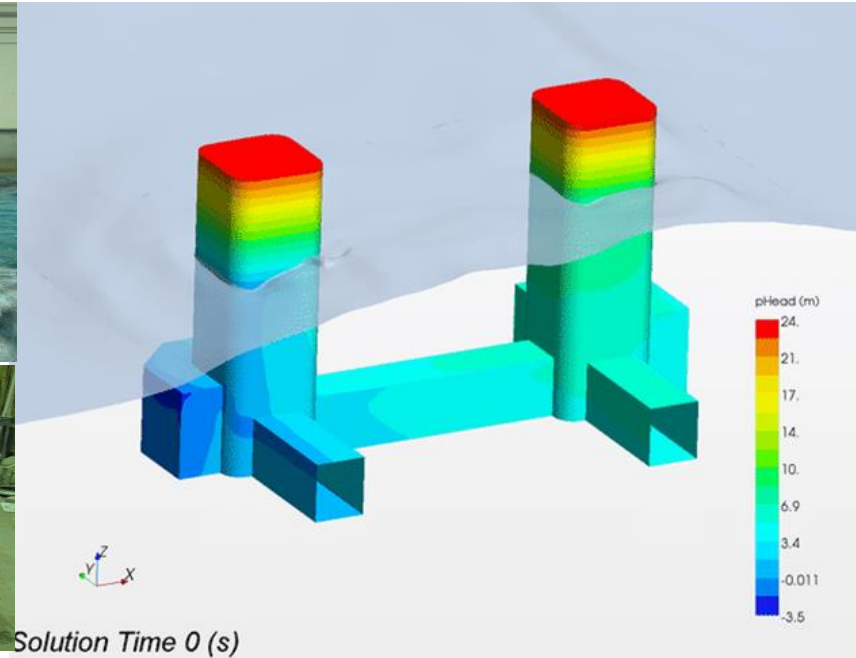
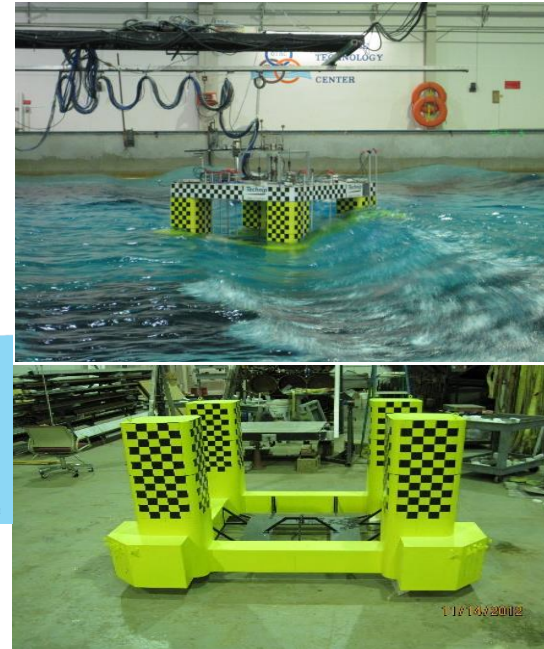
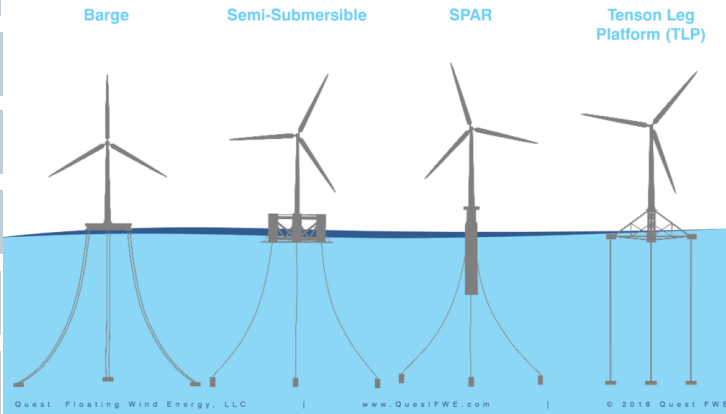
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Floating Offshore Semisubmersible Development

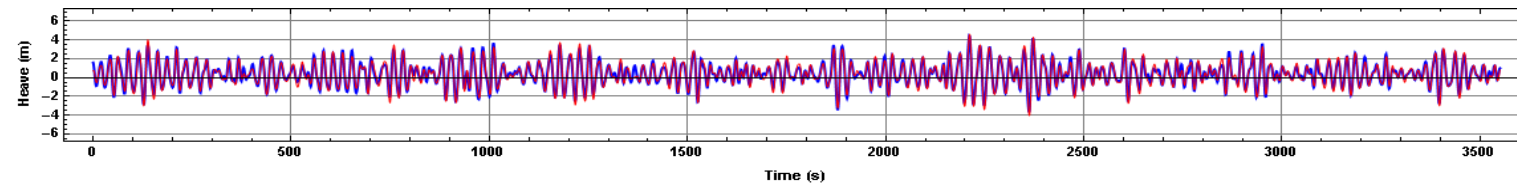
Star-CCM+



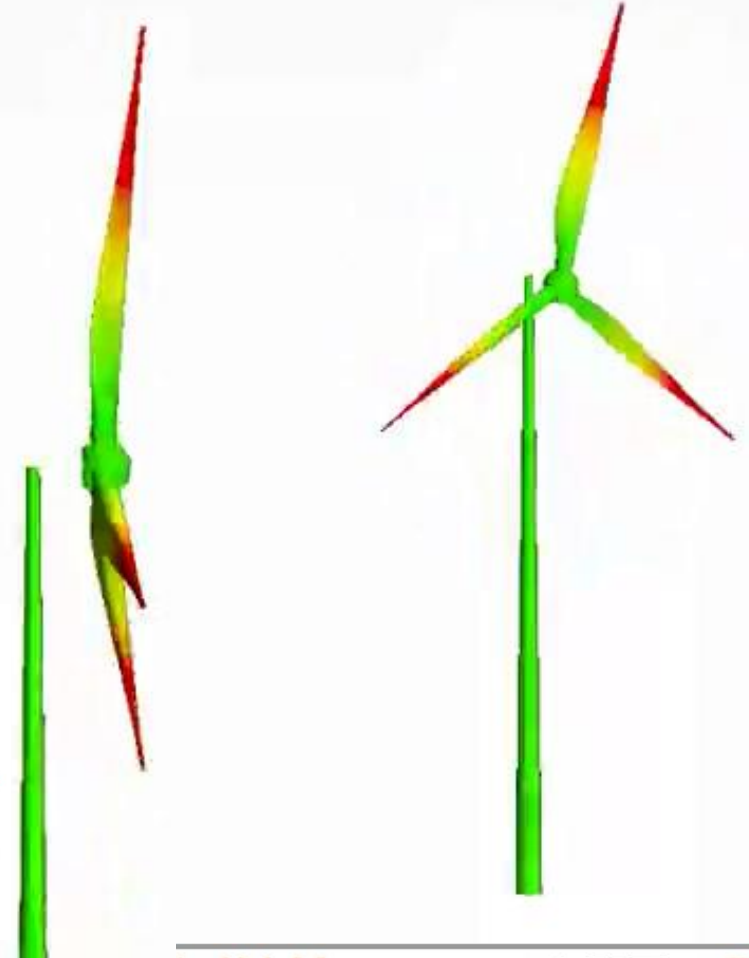
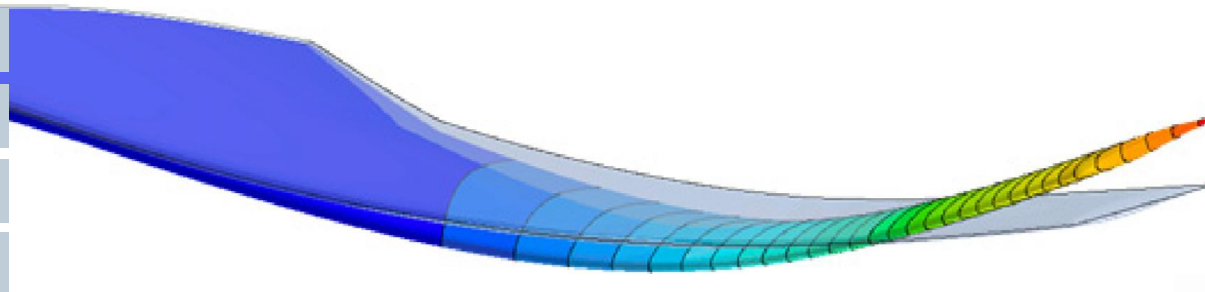
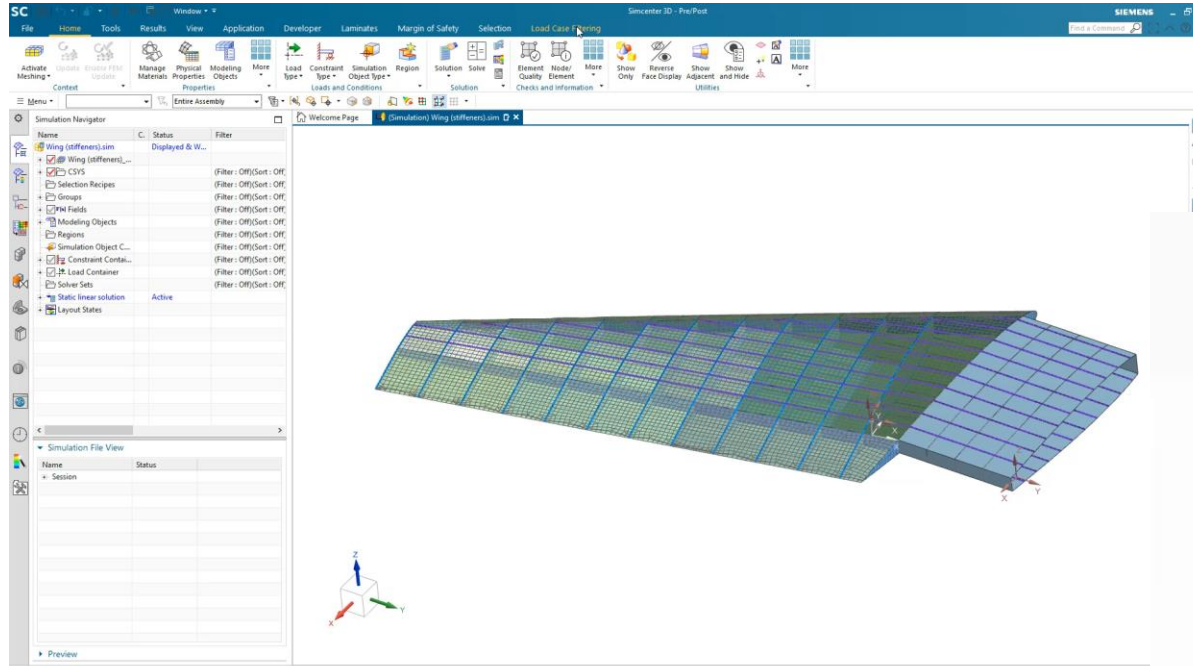
Principle Floating Wind FTU Floaters



Comparison of Heave Response (Blue : Model Test, Red : CFD)

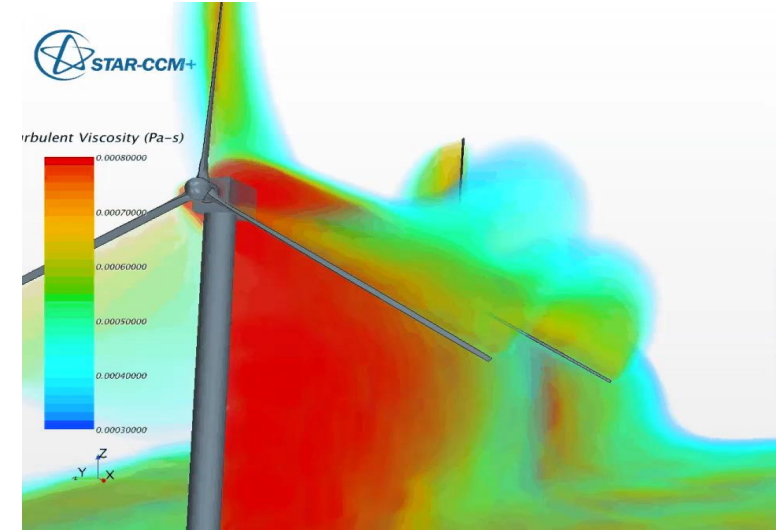
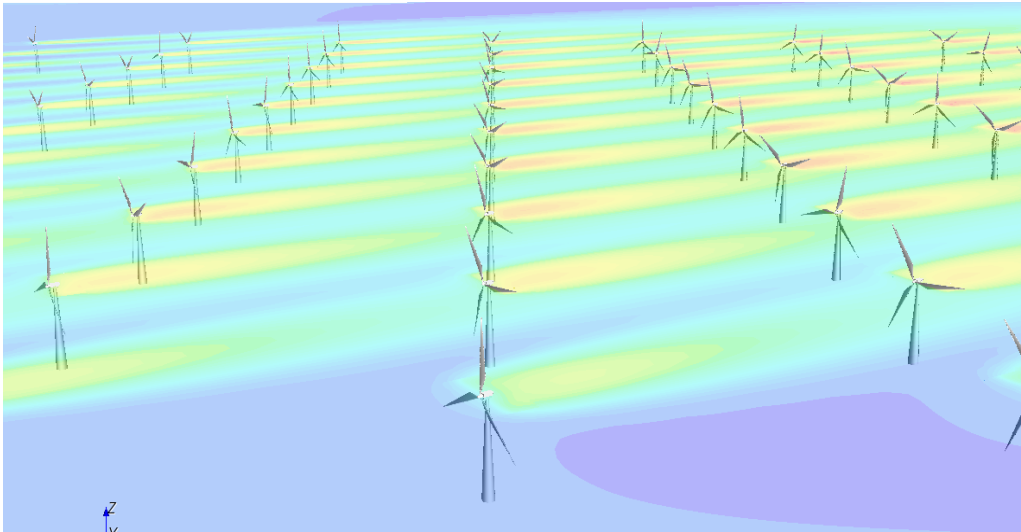


