Offshore YEKA – A new opportunity?

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A significant revision was made to the Turkish wind energy related regulation in the past two years, favoring the YEKA model over the traditional YEKDEM method. The first result of these revisions was a YEKA tender, held in August 2017, where 1 GW of onshore-wind capacity was dedicated to the Kalyon, Türkerler and Siemens consortium.

The related agreement was recently signed between the consortium and the Ministry of Energy in April 2018. Under this pilot YEKA model, the consortium commits itself to manufacture (mostly in Turkey) wind turbines of up to 1 GW of total capacity and in return is granted the right to operate wind farms with these turbines. The feed-in price over 3,48 USD-cents per kWh is guaranteed for a duration of 15 years. In order to keep up the pace gained by these recent developments, YEGM published the intention to hold a second YEKA tender in 2018; this time for a maximum of three sites around Thrace in form of an "offshore YEKA". This is fully in line with the "surprise" for the wind energy sector, announced during the TÜREK conference in Novermber 201 7 by Mr. Albayrak, the Minister of Energy and Natural Resources. With the 3rd postponement (to 2020) of the pending YEKDEM applications, we understand that YEKA is likely to become the favored investment model for wind energy in Turkey.

What is "Offshore Wind Energy" in general and why is applied?

In the broadest sense, "offshore wind farm" is defined as "wind turbine installations built further offshore on coastlines for commercial electricity generation". Initially the idea to place wind turbines offshore, right into the sea and far away from human settlements, came from the UK where there is (still) a strong opposition to "ugly" wind turbines, affecting the view of the landscape. This approach was picked up by developers, mainly due to the additional fact that far offshore, one gets significantly more constant and higher wind speeds, coupled with relatively less ambient turbulences, less loading from the ambient flow and hence generates a higher amount of electricity. Furthermore, the layout of the entire farm can easier be formed compared to complex terrain micro-siting of onshore wind farms. Even though, the potential energy yield is much higher offshore, the wake effects from the wind turbines are much more significant and cause for lower wake recoveries due to the relatively lower ambient turbulence intensities. Thus, the inclusion of advanced wake models are required for much accurate energy calculations.

The drawbacks and benefits of offshore wind farms in Europe can be roughly summarized in the below matrix:

Benefits	Drawbacks
Technical / Infrastructural	**Technical / Infrastructural**
Higher wind potential, higher efficiency, minimum turbulences	20 times higher costs for wind measurements
	Lack of trustable and up-to-date input data (seabed, sea depth, etc.)
	3 times higher CAPEX investment in comparison to onshore
	3 times higher OPEX costs in comparison to onshore
	Need for very special and expensive) naval vessels
Environmental	**Environmental**
Less impact on human settlements	Major impact on submarine habitat
Less impact on onshore environment	Major impact on migrating birds (due to turbine size)
	Impact on land (especially coastal area) with the construction of large
	substations and grid connection line
Legal / Permitting	**Impact on tourism along the coastal area**
Minimum zoning permission risks	Unclear legislation on permitting and construction
Minimum land securing risks	
Others	**Others**
	Conflicts with other investments due to geopolitical position
	Oppositions of local people living around the coastal area
	Impact on military and civil aviation

Table 1: *Benefits and Drawbacks of offshore wind farms*

Basically we understand that in comparison to onshore wind farms, offshore wind farm applications appear to have a very low impact on human settlements and benefit from more reliable and stronger winds; these benefits however are being "paid for" by threefold higher CAPEX and OPEX expenses in combination with significantly higher costs (and risks) for reliable project development.

Offshore wind farms in Turkey – A general look

In April 2018, YEGM announced three potential project sites for offshore wind farms in Turkey, to be tendered under the YEKA model later in 2018. All sites are located around Thrace; in the Black Sea, the Marmara Sea and the Aegean Sea.

