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Renewable energy for offshore platforms energy optimization

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RENEWABLE ENERGY FOR OFFSHORE PLATFORMS ENERGY OPTIMIZATION

By

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): **...**

(Date): **................20/09/2022....**

Supervised by: **..**

Supervisor’s affiliation**.......**

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Abstract

Title of Dissertation**:** **Renewable energy simulation and optimization for offshore oil and gas platforms electricity production.**

Degree : **Master of Science**

With respect to many prospects that are now accessible, a large number of significant firms are doing research in this area to determine whether or not offshore platforms may make use of Renewable Energy Source (RES), such us wind energy, solar panel and wave power. The objectives of the research included to assess how to decrease the level of Greenhouse Gas (GHG) emissions from the offshore platforms, to assess how to optimize the level of the energy consumption of those structures and turn them into significantly energy efficient platforms using Homer pro software.

As the methodology, the researcher has implemented case study method to find out optimum and most suitable renewable energy sources for the purpose of offshore platforms energy optimization and also to find out that how this can result in the reduction of the Greenhouse gases, have economic benefits for the offshore platforms and result in better environmental and social impact for the offshore platforms. The modelling software known as HOMER Pro is implemented in the study. The size of the energy system that was estimated was compared to the size of the system that would have been optimum, which was calculated using software simulations using HOMER Pro.

The first simulation was done using only hybrid RES (wind and solar) with battery storage, and the optimum solution needs 89 batteries capacity, 23 wind turbines and 2.3GW from solar panels. For the last simulation we added gas turbine generator, the best scenario in this case needs 20 wind turbines, 748.7MW solar power and 96 batteries. After analyzing all the scenarios, the results show that the best energy mix (RES and thermal source) is the best option when it comes economical benefit, but if we add the emission aspect, full RES solution will be the choice. The fact that RES availability depends on many factors such as weather, sun, so selecting hybrid solution is the path to take, because it gives us the balance between energy cost and GHG emissions.

Keywords: Renewable Energy, Offshore Platforms, Energy Optimization, homer pro, hybrid system simulation.

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List of Abbreviations

AI	Artificial Intelligence
CO2	Carbon Dioxide
COE	Cost of Energy
EROI	Economic Return on Investment
GHG	Greenhouse Gas
GHI	Global Horizontal Irradiance

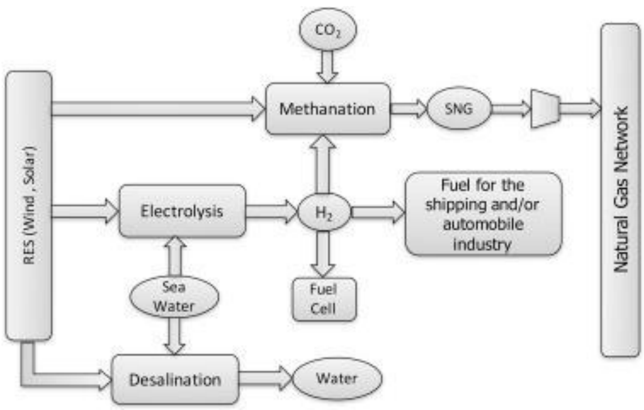
GT	Gas Turbine
HOMER	Hybrid optimization of multiple energy resources
IRENA	International Renewable Energy Agency
NASA	National Aeronautics and Space Administration
NO2	Nitrogen dioxide
NPC	Net Present Cost
OECD	Organization for Economic Co-operation and Development
ORE	Offshore Renewable Energy
RE	Renewable Energy
RES	Renewable Energy Source
SDGs	Sustainable Development Goals
SO2	Sulfur Dioxide

Chapter 1: Introduction

1.1. Research background

During the next three decades, the current energy transition will be characterized by many sub-transitions in their various iterations. Oil and gas, in addition to other types of renewable energy sources, will continue to play a significant part in the energy mix of the future. There are several offshore platforms that need to be optimized via the use of cutting-edge technologies and alternative sources of power (Abaei, Arzaghi, Abbassi, Garaniya, & Penesis, 2017; Banos et al., 2011). In this context, many initiatives have been established with the primary purpose of building a model for the reuse of decommissioned offshore oil and gas platforms for the production of renewable energy. One such initiative is titled "Renewable Energy for a New Life of Offshore Platforms," and it is one example of such an initiative (Halabi, Al-Qattan, & Al-Otaibi, 2015).

Figure 1. *Reconversion of offshore oil and gas platforms into renewable energy sites*



Source: Leporini et al (2019)

Diab, Lan, and Ali (2016) offshore oil and gas sites have reported that in order to power their activities, a total of 16 terawatt-hours of energy is needed on a yearly basis. There are a number of different approaches that may be used to incorporate renewable energy sources into offshore projects (Leporini, Marchetti, Corvaro, & Polonara, 2019). Multi-use offshore platforms that combine renewable energy from the sea with aquaculture and transportation infrastructure should be viewed as a challenging strategy in order to stimulate blue growth and make renewable energy environmentally and socioeconomically sustainable (Mohammadnejad, Ghazvini, Mahlia, & Andriyana, 2011; Nguyen, Voldsund, Breuhaus, & Elmegaard, 2016). These platforms would combine aquaculture with the production of renewable energy from the sea. The time is ripe for the development of solar and wind power. Fueling offshore production platforms consumes around 5 percent of the world's offshore oil and gas wellhead output on average. Offshore production platforms are located all over the globe (Østergaard, Duic, Noorollahi, Mikulcic, & Kalogirou, 2020). On the other side, using wellhead output to power operations lowers sales volumes and increases the carbon footprint of activities, which may result in an increased tax burden for oil and gas businesses in the future (Pastor & Liu, 2014). Prospects for the energy business and for society as a whole may be found in the use of marine renewables to power offshore oil and gas operations. To begin, significant reductions in emissions caused by offshore oil and gas activities may be possible. Second, there is the possibility that marine renewables may open up new "niche" market expansion potential (Pierobon, Nguyen, Larsen, Haglind, & Elmegaard, 2013). At the conference titled "Powering Offshore Oil and Gas with Marine Renewables," which took place on September 18, 2019, at the University of Aberdeen, these topics were among those that were addressed. The presentations given by Professor Alex Kemp and Lee Senoussi indicate that oil and gas offshore activities are responsible for more than 3 percent of the total carbon emissions in the United Kingdom (Rafiee & Khalilpour, 2019). Importantly, it releases around 200 million tons of CO2 into the atmosphere every year as a result of burning, which is roughly equivalent to Vietnam's entire CO2 emissions. Consequently, marine renewables have the potential to achieve this goal, in addition to making oil and gas activities more carbon efficient (Sommer et al., 2019).

In view of the many prospects that are now accessible, a large number of significant firms are doing research in this area to determine whether or not offshore platforms may make use of wind or solar power. The French energy company Total has joined a project to investigate whether or not it would be possible to use floating wind and wave energy generators to power offshore oil and gas installations (Samsatli & Samsatli, 2019).

Potential energy consumers face a challenge in the short term in terms of cost, timescale, and power supply certainty due to the development costs and timelines associated with floating wind farm scenarios. Nevertheless, possibilities have been recognized that may enable the development of a more preplanned advancement integrating power from shore within an accelerated timeline that provides power certainty (Sommer et al., 2019). Given the potential for financial gain associated with participation in this market, it is of the utmost importance to identify a strategy for its optimization (Weller, Johanning, Davies, & Banfield, 2015).