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Simcenter 3D & Star-CCM+

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Challenges

- Improve annual power of a wind farm
- Maximize Annual Energy Produced (AEP)

Constraints

- Terrain and multi-turbine wakes effects

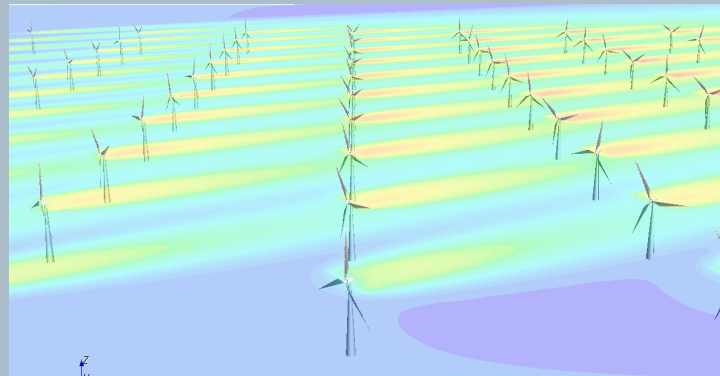
Design variables

- Location of each turbine

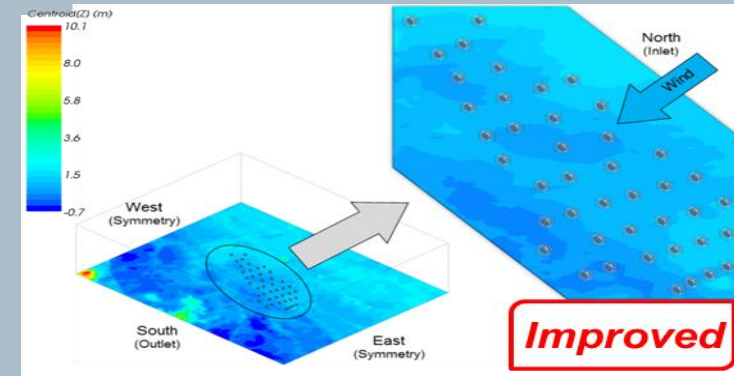
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Aero-dynamic simulation in combination with design exploration



Wake effect in caused neighboring turbines



Optimized layout of turbine locations

- Detailed analysis in Simcenter STAR-CCM+
- Terrain and multi-turbine wake effects were causing energy output to suffer
- A design exploration process was initiated to identify a new layout of turbines

“Increased Annual Energy Production (AEP) by 8.5% compared to the original design”

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Could vertical wind turbines finally have their day, and be the future for wind farms?

[Joshua S Hill](#)

5 May 2021

8

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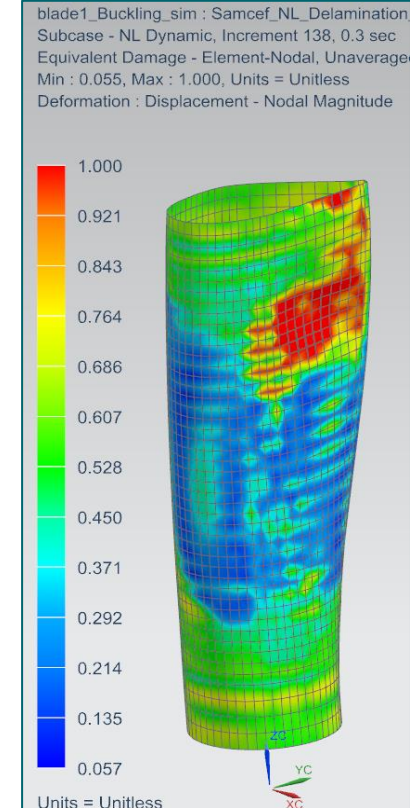
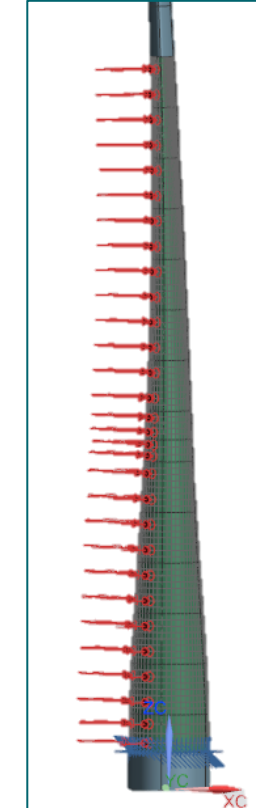
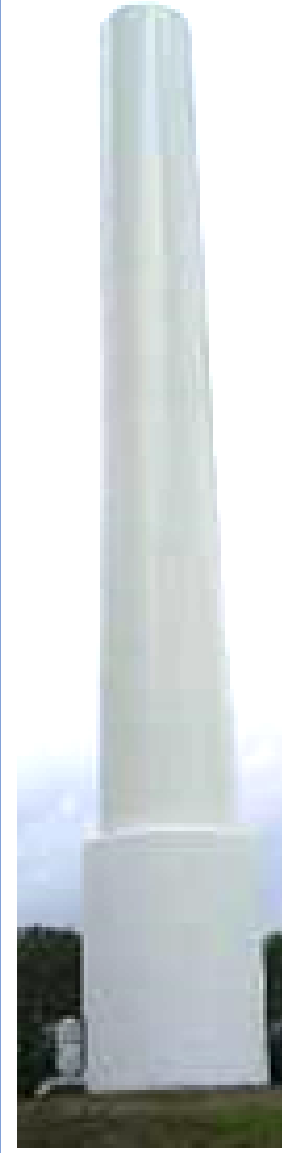
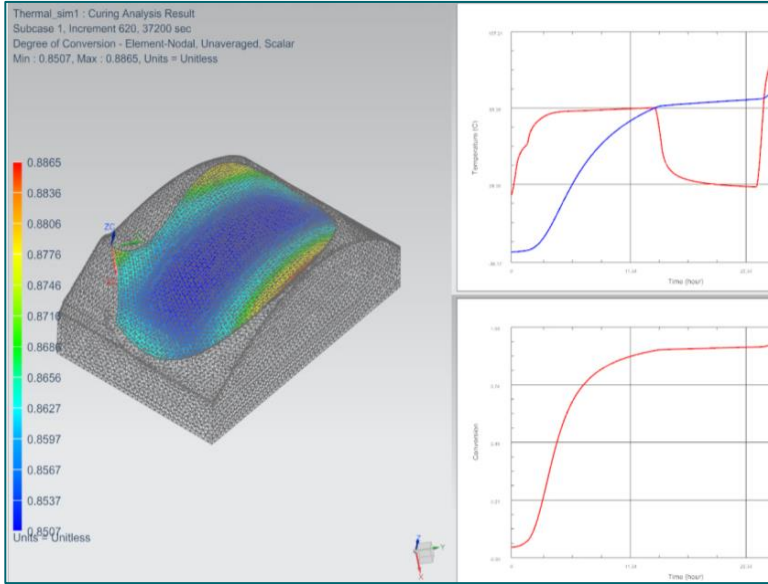
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A new study published last month by researchers at Oxford Brookes University in England has raised the possibility that traditional propeller wind turbines be replaced by more compact and efficient vertical wind turbines.

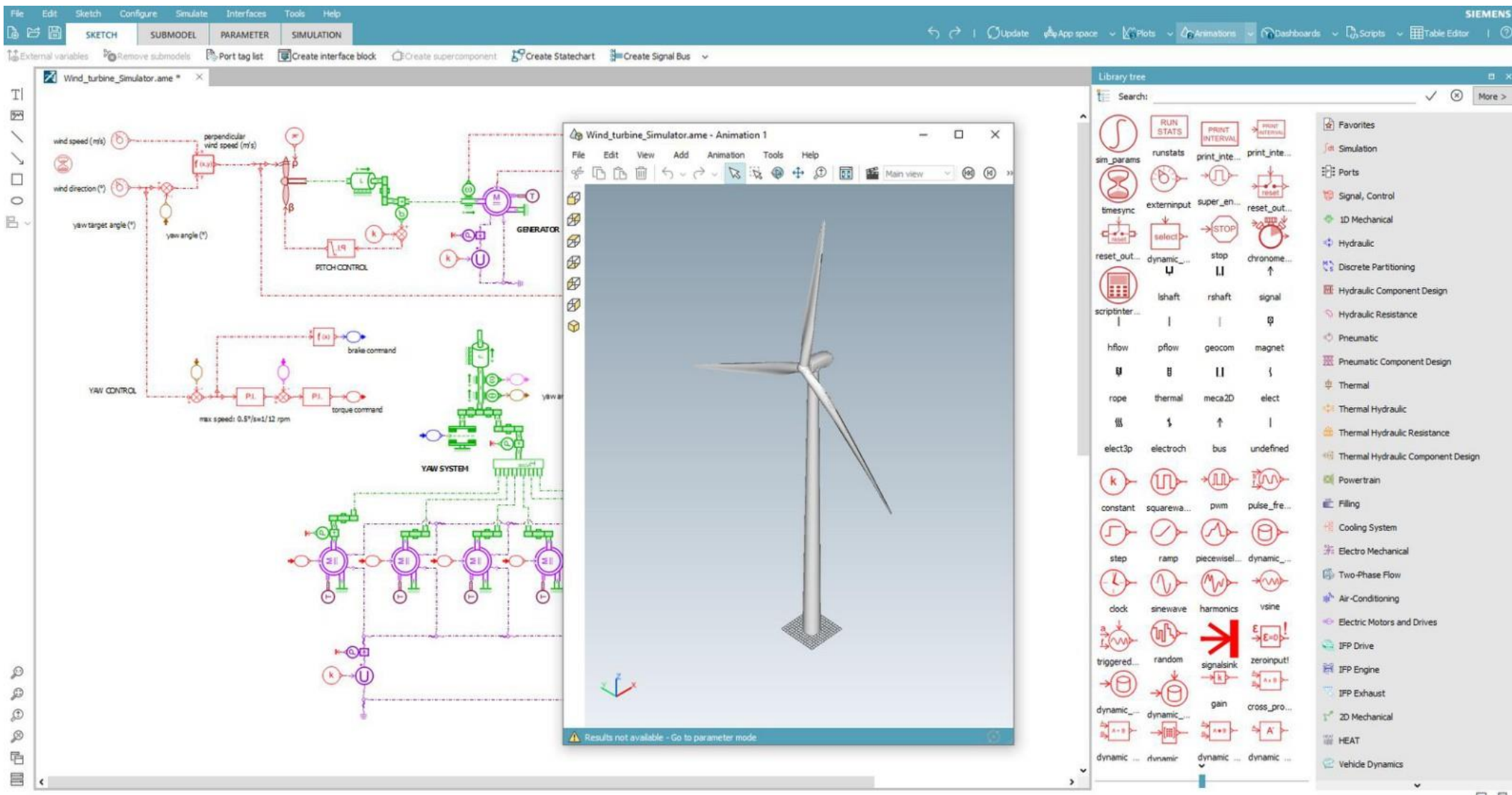
The standard wind turbine is the three-blade propeller wind turbine, also known as a Horizontal Axis Wind Turbine (HAWT), and are generally assumed to be the future of wind energy technology, in both onshore and offshore projects.