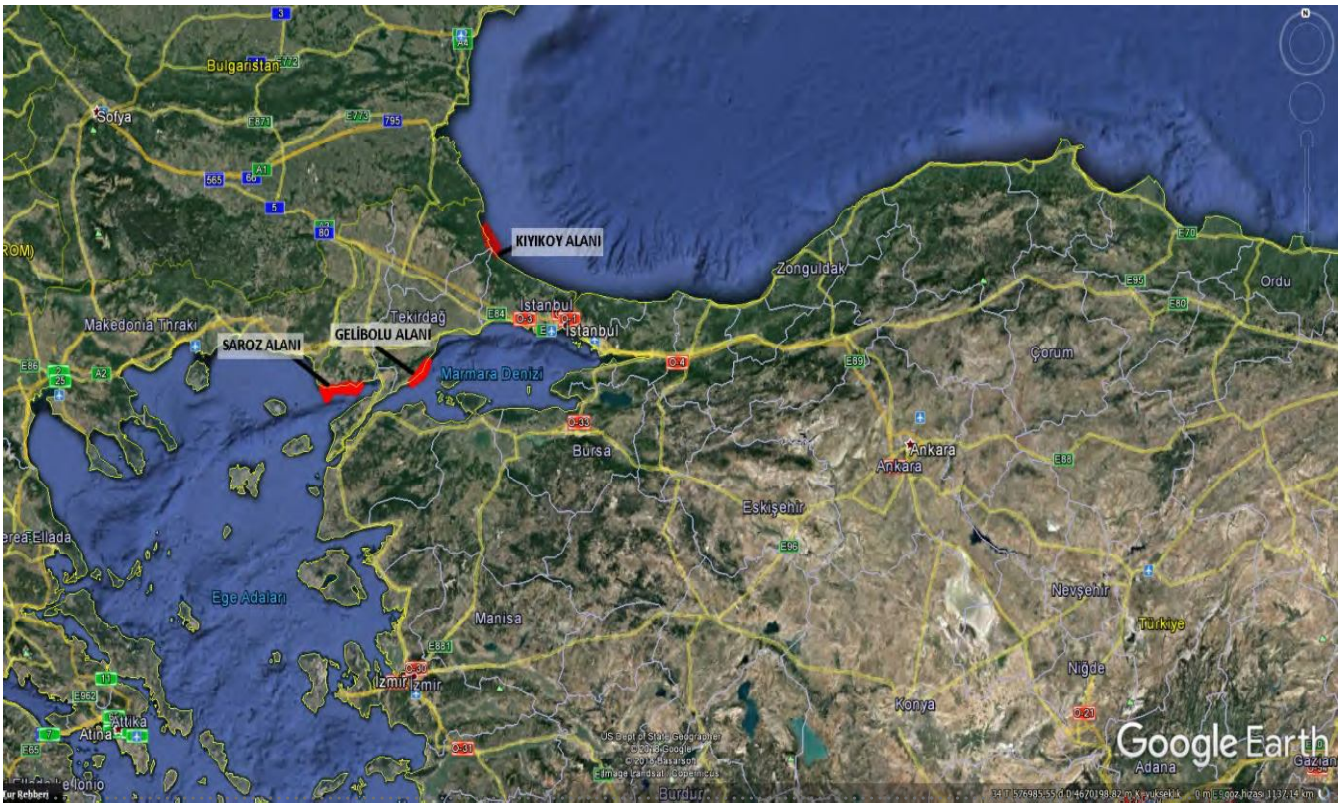

Fig 1: *Locator map of the 3 YEKA sites*

Like with onshore project development, a proposed site needs to undergo a detailed risk assessment and a constraint map needs to be drawn on top of the development area. Constraints can be of various nature; Turkey-specific offshore constraints are listed below, but are not limited to these:

Environmental:

Bird migration routes, fishing, tourism, earthquake fault lines, sea mines (especially from WW1), military training areas, protected lands on coastal areas

Infrastructure:

Sea depth (minimum 30m and maximum 70m), pipelines, telecom cables, shipping lanes, ferry routes, sea bed conditions, closeness to large ports, civil aviation radars

Legal:

International borders (exclusive maritime zones), military restricted zones

Wind-technical:

Wind potential, ambient and wake turbulences, performance of the wind turbines

Since the idea of offshore wind farming is brand new to Turkey, it is difficult (sometimes even impossible) to get reliable input data in order to draw a constraints map. In addition, turbine manufacturers are keeping the power- and thrust curves of their > 6MW offshore wind turbines confidential, hence it is difficult to calculate energy yields based on (at least simulated) wind data. Offshore wind data is not available at all for sites in Turkey.

Based on the constraints which we were able to define and locate within the proposed project areas, we are screening the feasibility of these projects below. In order to understand the maximum installable rated power of the project areas, we are using the 8 MW Siemens 167 offshore wind turbine as an example for each layout. For energy yield calculations we are using a turbine layout, based on the Vestas V150-4.2 on-shore wind turbine, just in order to publish a brief idea of what to expect as Capacity Factor.

