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Ukraine – Taiwan Offshore Wind Joint Venture Promising Cooperation for Achieving Energy Independence

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ABSTRACT

An Offshore Wind joint venture between Ukraine and Taiwan is proposed to exchange Ukrainian welding experience for Taiwan's offshore wind technology, notably floating. The first Black Sea offshore wind farm is envisioned as the first economic driver of the project, with the production of the later joint fixed and floating offshore wind turbine foundations envisioned. The dangers and benefits of this project from technical and board socio-political aspects were analysed using the SPEED framework. The analysis indicates that leveraging Ukrainian welding expertise could significantly enhance Taiwan's offshore wind capacity, leading to potential economic and technological gains for both countries. As Ukraine and Taiwan governments search for possible post-war cooperation directions, this paper provides a promising idea in Offshore Wind. The goal is to support the establishment of friendly relations between Taiwan and Ukraine.

JEL Classification: L640, J230

Keywords: balance of plant (BoP), corporate power purchase agreement (CPPA), exclusive economic zone (EEZ), feed-in-tariff (FIT), offshore wind turbine (OWT), floating offshore wind turbine (FOWT), levelized cost of energy (LCOE)

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I. INTRODUCTION

A. Background

Taiwan and Ukraine share values such as democracy, freedom, and the readiness to repel an invasion from a big neighbour but have had almost no formal or informal exchanges due to historical and political reasons. The Soviet Union's vote to kick Taiwan out of the UN in 1971 and the Ukrainian government's strong support of China's One China policy have hindered diplomatic relations between Taiwan and Ukraine. However, with Ukraine increasingly looking to diversify its foreign policy and move away from its old paradigm of China relations, the two countries can establish closer ties, especially in the context of contemporary offshore wind cooperation.

B. Current Initiative

However, with Ukraine increasingly looking to diversify its foreign policy and move away from its old paradigm of China relations, the two countries can establish closer ties. This shift in foreign policy opens up new opportunities for collaboration in areas of mutual interest, particularly in the renewable energy sector. The proposed offshore wind cooperation between Ukraine and Taiwan represents a strategic initiative that aligns with both countries' goals of achieving energy independence and economic growth. By leveraging historical strengths in shipbuilding and welding from Ukraine and advanced offshore wind technology from Taiwan, this partnership can address the challenges of transitioning to renewable energy while fostering stronger bilateral relations.

C. Research Gap and Motivation

Despite the potential for collaboration in various fields, more research on Taiwan-Ukraine relations, particularly in English, must be done. This paper aims to contribute to studying the relationship and focus on possible cooperation in marine engineering and wind energy industries. The historical context of limited interaction between the two nations provides a foundation to explore how contemporary initiatives, such as offshore wind projects, can bridge this gap and pave the way for future collaborations.

D. Challenges

One of the challenges in establishing closer ties between Taiwan and Ukraine is the lack of awareness of each other’s needs and abilities. Furthermore, political tensions between Ukraine and Russia and Ukraine's support of the territorial integrity of different countries make it difficult for Ukraine to establish diplomatic relations with Taiwan without angering China.

E. Contribution

This paper aims to provide a starting point for research on Taiwan-Ukraine relations and identifies potential areas for collaboration in the marine engineering and wind energy industries. A joint venture in offshore wind projects is proposed.

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F. Paper Organisation

The paper is divided into several sections:
Review of the literature on Taiwan-Ukraine relations; a review on Taiwanese Offshore Wind policy;
Analysis of the challenges and opportunities for collaboration in the marine engineering and wind energy industries;
Calculation of wind farm profitability and the broad societal impact using the SPEED model;
Discussion highlighting the main pitfalls the project could encounter and the findings.

II. UKRAINE – TAIWAN RELATIONS AT A GLANCE

Democracy, Freedom and the readiness to repel an invasion from a big neighbour — are some of the values that the island nation of Taiwan and Europe's biggest country, Ukraine, share and stand for. Despite that, the countries had almost no formal or informal exchanges. Soviet Ukraine voted along with the USSR to kick ROC (Taiwan) out of the UN in favour of China back in 1971 (U. N. General Assembly, 1972), even as the Taiwanese ambassador to Honduras suggested dual representation of ROC and PRC, citing the example of triple representation of USSR by Russian SFR, Belarus SSR and Ukrainian SSR. This action was preceded by a Soviet Ukrainian representative's speech at the UN on 24 November 1966, urging to change China's representation to PRC. (Hu Peiying, 2013) One of the formal reasons for this

As the US's ally, Taiwan was expected to help the collapsed USSR states with the US. Living supplies, medicine and medical equipment worth US$10 million were shipped by Taiwan to Ukraine in April 1992 (Guangyi, 2022). Taiwan's Undersecretary for Foreign Affairs, Chiang Hsiao-yen, visited Ukraine to talk about setting up a representative office in Ukraine. However, his mission failed due to the Ukrainian government's strong support of the PRC. As expressed by Mykola Kulinich, vice dean of the Ukrainian Institute of International Relations at the time and later ambassador to Asian countries: "If Ukraine establishes diplomatic relations with Taiwan, it is tantamount to China recognising the independence of Crimea. Please think seriously about the seriousness of this issue." This position has continued until now and was re-affirmed after the Russian Invasion of 2014. As Ukraine had parts of its territory controlled by Russian-backed unrecognised separatist states, its position in the international arena was always in support of a given country's territorial integrity under any circumstances. Otherwise, its treatment of the separatist crisis would be hypocritical. This position resulted in full support of Beijing's One China policy and political tensions with Israel (which has territorial disputes with Arab countries) despite much of its population consisting of Ukrainian émigrés.

Despite that, there was another visit to Kyiv by Taiwan's ex-vice president, Lien Chan, the only result being China's angered response, prompting Ukrainian officials to drop the plans about relations with Taiwan (Bai-Ku & Viktor, 2007). It's worth noting that Lien Chan believed Taiwan and Ukraine could cooperate in the aviation and metallurgy industries, which are closely related to the ideas proposed in this paper. Disavowed by ex-USSR states, Taiwan closed its representative office in Belarus in 2006. The relations were so bad that Ukraine's foreign ministry didn't grant visas to Taiwanese

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politicians, in fear of angering China, when a group of Ukraine's parliamentarians invited them for discussion again.

However, as the Russo-Ukrainian full-scale war raged for a year, the PRC didn't support or help Ukraine; Ukraine is moving away from the old paradigm of China relations and is increasingly looking to diversify its foreign policy and align it with its Western allies (Poita, 2022). So far, the diversification effort has resulted in the opening of new embassies in 10 African countries, which were considered to be in the Chinese sphere of influence in China. ("Ukraine will open embassies in 10 African countries," 2022), and, most importantly, a start of a dialogue between Ukraine and Taiwan, establishing a "Taiwan Friendship Group" in the Ukrainian parliament, aimed at developing relations with Taiwan in various fields, including economic, cultural, and humanitarian aid. Foreign Minister Joseph Wu also spoke with Kyiv Mayor Vitali Klitschko in April and Kharkiv Mayor Ihor Terekhov in May (Chen, 2022). So far, this has culminated in the meeting of the Ukrainian parliamentary, Kira Rudik, with the President of Taiwan, Tsai Ing-wen. Right now, the two countries are searching for possible fruitful collaboration areas between the two countries. There are many opportunities, but the task is complicated, as the two countries' populations have little awareness of each other. No peer-reviewed published research on Taiwan-Ukraine relations in English as of May 2024. This paper aims to start the study of the relationship and focuses on possible cooperation in marine engineering and wind energy industries.

III. OFFSHORE WIND IN TAIWAN

When achieving carbon neutrality, a spotlight is on Offshore Wind. OWT are the maritime peers of land-based turbines shown as (1) in Figure 1, but they grow much larger; because their components are manufactured and assembled on the shoreline, their size is not limited by transportation constraints, e.g., blades too long to make a turn on a road. This makes them more effective due to the economy of scale, and hence, they became the means of choice for many governments to achieve a green energy transition; at the same time, they pose challenges to supply chain and manufacturing abilities, and this paper discusses Ukraine-Taiwan cooperation potential in this area. As of 2023, the vast majority of power was generated by fixed bottom turbines (2,3), which are supported by foundations stuck in the seabed – they are simpler and thus have lower LCOE. Still, the windy, shallow areas where they can be installed are hard to come by. As more are utilised, the only way forward is the transition to Floating Offshore Wind Turbines (FOWT)(4,5,6), technology when an even larger turbine is supported by a floater moored in place with anchors.

Fixed bottom OWT became an established technology just a decade ago, but the number of installations grows yearly, with now China's 23.9 GW. (Ferris, 2022b) It is surpassing the other pioneers in the field – the UK and Germany. Many of the Chinese turbines are situated around the Taiwan Strait.