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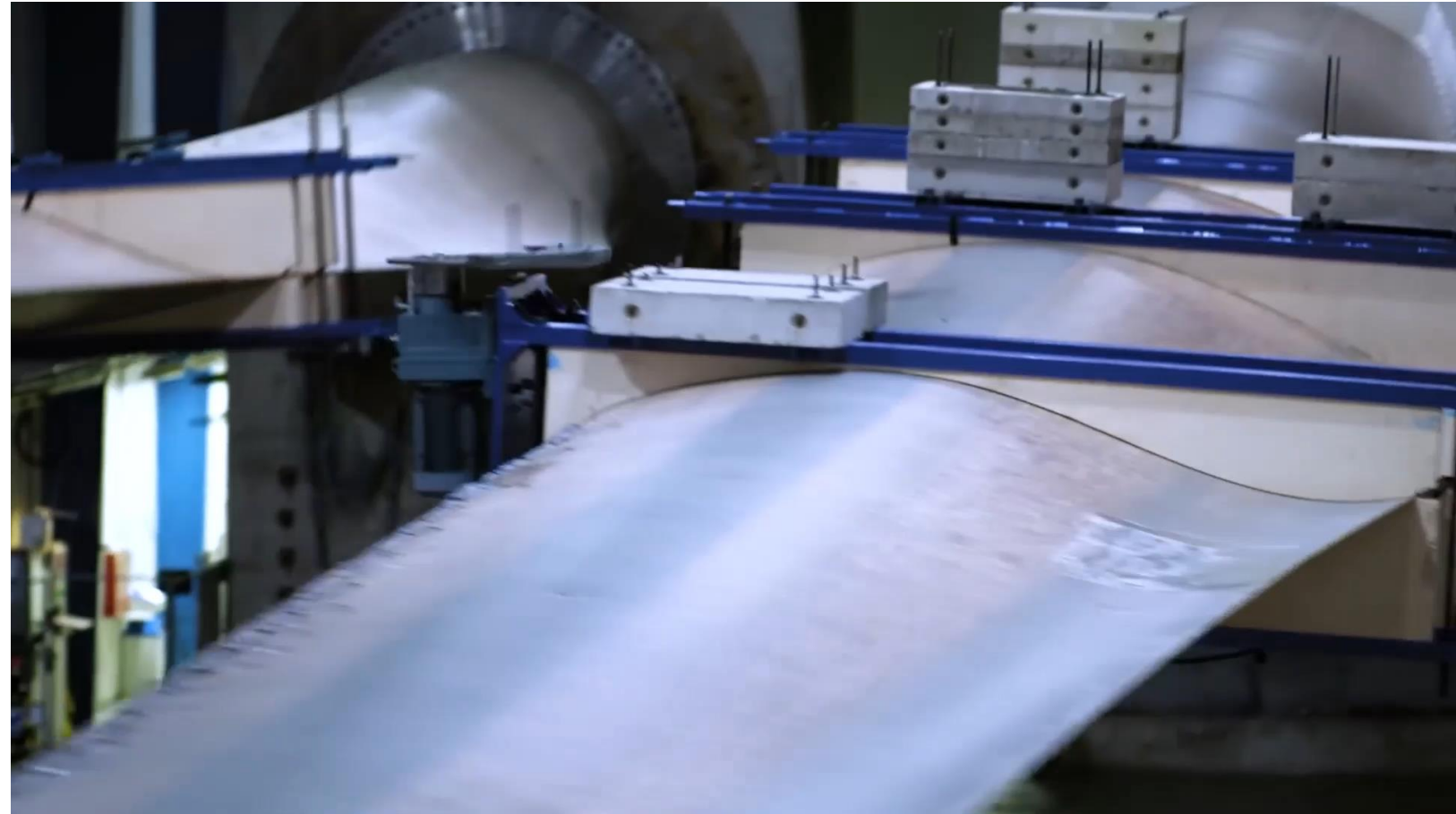
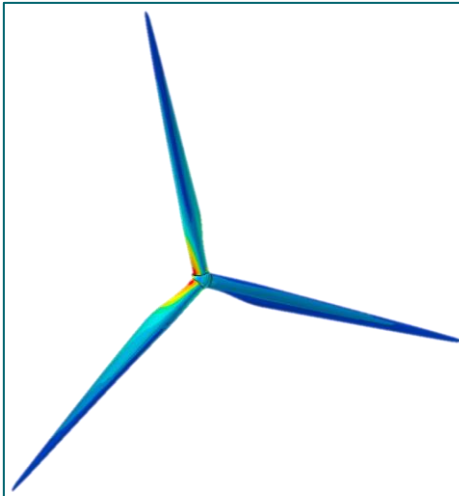


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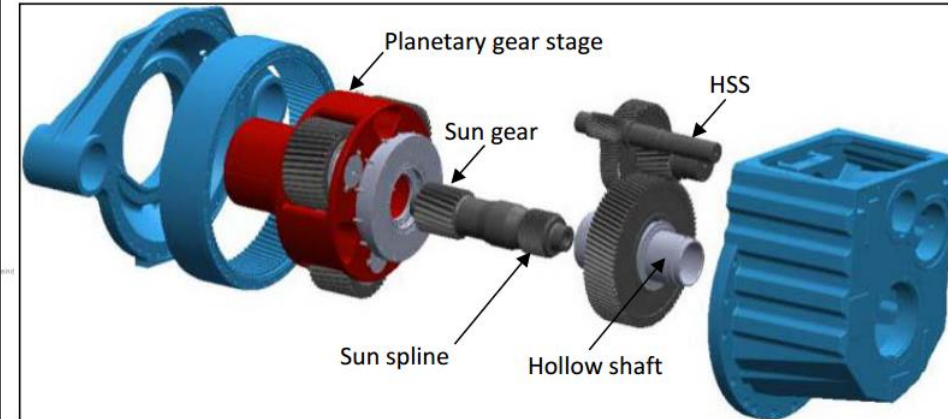
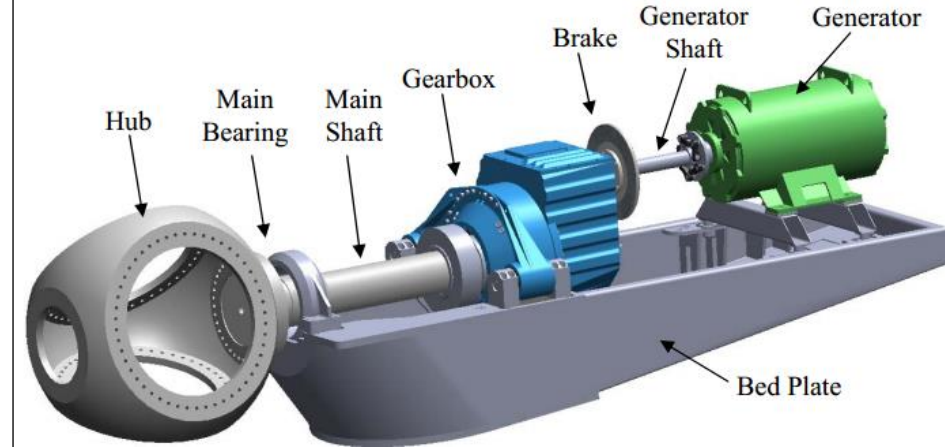
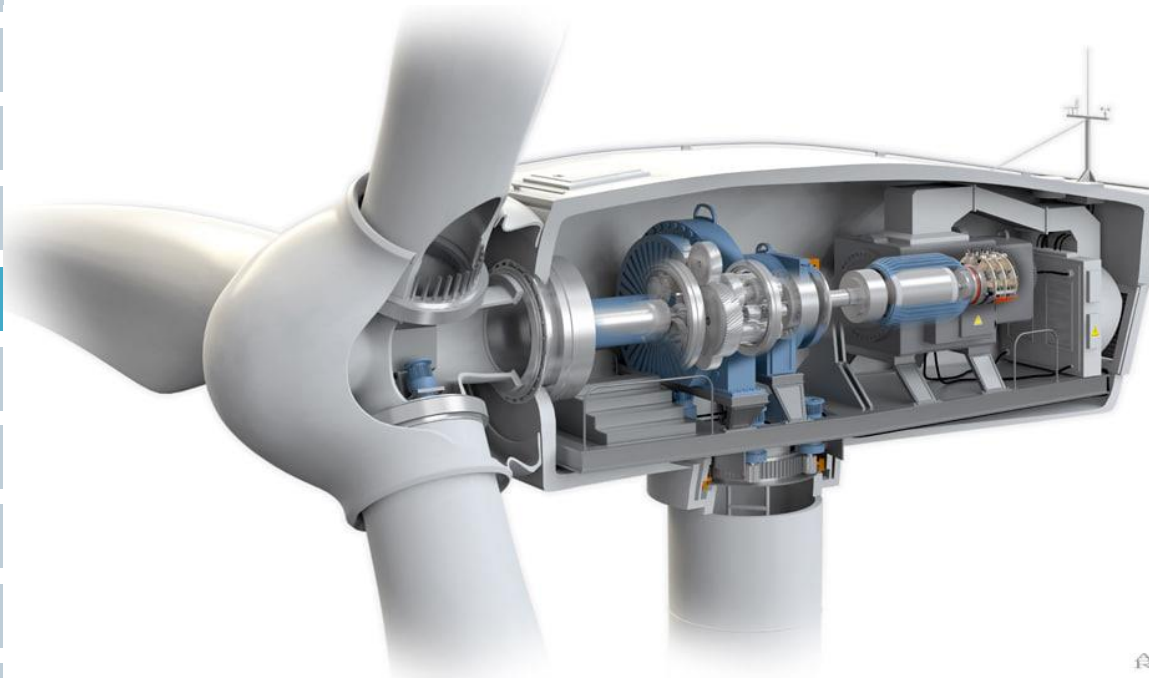
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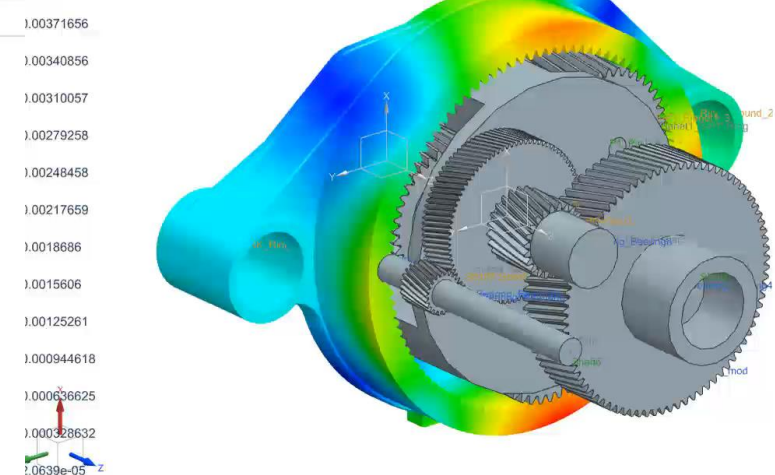
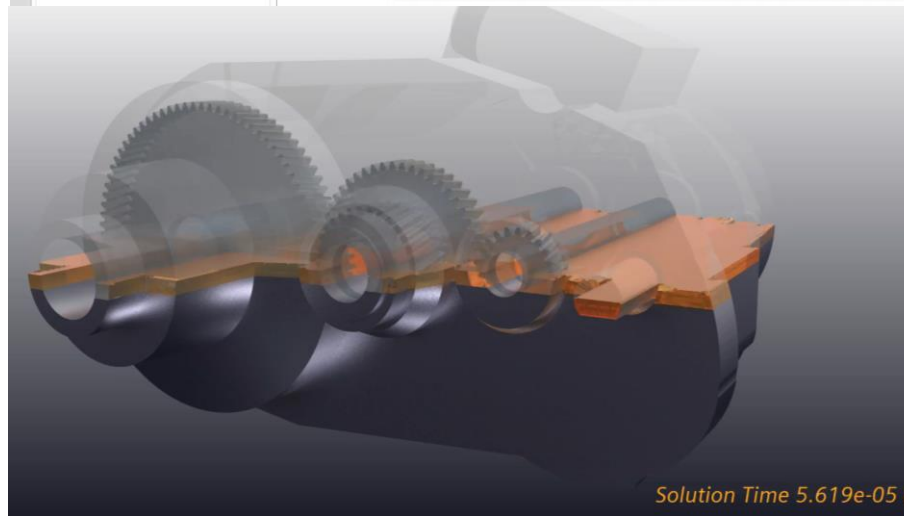
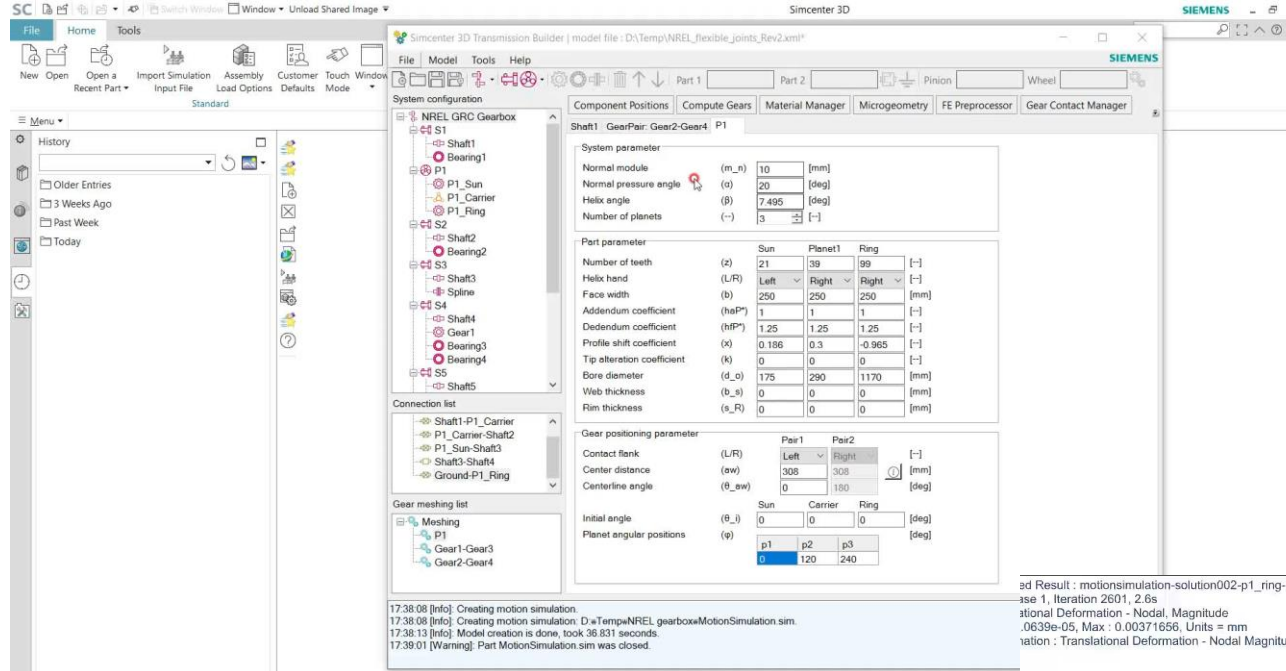


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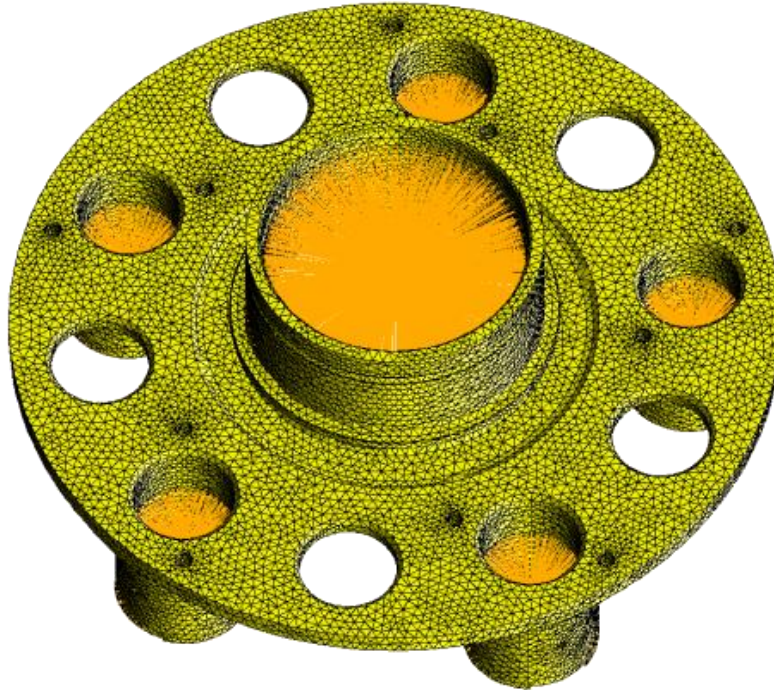