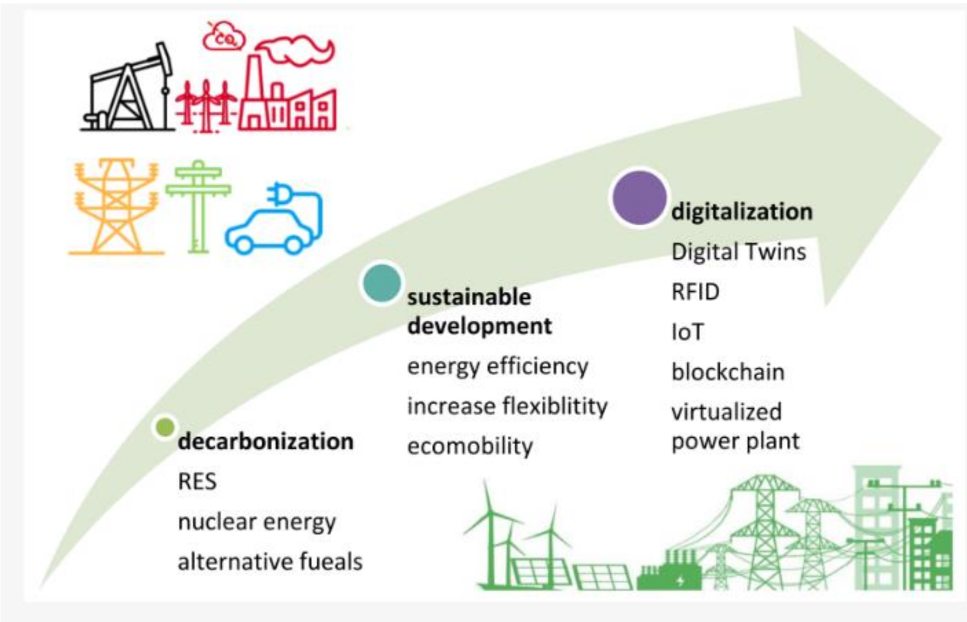
However, in order to realize these advantages, the expenses of installation, maintenance, and repair must be cut down, consideration must be given to the influence that the structures would have on the maritime environment, and problems with public acceptance must be overcome (Weller et al., 2015). Because different regions or countries may have contrasting viewpoints, there are several obstacles to overcome in terms of law and policy. These obstacles take a variety of forms. Previous research has highlighted the challenges associated in transferring regulatory practices from one regime to another. This is due to the fact that regulatory practices are largely dependent on the social, cultural, and political dynamics of the nation in which the system is founded. In addition to this, there is a dearth of regulatory oversight on a global scale (Abaei et al., 2017; Banos et al., 2011). Although the relevant sections of the United Nations Convention on the Law of the Sea are present, no international convention on the safety of offshore drilling operations has yet been ratified, and there is no ongoing mechanism to fill this void. This is despite the fact that these sections are present in the convention. Policy options for overcoming these impediments, supporting the development of offshore renewable energy, and levelling the playing field for these resources are being considered (Banos et al., 2011).

1.2. Problem statement

When it comes to their use of energy, the vast majority of people on the planet continue to place a large reliance on fossil fuels. The possibility that these fuels may have an adverse impact on the surrounding ecosystem is constantly pounded into our heads (Diab et al., 2016; Halabi et al., 2015). As a consequence of this, the fundamental purpose of installing offshore renewable energy platforms is to promote economic growth, increase energy security, extend energy access, and combat climate change.

It is possible to achieve sustainable development by making use of renewable energy sources and by providing communities with access to energy that is all of the following: modern, inexpensive, dependable, and renewable (Pierobon et al., 2013; Rafiee & Khalilpour, 2019). In addition, combining this renewable energy source with new technologies such as artificial intelligence, the internet of things, and digital twins will boost the efficiency of these platforms, enabling companies to create greater long-term profits (Leporini et al., 2019; Mohammadnejad et al., 2011). Figure 1 shows how the combination of digital solutions and RES will lead best sustainability and decarbonation.

Figure 2. *Direction of energy sector development*



Source: own elaboration (2021).

1.3. Research objectives

In the present day, all offshore oil and gas platforms use gas or diesel as their main source of electricity, but if we want to meet the UN sustainable development goals (SDGs) we need to change the way electricity is generated on offshore rigs. So, the best path to take in order to achieve those goals, is to use RES to meet the energy demand of the platforms. For the current study, the research objectives include the following ones:

1. To decrease the level of Greenhouse Gas (GHG) emissions from oil and gas industry in the maritime environment.
2. To optimize the level of the energy consumption of those structures and turn them into significantly energy efficient using HOMER pro.
3. To assess the benefit and cost analysis for the companies to invest significantly in green energy.

1.4. Research questions

In accordance with the above objectives, the study has the following questions to address:

1. What is the level of the energy consumption and greenhouse gas emissions of the offshore platforms?
2. How can novel technologies make these offshore platforms more efficient and sustainable?
3. Where and when will this project be implemented?
4. How can the companies make significant use of the solution regarding making profits?

1.5. Scope of study and Limitation

For the method of the study, the researcher is implementing case study method to find out optimum and most suitable renewable energy sources for the purpose of offshore platforms energy optimization and also to find out that how this can result in the reduction of the Greenhouse gases, have economic benefits for the offshore platforms and result in better environmental and social impact for the offshore platforms. For this specific case study, the researcher will be performing simulations in the designated sites in Norway which are prominent offshore sites for the gas and oil platforms. For the optimization and the simulation in the experiment, the researcher will be using homer pro. The modelling software known as HOMER Pro is often used throughout the building process of off-grid energy systems. At each time step, the software mimics the functioning of the system by carrying out computations to determine the system's energy balance. After that, optimization is performed in order to find the settings that are the most effective and efficient for the system. In this study, the main limitation comes from the lake of real-world data for the simulation. In addition, we did not find any research in hybrid RES solutions for offshore platforms, many studies are focus on how to integrate wind farm in power generation on platforms. Due to the time frame for thesis, only two simulations were done and the electricity consumption was set to 4OMW. The author is also aware of additional resource constraints, such as those related to financing, time, and researcher experience.

1.6. Structure and organization of the study

In this research comma there are six total chapters.

Chapter one: is the introduction of the study, it gives what the dissertation is about, and it defines the scope and limitations of the thesis.

Chapter two: goes through the literature review of existing solutions and studies on offshore energy and oil platforms.

Chapter three: describes the methodology and simulation software used in the study.

Chapter four: is about the case study, which simulate oil and gas platform in Norway and it shows the results and findings.

Chapter five: discusses and interprets the results in detail.

Chapter six: conclusion of the study, implications of the study and the research limitations and recommendations

Chapter 2: Literature review

2.1. Potential for renewable energy

Offshore oil and gas platforms may have power needs anywhere from 10 megawatts (MW) to multiple hundreds of MW, depending on a variety of criteria such as the size of the platform or the circumstances and features of the field. They employ distinct electrical systems that are equipped with a large number of redundant gas turbines that run under partial load conditions and are closely integrated with electric generators in order to meet their power requirements.