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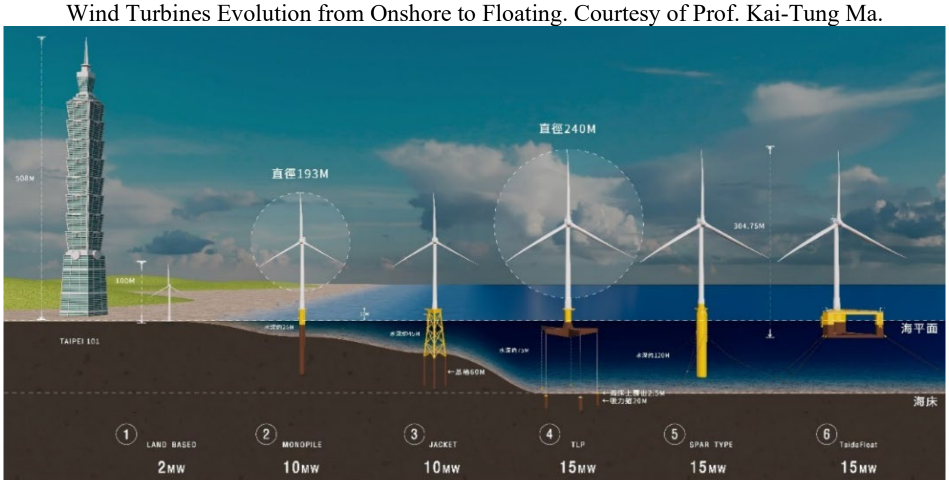
Figure 1
Wind Turbines Evolution from Onshore to Floating. Courtesy of Prof. Kai-Tung Ma.



On the other side of the Taiwan Strait, Taiwan is also making considerable progress in the field, with 900 MW of Offshore Wind Power installed and 22.2 GW more in the pipeline. (Ferris, 2022b). The Taiwanese government is one of the most dedicated to the Net Zero goals among its Asian neighbours. (National Development Council, 2022), shown in Figure 2. Taiwanese president Tsai Ing-Wen has stated that 200 Offshore wind turbines will have been built as of the end of 2022; she noted that energy transition had been a big priority for her government since taking office in 2016 (Joy Tseng, 2022). The history of Taiwanese Offshore Wind Power and its implications are discussed in detail in (Chang et al., 2022).

Figure 2
Taiwan's Energy Transition Goal

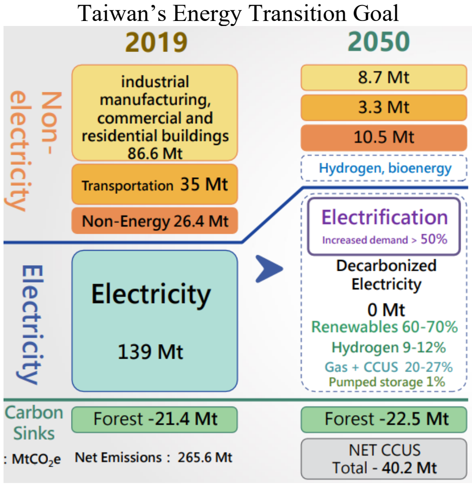
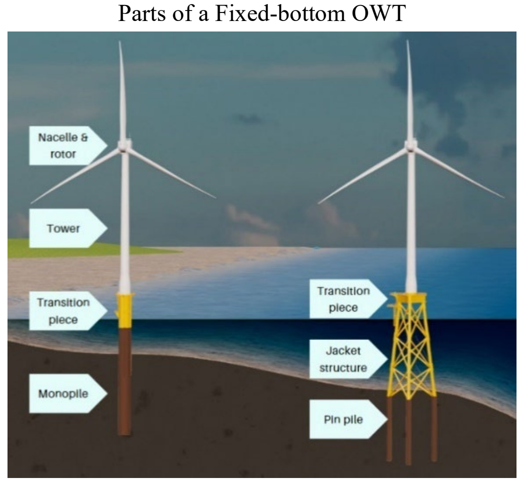


Figure 3
Parts of a Fixed-bottom OWT



Taiwan faces global and local challenges in realising its renewable energy plans, just like other countries. Global challenges that also apply to Taiwan include supply chain shortages and delays, high levelized cost of energy, and the need for installation vessels. Local challenges encompass strict localisation policies set by the government, lack of investment security, and leapfrog target planning (Gao et al., 2021), legal barriers for installation vessels and crews operating in Taiwan (Kao & Pearre, 2017) and limited supply of suitable foundation fabrication facilities and professionals (Ferry, 2022; Metal Industry Intelligence, 2022). These challenges could be addressed explicitly by leveraging Ukrainian expertise in welding and shipbuilding, offering a solution to enhance Taiwan's offshore wind capabilities.

Many companies that assemble the foundations do it in partnership with European companies, as they lack the experience and specialists on their own (Russell, 2020). During the first stage of OWT development in Taiwan, foundations were fabricated abroad, mainly in South Korea and some in Europe, by Samkang (Durakovic, 2021) (Hai Long Offshore Wind, 2023) and Hyundai Heavy Industries (OffshoreWIND, 2019). Then, they are shipped to Taiwan, where they are assembled by a plethora of companies, subcontracted by Sing Da Marine Structure (SDMS) and Century Steel, which are the principal contractors. These two companies don't have enough facilities to assemble many foundations simultaneously, so they subcontract it to first, second and third-tier down subcontractors. These companies are small enterprises in steel structure fabrication, notably pressure vessel fabrication. Apart from insufficient capacity, another reason for fabrication abroad is that it is cheaper than what is made in Taiwan. After the delays in production in Taiwan, Orsted decided to procure the remaining foundations from South Korea. (OffshoreWIND, 2019).

A more complicated part of a jacket foundation is called a transition piece, shown in Figure 3. In Taiwan, Century Steel (Century Steel, 2018)SDMS, China Shipbuilding Corporation (CSBC), and China Steel Machinery Corporation (CSMC) have engaged in making them so far, albeit encountering difficulties with welding. On the other hand, simpler monopile foundations and their transition pieces were made in Taiwan by CTCI Machinery.

Corporation (CTCI Reliable, 2020) and Formosa Heavy Industries (Yunlin OWF, 2020) (Orsted Taiwan, 2018), as well as the previously mentioned companies, are all engaged in pin pile manufacturing for OWT. The same applies to all parts of the OWT supply chain, including foundations, wind turbine parts, installation and supply vessels, seabed analysis, class inspection, engineering consultants and so on, which are either directly sourced abroad or made in Taiwan with foreign technology and specialists (Metal Industry Intelligence, 2022) (Russell, 2020; Yunlin OWF, 2020), despite the 100% localisation goal. The companies involved, and their respective home countries and services are shown in Figure 4. Thus, the Taiwanese have enough experience in international collaboration and research shows, they will be willing to partner with new suppliers if they meet the criteria (Wu & Yung, 2021).

They might be inclined to search for new partners since there have been delays due to welding initially failing to pass quality standards when the assembly had to be redone. Then there have also been three major accidents related to the transportation and installation of the foundations (Bajic, 2020; Oung, 2022).

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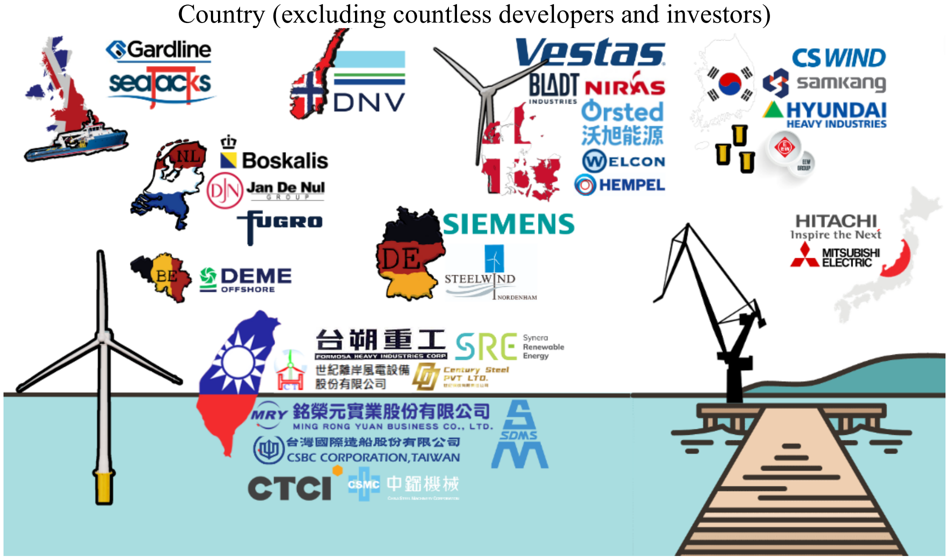
Figure 4
Notable Companies Involved in Taiwan's Offshore Wind Industry Supply Chain by Country (excluding countless developers and investors)



When it comes to FOWT, only CSBC has the dry docks, gantry cranes, other equipment and shipbuilding specialists required to manufacture floater support structures, while the company has aims to do that, none have been manufactured to date (Metal Industry Intelligence, 2022).

IV. SHIPBUILDING POTENTIAL OF UKRAINE

To summarise, Taiwan is struggling with foundation manufacturing/assembly, this is precisely where Ukraine might help. During Soviet Union times, Ukraine had been one of the leading Shipbuilding regions in the world, much of this industrial potential is still left, even though much was lost to the post-collapse economic depression (Ilchenko, 2021). Ukrainian naval architects, shipbuilding welders and engine specialists' abilities were often re-affirmed. A recent domestic example, just before the War in Ukraine broke out, "Nibulon Max" was launched at Ukrainian agricultural giant Nibulon's wharf, recently modernised to build and maintain the company's export fleet, but then also increasingly used for national defence orders, such as patrol boats building in contract with France ("«Nibulon» will build 5 patrol boats on a French contract," 2020). The ship "Nibulon Max", shown in Figure 5, is particularly notable for the usage of the latest technologies in the field of shipbuilding, such as increased coaming height and X-bow (Mosaad et al., 2017).

On the international level, and especially in Asia, China bought its first Aircraft Carrier Liaoning from Ukraine, and its two following domestic-built carriers were constructed with the critical assistance of numerous Ukrainian shipbuilders (Gerasymchuk & Poita, 2018; Ryou, 2009). This was possible due to the "strategic partnership" of the two countries at the time, which is not an option now as discussed in the introduction.