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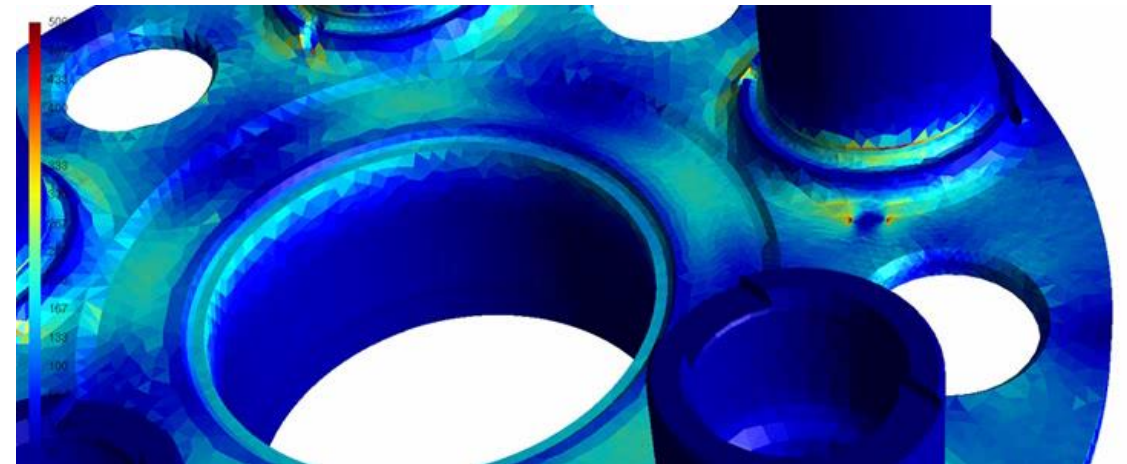
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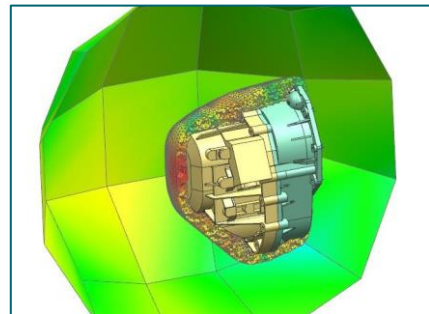
- Wind Loads
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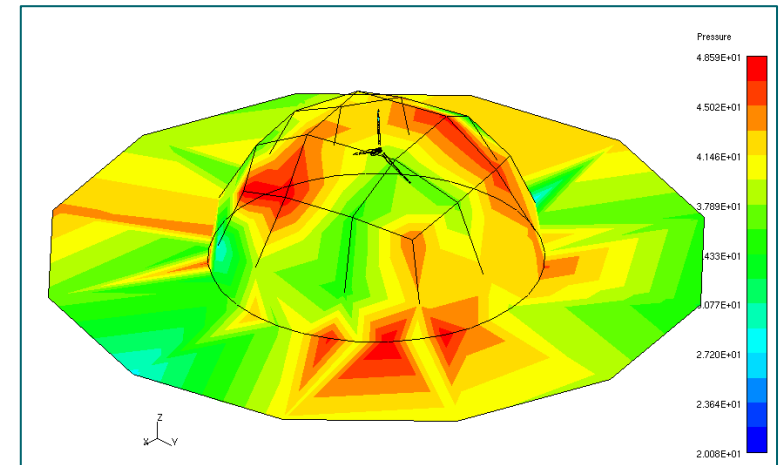
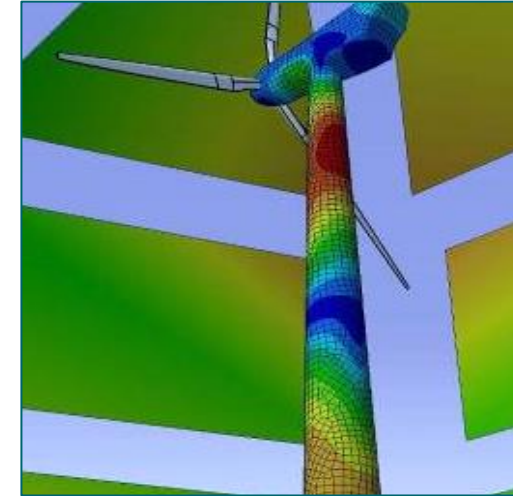
With courtesy of Eurocopter



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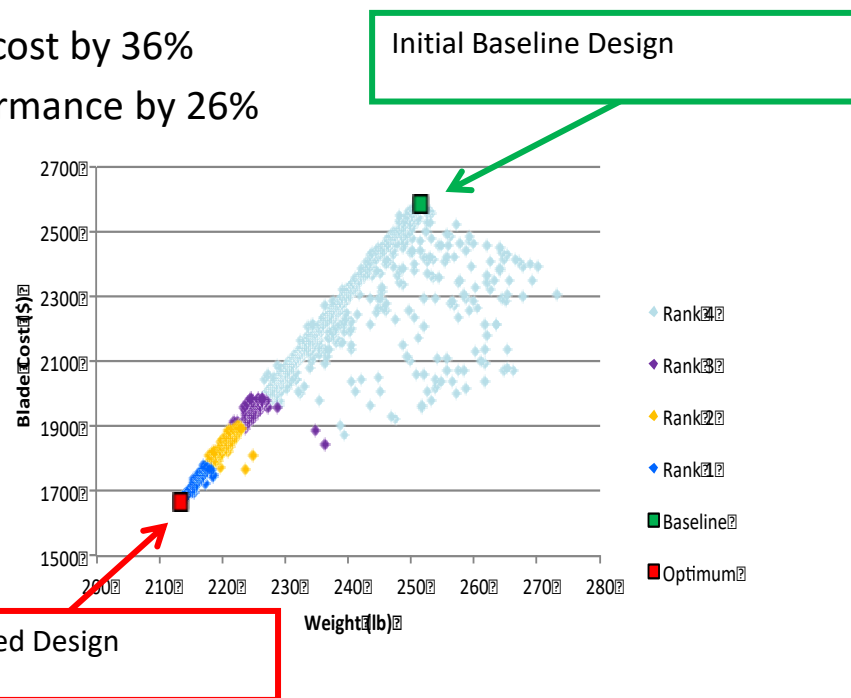


Noise radiation
Transmission loss
Enclosures
Acoustic scattering
Acoustics modeling

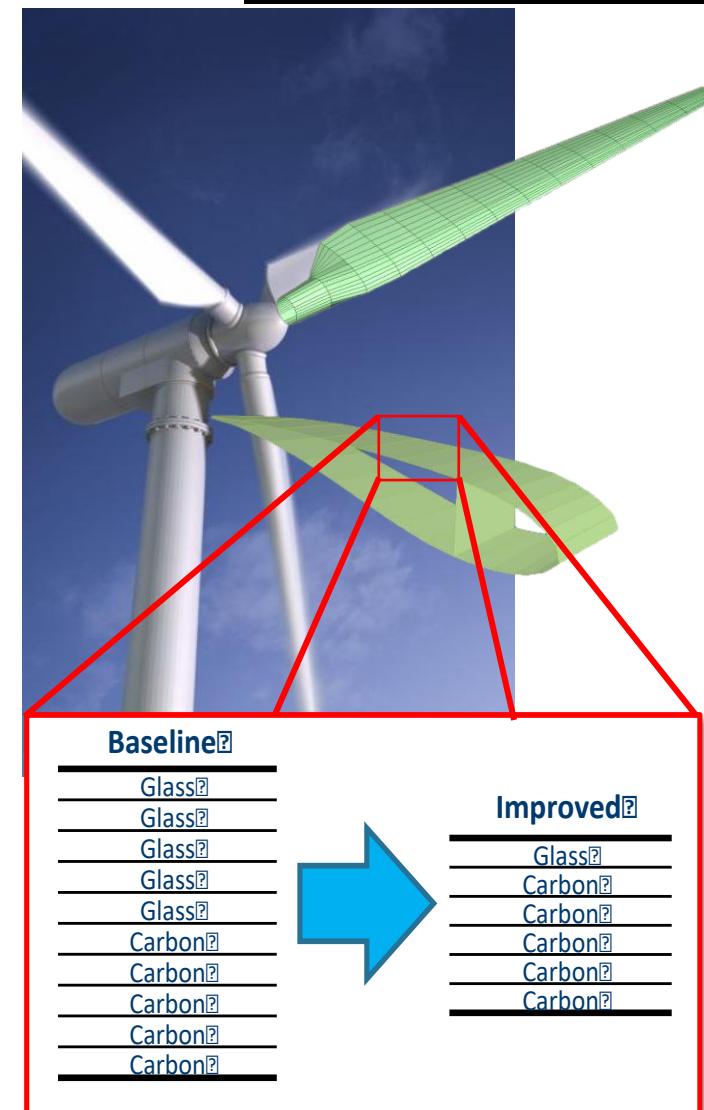


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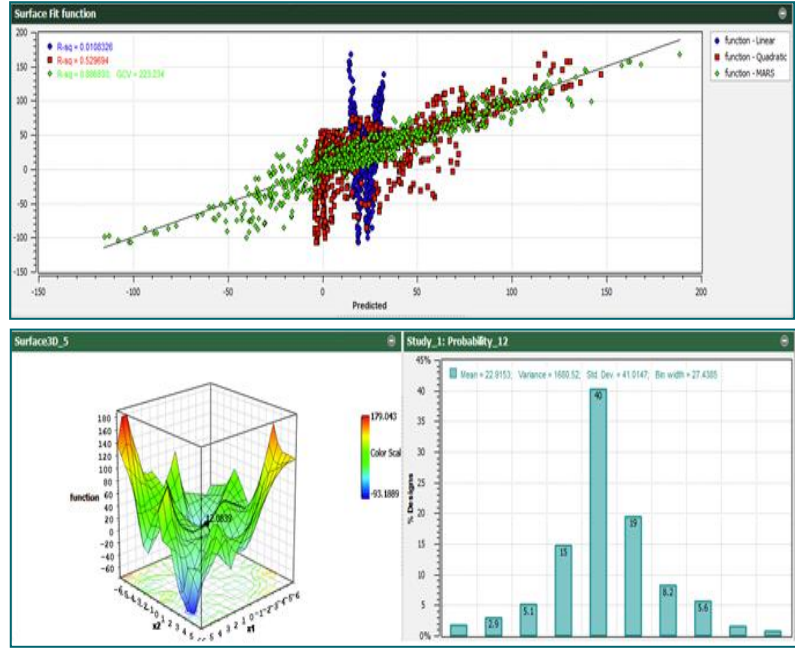
- Challenge:
 - Maximize wind energy KWh produced
 - Minimize blade weight and power production cost
 - Constraints
 - Laminate failure, deformation, mode separation
 - Design variables
 - Laminate lay-up, scale of blade
- Results:
 - Reduced blade cost by 36%
 - Increased performance by 26%



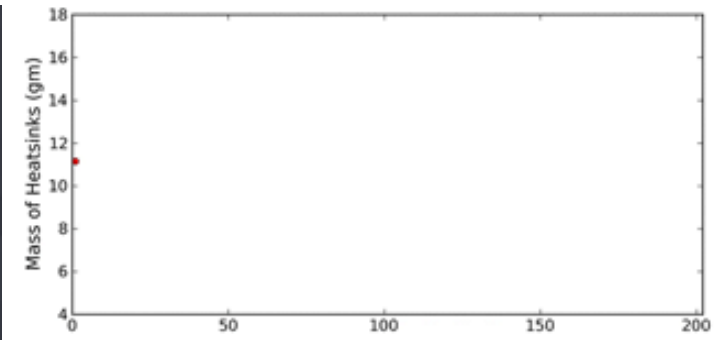
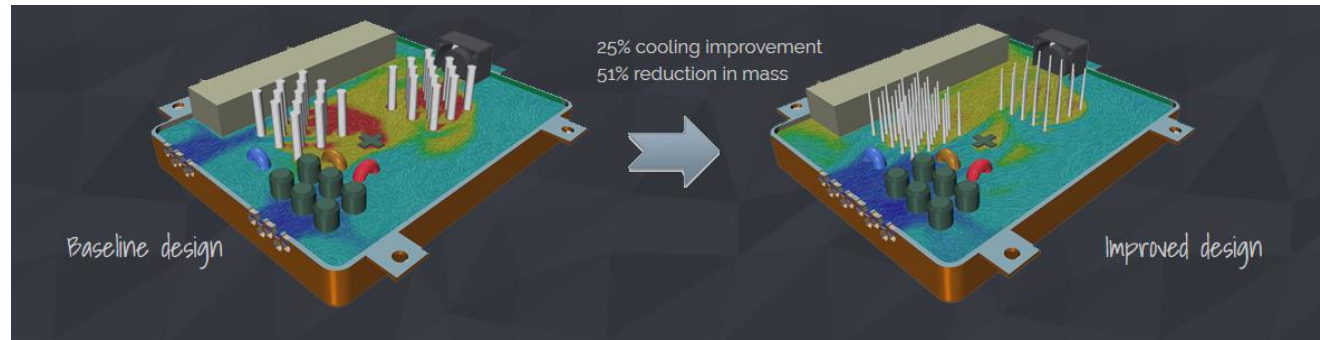
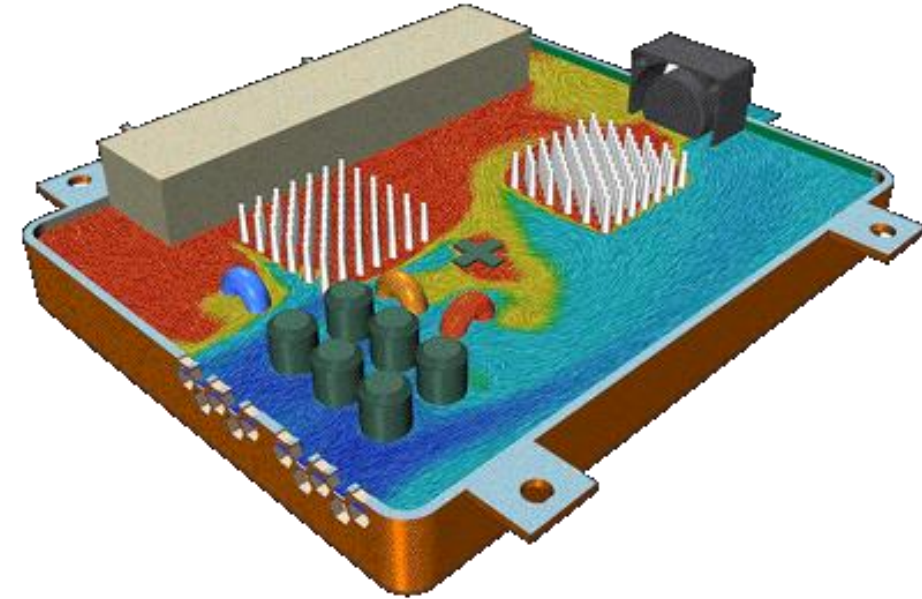
Simcenter 3D & HEEDS



