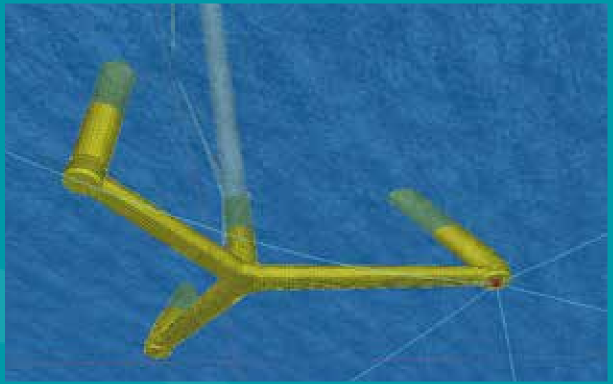
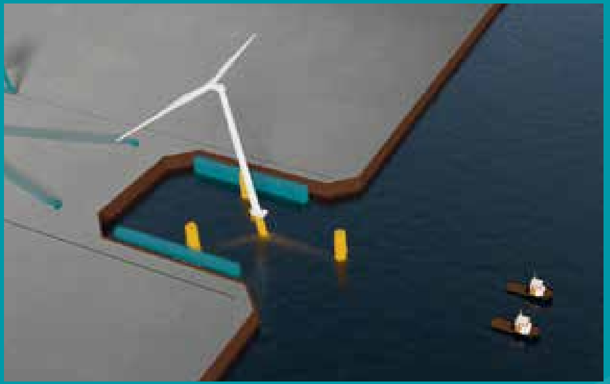
THINKING OUT OF THE BOX