As a direct consequence, this leads to an increase in fuel consumption as well as operations that are around 30 percent less efficient, both of which have a negative impact on their carbon footprint. Due to the ease with which it can be extracted in oil fields, natural gas has quickly become the most common type of fuel. Several studies conducted on offshore oil and gas platforms concluded that GTs are the industry's leading contributor to emissions of CO2 and NOX. The industry is looking for alternate ways to serve the need for electricity from oil and gas offshore infrastructures for a number of reasons, the most important of which are the threat of financial penalties, regulations to reduce greenhouse gas emissions, and a decreasing supply of natural gas. The extent of this study's calculations about renewable energy is rather expansive. It is believed that there is between 30 and 50 EJ of energy absent from hydropower. The presence of RE exceeds the maximum allowed concentration. Estimates place the amount of energy from solar energy, biofuels, and geothermal heat at around 1500EJ (Ahmadi, Mehrpooya, Abbasi, Pourfayaz, & Bruno, 2017). These resources can be of great assistance in energy consumption in the future. However, it has been suggested that these projections are not plausible. An argument regarding the limitations of RE includes a generalization to the effect that the limits of demographic constraints are more restrictive than the limits of beliefs (Apostolaki-Iosifidou, Mccormack, Kempton, Mccoy, & Ozkan, 2019). Solar and wind power cannot be generated in places such as the ocean, mountain ranges, forests, and ice caps because these environments are too variable. Since hydroelectric dams were built, many kinds of wood have been submerged, and some towns have been reconstructed as a result of the dams. And for as long as wind energy remains, it will be more constrained (Apostolaki-Iosifidou et al., 2019). Along with reducing the heat it will also reduce the noise pollution around the offshore rigs and will help in meeting the amount of energy which is demanded by the offshore rigs (Taheri, Vieira, Salles, & Avila, 2021; Uddin, Biswas, & Nuruddin, 2022).

On the other hand, the idea of geographical limitations does not apply to the many other types of renewable energy sources. Public opposition is another factor that makes wind energy more challenging to implement. Wind energy is responsible for the loss of visual quality, increased rates of property values, and the deaths of birds and bats in several nations that are members of the OECD (Ashuri, Zaaijer, Martins, Van Bussel, & Van Kuik, 2014). The amounts documented for geothermal energy sources are quite low and range from 1 to 22 EJ since the actual estimate is more than 5000 EJ. However, because of yet another kind of geographical constraint, the use of this energy is quite restricted. Because heat with a conventional rate of transmission cannot be transferred farther than 8 kilometers, the use of geothermal energy is restricted in the same way as it is in the United States. Therefore, only a tiny percentage of the geothermal energy that is available may be used (Besnard, Fischer, & Tjernberg, 2012).
Second, the amount of output relative to the amount of energy input is not particularly useful. The economic return on investment, often known as (EROI), is the ratio of the total output to the total input. Both of these forms of energy are put to use in a wide variety of manufacturing, maintenance, and other sorts of processes. The term "net energy" refers to the difference between the total amount of energy intake and the total amount of energy production (Bhowmik, Bhowmik, Ray, & Pandey, 2017). Therefore, the available net energy may be utilized to fulfill the energy needs due to the fact that deserts encompass an area of more than 10 million km^2. Therefore, to build a massive solar energy system to transfer energy from North Africa and the middle east to central and northern Europe, the solar energy farms will require a massive water supply for cleaning and coolant for the (STEC) and other workforce settlements. This will allow the solar energy system to transfer energy from North Africa and the middle east to

central and northern Europe. Then, to produce the output, you will also need energy storage (Bieber et al., 2018). And if the quantity of hydrogen that is required is also required, then the quantity of water that is required will also be required for that. These variables contribute significantly to a reduction in the amount of EROI that is achieved (Camacho, Samad, Garcia-Sanz, & Hiskens, 2011).

Thirdly, safety concerns are one of the factors that limit the potential of renewable energy sources, considering that the total quantity of power in the world is just 1.4 percent. And almost two-thirds of the total volume of oil and other goods pass across foreign borders (Camacho et al., 2011). Consequently, it is possible that other nations will become reluctant to be reliant on the power coming from another country. Fourthly, there are instances when it becomes more particular about the output/m2. This is a possibility for solar energy since the entire area for existence (PV/STEC) is greater than the space that is now being used. There is not much of a decrease in costs observed by (b.o.c) goods technology. The current photovoltaic capacity is placed on roofs, and although this helps to cut down on the cost of the structure, it does not allow for the output of the PV to be increased. The cost of the energy input will stay sustainable, regardless of how much the cost of energy falls (Day et al., 2015).

It is clear that the quantity of energy generated in 1993 had the capacity of 3.75 in several nations that are members of the OECD. Still, between 1994 and 2011, that capacity dropped to a ratio of 1.43. Even the capacity constructed in 2011 was just a third of the worldwide potential that was often utilized. In countries like Italy, Japan, New Zealand, and the United States, where the practice has been going on for more than half a century, the abuse of geothermal energy reached a high between 1990 and 2011. But despite these challenges, the potential for the generation of power is far more than the amount that is produced (Diemuodeke, Addo, Oko, Mulugetta, & Ojapah, 2019).

2.2. Offshore Renewable Energy

Offshore Renewable Energy, often known as "ORE," is an abbreviation that is frequently used to refer to the most cutting-edge and cutting-edge technologies as well as the most mature approaches that are employed for the acquisition of the most dependable renewable energy sources. These may be the fully developed and sophisticated technologies that are now within reach of contemporary man, or they can be the somewhat less developed but closely related technologies of the offshore tidal, wave, and wind energies (T. He, Karimi, & Ju, 2018). The use of these advanced and well-established methods of offshore renewable energy is the central focus as well as the primary focus of this report's research and analysis. In addition, this paper does not include the processes and technologies of other renewable energy sources that are not yet fully developed, such as the conversion of thermal and water energy, as a result of the complexity of these topics and our limited understanding of them (Henning & Palzer, 2014). Now, for additional clarification, we will refer to the machines or technologies that have been created for the production and acquisition of wind, wave, and tidal energy that is produced and acquired offshore. These could include the gadgets that are explained in the following paragraphs (P. Hou, Hu, Soltani, & Chen, 2015).

Offshore wind turbines are among the most practical and cost-effective technologies for harnessing wind energy in offshore locations. These large turbines that resemble fans are often categorized according to their outward appearance; nevertheless, the basis of these turbines is an essential factor in determining their category, and this foundation may be floating or fixed. The term "foundation" refers to the base point of these turbines in general. The second characteristic that categorizes wind turbines is their orientation, which may either be flat and horizontal or a position that is perpendicular to the ground, which is also referred to as a vertical axis position (Karimirad, 2014). On figure 3, Using 30 gigawatts of new offshore wind energy by 2030 would sustain 77,000 jobs, power 10 million homes, and reduce carbon emissions by 78 million metric tons.

Figure 3. *Economic impact of offshore wind*

Source: U.S. Department of Energy (2018)

The operation of this mature and sophisticated offshore technology will now be discussed, namely how it functions as a source to create an essential kind of renewable energy, wind energy. Wind power can only be generated using actual wind, as suggested by its name. The wind is caused by the difference in pressure that exists at various locations along the route that air travels as it moves through the atmosphere (Li et al., 2020). Variations in the wind speed and direction are caused by the fact that this wind may be sluggish in some locations, quite strong in others, and very moderate in others. When the wind blows, the massive fan-like structures outside offshore wind turbines move. Consequently, the turbines on the interior of the machines start turning, generating electricity (Mazzetti, Nekså, Walnum, & Hemmingsen, 2014).