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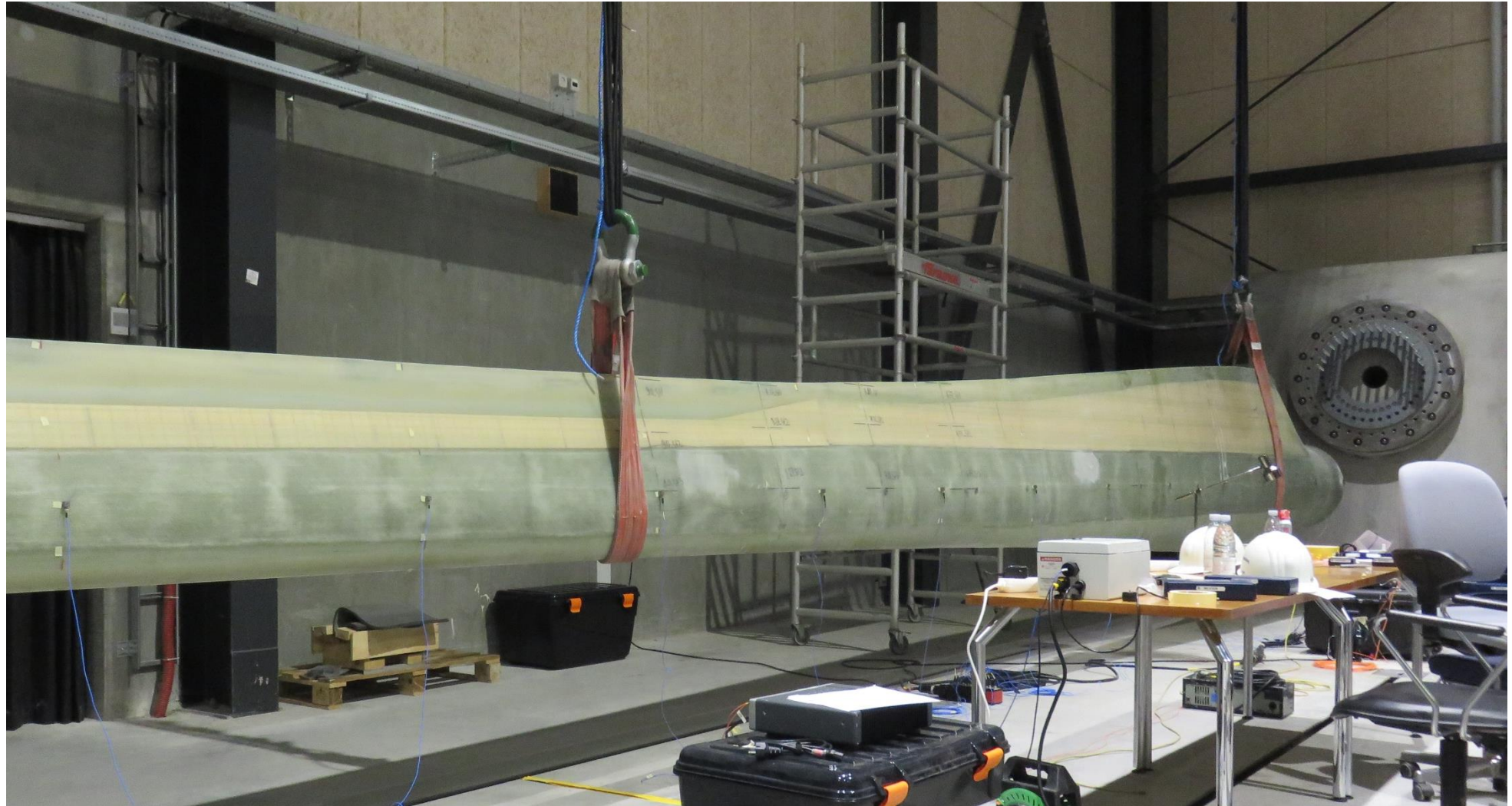
Star-CCM+ & HEEDS



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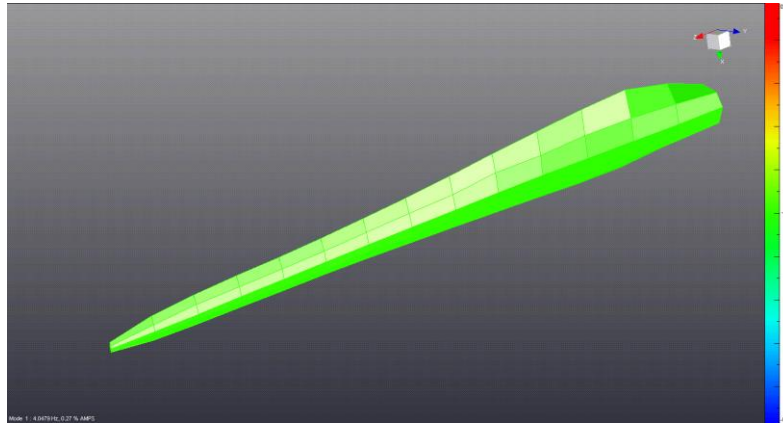
Free-free setup

Simcenter 3D

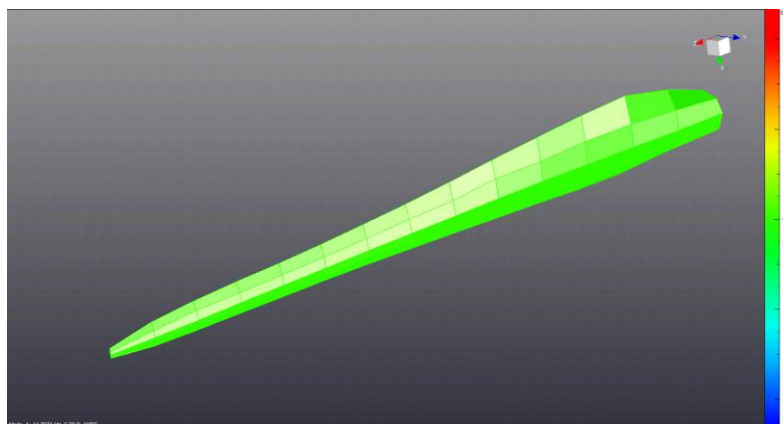
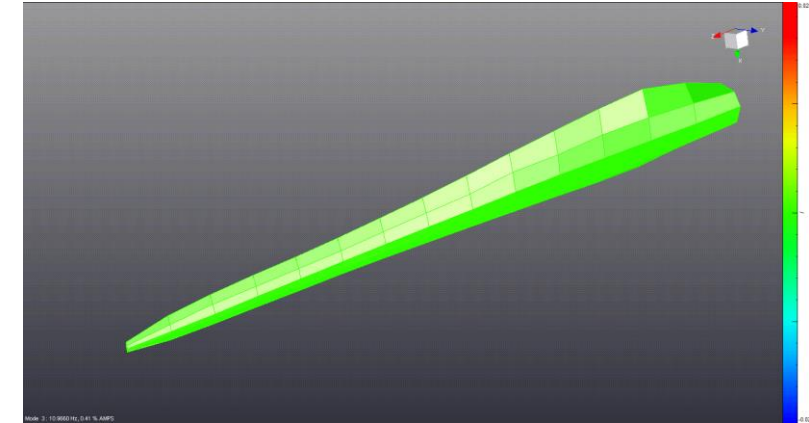


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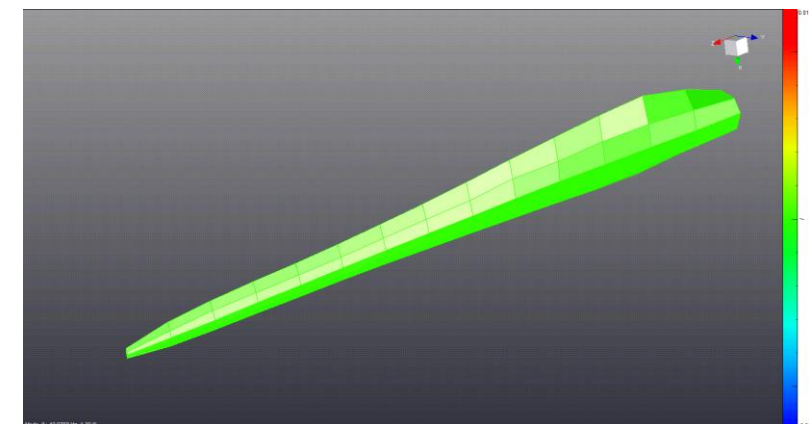
Experimental setup: Mode shapes



1st flap mode
4.05 Hz

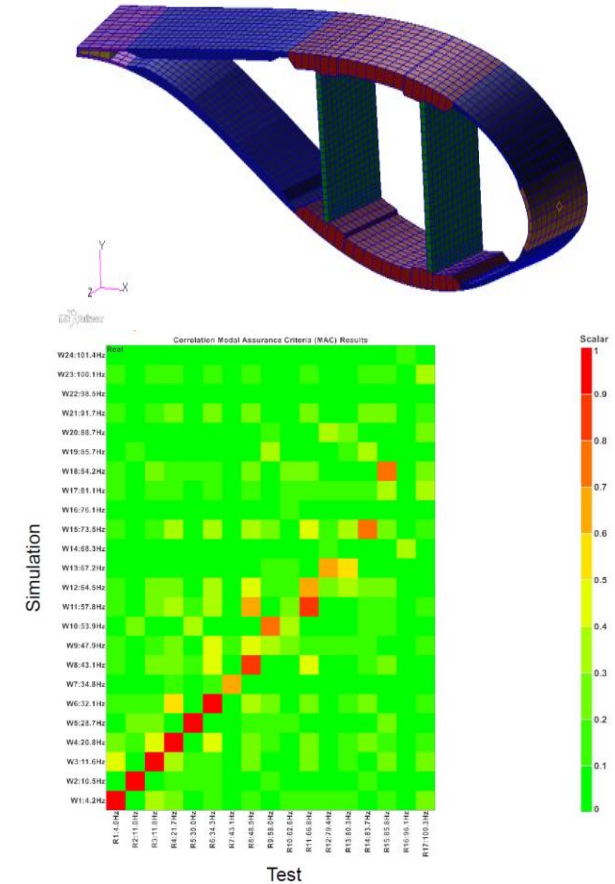
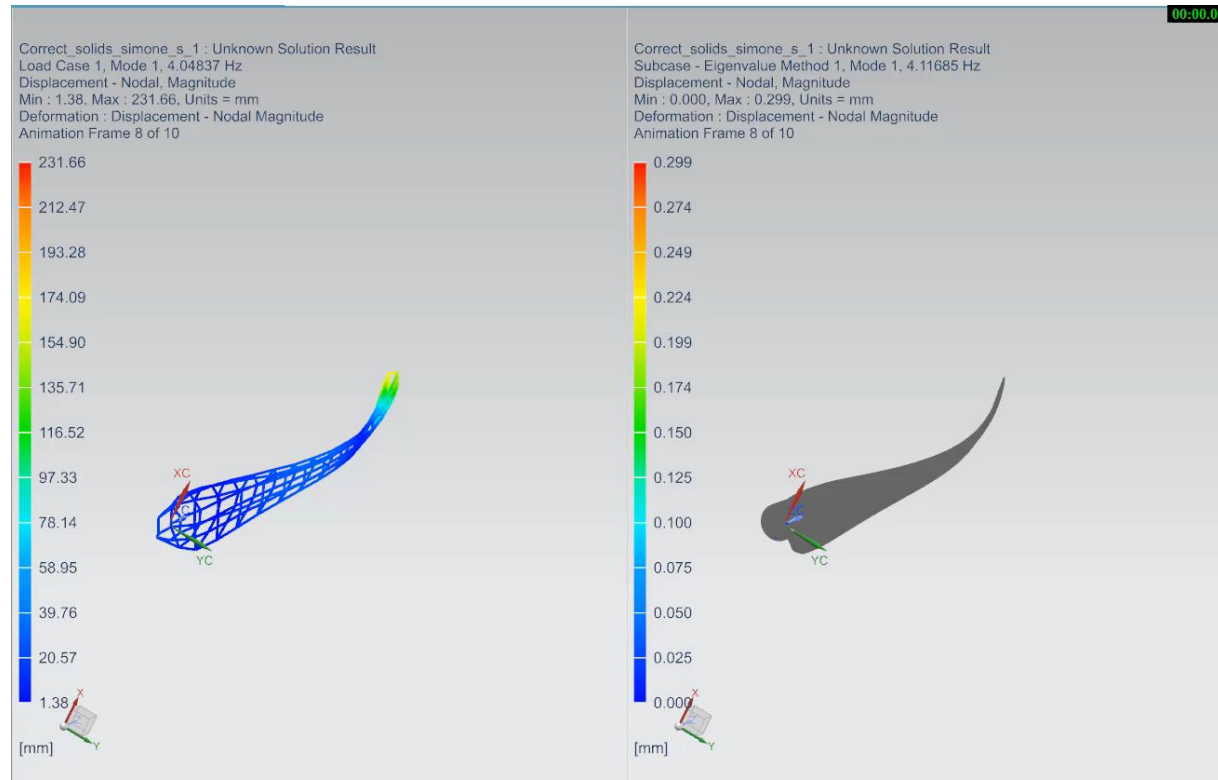