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Figure 5
Nibulon Max Completion Ceremony

The shipbuilding industry is one of the most globalised industries because most ships are made in Asia. At the same time, the equipment is manufactured in Europe and other regions, necessitating international cooperation for the large projects to be completed, which are the building of ships and offshore structures. For example, there are many hulls for smaller barges constructed in Ukraine, as the steel is manufactured in Ukraine, and there is cheap but qualified shipbuilding labour; the hulls are then towed to the Netherlands or Germany for outfitting, where the equipment is manufactured, but labour cost is higher; at the same time, the project drawings could be many anywhere – in Ukraine or the Netherlands, or a third country – this is a typical example of international cooperation in the shipbuilding industry (""Okean" delivered two vessels for Eurobulk," 2020).

Other than Nibulon, there are several shipyards in Ukraine which have the following competitive advantages as they are defined by (Barney, 1991).

- Valuable, i.e., to help produce goods and services which have demand in the market
- Rare, meaning that there is limited availability of such or similar resources and capabilities at competitors
- Imperfectly imitable, implying that it is difficult or costly to reproduce resources
- Imperfectly mobile, meaning that resources cannot be moved physically or relocation will entail high transaction and transfer costs.

Taiwan wields a considerable advantage in shipbuilding – the world's largest drydock, at CSBC's yard in Kaohsiung, spans 950 m and is 92 m wide, with a draft of 14 m. However, when it is already utilised by the navy's orders, it wouldn't be practical to build FOWT floaters in it. Due to scarce flatland and densely populated coastal regions, no more docks could be constructed in Taiwan, leaving only a small one in Keelung, which is also usually busy with small ship repair. An alternative option of on-quay assembly in Taichung Harbour was also investigated by the author (Ivanov & Ma, 2024).

In Ukraine, however, many shipyards remain from the USSR times. The notable large-scale shipyards include Black Sea Shipyard, Okean Shipyard (shown in Figure 6), Mykolayiv Shipyard, and a smaller but the most modern Nibulon wharf – located in Mykolayiv; Kherson Shipyard, Chornomorsk Shiprepair Yard and Odesa Shiprepair Yard – located in other cities, as well as other small-scale/river shipyards. The scales of the facilities are different, but all could assemble monopile and jacket foundations; for structures requiring a large, the newly renovated 2021 dock of Okean Shipyard is available, which is 355 meters long, 60 meters wide, 17.1 m deep, gantry crane capacity 320 t, shown on pic X. It is of course, not as large as CSBC dock. However, it is still one of the biggest in Europe and could fit a smaller FOWT floater, for example.

A. The Challenge of Welding

The most essential process in today's maritime construction, be it ships, oil platforms, or wind turbine foundations, is arguably welding. These vast structures are assembled from smaller parts, which must be connected by welding to be watertight and withstand exploitation loads. The welding field is extensive, but the technology used in foundation manufacturing is the same as in shipbuilding, which is why shipbuilding enterprises were discussed. Many companies from the generic steel structure manufacturing field that engaged in foundation fabrication found it challenging to apply their equipment and knowledge to foundations because the steel plates used in the offshore industry are much thicker than on land, requiring different processes to weld. Moreover, during recent decades, all kinds of companies utilising welding have found it challenging to find new welders; even as automatic welding is improved, it still requires specialists to operate, and the specialists must be more trained to use the advanced technology; still due to the nature of shipbuilding processes, much of the welding has to be done by hand. An example of the manufacturing process of a monopile foundation is shown in Figure 7. Often, each step of this process is assigned to a different subcontractor.

Figure 6
Okean Shipyard's Dry Dock

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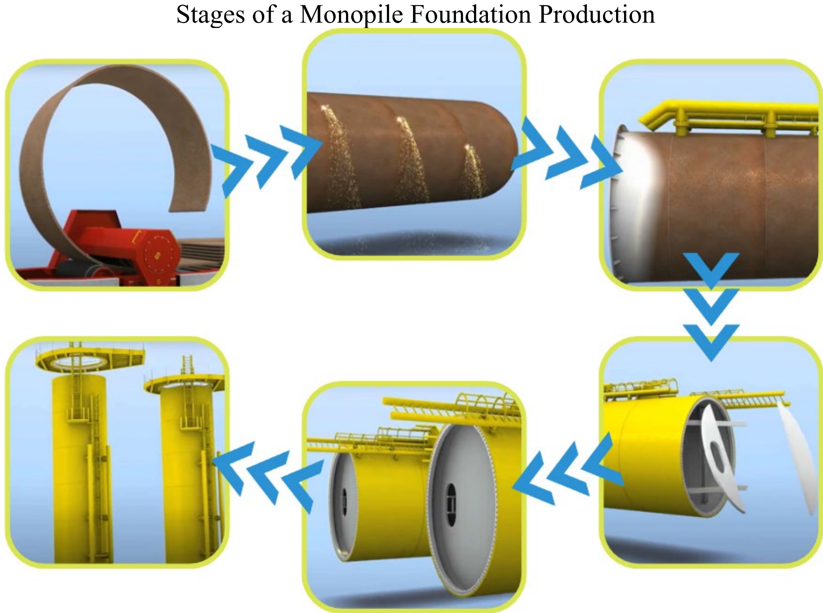
Figure 7
Stages of a Monopile Foundation Production



Qualified and even entry-level welders deficit is a well-known problem in all industries worldwide (Benway, 2010). For example, only in the US alone, a country that attracts professional immigrants and therefore has one of the best situations overall, still runs short of about 300 000 welders ("What's the Welding Job Outlook for 2021?," 2021), worse or similar situations can be felt in other countries (Solesvik, 2011). As of 2021, the situation in Taiwan is even direr, as increasingly few institutions provide welding education, and those who want to learn it are forced to pursue education abroad (Xiao Chunyun, 2021), often resulting in them staying abroad for work. Taiwanese National Development Council has recognised the lack of welders among all industries as one of the critical industry problems for 2021-2023 (National Development Council (Taiwan), 2021), highlighting the lack of shipbuilding welders in particular. The studies reporting on it propose solutions to the challenge, chiefly focused on education reform using modern technologies such as VR to improve the qualification of young specialists and better incentives to attract more people into the profession. Nevertheless, these solutions are long-term, while the welders are needed now, as the climate goals are pressing.

While this problem is acute for many countries, Ukraine is traditionally strong in this field – as a brief excurse into history, welding was invented by a Ukrainian-born scientist – N. N. Benardos (A, 2006). He died in his home near Kyiv, where K. K. Khrenov continued his work, inventing and dedicating his life to underwater welding (Kononenko, 1999), which became a colossal revolution in ship repair and shipbuilding, allowing for the practical floating of sunk vessels. Named after another scholar of welding, the inventor of electro-slag welding, the Paton Institute is one of the few institutions dedicated to advancing welding. It is still in Kyiv, and its technological improvements are implemented in Ukraine's yards. (Dragan et al., 2004) With a history like this, the welder profession is popular and respected in Ukraine. Welding is a mandatory class in many technical universities around the country. Ukraine's shipyards are renowned for the best-quality of welding (Solesvik, 2011). This experience might be needed to ensure success in producing new FOWT floater structures.

B. Rationale for Cooperation

Shipbuilding is a distinctly cyclical industry, where the periods of full-scale production alternate with periods of almost zero activity, as shown in Figure 8. Globalisation in the 21st century allowed shipbuilding companies to cope with this cyclicity through (primarily international) cooperation (Solesvik, 2011).
The two existing Taiwanese shipyards are expected to be in the Peak phase during the following years, as they will be preoccupied with:

1. Increased navy orders, which are difficult to outsource and provide better income to the shipyard than manufacturing OWT foundations. Also, the quay space for foundation fabrication is already taken by other orders (Shih-ching, 2019).
2. Possible numerous FOWT floaters construction, as the best areas for fixed-bottom OWT are populated, the Taiwanese government had stated its intentions to develop the FOWT industry.

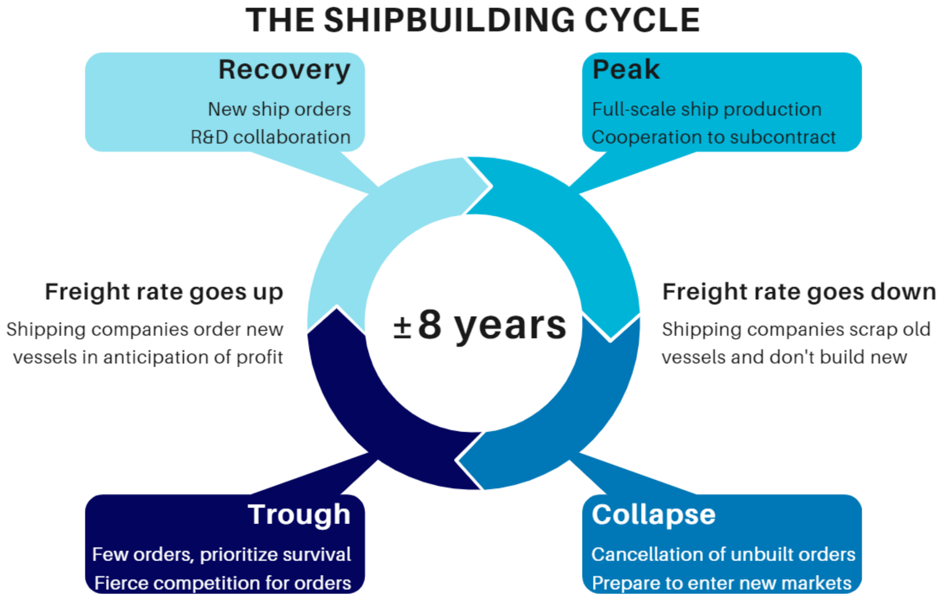
The Ukrainian shipyards are in the Trough phase due to the nearly complete half of shipping due to the war and will enter the Recovery period sometime after the war. As shown in (Solesvik, 2011), the rationales for collaboration are:
For Ukraine (Through and then recovery): Collaboration to attract new orders; New market entry; Utilisation of excess production capacity.
For Taiwan (Peak): Attracting missing human, technological, and production resources (with smaller shipyards, subcontractors, and foreign shipyards) to complete vessels in time.