As was mentioned earlier, the wind blows in a pattern that varies, which ultimately leads to variable levels of energy production. When the wind is blowing quickly, a more significant amount of energy will be produced, while other times, when the wind is blowing slowly, a smaller amount of energy will be produced, and vice versa (Myhr, Bjerkseter, Ågotnes, & Nygaard, 2014). Experts have determined that in light of the variations described above, the production of energy from offshore wind turbines will be significantly greater than that of wind turbines installed on land-based sites or in lower residential areas. This conclusion was reached in light of the fact that these offshore wind turbines can be installed and implemented on higher grounds such as mountains and valleys (Myhr & Nygaard, 2012). Fixed bottom wind turbines are the most modern and mature kind of offshore technology in the area of production of ORE (offshore renewable energy), which stands for offshore renewable energy. These turbines are used to acquire wind energy. It's the same tried-and-true technology that is used overseas, and it's extensively implemented in a lot of different nations across the globe (Oliveira-Pinto, Rosa-Santos, & Taveira-Pinto, 2019).

Floating wind energy turbines are yet another kind of offshore wind energy technology. However, at this point, this cutting-edge technology is not widely used anywhere around the globe. Nevertheless, it is now being developed, and in the not-too-distant future, this may also be able to provide us with a source of wind energy. In 2017, it was evaluated to ensure that it functions correctly; nevertheless, it is still being developed and improved so that it may one day be helpful to the general public (Oliveira-Pinto et al., 2019).

Tidal energy generation is the second important and established technique for offshore energy production. Some of the most critical aspects of the idea behind tidal energy are barrages and turbines that may be put at dams or other places in rivers, streams, and lakes (Pérez-Collazo, Greaves, & Iglesias, 2015). The alternating crests and troughs of water waves that occur as they travel across seas and lakes are the primary contributors to the generation of tidal energy. In the 20th century, specific engineers of the period produced the idea that energy may be extracted from tides and changed into other helpful forms. For this reason, they developed technologies for the need for energy (Pierobon et al., 2013).

Tidal barrages are the offshore tidal energy technique that is the most mature and sophisticated. However, there are relatively few tidal barrages in existence, and they are among the offshore energy production technologies that are employed the least across the world. When the runoff from rivers and streams reaches the turbines, tidal energy is generated (Pierobon et al., 2013). This occurs because the potential energy contained in such large water volumes is turned into kinetic energy, which drives the turbines, resulting in the creation of electricity. Wind energy is variable and not produced equally; however, there is some degree of uniformity, and energy production is a bit more consistent as tidal cycles have a long life compared to the wind with a uniform speed. Another significant aspect that makes a good comparison between wind and tidal energy is that wind energy is variable and not produced equally (Riboldi, Völler, Korpås, & Nord, 2019).

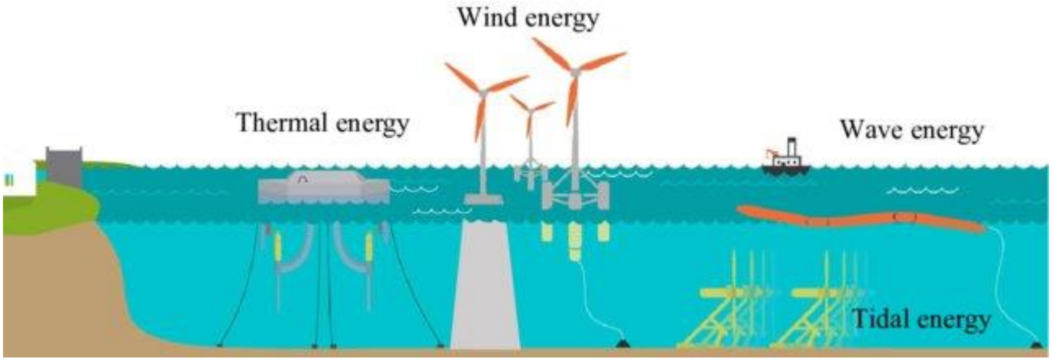
Tidal energy, on the other hand, does produce energy equally. Wave energy production is the third most significant and established offshore energy technology. It utilizes the ocean's waves. This is one of the most established renewable energy sources available offshore. Wave energy conversion, sometimes abbreviated as "WECs," is the name of the developed and cutting-edge technology used in this context (Ritzenhofen & Spinler, 2016). These machines are the most common and trustworthy sources in terms of their economic viability, and they are used to generate energy from waves. This mature offshore technology is used for the conversion of water waves directly into the form of electricity. Although energy cannot be destroyed nor created, it can be converted from one of its forms to another form that is more suitable and required (Siksnelyte, Zavadskas, Streimikiene, & Sharma, 2018).

As the name Wave energy converter suggests itself, this mature technology is used for the conversion of water waves directly into the form of electricity. This technology can be broken down into three categories according to its location: the first type is that which stays on land and has lower costs; the second type is that which rests at the shore of oceans submerged in the depths of 10-30 meters, and the third type is that which is below 30 meters in depth and has higher operational and managerial costs. Wave energy converters are expensive to operate and manage when located below 30 meters in depth. Wave energy may be generated in various ways, and scientists are constantly researching and developing new technologies to take advantage of these opportunities (Sinha & Chandel, 2014).

2.2.1. Offshore energy types

Compared to the substantial operating experience and maturity of fixed-bottom offshore wind energy technology, floating offshore wind energy technology is still in its infancy. Both the development of more realistic models of floating offshore wind turbines and the deployment of smaller-scale demonstration systems are now receiving a significant amount of attention from the scientific community (Sinha & Chandel, 2014).

Figure 4.*Diagram of the main types of Marine Renewable Energy*



Source: Taomina, B (2019).

Researchers will be able to explore the dependability of offshore wind turbines via the use of simulations, and researchers will be able to use data from demonstration installations to further analyze the reliability of these floating systems. The remainder of this section will concentrate on the technologies related to fixed-bottom offshore wind energy due to the substantial difference in technological improvement between floating offshore wind turbines and fixed-bottom offshore wind turbines. Because of the expertise of the onshore wind energy sector, Europe has made tremendous headway toward the commercialization of technology related to fixed-bottom offshore wind energy.

Even though building on the first site started in 1991 in Vindeby, new markets have lately arisen in the United States of America, East Asia, and India. This is although construction on the first location began in 1991 in Vindeby (Sun, Huang, & Wu, 2012). The price of potential installations of fixed-bottom offshore wind farms dropped considerably in 2016, with developers in the Netherlands and Denmark making commitments to produce power from the facilities for 54.50 €/MWh and 49.90 €/MWh, respectively. In the Netherlands, the government expects that its offshore auctions will no longer require subsidies by 2026. In Germany, tenders won at the wholesale electricity price in an auction held in April 2017, indicating that wind farms would be supported entirely by market prices without the need for subsidies or government support (Yang et al., 2018). At this time, Europe is in charge of 88 percent of all the offshore wind projects around the globe, and it provides significant economic and regulatory support for offshore wind. Because of this, Europe has a developed supply chain, a high level of expertise, and challenging market competition. Expanding levels of investor confidence, falling levels of financial risk premiums, and progress made in technology areas are all factors that contribute to the growth of the company. The capacity of turbines has increased from 3–4 MW to 8–10 MW, and it is anticipated that versions with a capacity of 13–15 MW will be available by the year 2024. As a result of technical developments, the typical, expected operational life of turbines has grown from 15 years to 30 years, and there is also the potential for the life of the turbine to be extended and for it to be repowered (A. Zhang et al., 2019).