2nd flap mode
11.81 Hz



3D FE simulation and correlation with the test

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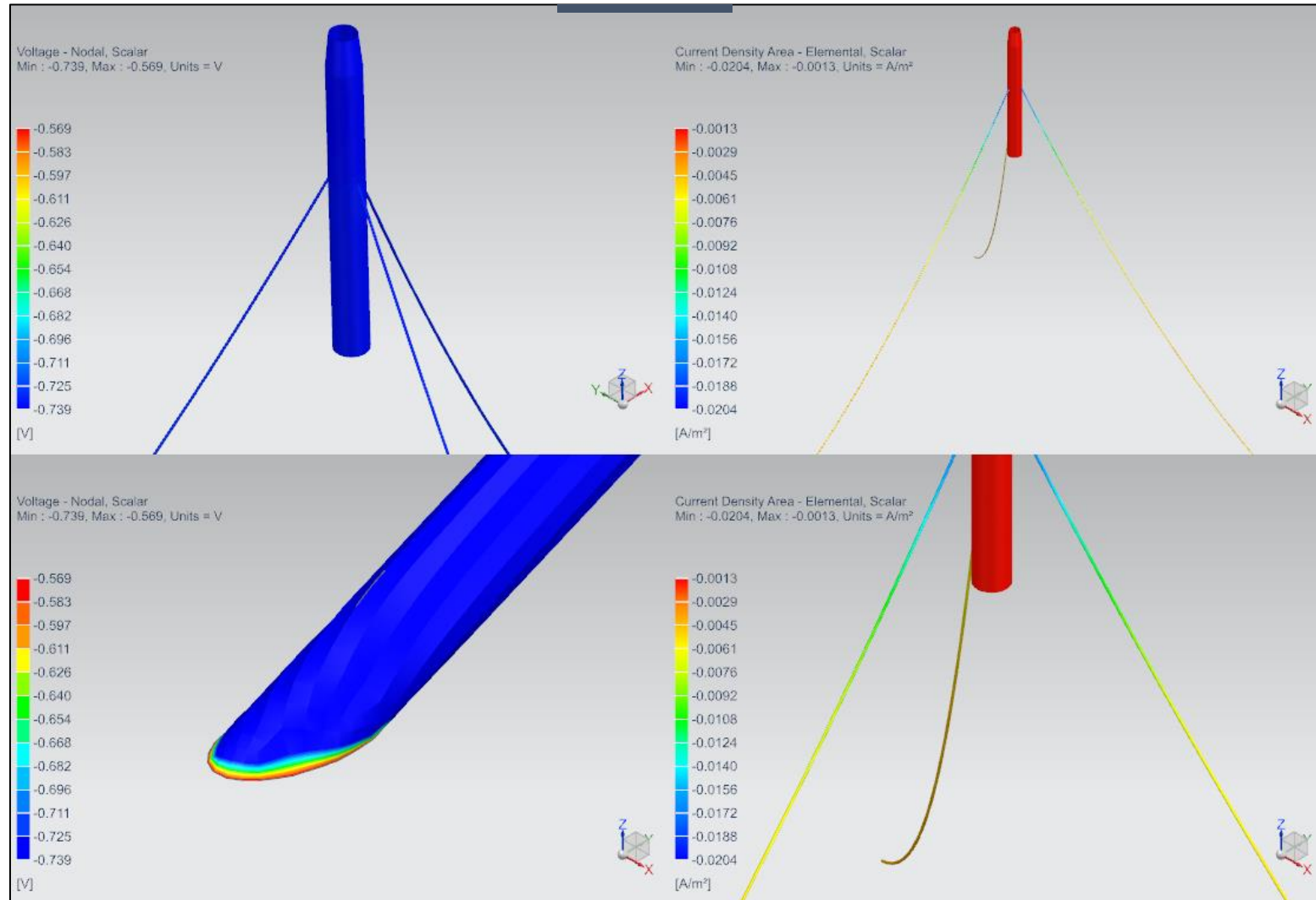
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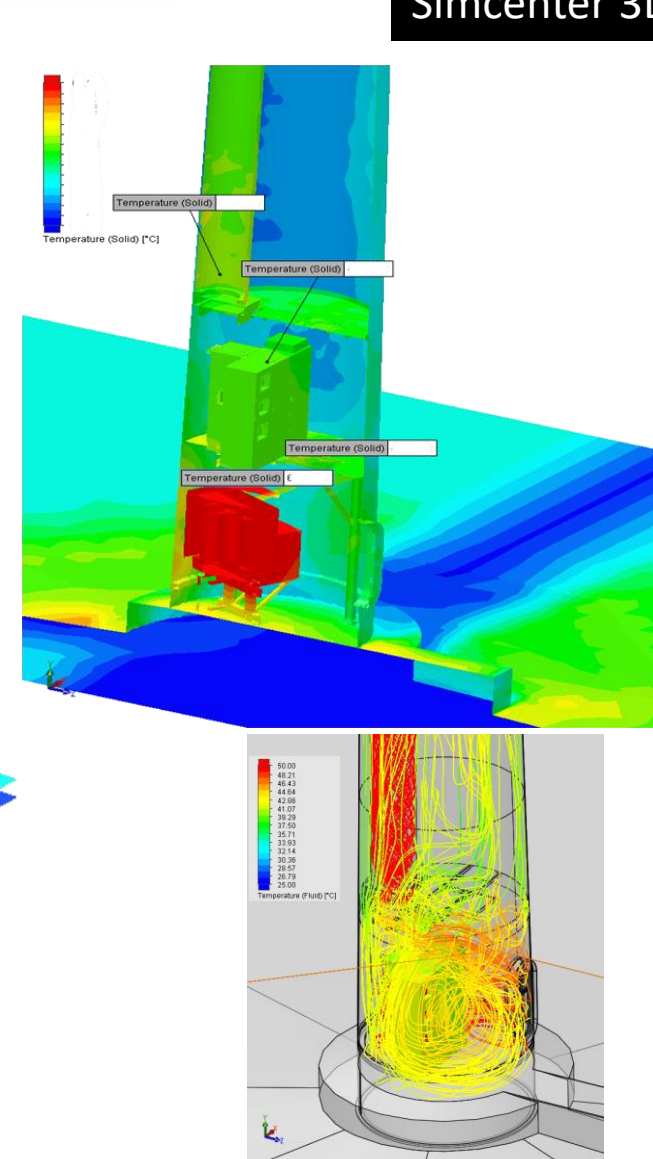
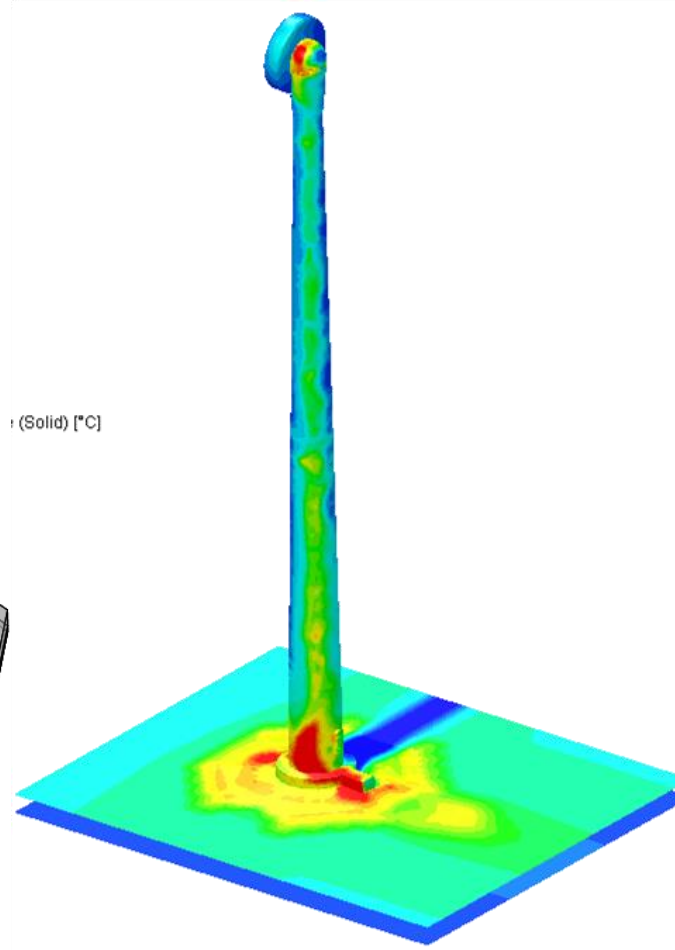
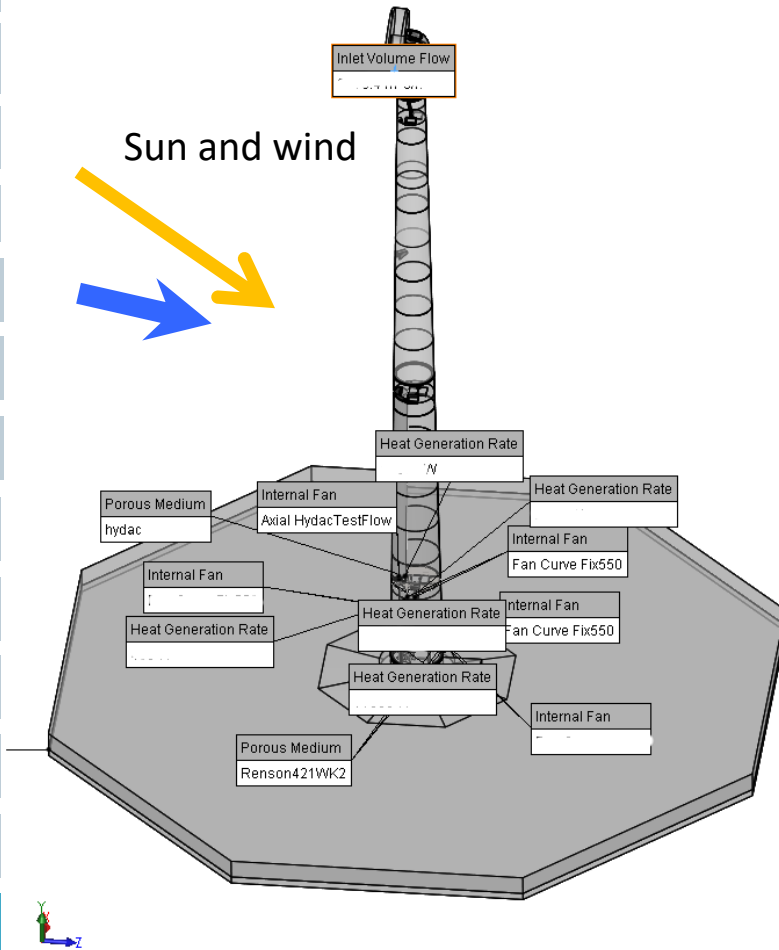
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CP on an 145m-tall floating offshore wind turbine