Concept



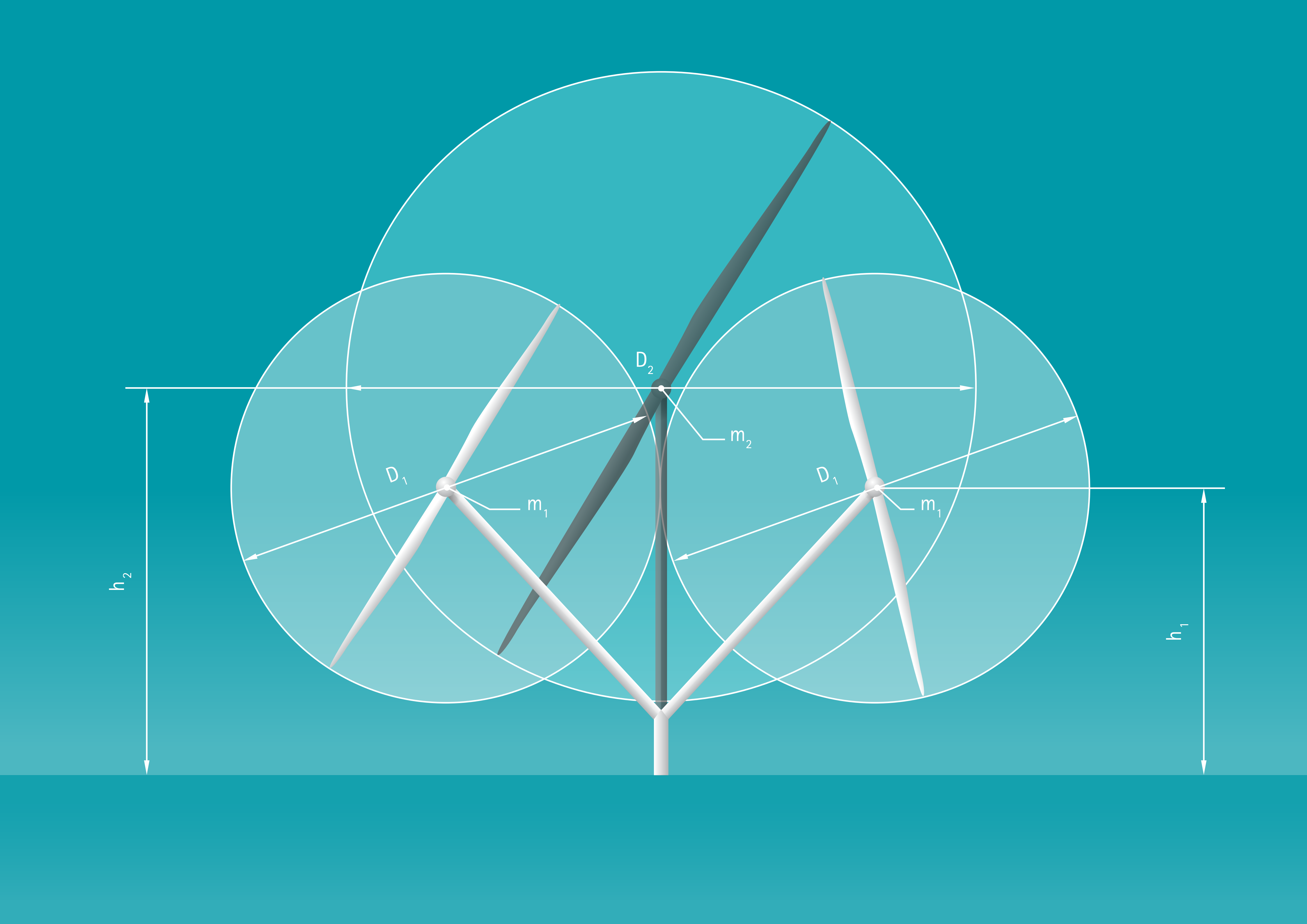


Based on the proven SCD-Technology and the innovative SCDnezzy technology the next development step is to increase the power rating. SCD Technology is a lightweight wind turbine drive train concept to reduce weight, number of parts and increase robustness. These features are ideal for a further development of the floating concept of SCDnezzy. A combination of 2 proven wind turbines on one installation site allows utilizing wind resources more efficient without any shading. The use of already developed wind turbines will decrease the development cost by increasing the power rating per installation point. As innovative floating solution SCDnezzy provides unique features to reduce the technical amount of work and increased simplicity in difficult environments. Especially the self-aligning feature allow for a radical new system designs using the wind more efficient. A single point mooring reduces installation works and allow for an easy exchange in case of main component exchange. Combined with a catenary mooring the system removal after reaching the 25 year end of lifetime the system is able to be removed entirely. This mooring system allows additionally for the smallest possible environmental encroachment. Concrete as foundation material is ideal to improve economics and local souring.

Gathered experience from the SCDnezzy development, the omitted yaw system reduces the tower top weight and system inertia significantly. Combining the low tower top weight with the lift and drag optimized, lens shaped, guyed tower structure SCDnezzy² improves the system integration principles.

aerodyn engineering as owner of the SCD-Technology optimized the turbine design for increased fatigue and floating environments. The two-bladed downwind oriented rotor improves the commissioning and installation work amount due to the proven single lift turbine installation. All necessary works are performed in harbor that power production starts immediately after system installation onsite.

aerodyn engineering provides all technology know-how to integrate SCD-Technology and SCDnezzy technology to a further step in the floating offshore wind turbine industry.



D2
m2
D1
m1
D1
m1
h2
h1

Economics

$$2 \cdot E_1 = E_2$$

$$\bar{v}_2 = \bar{v}_1 \cdot \left(\frac{h_2}{h_1}\right)^{0.16}$$

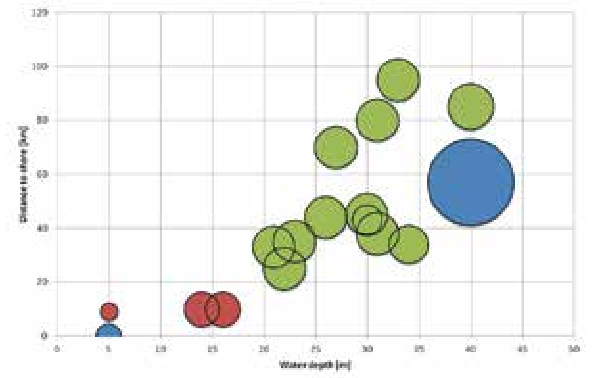
$$E^* \sim \left(\frac{\bar{v}_2}{\bar{v}_1}\right)^{1.12}$$