The term "offshore wind power" refers to the generation of electricity from wind farms located in bodies of open water, most often the ocean. Because wind speeds at sea are higher than on land, offshore farms with the same equipment may produce more power. Offshore wind farms are less divisive since they have a lower effect on people and the environment (Ghigo, 2020). Although the maritime sector has generally reserved the term "offshore" for deeper oceans, inshore water features such as lakes, fjords, and sheltered coasts are also feasible offshore wind generating sites. Offshore wind farms typically construct wind turbines with a permanent foundation in shallow sea. Floating wind turbines for deeper oceans were still in their early stages of research and deployment in 2020 (Otter, 2022).

Offshore wind turbines now produce 3% of the electricity in the European Union. In Europe, the total installed offshore wind capacity has reached 28.4 gigatons. More than 5,795 wind turbines from 123 offshore wind projects in 13 nations are linked to the grid. To meet Europe's climate ambitions, the European Union's government has promised to build up to 160 GW of offshore wind over the next decade (Vasconcelos, Passos Filho, de Oliveira, & Avila, 2019). This massive growth necessitates a considerable rise in the annual rate of new offshore wind installations in Europe, from 3 GW per year to 6 GW per year during the next five years, and around 25 GW per year by 2030. Ports are expanding their operations as part of this energy shift to provide more sophisticated assistance for offshore wind generation. A nearby port might help you save money and time (Otter, 2022).

In Vasconcelos et al. (2019), we offer an optimization cost function to optimize an economic cost criteria for a wind farm, which entails locating the best locations for wind resources. Initially, it is anticipated that a rm wind capacity connection would achieve a certain penetration goal related to wind energy. However, given the limits of the bulk of present energy transmission lines, this is unlikely to happen very soon (Korpås, Warland, He, & Tande, 2012). The challenge outlined in Vasconcelos et al. (2019) is an effort to improve by maximizing the current system's wind power capacity in the near term prior to long-term transmission expansion. When the optimization approach is no longer possible, the rm wind energy penetration objectives are gradually increased from a lower starting point.

Floating solar might give a significant boost to the energy transition. A significant area of the North Sea has been set aside for the installation of renewable energy installations. There is considerable space between offshore wind turbines for solar panel installation (W. He et al., 2013; Korpås et al., 2012). TNO is now undertaking various studies on the technology and economic viability of large-scale floating solar energy systems in offshore locations. Significant progress is being made to pave the path for future solar energy production in the North Sea (Vasconcelos et al., 2019).

It may be challenging to evaluate dependability in immature systems like a wave and tidal energy systems. The first two reliability studies for WECs were conducted during the 1970s and 1980s, respectively. In these studies, failure rates were calculated from generic subsystems and components. In addition, environmental and operational unpredictability was accounted for by multiplying failure rates by 15–20 safety factors. According to the findings of one study, 2000–3000 MW capacity plants. Using a Monte Carlo simulation, we were able to determine that the availability of each array ranged anywhere from 16.2 percent to 96.1 percent. In each of these investigations, a fundamental random failure rate model was utilized (Q. Zhang, Ogren, & Kong, 2018). This model did not take into consideration common failure types or processes, nor did it include the likelihood of cascading failures. This use of significant safety factors and broad ranges for potential energy production and availability reflects the unpredictability of the performance of these WECs. Engineers have challenges while designing new technologies since there is a shortage of data on the performance and dependability of the technologies. Since these discoveries, there have been advancements made in both dependability analysis and uncertainty quantification; nonetheless, their implementation is still met with challenges (Zhou, Benbouzid, Charpentier, Scuiller, & Tang, 2013).

Techno-economic assessments are used within the sectors of wave and tidal energy in order to determine the feasibility of various devices and to entice investment. Wave and tidal energy sectors, in contrast to the offshore wind energy market, have limited experience upon which to base device design or industry standards since both are currently in the demonstration project phase. This is because offshore wind farms have been in operation for decades.

The assessment of devices is made even more difficult by the significant amount of variation that exists within the wave and tidal energy technologies (Apostolaki-Iosifidou et al., 2019). Due to the high cost of conducting reliability assessments that are individual to each device and subcomponent, the number of tests that can be performed on devices is restricted. While the offshore wind energy business has achieved design convergence and optimized that design to satisfy reliability criteria, the wave and tidal energy industries now have to optimize each device idea to meet an unproven reliability criterion. This is in contrast to the offshore wind energy business, which has already accomplished these tasks (Bieber et al., 2018). Due to a lack of design consensus and standards, there is a greater risk of inadequate involvement with potential manufacturers and subcomponent suppliers to build and support the construction of supply chains. Switching from custom-made to off-the-shelf, homogeneous components would enhance the device and subcomponent quality consistency, save money, and lessen the unpredictability associated with low-volume manufacturing (Diemuodeke et al., 2019).

Chapter 3: Research methodology

3.1. Research method

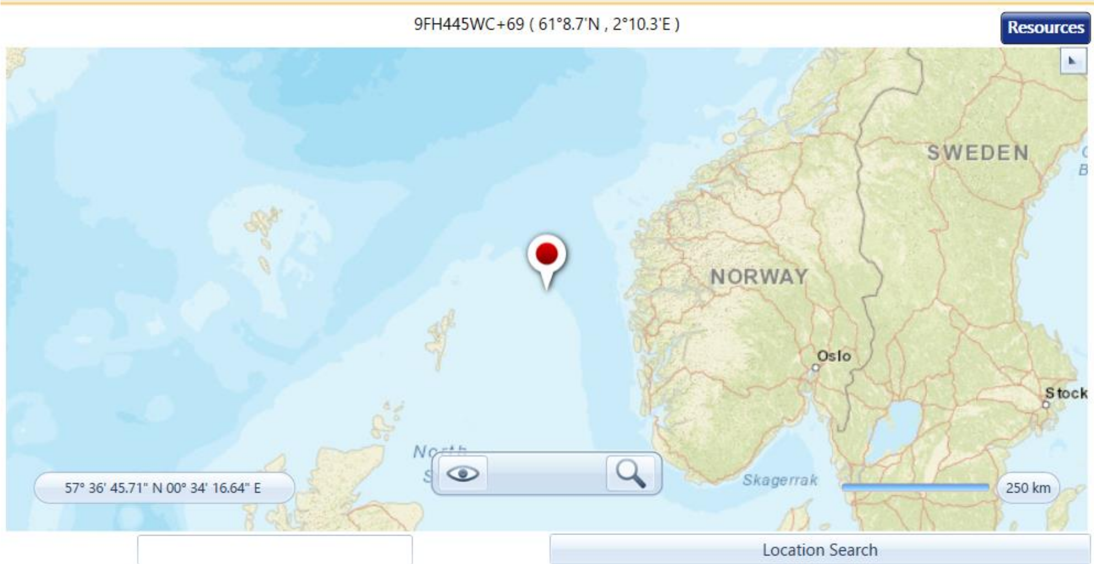
In the method of research known as the case study approach, one of the components of the approach is to provide the student with a specific scenario, also known as a case. The case study makes it possible to investigate a real problem within the confines of a certain setting by making use of a wide range of different data sources (Antonio Barrozo Budes, Valencia Ochoa, Obregon, Arango-Manrique, & Ricardo Núñez Álvarez, 2020).