PITHIA-CP

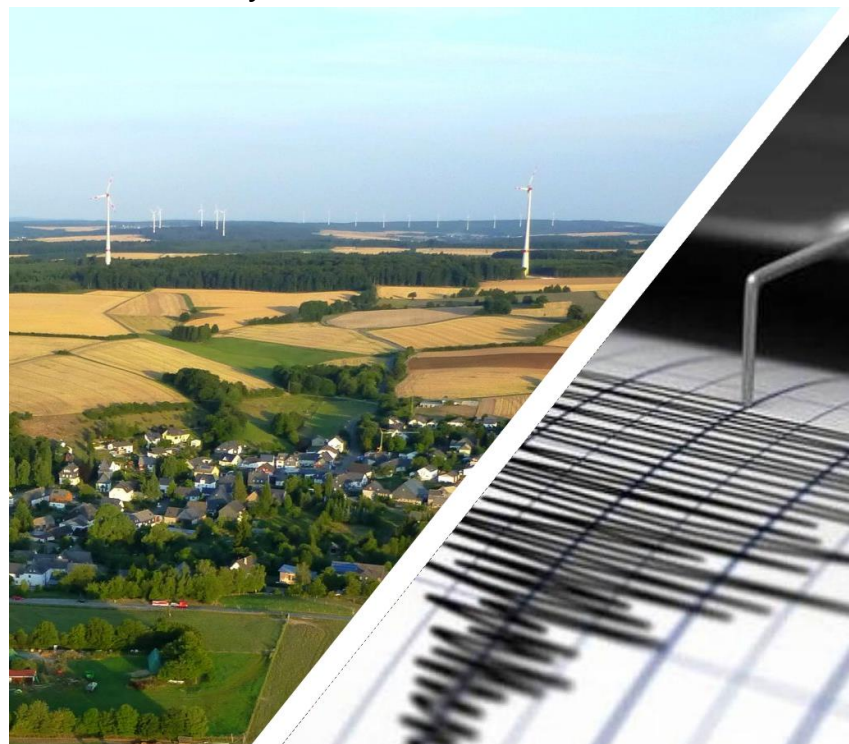


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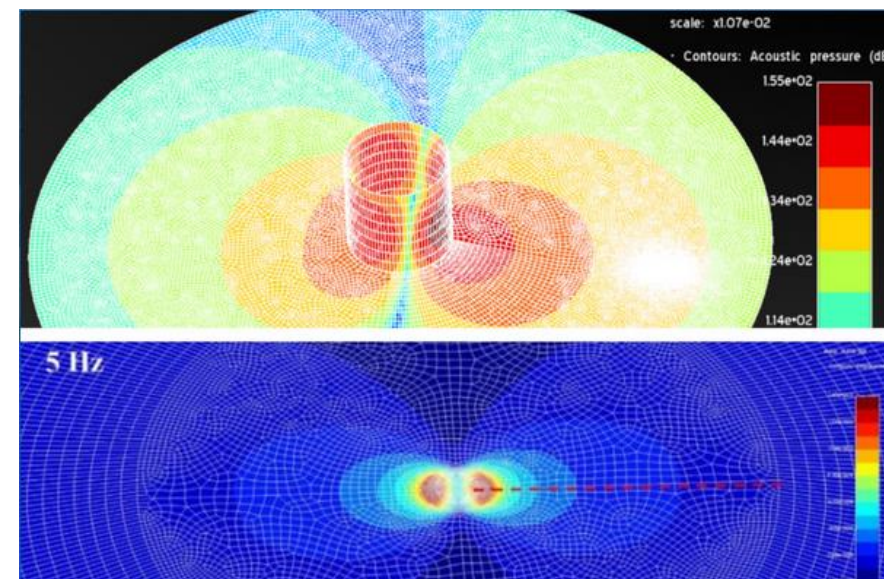


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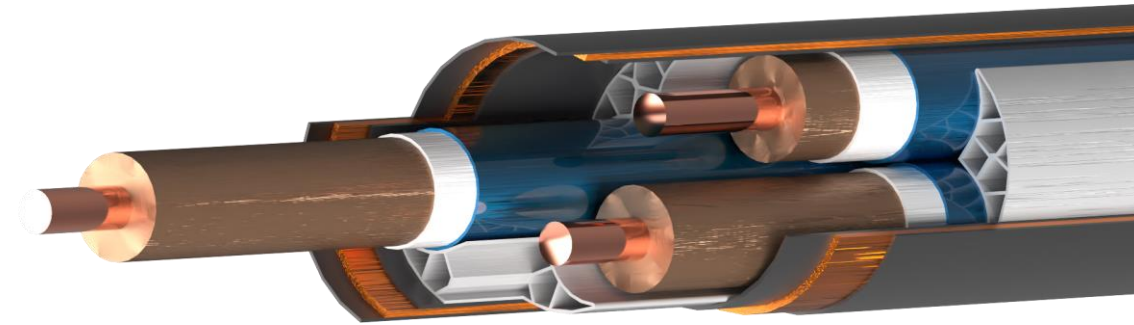
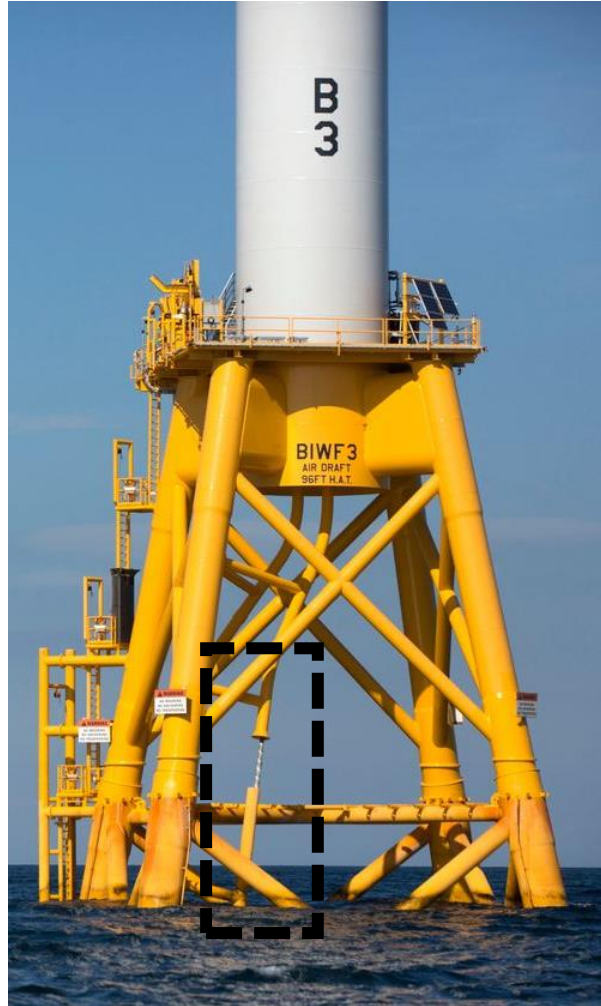
- Given the complexities associated with ship design and construction, the IMO Guidelines focus on primary sources of underwater noise, namely on propellers, hull form, on-board machinery, and various operational and maintenance recommendations such as hull cleaning. Additionally, piling operations performed during the installation of offshore wind turbines or the construction of bridges influence heavily the underwater life.



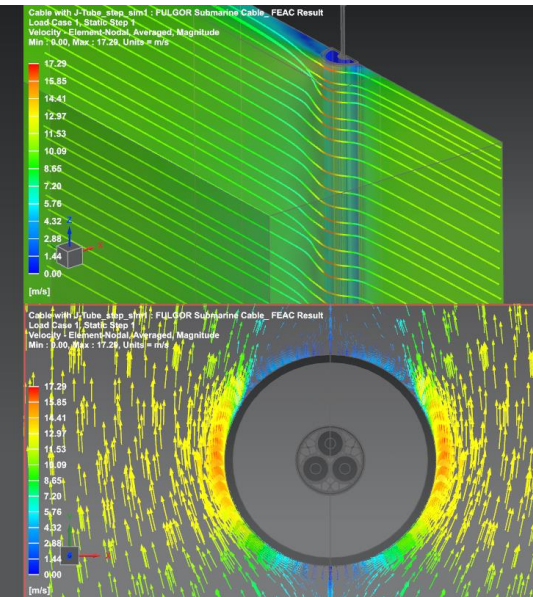
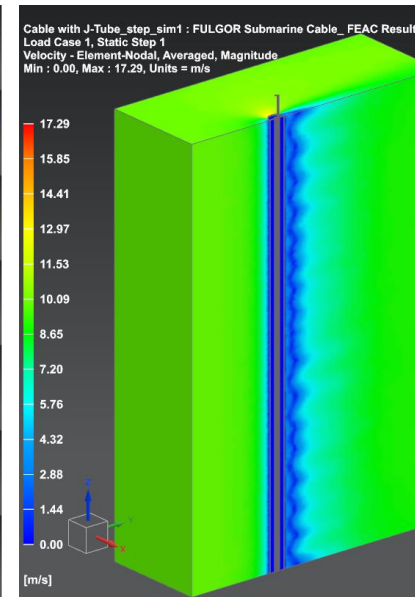
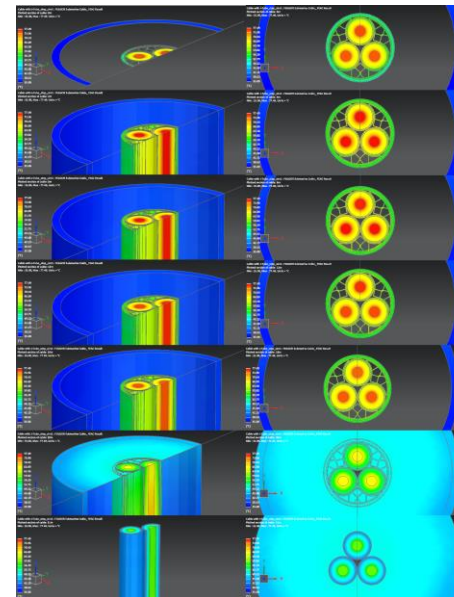
- Study of micro-seismic & infrasound noise generated by wind turbines. The waves are propagated through the air and soil possibly affecting nearby residences or Seismological/Earthquake data centers. The simulation handles effectively the fluid-soil-structure interaction (FSI) phenomenon.



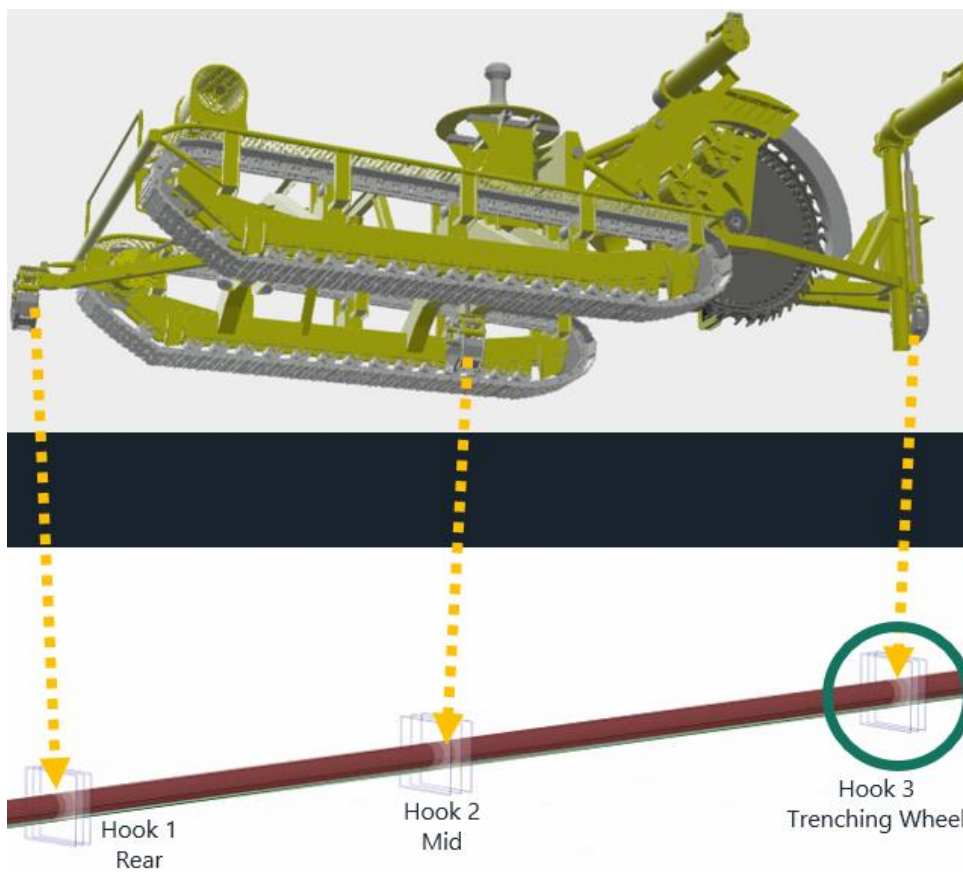
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20-m long cable. Heat transfer through Conduction-Convection & Radiation

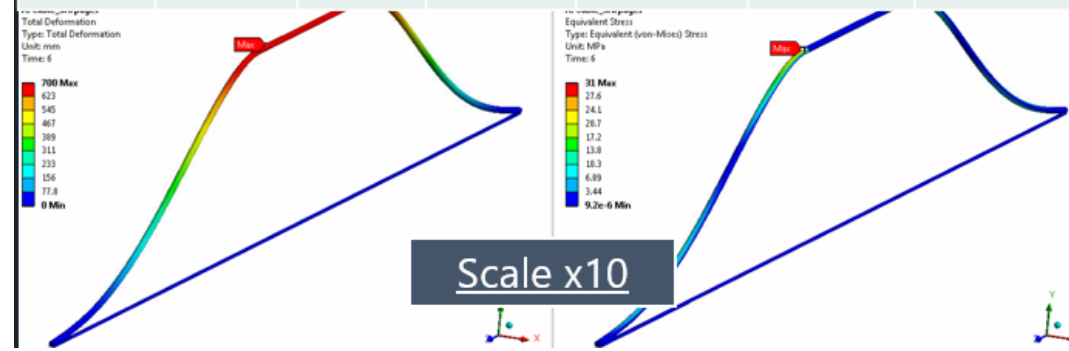


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Lifting from 3 Lifting Points:

Pre-tension (per side)	Pre-tension (total)	Lifting	Equivalent Stress	Reaction Force Hook 1 REAR	Reaction Force Hook 2 Mid	Reaction Force Hook 3 TRENCHING WHEEL
0 kN	0 kN	700 mm	30.755 MPa	9160.90 N	2307.03 N	8973.60 N
1.25 kN	2.5 kN	700 mm	30.785 MPa	9160.95 N	2307.035 N	8973.61 N
2.5 kN	5 kN	700 mm	30.815 MPa	9160.97 N	2307.04 N	8973.62 N
5 kN	10 kN	700 mm	30.875 MPa	9161.00 N	2307.05 N	8973.64 N
7.5 kN	15 kN	700 mm	30.936 MPa	9161.10 N	2307.06 N	8973.66 N
10 kN	20 kN	700 mm	30.996 MPa	9161.20 N	2307.07 N	8973.67 N