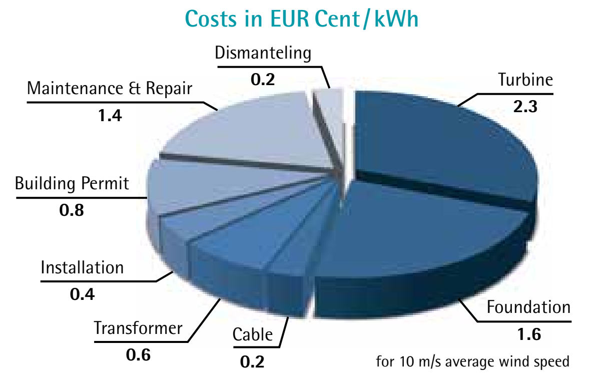
$$D_2 = \frac{\sqrt{2} \cdot D_1}{\sqrt{\left(\frac{\bar{v}_2}{\bar{v}_1}\right)^{1.12}}}$$

$$m_2 = m_1 \cdot \left(\frac{D_2}{D_1}\right)^{2.8}$$

$$h_2 = h_1 + \left(\frac{D_2 - D_1}{2}\right)$$

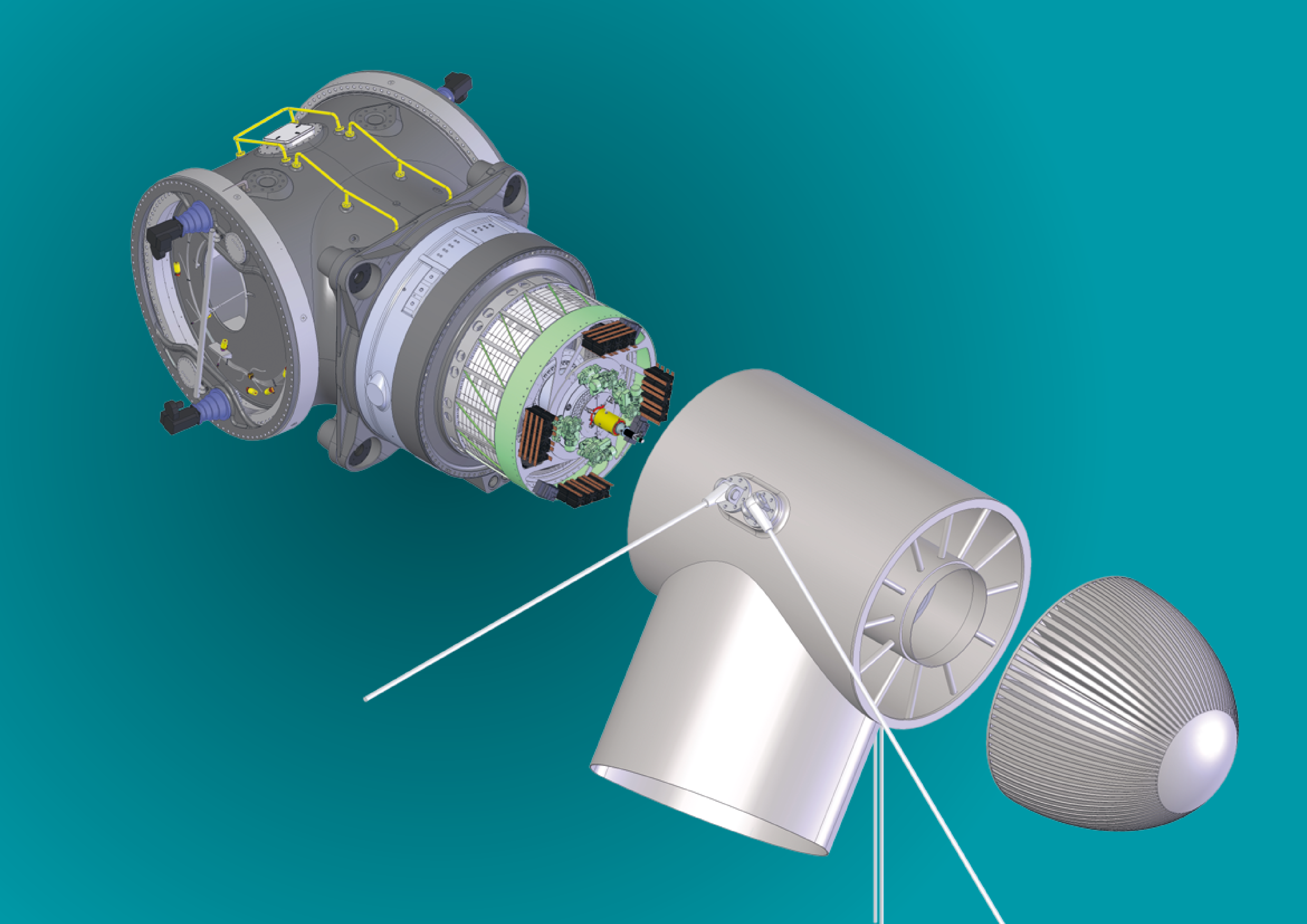
$$m_2 \cdot h_2 = m_1 \cdot \left(\frac{D_2}{D_1}\right)^{2.8} \cdot \left(h_1 + \frac{D_2 - D_1}{2}\right)$$