In a broad sense, an analysis methodology known as a case study is one that investigates a particular subject by basing its investigation on a real-world scenario and using data from the actual world as a methodological instrument (Budes, Ochoa, Obregon, Arango-Manrique, & Álvarez, 2020). Like in this specific case, the researcher is implementing case study method to find out optimum and most suitable renewable energy sources for the purpose of offshore platforms energy optimization and also to find out that how this can result in the reduction of the Greenhouse gases, have economic benefits for the offshore platforms and result in better environmental and social impact for the offshore platforms (Dash, Behera, Mohanty, & Hota, 2018). Moreover, the researcher will be following the Bloom's taxonomy, the researcher will create, evaluate, analyze, apply, understand, and remember to assess the benefit and cost analysis for the companies to invest significant in the green energy.

3.2. Site specification

For this specific case study, the researcher will be performing simulations in the designated sites including Norway, which are prominent offshore sites for the gas and oil platforms. The Gullfaks oil and gas fields in the Norwegian North Sea will receive electricity from the floating wind and solar PV plant in the simulation. In figure 5, we have the location of the site where the case study will base on; In the northernmost region of the North Sea, in block 34/10, is where you can find the Gullfaks field. The development solution for the main field consists of three sizable manufacturing platforms with concrete foundations.

Figure 5. *Gullfaks oil and gas fields site*



Source: Author.

3.3. Renewable energy sources

For this experiment and research, the researcher will be implementing wind, solar and wave energy to produce electricity on them during the simulation to find out optimum and most suitable renewable energy sources for the purpose of offshore platforms energy optimization and also to find out that how this can result in the reduction of the Greenhouse gases, have economic benefits for the offshore platforms and result in better environmental and social impact for the offshore platforms (Gospodinova, Dineff, & Milanov, 2020).

3.4. Tools and techniques

For the optimization and the simulation in the experiment, the researcher will be using homer pro programme. The modelling programme known as HOMER Pro is often used throughout the building process of off-grid energy systems (Halim, Fudholi, Sopian, Ruslan, & Phillips, 2018). At each time step, the programme mimics the functioning of the system by carrying out computations to determine the system's energy balance. After that, optimization is performed in order to find the settings that are the most effective and efficient for the system. The combined dispatch method and net present cost of an energy system are what define its feasibility from a technical and economic standpoint for any practical use (Hyett, Kenny, & Dickson-Swift, 2014;

Iacono, Brown, & Holtham, 2011). This evaluation is carried out for each and every combination of the chosen equipment that is practically possible. The present value of all of the expenses that are associated with installing and running the device, less the present value of any revenues made by the device, is the formula for calculating the net present cost of a device throughout the course of a project's lifetime. HOMER is able to calculate not only the net present cost of each individual component but also the net present cost of the system as a whole (Oulis Rousis, Tzelepis, Konstantelos, Booth, & Strbac, 2018).

The total net present cost is the most significant economic output that HOMER provides because it considers the costs of purchasing, installing, operating, maintaining, and eventually replacing components. This is because the total net present cost takes into consideration all of these costs. It is possible to compute the costs of fuel, environmental fines, and the cost of purchasing electricity from the grid for systems that are linked to the grid (Pradhan, Mohanty, & Kar, 2017). This calculation may be done for systems that are connected to the grid. The cost of operating and maintaining the system is taken into consideration by the mixed dispatch strategy when deciding whether the battery should be charged with renewable sources when the net load is low or with a diesel generator when the net load is high (Santos et al., 2021). The approach decides on how the battery ought to be charged based on this information. As a direct result of this, the premium price of the gasoline will be reduced. Because of this, it is required to do a sensitivity analysis on the state of charge of the battery in order to ascertain the impact that an appropriate control mechanism will have on the model that has been optimized (Singh, Baredar, & Gupta, 2015). Other aspects, such as the tower heights for wind turbines (for which two distinct towers were chosen), as well as the reflectivity of solar photovoltaic panels, were put through sensitivity testing since it was anticipated that the energy systems would be installed at sea. During the course of the testing, both of these considerations were given attention and attention was paid to them (Yasin & Alsayed, 2020).

Chapter 4: Case study and Results

Norway is a nation in Scandinavia that is well-known for the mountains, glaciers, and enormous fjords that can be found there. The Viking Ship Museum in Oslo, Norway, has reproductions of ships that were in use during the Viking Age.

The construction of Hywind Tampen is now under way, and the company Equinor, which is the leading natural gas exporter in Europe, is in charge of the project. Despite the company's current efforts to establish itself as a pioneer in the field of renewable energy and become a market leader there, it appears that Equinor is unable to move beyond its roots in the oil and gas industry. This is the case despite the fact that the company is currently attempting to move beyond its roots in the oil and gas industry. In addition to this, the process of drilling for oil uses a substantial amount of energy, particularly when it is carried out at sea. Diesel engines are typically the ones responsible for the generation of energy of this sort.

Electrek reports that construction of what will be the world's biggest offshore floating wind farm has begun in Norway. The farm will be situated off of Norway's western coast and will be used to power local oil and gas operations. In the past, the North Sea has been recognized for having wind speeds that are considered to be rather high. It is feasible that floating offshore wind energy facilities might prove to be quite advantageous in this region. In 2018, we reported that preparations were being made for the operation of a floating offshore wind farm in Scotland with a capacity of 50 megawatts (MW), which is enough to supply power to 55,000 families. The farm is expected to have a capacity of 50 megawatts (MW). Just before the year ended, a brand-new wind farm was put into operation in the United Kingdom off the coast of Yorkshire. This wind farm has the potential to produce 1.3 gigawatts of electricity.

Key Assumptions:

The hybrid energy system was designed with secondary data, which was calculated using software simulations using HOMER Pro. The well-known organization NASA provided meteorological data base on the site location, and the price or cost of renewable energy components were collected from recognized source like IRENA and many official websites were used as well. Table 1, shows the summary of the main assumptions.

Table 1. *Key assumptions*

	KEY ASSUMPTIONS		
	Data	**Value**	**Source**
1.	Inflation rate	6.80 %	https://tradingeconomics.com/norway/inflation-cpi
2.	Project lifetime	25 years	Homer pro
3.	Discount rate	8 %	https://tradingeconomics.com/norway/inflation-cpi
4.	Gas	$ 1. - $ 1.5 /litre	from Market vendor
5.	Diesel	$ 1.750 - $ 1.850 /litre	Cnn money
6.	Offshore Wind	$ 780-2000/kW	National Renewable Energy
7.	Floatting solar	$ 800- 1800/ kW	National Renewable Energy

The model is dependent on a number of assumptions due to the fact that the specific location of the site has not yet been defined. Several of these presumptions will be discussed in further depth in the following sections. An internal dataset that mirrored a normal climatic year was used to predict the location. It was modelled that a solar block might have a power output of 50 megawatts (MW), a storage capacity of 50 megawatt hours (MWh), and a cost of $3.8 per kilowatt-hour (380 USD/AC).