Thus, the two countries' supply and demand are in perfect alignment during this period (around eight years from the war's end, as eight years is a typical cycle in shipbuilding).

There are several models of cooperation, as shown in Figure 9:

1. The best case for Ukraine would be if both manufacturing and assembly of foundations (floaters) were done in Ukrainian shipyards and then shipped by sea to be installed in Taiwan. This path would provide the most benefits to the post-war economic restoration of Ukraine. It will help Taiwan reduce LCOE as much as possible, as this past entails significant cost reduction for Taiwanese developers. At the same time, there are more probable paths than this because of possible steel shortages and transportation difficulties, which will be discussed later.
2. The second path would be manufacturing parts in a third country, ensuring a stable metal supply and a proven track record of foundation manufacturing while reaping the cost-efficient assembly in Ukraine, aiding the country's post-war restoration. However, this option will not be as cost-effective for the wind farm developers and Taiwanese power end consumers, as manufacturing in Europe is expensive and/or added transportation processes will increase costs, too. Nevertheless, it could be a compromise option for the initial cooperation period, when Ukrainian yards will slowly build up their manufacturing capacity and hone the technology.

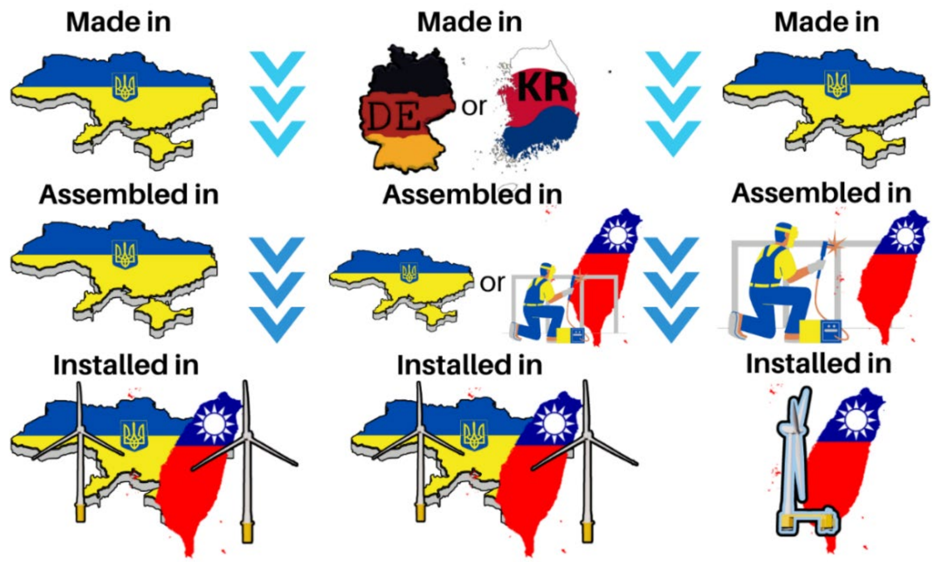
Figure 8
The Shipbuilding Cycle



3. The third path is pre-fabricating the foundations (floaters) in Ukraine, like in Germany before, and then shipping them to one of the Taiwanese harbours, where they will be assembled on a joint Taiwan-Ukraine company. Considering the welder professionals' distribution in two countries, the partnership could look like this: Ukrainian high-class welding professionals will come to Taiwan to work on shift-based, short-term or long-term contracts, possibly teaching Taiwanese apprentices, while the Taiwanese partner entity will manage the facilities, equipment and supplies. This path will require thorough planning but will easily comply with the Taiwanese government's localisation policy. For such work migration to be possible, a representative office establishment will be a prerequisite to handle the consular and legal matters.

In any case, establishing a Ukrainian Welding School in Taiwan would also be an option to aid with welding education and ensure a steady personnel supply.

Figure 9
Possible Collaboration Paths for Foundation Manufacturing



Building an offshore wind farm is challenging regardless of the chosen model. As evident from Figure 10, the whole process of site assessment, design, permit application and construction can last as long as a decade, sometimes even longer (RenewableUK, 2017). Thus, this process gets faster every year as experience is gathered. Moreover, it involves the country's government, which will build the farm in multiple stages. First, during environmental impact assessment in Asia, this often involves getting approval from and bargaining with fishermen associations, as fishermen have traditional solid rights to the water they fish in (Zhang et al., 2017). They tend to see the wind farms as obstacles to their fishing operations, impeding navigation, net fishing and turbine sound spooking fish away. Usually, the discussion ends with monetary compensation by the developer to the fishermen, and the proposal to employ fishermen's boats as supply vessels has been made. When this is done, the potential farm site is a subject of close inspection by different authorities. The exact organs vary in various countries, but their duties always include checking if the farm will impede or obstruct ship or aeroplane navigation, be a visual nuisance for people near tourist destinations or picturesque scenery, damage existing subsea cables while laying the power cable (mooring system for FOWT). Only after these checks have been successfully passed will the permit application be reviewed by another government branch. Some countries, including Taiwan, have mechanics in place to choose the projects that might benefit the country the most; the mechanics include auctioning development rights. In Taiwan, LCOE is not the only one considered. Still, the localisation score, which has a minimum to be achieved, is assigned bonus points if higher localised content is employed, e.g., turbine parts designed/made/assembled by local labour in local harbours, etc. The strictness and the impact of these measures were discussed in other research (Ferry, 2022), the takeaway is that even more cooperation with the government is required. It is now clear why setting up an international collaboration in Offshore Wind would not be possible with just

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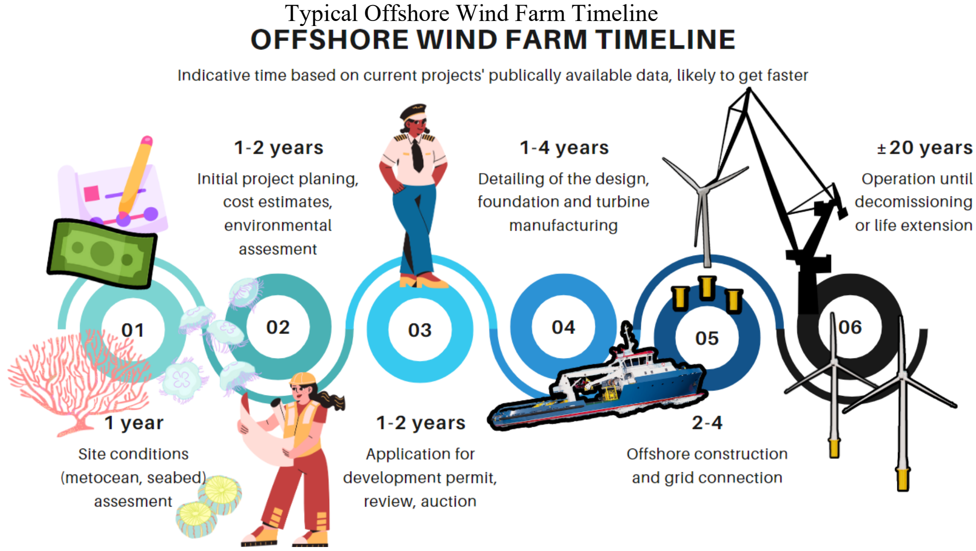
company-level contacts, and the close cooperation of both governments will be required to achieve this.

The competent authority responsible for Wind turbines' development and technology matters is the Taiwan Ministry of Economic Affairs (MOEA)'s Industrial Development Bureau. However, many other authorities are involved in different specific aspects of OWT manufacturing, installation and exploitation, notably the Department of Land Administration, Ministry of Interior and Maritime and Port Bureau, and Ministry of Transportation and Communication (Kao & Pearre, 2017), therefore it would be wise for the Ukrainian government to contact its Taiwanese colleagues on the highest level, given its direct focus on renewable energy. Then, the Taiwanese government can pass the orders down to the branches involved.

At the same time, the sheer length of a wind farm development provides benefits, too. Long-term planning is made possible; this way, Ukraine-Taiwan cooperation in foundations manufacturing could become a part of Ukraine's long-term effort to revitalise the maritime and shipbuilding industry; the full extent of such an effort was discussed before the war, as the old yards were modernising. It also means Ukraine's shipyards will not be in a rush and will have time to repair the damage caused by the war if the money is invested during the wind farm planning stage. Another benefit could be using this time to prepare for the next step in wind power development– the transition to floating.