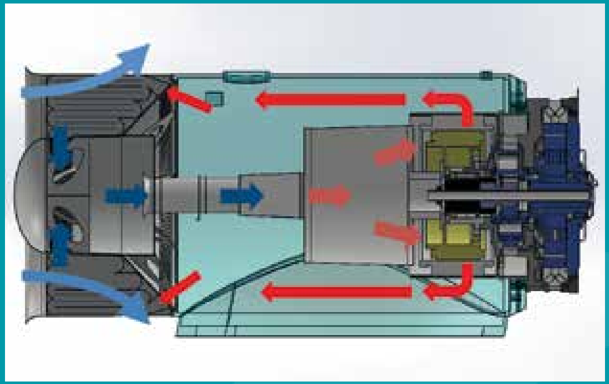


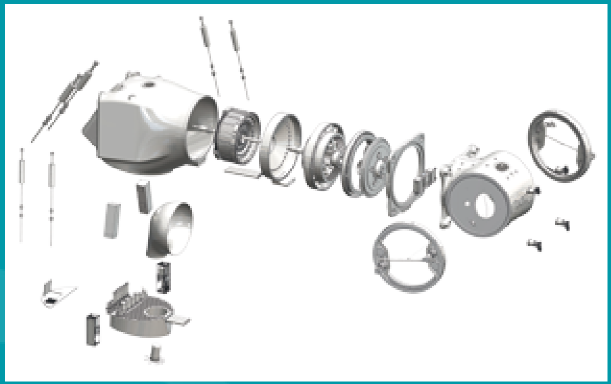
Decreasing the cost of electricity an efficient use of each installation point is necessary. In the past the rotor size per installed unit increases resulting in a significant raise in development and logistics cost. Additionally the installation of large wind turbines becomes more complex due to increased hub height, water depth and distance to shore. Connected to massive amounts of work in case of part exchange the further increase of turbine sizes should be discussed. A comparison shows that based on the same energy yield (E) the mass exponent for one large wind turbine is 2.8 compared to two smaller wind turbines with half power capacity. Driving the foundation design an increased mass and hub height result in ~ 1.55 times higher mass moment at water surface.