1. Kıyıköy YEKA project site

The proposed Kıyıköy project site covers an area of roughly 340 sqkm. The sea depth within this area ranges from 0m to 70m.

Environmental: The project area is environmentally sensitive and overlaps on the onshore side with the İğneada Longoz Ormanları National Park, Kasatura Körfezi Natural Protection Area, Çamlıköy Natural Park, Çilingoz Wild Life Protection Area and Kıyıköy Protected Area. In addition to these protected lands, the onshore side of the project area is also en-route of a major bird migration route and hence the offshore side is likely to be affected by this migration as well. The region around Kıyıköy is a special area for which Turkey signed international agreements to protect this area. On the offshore side of the project area, a special undersea forest ecosystem is located, inhabited by a variety of marine species that live and especially breed there. As per the latest fauna and flora census, there are 341 plant species found in that region, 12 of them are endemic (Source: Ministry of Forestry and Water Affairs).

Infrastructure: Observing the water depth limits of 30m (min) to 70m (max), the project area shrinks to 199 sqkm. Since the "Turkish Stream" pipeline crosses the site, the project needs to be cut into an independent southern and a northern part. "Crossing" the pipeline with submarine cabling is forbidden; Botaş expects to observe a minimum buffer zone of 500m to the pipeline.

Legal: The entire site is located within Turkish territorial waters.

Wind-technical: After avoiding all constraints (as far as we could define) there is space for 128 x Siemens 167 wind turbines, leading to an overall installed capacity of 1.024 MW. With an average wind speed of 7,1 m/s in 120m height a.s.l., the average capacity factor of a Vestas V150-4.2 onshore wind turbine with a hub height of 120m, calculated with generic wind data (EMD), would be 40,4%. This capacity factor would decrease significantly when employing an 8 MW wind turbine.

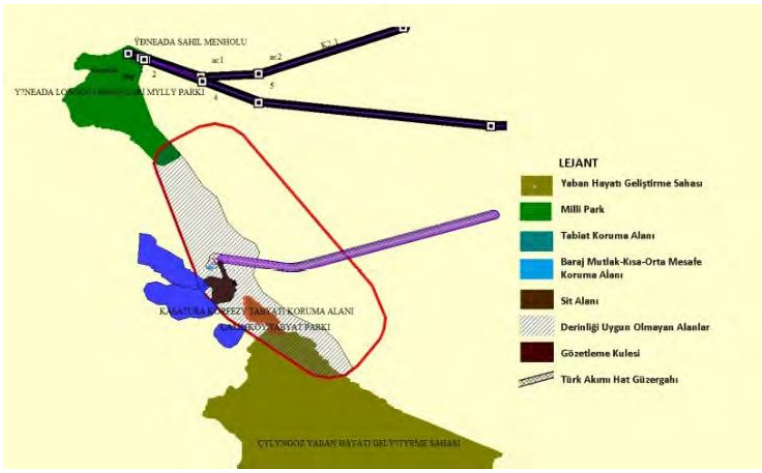

Fig 2: *Constraints map of Kıyıköy YEKA*

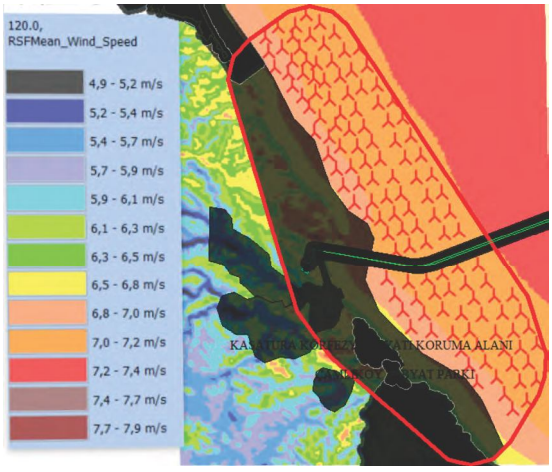

Fig 3: *Wind atlas and turbine layout on top of constraints map (all constraints in black)*

With the Turkish Stream pipeline, a valuable undersea forest ecosystem and significant bird migration, there are three major obstacles related to the Kıyıköy YEKA site that need to be observed. "Ramming" monopole foundations into the seabed would lead to vibrations of the seabed and could hence cause damage to the pipeline. Swirling of sand as a result of the foundation works could eventually suffocate large parts of the undersea forest. This undersea forest is a major breeding ground for fish in the area and hence the source of income for the local fishing industry. Due to the bird migration, radar tracking systems would need to be installed and the wind farm shut down in regular intervals during Spring and Autumn. All these constraints would need to be examined in detail and mapped and are likely to decrease the "usable" area for the project even more. A floating wind turbine would not solve the sand swirling problem, since also these turbines would need to be fixed to the seabed by means of concrete anchors.