Figure 10

Typical Offshore Wind Farm Timeline



C. Black Sea Wind Potential

Ukraine has considerable wind potential, as indicated by several studies (Makarovskiy & Zinych, 2014; Sobchenko & Khomenko, 2015). It's concentrated in the southeast region and Crimea, which were all temporarily occupied at the time of writing. There were as many as 1.9 GW (Ferris, 2022a) of land-based wind power installed in the country, the industry is booming as green tariffs promise hefty profits. Much damage had been done to Ukrainian renewable sources by Russian attacks, the majority of the infrastructure having been destroyed. Despite that, Ukraine is still committed to Green Goals, seeing Renewable Energy as one of the drivers of the post-war economy, with plans for green energy export and the decision to enter the Offshore Wind Industry after the War (Patricolo, 2022). So far, the worldwide development of Offshore Wind has coincided with the Russian occupation of Crimea, temporarily leaving Ukraine without a considerable length of its coastline and leaving the remainder under threat of Russian amphibious invasion; faced with a situation like this, Ukraine had only been developing land wind turbines, and no research was done on wind energy potential in Ukraine's maritime EEZ.

Luckily, such research was done plenty of times in nearby Romania. Published wind energy potential maps cover the southwestern part of Ukraine's coastline, the Odesa and Mykolaiv regions, where the shipyards are concentrated, and the environmental conditions there are practically the same as in neighbouring Romania. This research shows promising potential sites for offshore wind farms in Romanian and Ukrainian EEZs in the western Black Sea (Rusu, 2019). Due to the geographical relief in the region, the wind speeds are moderate in the area. It is considered that a 50% capacity factor is a good result for a turbine, allowing it to be efficiently employed in the region; it was found that turbines up to 7 MW can operate with a 50% capacity factor, while larger turbines will underutilise their capacity to some extent (Diaconita et al., 2021). So far, only shallow (up to 50 m depth) coastal areas suitable for fixed-bottom wind turbines have been analysed. The depth map is shown in Figure 11 for reference. In the deeper region, where the wind is unobstructed by the relief, mean wind speeds increase, allowing for bigger turbines to be utilised at total capacity; among those sites, parts of the Crimean peninsula's coastline are cited as having some of the best wind energy potential (Ganea et al., 2018). These areas deeper than 50 m can only be accessed with the help of a novel technology – FOWT.

There have been no published studies on the potential of FOWT in the Black Sea, and it's worth exploring. The Black Sea power atlas was compiled in (Aydoğan, 2017), and it shows that Ukraine has the most considerable Wind Energy potential among the Black and Azov Sea countries. Figure 12 shows potential wind farm sites at the best energy spots. A suitable pilot-scale farm layout consisting of 12 turbines was proposed in (Ma et al., 2025).

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Figure 11
North-western Black Sea Depth Map

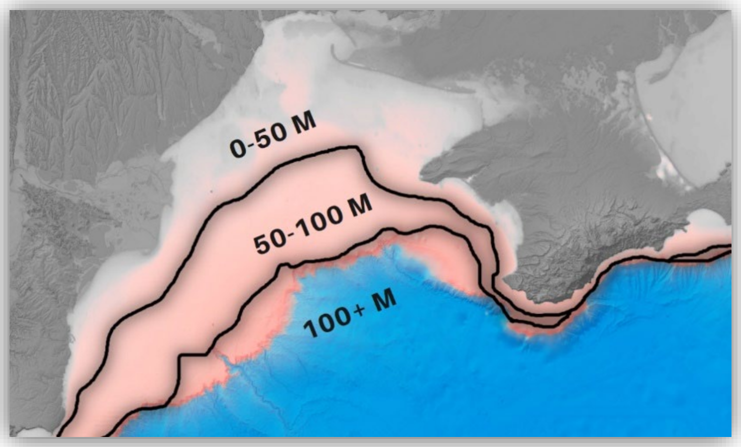
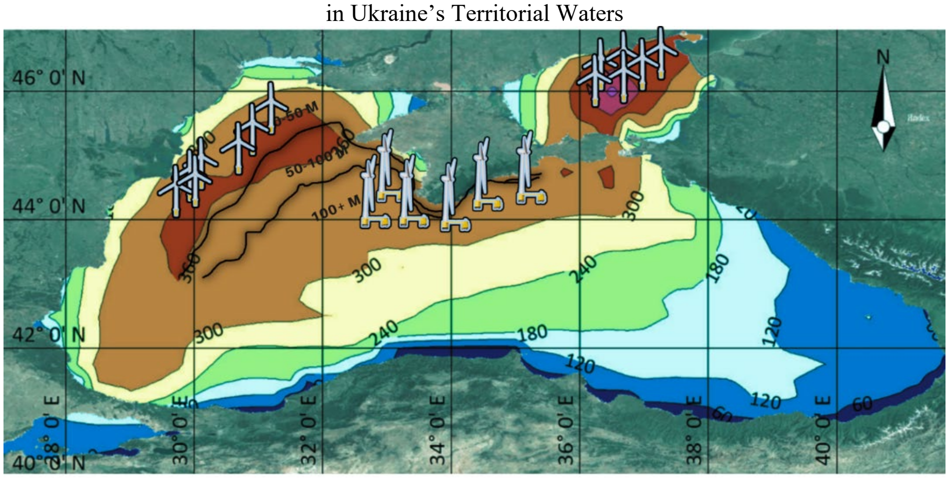


Figure 12
Black and Azov Seas Wind Power Density (High Values in Red) and Tentative Wind Farm Sites in Ukraine's Territorial Waters



D. Taiwan's Know-how

Given a good wind resource, other points of attention considered for FOWT design are storm conditions, which dictate how stable and robust the floater must be, and the general weather conditions, which set the weather window when the installation operations can be performed. Luckily, there exists published research on storms (Bernardino et al., 2021) and weather windows (Onea & Rusu, 2019), and the data are enough to start designing a FOWT in the Black Sea. Such a design might be produced in Ukraine; however, no design bureaus have experience with fixed, least floating offshore wind foundations in the country, and this is where Taiwan's knowledge could be applied. Floating turbines are actively researched in Taiwan, with foreign and indigenous concepts investigated in experimental basins and a handful of literature published. The Taiwan government has decided to procure a 100 MW FOWT demo project before 2026 (Buljan, 2022). There are at least two promising indigenous solutions – DeltaFloat, developed by Taiwan's Ship and Ocean R&D Centre (SOIC), which has recently passed wave tank trials (Ling, 2022), and TaidaFloat - its successor that implements innovations such as the different sizes of columns, adjusted for optimal stability (Hsu et al., 2022), and structure made of flat plates optimised for mass production. TaidaFloat has also undergone tank testing and was patented and exhibited at Taiwan's Tech Fair in late 2022 (FutureTech, 2022; Ivanov et al., 2023b; Wu et al., 2023), shown in Figure 13. These or possible future concepts might be directly applied to Black Sea conditions or need slight modifications. Of course, Ukraine could go the long route and develop its FOWT designs; however, as it's a very knowledge-demanding field, a relatively long time and enormous resources would have to be allocated for that, which might not be practical after the War. Other countries that have been developing FOWT for more than a decade have suffered setbacks and significant capital losses, as when Japanese platforms had sunk, for example (Kinoshita, 2022; Weston, 2014), not to mention all the fixed-type turbine accidents, but it's arguably impossible to develop a new technology without failure, so the wise choice could be to utilise the proven technology.

Figure 13
TaidaFloat

E. Wind Farm Joint Venture

As the economy is the underlying driver of all cooperation, a lucrative pilot would be the best way to fire up the collaboration. Such a project might be a wind farm established in the Ukraine-Taiwan partnership. If built in one of the sites shown in Figure 12, it would become the first offshore wind farm in the region and generate profits, fuelling future collaboration. One of the factors why Taiwanese investors might be hesitant to source their foundations from Ukraine is that Ukraine has zero experience in offshore wind despite its advancements in shipbuilding. Ukrainian enterprises can acquire this experience while building a wind farm in Ukraine's territorial waters and show the Taiwanese clients their skills. Such a farm will significantly be needed in post-war Ukraine as the government needs to transition from Russian fissile fuels.

Of course, the wind farm project should be lucrative and even considered for realisation. A simplified and conservative cost and revenue estimate was made.

Revenue comes from selling generated energy. It is calculated every year with equation (1) due to seasonal changes in wind energy. In Taiwan, the power is usually better in the winter.

$$Revenue = Tariff\left(\frac{\$}{kWh}\right) \times Power\ (kW) \times n_{turbines} \times time_{operation}(h) \times \eta_{transfer} \quad (1)$$

Feed-In-Tariff decreases with time but is set higher for newer power sources such as OWT. Ukraine has a FIT of 0.94$/kWh (3.78 UAH) for onshore wind turbines as of 2022; however, as there is no FIT set for future offshore developments, a conservative value, Taiwanese FIT of 0.13 $/kWh (4 NTD) is used, it is a reasonable approximation given the countries' almost equal energy cost and currency exchange rate before the war. In practice, tech companies buy out the power before it can be allocated to the national grid. However, the price in those Corporate Power Purchase Agreements (CPPA) is usually not made public and differs from case by case as it can't be used for this assessment; it is usually much higher than the average power price, allowing wind farms to operate without FIT and with more significant profits that will lead to faster pay-back periods.

Thirty turbines, with 11 MW power each, are installed, 11 MW is a standard for modern fixed-type OWT, and data on operation cost is available. 30 is close to the average number of turbines on a single farm.

Operation time depends on the energy capacity factor, which usually varies between 40 and 60%. A lower capacity factor is taken according to research (Diaconita et al., 2021).

A typical value of 0.92 is assumed for the transfer efficiency coefficient.

The yearly cost of operating a wind farm is found with formula (2).

$$Cost = n_{turbines} \times \left(\frac{(Equipment + Installation)}{Lifetime\ (years)} + (Turbine\ \&\ BoP\ maintenance)\right) \quad (2)$$

According to Taiwanese wind farms' experience, buying and installing 1 MW of offshore wind power costs 4 918 840 (150 000 000 NTD). According to the US National Renewable Energy Laboratory, a typical lifetime is 25 years and turbine and balance of plant maintenance costs are 124 $/kW/year; this number is expected to be much lower in Taiwan as local prices and salaries are cheaper but will be used nevertheless for the most conservative comparison.