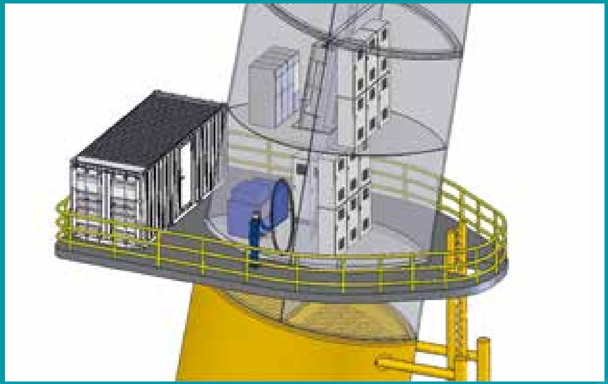
A competitive approach to decrease the Levelized Cost of Electricity is the use of two turbines per foundation. The use of a proven and bankable technology in an available scale results in lower investment cost per installed MW.



Design Features





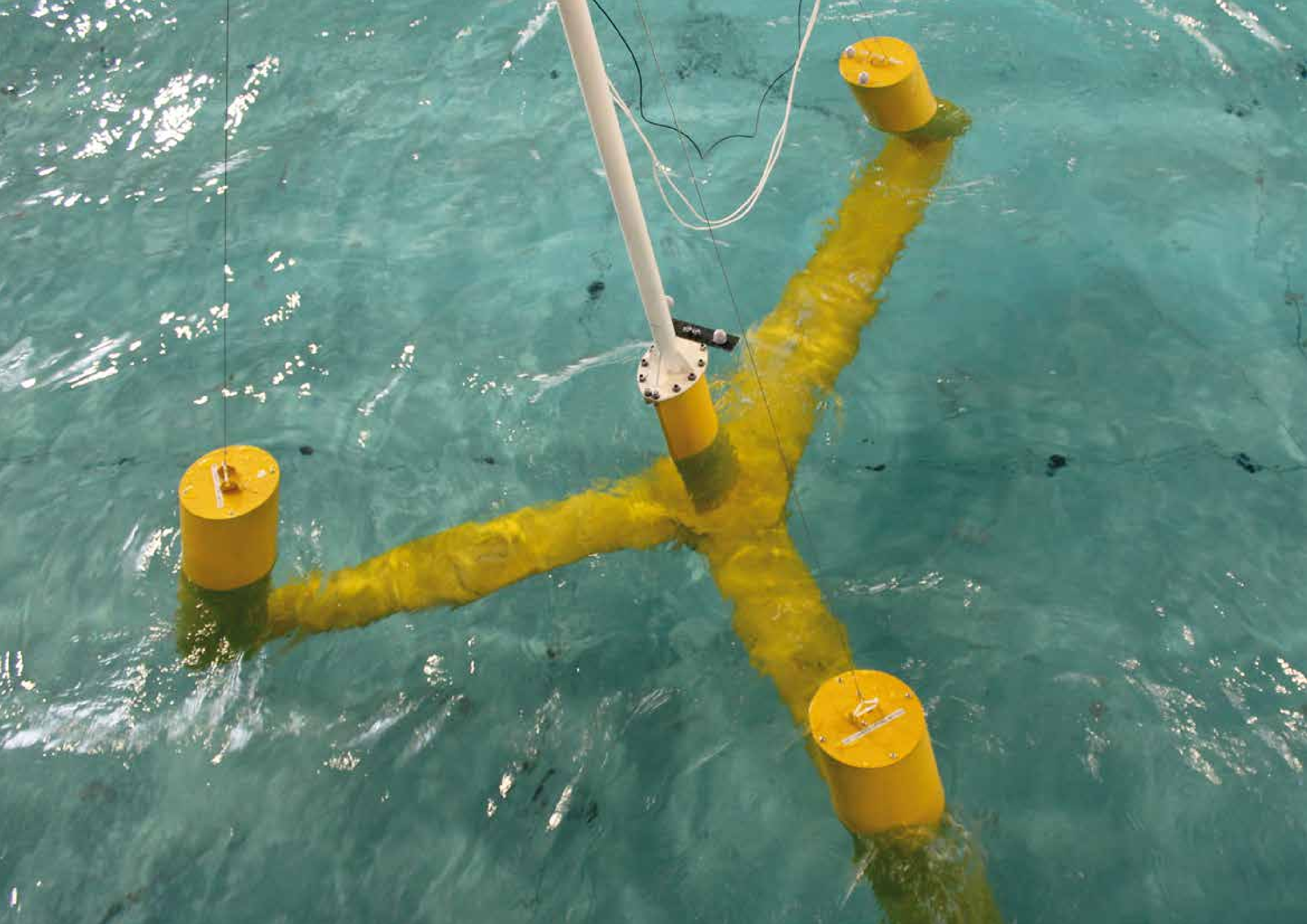


Basic Y structure of the floating foundation results in the use of 2 turbines per foundation leading to a small increase in cost by doubling the power output. Using the SCD-Technology as modification basis only a small adaption is needed for the use on SCDnezzy². Characteristic design feature is the two-bladed driven fully integrated drive train unit. 2-bladed rotors are operating with increased rotational speed to reach a comparable power rating of a 3-bladed rotor. The hub is directly connected to the two-stage planetary gearbox front plate. Flex pins are able to bear bending moments in the first gearbox stage leading to a light weight main bearing. The gearbox is connected via a torque limiting coupling to the external exited synchronous generator. No low speed or high speed shaft is installed to reduce the number of