Back in 2006 re-consult performed a wind measurement campaign in Kırklareli, roughly 30km inland from the proposed YEKA site. The average annual wind speed in 60m above ground level on that project site was 6,74 m/s and hence not significantly lower than the average wind speed of the generic wind data (7,1 m/s in 120m height) from EMD for the Kıyıköy YEKA site.

2. Gelibolu YEKA project site

The proposed Gelibolu project site covers an area of roughly 290 sqkm; the sea depth within this area ranges from 0m to 600m.

Environmental: As discussed with experts of the Ministry of Forestry and Water Affairs, the project is likely to affect the submarine habitat of the Şarköy-Gaziköy area, so a detailed study needs to be performed at site. The onshore side of the project area is a geologically risky area in terms of landslides. No data could be found for the undersea slide related risks, however there is a fault line very close to Gaziköy and this fault line continues submarine up to Marmara Ereğlisi. Based on the findings of İstanbul Technical University, this fault line creates a major risk for the entire Marmara Sea. The project area is very close to a major bird migration route on both, the onshore and the offshore side.

Infrastructure: Observing the water depth limits of 30m (min) to 70m (max), the project area shrinks to 67 sqkm. As per an opinion received from the General Directorate of Türk Telekom, two undersea cables interfere with the proposed project site; one of these cutting the site in half. These cables are part of an international project, therefore a buffer zone of at least 500m from both sides of the cables need to be observed.

Legal: The entire site is located within Turkish territorial waters.

Wind-technical: After avoiding all constraints (as far as we could define) there is space for 65 x Siemens 167 wind turbines, leading to an overall installed capacity of 520 MW. With an average wind speed of 7,3 m/s in 120m height, the average capacity factor of a Vestas V150-4.2 on-shore wind turbine with a hub height of 120m, calculated with generic wind data (EMD), would be 39,5%. This capacity factor would decrease significantly when employing an 8 MW wind turbine

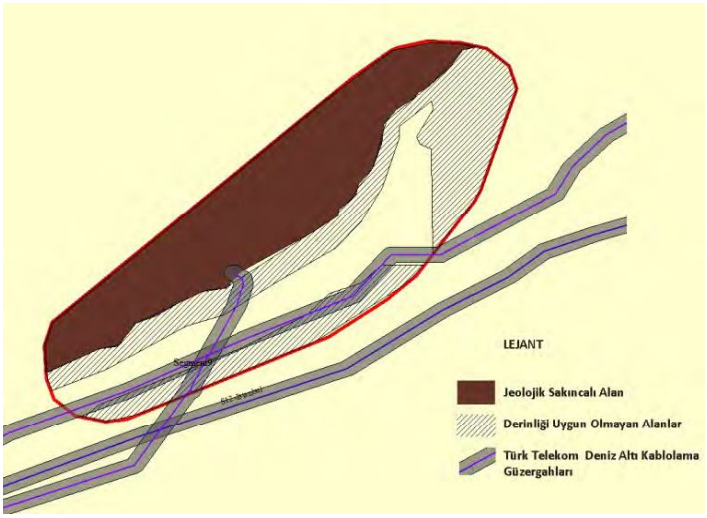

Fig 4: *Constraints map of Gelibolu YEKA*

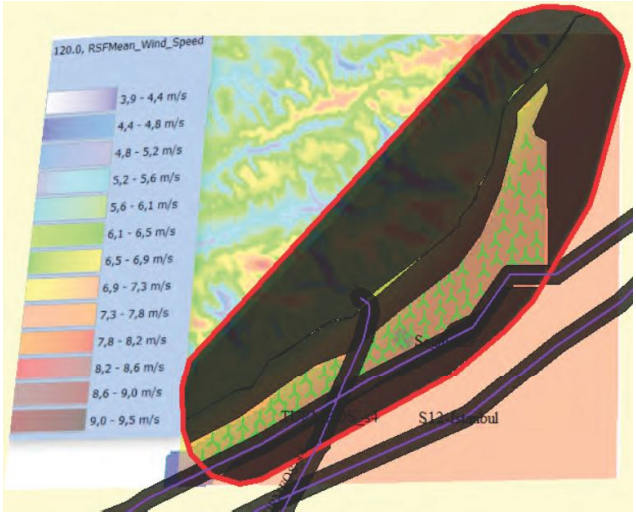

Fig 5: *Wind atlas and turbine layout on top of constraints map (all constraints in black)*