With the assumed parameters, the payback period is 20 years, which is still within the scope of some projects. The payback period will be shorter, as over-conservative assumptions were used. The timeline for the project development, including legal matters and possible welding school establishment, is shown in Figure 14.

According to the SPEED model (Stephens et al., 2013; Stephens et al., 2008), the situation should be assessed not only from a technical but also from a broad societal perspective. Categories of SPEED include technical, institutional, regulatory, political, economic and social aspects. These aspects were discussed throughout the paper and are briefly summarised in Figure 15; short- and long-term stakeholder impact analysis in the two countries is shown in Figure 16. Despite some difficulties described below, the project's outlook is positive in all categories.

F. The Uncertainty

Every project should be scrutinised to try and see what will make it fail. There are plenty of things that can go wrong.

Figure 14
Ukraine-Taiwan Offshore Wind Joint Venture Development Timeline

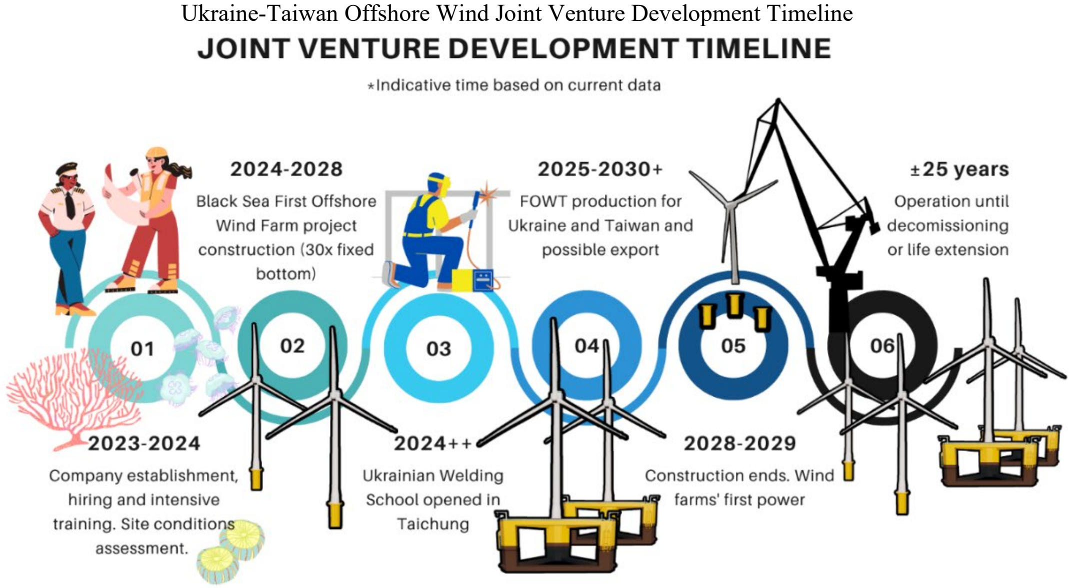


Figure 15

Comparative Assessments of Offshore Wind Cooperation between Taiwan (blue) and Ukraine (yellow)

	Taiwan	Ukraine
Technical	Has experience in Offshore Wind and develops Floating Wind technology. Has not developed its potential to its full. Relies on import due to lack in production capability for turbine foundations and welding specialists.	Has a developed maritime industry and world-class welding technology and specialists. Has zero experience in offshore wind but large offshore wind energy potential.
Institutional	Necessity to establish representation and legal framework	Status quo is that economic ties to China lead to completely ignoring Taiwan.
Regulatory and legal	Representation and legal framework not yet established to allow for international business contracts and visa issuance. Strict localization requirements make it difficult to use foreign parts in domestic projects.	No representation of Taiwan. Dubious position in Ease of Business index due to administrative inefficiency and corruption.
Political	Not recognised by many countries and excluded from international organisations.	Need for energy independence from Russia Plans to develop foreign relations with Asia.
Economic	Investments opportunities in Ukraine and cheap energy at home. Lack of green energy resulting in high CPPA prices paid tech giants.	Large governmental spending required during post-war recovery. FIT will be a burden on the population, but less than the War Tax.
Social	Aid to and cooperation with Ukraine are currently regarded as important by the population.	Population unaware of Taiwan and sees it as a part of China, perception of which is negative.

Figure 16

Possible Stakeholder Impact from the Project

	Short Term	Long term	Short Term	Long term
Utility and Energy companies	Investment opportunities and costs	Clean Energy and revenue, grid upgrade necessity	Investment opportunities and costs	Clean Energy and revenue, grid upgrade necessity
Local and national governments	Necessity to establish representation and legal framework	Recognition of ROC by a European power - diplomatic victory for DPP or KMT	Necessity to abandon the status-quo on China relations	A respected and loyal partner in Asia sharing common interests
Consumers of electricity	CPPA allows for acquisition of so much needed Green Energy for tech giants	Technology improvement leads to cheaper renewable energy	FIT will be a burden on the population, but less than the War Tax	Energy independence from Russia and fossil fuel
Civil society	Growth of mutual awareness of the two populations	Military collaboration with Europe's best battle hardened army	Growth of mutual awareness of the two populations	A jumpstart to Ukraine's strategy in Asia

Blue is Taiwan, and Yellow is Ukraine

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- The war's outcome is unclear yet; as much as it is certain the good will triumph and Ukraine will resist Russia's invasion, it's not yet what the final border will look like. Will Ukraine re-gain all of its territories with Russia's retreat, or will a cease-fire be brokered, allowing Russia to hold on to its occupied regions, or, even if the sides will not come to any agreement, and neither side will have a decisive military victory, the conflict might get frozen like it was before, and in many regions around the world, making Ukraine a dangerous or uncertain region to invest in or develop international projects?
- Steel is the crucial material that the foundations are made from, and Ukraine is one of the leading steel producers in Europe, with its industry export-oriented, mainly supplying rolled steel to developing countries (Nikiforova, 2022). Unfortunately, during the last years before the war, the trend was the decline of the industry. Moreover, the steel plants are primarily situated in the eastern part of the country, and many factories were damaged, like the biggest one – Azov Steel, entirely destroyed by Russian artillery. Only after the war can the damage be assessed, and it remains to be seen if enough high-quality steel required for OWT foundations could be produced for the needs of the Taiwan-Ukraine cooperation project. If the supply is insufficient, steel will have to be sourced elsewhere, increasing its price.
- Currently, the foreign companies engaged in OWT development in Taiwan have encountered many difficulties and complained about Taiwan's localisation policies (Ferry, 2022). Most recently, the largest foreign company involved in Taiwan OWT farms, the developer of the country's first farm Formosa 1, Orsted, has announced it will not participate in future auctions, quoting localisation requirements as impractical to fulfil (Martin, 2022). The Taiwanese government's strategy is to declare a 100 % localisation goal and then make tacit case-by-case concessions to companies, as they can't possibly fulfil those without changing the declared goal. Unless the foundations are assembled in Taiwan, this project will not fully comply with the localisation requirements as of now; the drawbacks of assembly in Taiwan were discussed earlier (Ivanov et al., 2023a).
- A possible solution could be a barter – Taiwanese FOWT technologies will be used in the Black Sea. Taiwanese design companies will handle the project in exchange for dropping localisation requirements for the Ukraine-Taiwan partnership in foundations manufacturing.
- It should be noted that the two countries are situated on opposite sides of the globe, and it would take a long time for a cargo ship to deliver Ukrainian produce to Taiwan. Nevertheless, it was shown that travel distance is not the most critical factor in shipping cost (Ivanov, 2023), and the distance didn't prevent Taiwan from successful collaboration with all the European companies, delivering parts from Germany, etc.
- The last, but not most minor, problem is the yet absent representation of two countries in the form of embassies/offices, etc. Such a large project involving direct communication between the two governments, companies' legal affairs and consular matters (visa issuance) for the frequently travelling personnel necessitates a form of representation. However, the exact solution must be chosen carefully, considering the existing situation concerning China relations.

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The future does not only bring possible problems but also other possible cooperation directions. The Ukrainian army is already recognised as the strongest in Europe, and Taiwan wants to catch up on its military development to be ready to defend against an attack. In this light, Taiwan is learning from Ukraine's military experience, and after the war, it can benefit from it by ordering first-grade military equipment from Ukraine. Ukraine has already been an established military equipment exporter, China being its top customer by trade volume (Statista, 2021); as military exports to China ceased following its position in the Russo-Ukrainian War, Ukraine will explore new markets. There is no shortage of potential clients: according to (Adamowski, 2022), "Ukraine's defence industry is observing a spike in demand from foreign customers interested in securing weapons proven in combat against Russia's invasion". With Ukrainian shipbuilding capability in mind, an exciting weapon for Taiwan to acquire is the sea drones (underwater unmanned attack vehicles), as Taiwan's small fleet will have to face PRC's largest-in-the-world fleet if a naval invasion was to happen. Ukrainian sea drones have been identified during the attacks on the Russian Fleet as immensely effective at sinking ships at low cost. However, no public characteristics or data were released for obvious security reasons during the war. It is most probable that their export can be started after the war (Sutton, 2022).

V. CONCLUSIONS

Taiwan and Ukraine share many common values and similar geopolitical challenges; however, the two countries have had almost no interaction due to their geographical remoteness and Ukraine's old foreign policy on China. Recently, cooperation has been sought, and this paper explores a prospective idea of collaboration in Offshore Wind, particularly in foundations manufacturing.