CONTENT

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Introduction: FEAC Engineering

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Why Simulation? Simcenter Portfolio

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Digital Twins & Industrial Applications

04

Executable (real-time) Digital Twin

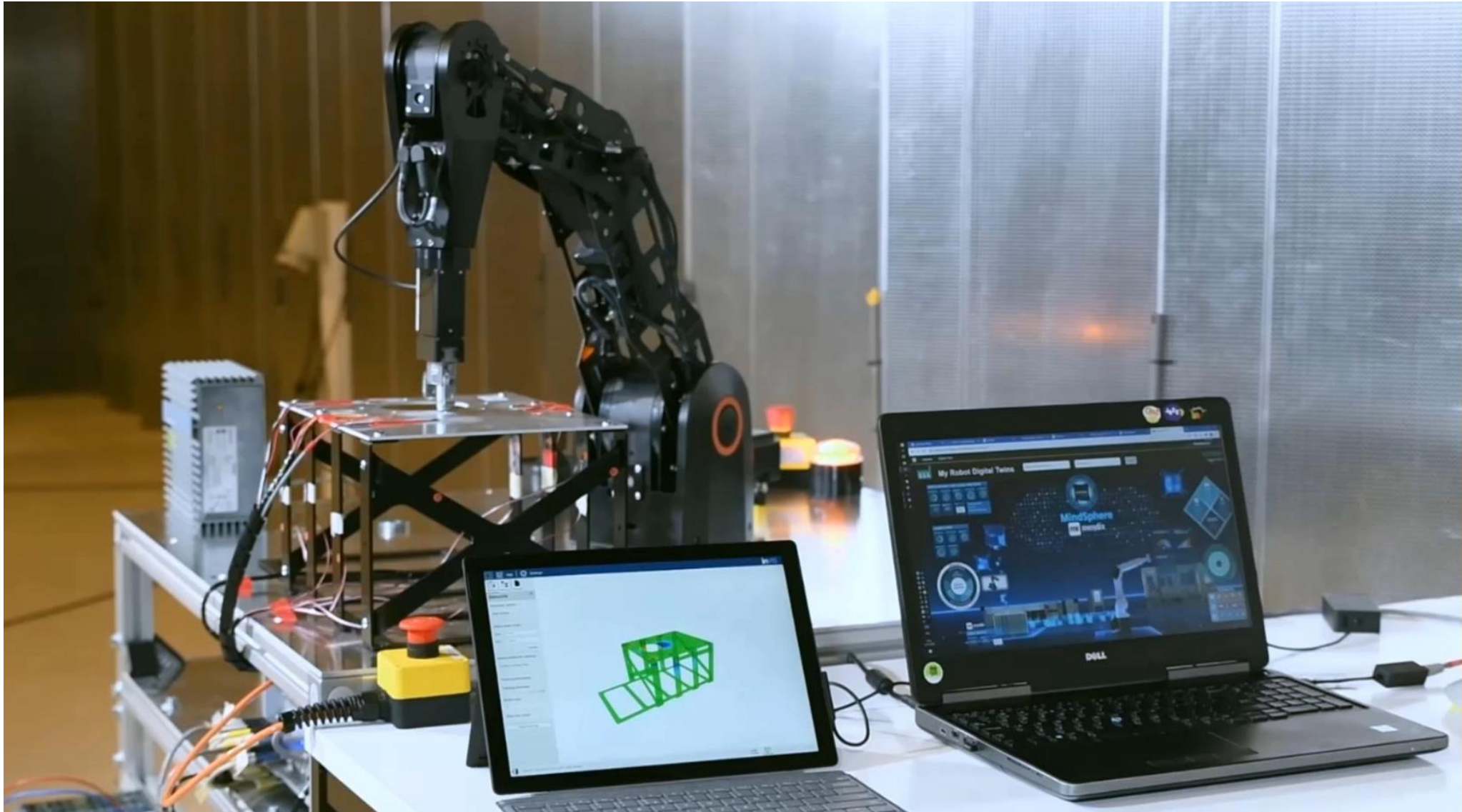
Executable Digital Twins

5. Real-time simulations?

What is an...

Executable (real-time) Digital Twin

Is a virtual representation connected to a physical product or process, used to understand, predict and monitor the physical counterpart's performance characteristics. It provides simulation results in real-time.



Connecting directly **virtual sensors** to Physical assets by **Physics based models**, measuring real sensors and using the data leads to **real time** prediction of quantities that were previously not measurable.

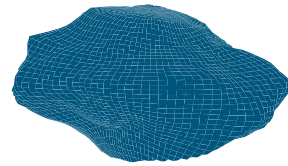
Physical assets

Create xDT Reduced Order Model

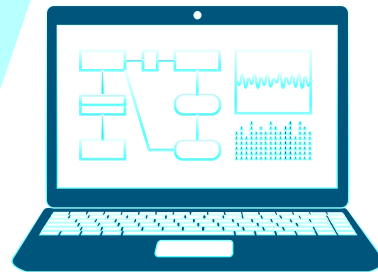
Deploy xDT



Create and
validate



3D CAE



1D

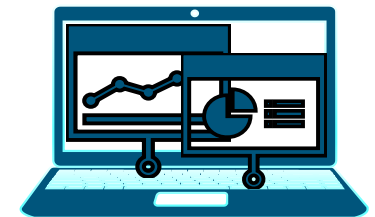
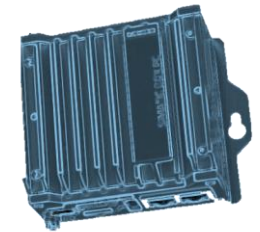


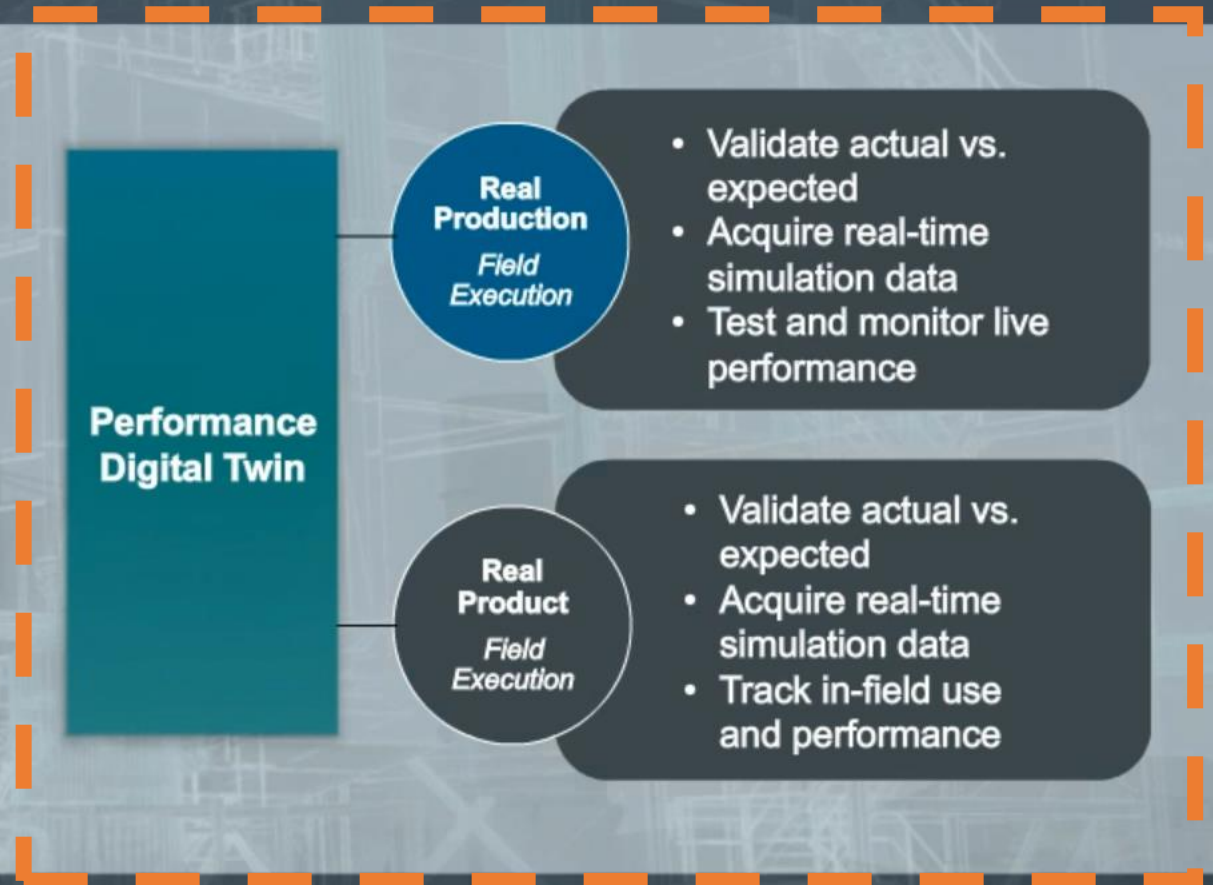
3D CFD



Test and Data driven

Package and
deploy
xDT



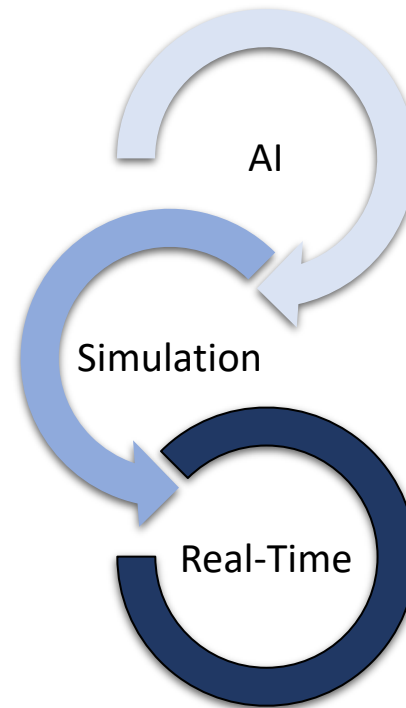




Simulation

Advantages/Disadvantages of Simulation

- (+) Can be explained and reconstructed
- (+) Describe Complex multiscale & multiphysics phenomena
- (-) Costly & Time Consuming
- (-) Only numerical experts can create well accurate simulation models



Artificial Intelligence

Advantages/Disadvantages of AI

- (+) Can be created easily and quickly with sufficient data
- (-) Can not describe accurately the physics of the system
- (-) Difficult to obtain enough training data
- (-) The mathematical context can not be modified by humans

| Synergy is the key!

Contact us in case you...



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+
Free Trials**



Certified Trainings



Research projects

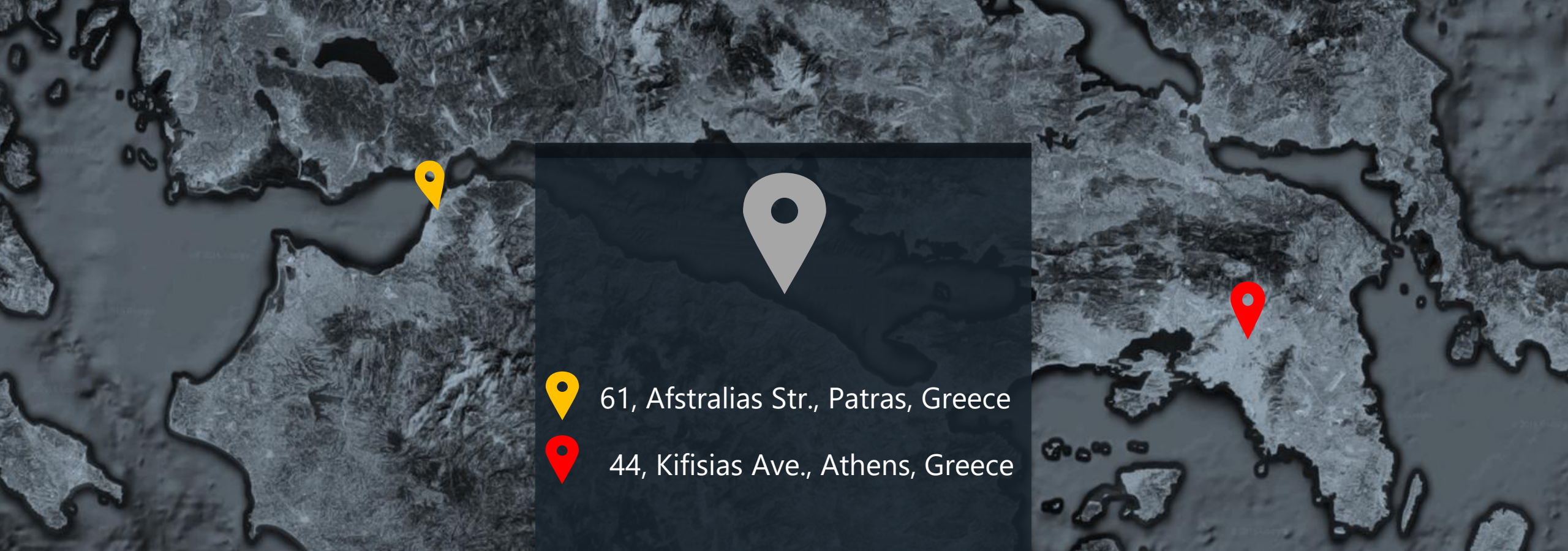


Master Degree



**Want to start
your digital
journey**

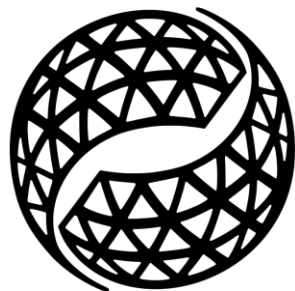
..and let's Realize your Digital Twin



61, Afstralias Str., Patras, Greece



44, Kifisias Ave., Athens, Greece



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