heavy weight components. The generator technology is designed to reduce the use of rare raw materials and the external excitation enables a more efficient generator control. The rotors are counter rotating with an offset of 90 degree to avoid any excitation from each other.

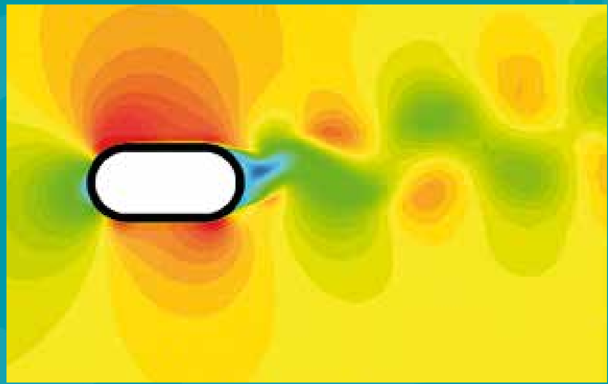
Simply inserted to the horizontal tower top flange the drive train unit is easy to assemble and to install. Opposite of this flange the air-cooling system is attached to provide a sufficient and reliable system cooling for all key components including power electronics at the tower top.

Foundation and tower will be assembled in the harbor. The T-shaped tower top flange is able to transfer all loads from the rotor into the guy wire system. The guy wire system supports the load transfer into the foundation.

Most power electronics is contained in the tower bottom section and the transformer container is located on the transition piece. This power electronics unit will be pre-assembled and integrated in one step during the main assembly. The SCD-technology provides innovative and robust features optimized for floating offshore applications.