Ukraine is strong in shipbuilding and welding, while Taiwan is struggling with the welding workforce and infrastructure and is busy with other projects that cannot scale up. Taiwan has problems with current foreign cooperation but wants to engage with new stakeholders and develop economic and political relations with Ukraine. This is where the cooperation can begin. At the same time, Ukraine has a significant offshore wind potential that has not been developed due to the occupation of the coastline and war. Taiwan can apply its rich expertise and technologies to build Ukraine's Black Sea offshore wind power. In this regard, cooperation is equal and mutually beneficial.

There are several challenges to overcome to realise this idea. Notably, establishing a foreign relations model will not escalate the geopolitical situation but will allow for deep cooperation on all levels. Another challenge is choosing a cooperation model and localisation policy to satisfy all the stakeholders. The project itself is being threatened by the war's uncertain outcome and the post-war situation in Ukraine. Nevertheless, the war will inevitably end, and the two countries' future cooperation can flourish. The wartime experience even opens new possibilities for the exchange of military technologies.

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REFERENCES

Adamowski, J., 2022, Ukraine Arms Maker Finds Export Interest in 'Combat-proven' Missiles, *DefenceNews*. https://www.defensenews.com/global/europe/2022/09/06/ukraine-arms-maker-finds-export-interest-in-combat-proven-missiles/

Aydoğan, B., 2017, "Offshore wind power atlas of the Black Sea Region", *Journal of Renewable and Sustainable Energy*, *9*, 013305. https://doi.org/https://doi.org/10.1063/1.4976968

Bai-Ku, W., and Viktor, K., 2007, "Taiwan-Ukraine Relations: Bilateral Points of View", *Russian Scientific Journal,* https://web.archive.org/web/20150612231309/http://www.sinologist.com.ua/doc/Kiktenko/Taiwan_Ukraine.pdf

Bajic, A., 2020, "Heerema Suffers Dropfall Incident While Piling in Taiwan", *Project Cargo Journal*, https://www.projectcargojournal.com/offshore/2020/06/22/heerema-suffers-dropfall-incident-while-piling-in-taiwan/

Barney, J., 1991, "Firm Resources and Sustained Competitive Advantage", *Journal of Management*, *17*, 99-120.

Benway, E.A., 2010, As National Welder Shortage Looms, Proper Training becomes a Critical Asset. *Plant Engineering*, 43-46. https://go.gale.com/ps/i.do?id=GALE%7CA237602115&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=0032082X&p=AONE&sw=w&userGroupName=anon~bd45a45e

Bernardino, M., Rusu, L., and Guedes Soares, C., 2021, "Evaluation of Extreme Storm Waves in the Black Sea", *Journal of Operational Oceanography*, *14*, 114-128. https://doi.org/10.1080/1755876X.2020.1736748

Buljan, A., 2022, Taiwan Preparing to Procure 100 MW of Floating Wind Demo Projects. *offshoreWIND*. https://www.offshorewind.biz/2022/08/25/taiwan-preparing-to-procure-100-mw-of-floating-wind-demo-projects/

Century Steel, 2018, Ørsted Signs Contract with Century Steel: Wind Turbine Foundations for Four Offshore Wind Farms to be Produced Locally with the Total Capacity of up to 60 Billion Taiwanese Dollars. http://www.century.com.tw/en/report/31/324

Chang, H.-C., Ma, K.-T., Wang, C.-W., Liu, C., Hsiao, Y.-S., Wu, H.-P., Hsu, I.-J., Ivanov, G., and Chiang, M.-H., 2022, "Prospects of offshore wind power in Taiwan and the development of semi-submersible floating platforms," *Taiwan Wind Energy Symposium*. https://www.researchgate.net/publication/364955126_taiwanlianfengdianzhiqianjingyubanqianshifutaizhifazhan

Chen, K., 2022, Ukraine parliament to establish Taiwan Friendship Group. *Taiwan News*. https://www.taiwannews.com.tw/en/news/4629985

CTCI Reliable, 2020, CTCI MAC's Transition Pieces Ready for Load-out to Yunlin Offshore Wind Farm. *CTCI E-Newsletter*. https://www.ctci.com/e-newsletter/EN/465/hot-news/article-07.html

Diaconita, A.I., Rusu, L., and Andrei, G., 2021, "A Local Perspective on Wind Energy Potential in Six Reference Sites on the Western Coast of the Black Sea Considering

Five Different Types of Wind Turbines", *Inventions*, *6*, 44. https://www.mdpi.com/2411-5134/6/3/44

Dragan, S., Kvasnitsky, V., Romanchuk, N., Solonichenko, Y.V., and Goloborodko, Z.G., 2004, Welding and cutting processes in shipbuilding of Ukraine. *PATON WELDING JOURNAL C/C OF AVTOMATICHESKAIA SVARKA*, *2004*, 2-5.

Durakovic, A., 2021, Samkang M&T Wins EUR 426 Million Offshore Wind Contract. https://www.offshorewind.biz/2021/12/23/samkang-mt-wins-eur-426-million-offshore-wind-contract/

Ferris, N., 2022a, "Amidst the Carnage of War, Ukraine Reaffirms Commitment to Renewables" *Energy Monitor*. https://www.energymonitor.ai/tech/renewables/amidst-the-carnage-of-war-ukraine-reaffirms-commitment-to-renewables/

Ferris, N., 2022b, Weekly data: The number of countries generating offshore wind power is set to double. *Energy Monitor*. https://www.energymonitor.ai/sectors/power/weekly-data-the-number-of-countries-generating-offshore-wind-power-is-set-to-double/

Ferry, T., 2022, Offshore wind industry struggles with localisation. *Euroview*. https://euroview.ecct.com.tw/category-inside.php?id=412

FutureTech., 2022, *TaidaFloat – a Novel Floating Wind Turbine Platform for Taiwan*. Taiwan Innotech Expo. https://www.futuretech.org.tw/futuretech/index.php?action=product_detail&prod_no=P0008700007129&web_lang=en-us

Ganea, D., Mereuta, E., and Rusu, L., 2018, "Estimation of the Near Future Wind Power Potential in the Black Sea", *Energies*, *11*, 3198. https://www.mdpi.com/1996-1073/11/11/3198

Gao, A. M.-Z., Huang, C.-H., Lin, J.-C., and Su, W.-N., 2021, "Review of recent offshore wind power strategy in Taiwan: Onshore wind power comparison", *Energy Strategy Reviews*, *38*, 100747. https://doi.org/https://doi.org/10.1016/j.esr.2021.100747

Gerasymchuk, S., and Poita, Y., 2018, "Ukraine-China after 2014: a new chapter in the relationship. *Friedrich Ebert Stiftung*, 4-14.

Guangyi, L., 2022, I was Once Close to Ukraine. 30 Years Ago, the Special Plane to Aid Ukraine Flew Directly to Kyiv, and Lien Chan had a Secret Visit. *United Daily*. https://vip.udn.com/vip/story/121160/6134151

Hai Long Offshore Wind. 2023, *Hai Long Project Conducts 1st Cut of Steel for Foundations Fabrication at Samkang's Sub-assembly Shop in Korea*. https://hailongoffshorewind.com/en/Samkang-Steel-Cut

Hsu, I.-J., Ivanov, G., Ma, K.-T., Huang, Z.-Z., Wu, H.-T., Huang, Y.-T., and Chou, M., 2022, Optimization of Semi-Submersible Hull Design for Floating Offshore Wind Turbines. 41st International Conference on Offshore Mechanics and Arctic Engineering (OMAE 2022), Hamburg, Germany.

Hu Peiying, 胡, 2013, Ukraine and the Republic of China—From the Orange Revolutionary Scarf. *Academia Historica Research Newsletter*. https://www.drnh.gov.tw/var/file/3/1003/img/29/6_28.pdf

Ilchenko, S., 2021, Conceptual Aspects of Achieving Competitive Advantages by Shipbuilding Enterprises of Ukraine. *Economic innovations*, *23*, 84-94. https://doi.org/https://doi.org/10.1504/IJBSR.2011.040788

Ivanov, G., 2023, "Efficient Application Range of Electric Cargo Ships", *International*

Journal of Maritime Engineering, *165*, 1-10. https://doi.org/https://doi.org/10.5750/ijme.v165iA1.743 (All-Electric Cargo Ships Data Analysis and Efficiency vs Fuel Ships Comparison)

Ivanov, G., Hsu, I.-J., and Ma, K.-T. 2023a, *Design Considerations on Semi-submersible Columns and Pontoons for Floating Wind* 42nd International

Conference on Ocean, Offshore and Arctic Engineering, Melbourne, Australia. http://dx.doi.org/10.20944/preprints202307.0643.v1

Ivanov, G., Hsu, I.-J., and Ma, K.-T., 2023b, Design Considerations on Semi-Submersible Columns, Bracings and Pontoons for Floating Wind. *Journal of Marine Science and Engineering*, *11*, 1663. https://doi.org/https://doi.org/10.3390/jmse11091663

Joy Tseng, T.P.J., 2022, 200 offshore wind turbines to be built in Taiwan in 2022: President Tsai. *Focus Taiwan*. https://focustaiwan.tw/business/202210190021

Kao, S.-M., and Pearre, N.S., 2017, Administrative arrangement for offshore wind power developments in Taiwan: Challenges and prospects. *Energy Policy*, *109*, 463-472. https://doi.org/https://doi.org/10.1016/j.enpol.2017.07.027