This is equal to 181.47 euros per megawatt hour (based on the current exchange rate of the euro to the dollar, prices for ICE are presented in euros per MWh). The price of gasoline just hit an all-time high of $2,145 for every 1,000 cubic meters that are sold, surpassing any previous record

The assumption of a DC:AC overload ratio of 30 percent results in an increase in the estimated yearly generation. It is possible that the actual capacity utilization factor will reach as high as 23.74 percent of its potential. If the procurement process took place in either May or June of 2018, the total cost of Engineering, Procurement, and Construction (EPC) would be about US$540 per kW of AC, with an overage of 30%. In the event that we do any shopping in 2018, we should plan on spending around this amount. The component that is used to define the panel has to account not only for the deterioration of its individual modules but also for the overall deterioration of the panel as a whole. It is anticipated that the pace of system deterioration would accelerate by 0.8% per year going forward. We have operated on the assumption that the annual rate of inflation would be 6.5%. It is anticipated that the yearly operating and maintenance expenses associated with solar blocks will be 350,000 Indian rupees per megawatt, which is equivalent to around $5 per kilowatt. It is projected that the cost of the storage block will be ten dollars (USD) per kilowatt (KW) each year. It considers the often more affordable price that may be found given by Indian enterprises. A rate of interest of 10% has been taken into consideration as an option. It is standard operating procedure for the company to replace a battery whenever its capacity drops below 80%. If the battery's performance drops to less than 80 percent of its full capacity, this indicates that it should be destroyed and replaced with a new one. After this is finished, there is a good chance that eighty percent of the functioning will be back to normal. This mechanism will remain in continual operation for the whole of the plant's productive life. The model does not take into consideration the possibility that after a certain amount of time, a large number of batteries may need to be replaced all at once. It has been hypothesized that there would be a rise of 3 cents in the price of power purchase agreements for every extra 50 MWh of storage capacity in the United States. The financial model and the economic model are both based on the same set of basic assumptions that were used to create them. The following are taken into consideration, although in a more abbreviated manner, in the economic analysis: decreased emissions of greenhouse gases, which is equivalent to preventing production at thermal power plants that rely on fossil fuels (mostly coal). The gas turbines are the common source of electricity for the offshore oil and gases. These turbines are located on the platform where the offshore and gas rigs work. But there are some bad outcomes of this source of electricity. The demand of the electricity is completed with the help of two turbines. As for backup a third turbine is also present. They add environmental threats by gas emission, by releasing heat and by generating noise (Jaurola, Hedin, Tikkanen, & Huhtala, 2019; N. Majdi Nasab, M. Islam, K. Muttaqi, & D. Sutanto, 2021).

Project Resources:

To start any project with Homer pro, we should define the location where the system will be installed. After that, the software suggests wind and solar data to start simulation. There are many other parameters add in the system, such as temperature and wind speed, they are provided NASA power.

The use of solar energy can lower the use of fossil fuels they ensure sustainable upstream petroleum industry (N. Majdi Nasab, M. R. Islam, K. Muttaqi, & D. Sutanto, 2021; Majdi Nasab, Kilby, & Bakhtiaryfard, 2021). The size of solar energy system was estimated according to the power requirement by the production site.

Figure 6*. Solar Global Horizontal Irradiance (GHI)*

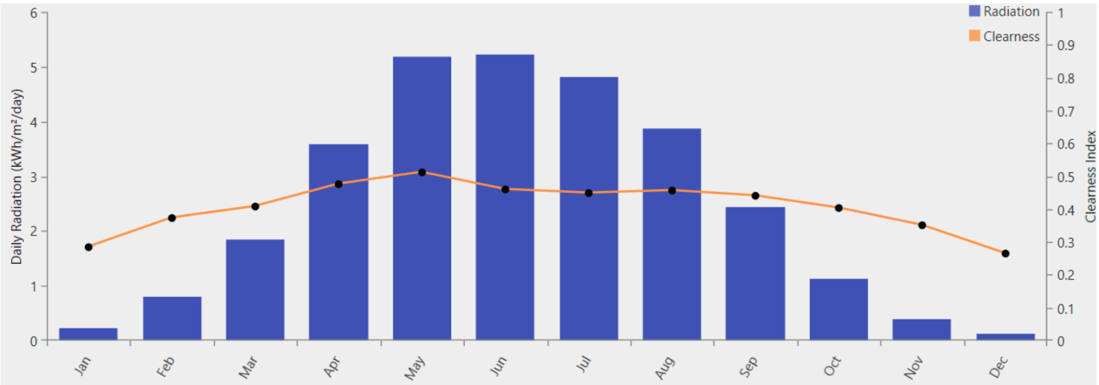


***Table 2**. Solar GHI Table*

Month	Clearness Index	Daily Radiation (kWh/m²/day)
Jan	0.284	0.230
Feb	0.373	0.790
Mar	0.408	1.840
Apr	0.476	3.580
May	0.512	5.180
Jun	0.460	5.230
Jul	0.449	4.820
Aug	0.456	3.870
Sep	0.441	2.430
Oct	0.403	1.130
Nov	0.351	0.380
Dec	0.265	0.130

Figure 6 and Table 2 present the monthly solar GHI, the maximum value for Clearness Index is 0.512 in May and the daily radiation is higher in June with 0.460 kWh/m^2. The software will use these results to find the power generation capacity.

It depends upon the intensity of sunlight, the efficiency of the solar cell, the size of the panel and the amount of sunlight hitting directly to the panel (Recalde et al., 2019; Shaikh, Shaikh, Memon, Lashari, & Leghari, 2021). The output energy gained from the solar energy system depends on the latitude of the point, the time, and that day of the year.

***Figure 7**. Monthly Average Wind Speed*

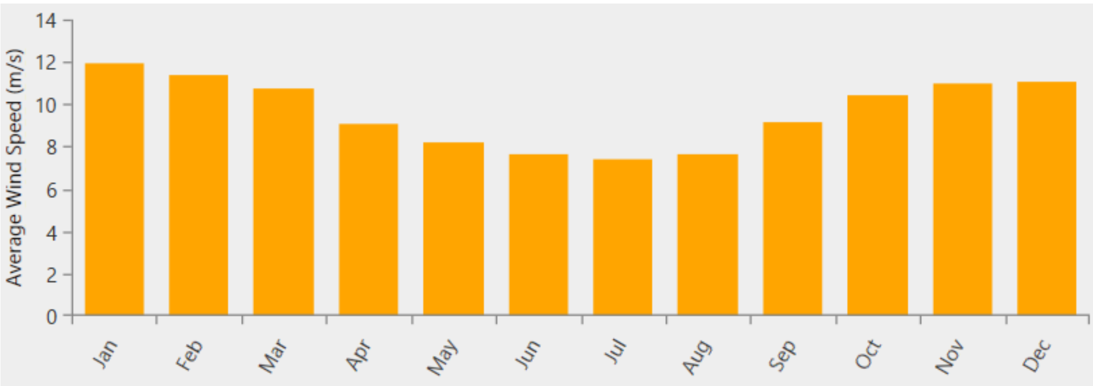
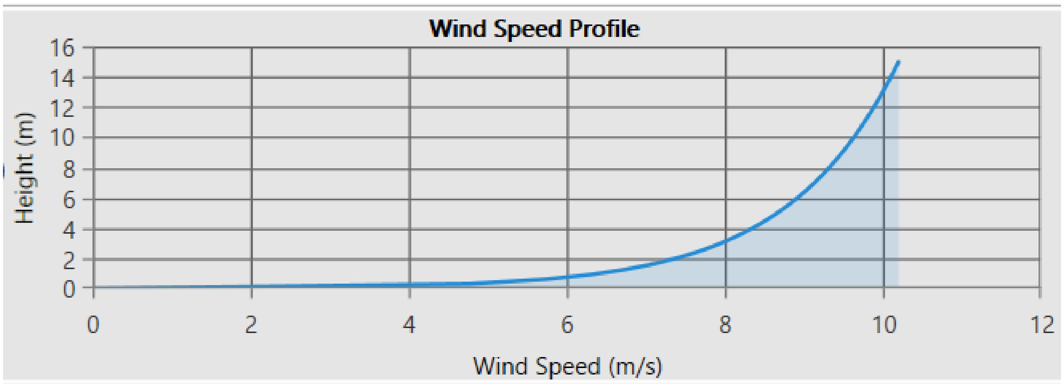