Development Process

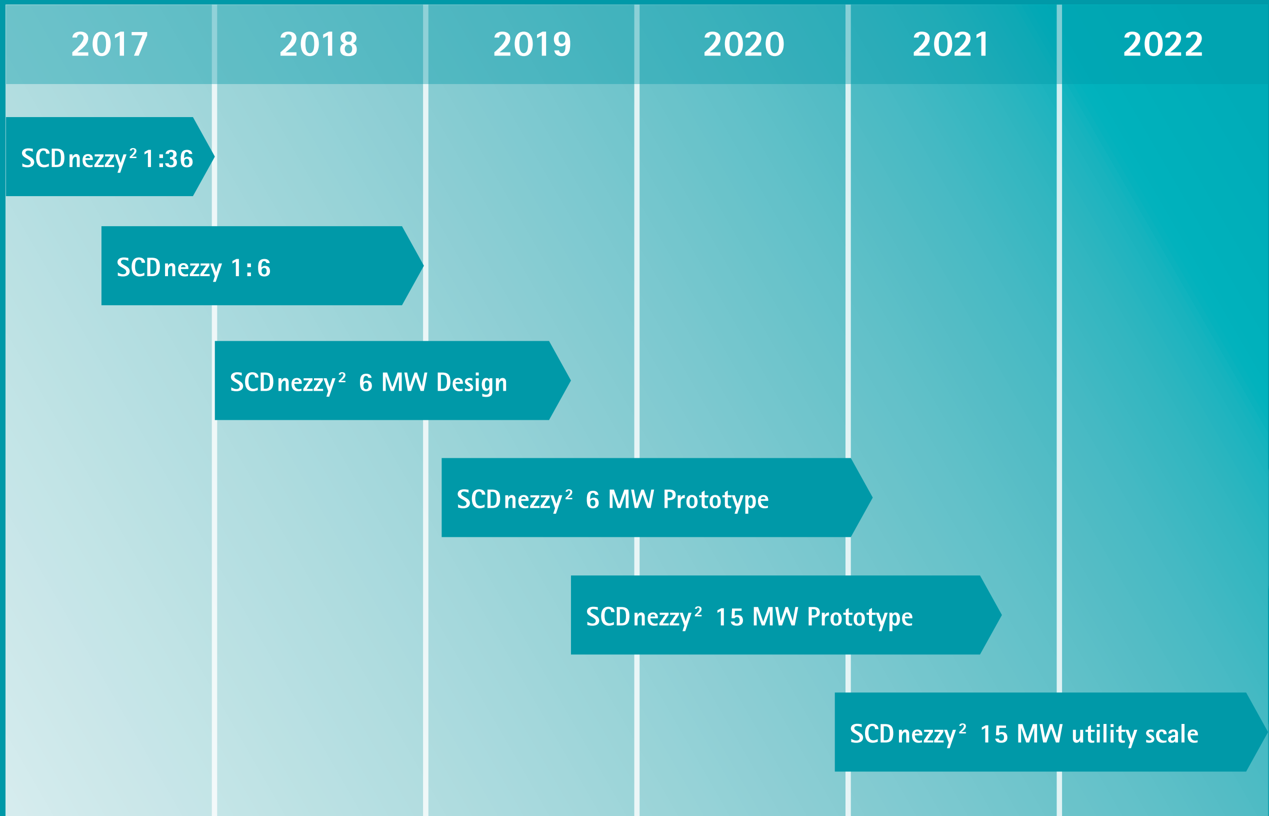


SCDnezzy development started in 2014 with several feasibility studies and technology approvals. Additionally numerical simulations for wind, waves, currents and combinations of them are performed before the model tests started. The comparison of simulation results and a 1:36 scaled model in a wave tank showed very good compliance. Regular waves, irregular waves, extreme waves and transport and installation were successfully tested in laboratory environment. Especially in extreme natural environment SCDnezzy delivers a superior performance.

Avoiding current driven yaw misalignments the cross shape of the foundation structure is optimized for low drag and high material utilization. A hollow precast and post-tensioned foundation structure enables a foundation system passively stabilized by ballast water in operational environment.

The wind turbine SCD-Technology was tested on a full load test bench with additional load application in 6 degree of freedom. The integration of this robust turbine technology with the light weight SCDnezzy foundation provides a robust floating offshore wind system.

Future Prospects



In general the SCDnezzy² technology is applicable for 2-bladed and 3-bladed rotors. A combined development approach focused on the foundation development will drive the technology timeline. Finishing the technology feasibility for SCDnezzy² in the first half of 2017 the second half will be used to perform a 1:36 scaled tank test in an ocean wave basin. In parallel a 1:6 scaled SCDnezzy open sea test is carried out to validate the foundation technology in a medium scale environment.

In 2018 the detailed design of SCDnezzy² 6 MW with two SCD 3 MW turbines starts, enabling a prototype construction until end of 2019 with test in 2020. In 2019 a full scale SCDnezzy² 15 MW prototype design and one year later the construction starts with two SCD 7.5 MW turbines starts. After prototype fabrication and validation a utility scale series production is aimed from 2022 onwards. A dedicated marine operation and mooring procedure has to be developed for each wind farm location. Key market is the global offshore floating market demanding for local sourcing, reliable energy output and robust turbine technology.

SCD-Technology One Step Ahead

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