Kinoshita, S., 2022, Failure of world's 1st offshore floating wind farm in Fukushima disappoints 3.11 survivors - The Mainichi. https://mainichi.jp/english/articles/20210305/p2a/00m/0na/034000c

Kononenko, V.Y., 1999, Current state of underwater welding and cutting. *Welding International*, *13*, 918-920. https://doi.org/10.1080/09507119909452075

Kornienko, A.N., 2006, *Benardos Nikolai Nikolaevich and his famous invention*. Igor Sikorsky Kyiv Polytechnic Institute. https://kpi.ua/en/benardos

Ling, C.Y., 2022, SOIC demonstrates the in-situ design capacity of the floating platform, DeltaFloat scale model test, and enters the real sea area test stage in 2023. *WindTAIWAN*. https://windtaiwan.com/ArticleView.aspx?ID=ART00906

Makarovskiy, Y., and Zinych, V., 2014, Wind energy potential assessment of Ukraine. *Romanian Journal of Geography (submitted for publication)*. http://www.rjgeo.ro/issues/revue%20roumaine%2058_2/makarovskiy%20et%20al..pdf

Martin, P., 2022, Orsted drops out of Taiwanese offshore wind tender. *Carbon Economist*. https://pemedianetwork.com/carbon-economist/articles/renewables/2022/orsted-drops-out-of-taiwanese-offshore-wind-tender/

Metal Industry Intelligence, 2022, *The Supply Chain Study of Offshore Wind Industry in Taiwan*. https://www.bcctaipei.com/sites/default/files/2022-03/Taiwan%20Offshore%20Wind%20Supply%20Chain%20Report%200322.pdf

Mosaad, M., Gafaary, M., Yehia, W., and Hassan, H., 2017, On the design of X-bow for ship energy efficiency. Influence of EEDI on Ship Design & Operation, London, UK.

National Development Council, 2022, *Taiwan's Pathway to Net-Zero Emissions in 2050*. National Development Council. https://www.ndc.gov.tw/en/Content_List.aspx?n=B927D0EDB57A7A3A

National Development Council (Taiwan), 2021, *2021-2023 Annual survey and estimation of talent supply and demand in key industries*. https://ws.ndc.gov.tw/Download.ashx?u=LzAwMS9hZG1pbmlzdHJhdG9yLzE4L3JlbGZpbGUvNjAzNy85NTEwLzkxN2I0ZDk4LTRkNzAtNDk0OC1hNDM3LTVhMmI4MGVkNDQ0Ni5wZGY%3D&n=MTEwLTExMuW5tOmHjem7nueUou

alreS6uuaJjeS%2Bm%2BmcgOiqv%2BafpeWPiuaOqOS8sCgxMDnlubTovqbnkIbmiJDmnpzlvZnmlbTloLHlkYopLnBkZg%3D%3D&icon=..pdf

«Nibulon» will build 5 patrol boats on a French contract. (2020, 5 June). *Military*. https://mil.in.ua/uk/news/nibulon-zbuduye-5-kateriv-za-frantsuzkym-kontraktom/

Nikiforova, V.A., 2022, Long-term factors and trends of the Ukrainian steel industry development. *Economy of Industry*, 32-60. https://doi.org/http://doi.org/10.15407/econindustry2022.01.032

OffshoreWIND., 2019 Ørsted Orders Changhua Jackets in South Korea. *Offshore Energy*. https://www.offshorewind.biz/2019/06/11/orsted-orders-changhua-jackets-in-south-korea/

"Okean" delivered two vessels for Eurobulk, 2020, *Mykolaiv - The city of shipwrights*. http://shipbuilding.mk.ua/?p=2819

Onea, F., and Rusu, L., 2019, Long-Term Analysis of the Black Sea Weather Windows. *Journal of Marine Science and Engineering*, *7*, 303. https://www.mdpi.com/2077-1312/7/9/303

Orsted Taiwan, 2018, *Ørsted signs a pin-piles manufacturing contract with Formosa Heavy Industries*. https://orsted.tw/en/news/2018/10/fhi-pinpile-contract

Oung, A., 2022, Yunlin Project Delayed by Lost Monopile. *Unredacted Taiwan Offshore Wind*. https://unredacted.biz/en_us/news/yunlin-project-delayed-by-lost-monopile/

Patricolo, C. (2022, 2022-12-21). Wind power at the core of Ukraine's post-war recovery. *CEENERGYNEWS*. https://ceenergynews.com/renewables/wind-power-at-the-core-of-ukraines-post-war-recovery/

Poita, Y., 2022, Opportunities and Risks from the Belt and Road Initiative in Ukraine | SpringerLink. *Securitization and Democracy in Eurasia*. https://doi.org/10.1007/978-3-031-16659-4_22

RenewableUK, 2017, *Offshore Wind Project Timelines*. https://cdn.ymaws.com/www.renewableuk.com/resource/resmgr/publications/RUK17_Offshore_Timeline_v4.pdf

Russell, T., 2020, Century Bladt Foundation facility takes shape. *4C Offshore*. https://www.4coffshore.com/news/century-bladt-foundation-facility-takes-shape-nid16947.html

Rusu, L., 2019, The wave and wind power potential in the western Black Sea. *Renewable Energy*, *139*, 1146-1158. https://doi.org/https://doi.org/10.1016/j.renene.2019.03.017

Ryou, H., 2009, Chinese Aircraft Carrier Program. *IPCS Issue Brief*(101).

Shih-ching, K., 2019, CSBC Reduces Annual Losses by 51.5%, Focuses on Diversifying income sources. *Taipei Times*. https://www.taipeitimes.com/News/biz/archives/2019/02/22/2003710164

Sobchenko, A., and Khomenko, I., 2015, Assessment of Regional Wind Energy Resources Over the Ukraine. *Energy Procedia*, *76*, 156-163. https://doi.org/https://doi.org/10.1016/j.egypro.2015.07.889

Solesvik, M.Z., 2011, Interfirm Collaboration in the Shipbuilding Industry: The Shipbuilding Cycle Perspective. *International Journal of Business and Systems Research*, *5*, 388-405. https://doi.org/https://doi.org/10.1504/IJBSR.2011.040788

Statista, 2021, *Ukraine: main destinations of arms exports 2021* https://www.statista.com/statistics/1294319/ukraine-arms-exports-by-country/

Stephens, J.C., Peterson, T.R., and Wilson, E.J., 2013, Socio-political Evaluation of energy deployment (SPEED): A framework applied to smart grid. *UCLA L. Rev.*, *61*, 1930. https://heinonline.org/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/uclalr61&section=42

Stephens, J.C., Wilson, E.J., and Peterson, T.R., 2008, Socio-Political Evaluation of Energy Deployment (SPEED): An integrated research framework analyzing energy technology deployment. *Technological Forecasting and Social Change*, *75*, 1224-1246. https://doi.org/https://doi.org/10.1016/j.techfore.2007.12.003

Sutton, H.I., 2022, Suspected Ukrainian Explosive Sea Drone Made From Recreational Watercraft Parts - USNI News. *USNI News*. https://news.usni.org/2022/10/11/suspected-ukrainian-explosive-sea-drone-made-from-jet-ski-parts

U. N. General Assembly, 1972, *Restoration of the lawful rights of the People's Republic of China in the United Nations* https://digitallibrary.un.org/record/192054

Ukraine will open embassies in 10 African countries. 2022, *The Kyiv Independent*. https://kyivindependent.com/news-feed/ukraine-will-open-embassies-in-10-african-countries

Weston, D., 2014, Japanese hybrid floating turbine sinks. *WindPower Monthly*. https://www.windpowermonthly.com/article/1327126?utm_source=website&utm_medium=social

What's the Welding Job Outlook for 2021? 2021, *PrimeWeld*. https://primeweld.com/blogs/news/whats-the-welding-job-outlook-for-2021

Wu, K.-Y., Ivanov, G., Hsu, I.-J., Ma, K.-T., and Chiang, M.-H., 2023. *Technology Development of a Floating Offshore Wind Turbine, "TaidaFloat"* Taiwan Wind Energy Conference 2023, Taipei, Taiwan.

Wu, M.-Y. C., & Yung, F., 2021, Investment Evaluation and Partnership Selection Model in the Offshore Wind Power Underwater Foundations Industry [Article]. *Journal of Marine Science and Engineering*, *9*, 1371. https://doi.org/10.3390/jmse9121371

Xiao Chunyun, L.Z., Cui Zhaohui and Zhou Peiyi., 2021, Lack of welding work has caused the industry to stop. How to keep the fading spark? *NCCU Uonline News*. https://unews.nccu.edu.tw/unews/%E7%84%8A%E6%8E%A5%E7%BC%BA%E5%B7%A5%E8%87%B4%E7%94%A2%E6%A5%AD%E5%81%9C%E6%AD%A5%E3%80%80%E5%A6%82%E4%BD%95%E5%AE%88%E4%BD%8F%E6%BC%B8%E6%BB%85%E7%9A%84%E7%81%AB%E8%8A%B1%EF%BC%9F/

Yunlin OWF., 2020, *Offshore project Yunlin: Local content strategy as a genuine pioneering feat*. https://owf-yunlin.tw/en/offshore-project-yunlin-local-content-strategy-as-a-genuine-pioneering-feat/

Zhang, Y., Zhang, C., Chang, Y.-C., Liu, W.-H., and Zhang, Y., 2017, Offshore wind farm in marine spatial planning and the stakeholders engagement: Opportunities and challenges for Taiwan. *Ocean & Coastal Management*, *149*, 69-80. https://doi.org/https://doi.org/10.1016/j.ocecoaman.2017.09.014

https://doi.org/10.55802/IJB.029(3).005