With the Telekom cables, a valuable undersea habitat, significant bird migration and the risk of landslides, there are four major obstacles related to the Gelibolu YEKA site that need to be observed while planning the project in detail. Swirling of sand as a result of the foundation works would eventually have a major impact on submarine life. Due to the bird migration, radar tracking systems would need to be installed and the wind farm shut down in regular intervals during Spring and Autumn. The onshore landslide risk is likely to extend to the undersea part of the project area, requiring a serious geological study especially to clarify the risk of the existing fault lines on onshore and offshore side. One Telekom cable cuts the site in half, so whether or not power cables can be laid across the Telekom cable needs to be examined carefully. All these constraints would need to be examined in detail and mapped and are likely to decrease the "usable" area for the project even more.

Demir Holding's "Sankaya RES" wind farm operates roughly 15km West of the proposed Gelibolu YEKA site with a capacity factor of around 34%, which is slightly lower than the capacity factor (39,5 %), calculated with the generic wind data from EMD for the Gelibolu YEKA site.

3. Saroz YEKA project site

The proposed Saroz project site covers an area of roughly 478 sqkm and is located close to the town of Mecidiye in Edirne. The sea depth within this area ranges from 0m to 180m.

Environmental: The project area is very close to the "Gelibolu Peninsula", one of Turkey's most important national parks, both in terms of environmental and archeological protection. As onshore archeological assets are found in abundancy, it is likely that there are also numerous submarine assets waiting to be discovered in the project area. Since the Gulf of Saroz borders the main WW1 battlefield of Gallipoli, there is a high risk of encountering yet not detonated but highly corroded undersea mines. Also under the "Saros Artificial Reef and Undersea History Museum Project", the area is specialized for diving with artificial reefs. Now, the area is one of the most popular diving places in the world. The project area also overlaps with the Gökçetepe Natural Park, home to a variety of endemic species. As per a written opinion received from the Ministry of Tourism, the project area is overlapping with the "Saroz Gulf Culture and Tourism Protection and Development Zone" and the related plan for this area will be published by the Ministry of Environment and Urbanization in the coming months. Additionally there are a variety of fishing facilities within the submarine area, where installing wind turbines may result in cancelling all fishing activities in the region or decrease in population of all livings under the sea, which will result in losing an entire habitat.

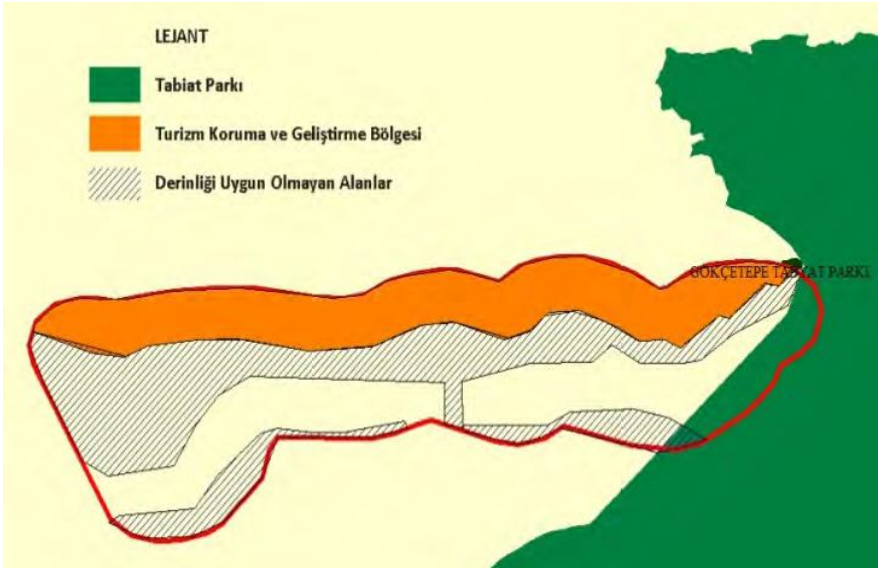

Fig 6: *Constraints map of Saroz YEKA*

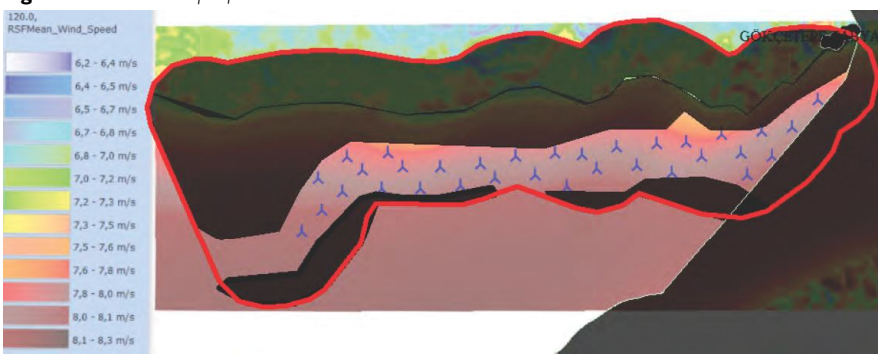

Fig 7: *Wind atlas and turbine layout on top of constraints map (all constraints in black)*

Infrastructure: Observing the water depth limits of 30m (min) to 70m (max), the project area shrinks to 150 skqm.

Legal: The entire site is located within Turkish territorial waters

Wind-technical: After avoiding all constraints (as far as we could define) there is space for 33 x Siemens 167 8MW wind turbines, leading to an overall installed capacity of 264 MW. With an average wind speed of 8,0 m/s in 120m height, the average capacity factor of a Vestas V150-4.2 onshore wind turbine with a hub height of 120m, calculated with generic wind data (EMD), would be around 48,4 %. This capacity factor would decrease significantly when employing an 8 MW wind turbine

> *Ener Holding's "Boreas RES" operates roughly 20km NW of the proposed Saroz YEKA site with a capacity factor of around 42%.*

With a valuable undersea ecosystem, significant bird migration and the risk of sea mines, there are three major obstacles related to the Saroz YEKA site that need to be observed while planning the project in detail. Artificial reefs located under the Saros Artificial Reef and Undersea History Museum Project will also be a major constraint for the turbines. The project area is one of the most popular diving places in the world, so any investment effecting the diving activities will most probably be considered as unacceptable. The sea mine risk will also require a detailed sonar study and (if found) costly removal of these explosives.

Ener Holding's "Boreas RES" operates roughly 20km NW of the proposed Saroz YEKA site with a capacity factor of around 42%.

Conclusion:

After addressing and considering all currently obvious development constraints, the three proposed YEKA sites would have an overall capacity of "1.808 MW" when employing altogether 226 x 8 MW offshore wind turbines. We understand this as "best case scenario".

Developing an offshore wind park in Turkey is challenging, since only very limited and reliable data (geological, environmental, archeological, etc.) is available from public authorities. Wind data from actual physical offshore measurement buoys is not available and would cost roughly 1 million Euro per measurement campaign. Onshore wind measurements, extrapolated to the offshore part of the project areas are cheaper, but not bankable.

When comparing the average capacity factors or wind speeds of the three proposed YEKA sites (Kıyıköy: 7,1 m/s, Gelibolu: 39,5% and Saroz: 48,4 %) with operating onshore wind farms or historical wind measurements in the wider surroundings (6,74 m/s, 20km West of Kıyıköy YEKA, 34%, 15km West of Gelibolu and 42%, 20km NW of Saroz), we understand that the offshore projects are not significantly more yielding than their onshore counterparts.

Internationally, the general reason to "go offshore" are capacity factor expectations way above 50%. From the CAPEX point of view: 1 MW offshore costs three times more than 1 MW onshore. In order to justify a 3-fold higher CAPEX, an investor would not only need reliable wind data, but also wind speeds high enough to achieve a capacity factor in the range of far higher than 50%.

Judging from the size of the offshore YEKA and the (currently) related uncertainties in terms of reliable wind data and environmental constraints, we as re-consult would suggest that YEGM fully develop and especially permit the offshore sites to the stage of "ready for construction" and then tender these sites as "executable packets" rather than publishing "project ideas", which are still fully in need of very cash-intensive pre-development activities. As re-consult we would expect to encounter a variety of further "surprises", resulting from detailed pre-project-planning which need to be addressed before the tender rather than after it. Consortiums would unlikely engage with millions of Euros and develop the sites to the stage of "ready for tender", knowing that only one consortium will win the tender.

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