***Table 3**. Wind Speed table*

Month	Average (m/s)
Jan	11.970
Feb	11.360
Mar	10.720
Apr	9.090
May	8.200
Jun	7.650
Jul	7.430
Aug	7.610
Sep	9.130
Oct	10.440
Nov	10.950
Dec	11.030

Figure 8. *Wind Profile*



The wind conditions near the platforms are really beneficial (Ishraque, Shezan, Ali, & Rashid, 2021; Jahangiri, Haghani, Shamsabadi, Mostafaeipour, & Pomares, 2019). As showed in the figure 7, the maximum speed of wind is 11.970 m/s. then it gives theoretically about 4000 to 4800 hours.

HOMER calculates the output power from the wind turbine using equation 2.

$$P_w(v) = \begin{cases} 0, & 0 \leq v \geq v_{in} \\ P_r \cdot \dfrac{v - v_{in}}{v_r - v_{in}}, & v_{in} \leq v \geq v_r \\ P_r, & v_r \leq v \geq v_{out} \\ 0, & v \geq v_{out} \end{cases}$$

…………… Equation 2

Where:

P_w = Output power of wind turbine

V= wind speed

P_R= turbine rated power

V_{IN} = Cut-in speed

V_{OUT} = Cut-out speed

P_R = Rated power of WT

Simulation Component:

The term "Component" in HOMER refers to any part of the system that generates, stores, or transmits electric or thermal energy and whose size or amount is an optimization variable. Components include photovoltaic panels, diesel generators, and wind turbines.

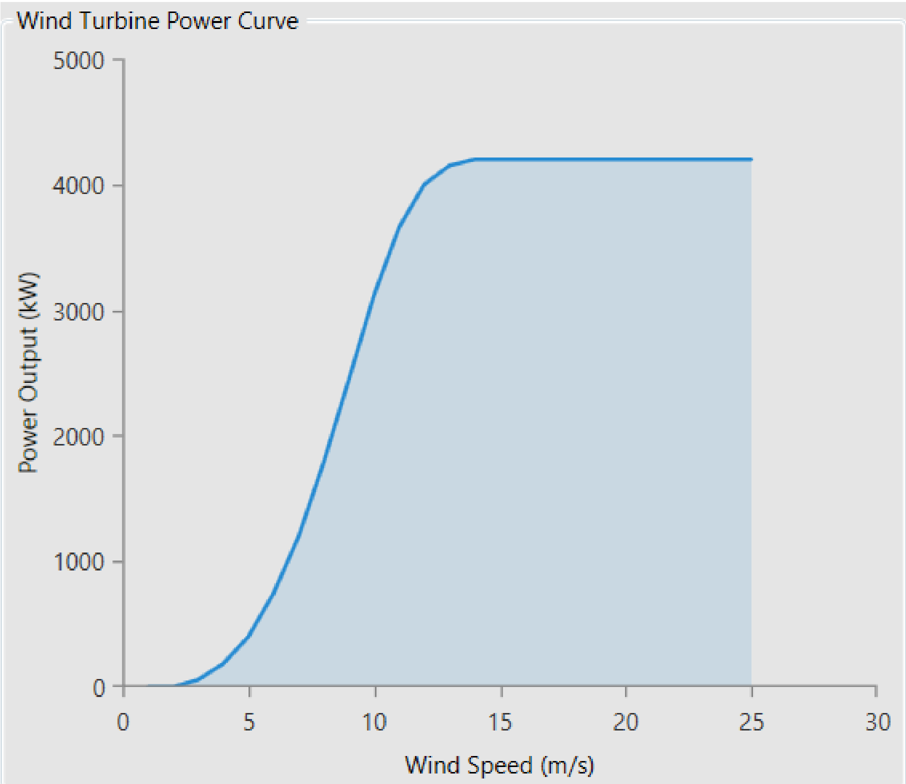
WIND TURBINE:

in this modeling, Enercon wind turbine was used, and the selected model is E-126 EPA with 4.2 MW power production capacity. Due to the high demand of energy, five units of the model were selected with total power of 21MW and the capital cost is around $5000000, Replacement cost and O&M cost are respectively $3000000 and $60/year. Table 4 gives a list of some important parameters of the turbine. This E-126 EPA model is suitable in site location, because the wind speed of the location (Maximum 11.9) is in the same range of the optimum production of the turbine, as showed in figure 9 of wind power curve.

Table 4. *Wind turbine parameters*

Component	Description	Source
Manufacturer	Enercon	Homer pro
Model	E-126 EPA	Manufacturer
Rated power	4200 kW	Manufacturer
Cut in speed	<3 m/s (6.7mph)	Manufacturer
Cut out wind speed	28-34 m/s	Manufacturer
Hub height	135m	Manufacturer
Life time	20 years	Manufacturer
Initial cost	$780/kW	(IRENA, 2022)
Replacement cost	$468/kW	(IRENA, 2022)
O&M cost	$60/year	Assumed

Figure 9. *Wind power curve*



SOLAR PV MODULES:

For the solar panel module, the Generic flat plate from homer pro catalogues, with 1KW power generation capability. The lifetime of the system is 25 years according the manufacturer brochure and it has 90%, which is found in table 5. According to the most recent annual U.S. Solar Photovoltaic System Cost Benchmark study that was carried out by the National Renewable Energy Laboratory, one-axis tracker utility-scale PV O&M costs have decreased from $20/kW/year in Q1 2017 to $14/kW/year in Q1 2018, including the costs of inverter replacement. This decrease came about as a result of a decrease in the cost of inverter replacement. This price decrease was seen in utility-scale PV installations (NREL).

Table 5. *Solar PV parameters*

Component	**Description**	**Source**
Manufacturer	Generic	HOMER
Model	Generic flat plate PV	HOMER
Rated capacity	1 kW	HOMER
Ground Reflectance	20%	HOMER
Panel type	Flat plate	HOMER
Capital cost	$2500/kW	IRENA
Replacement cost	$1500	IRENA
O&M cost	$50	Assumed
Derating factor	80%	HOMER
lifetime	25years	HOMER

Battery storage and Gas turbine Generator:

RES are not available all the time, because their production depends on the presence of sun or wind speed. So, to tackle those issues, there is a need of system storage, in this case the generic 1MW Li-on battery is installed, with 600V and more information are in table 6.

The current value of all expenditures incurred during installation and operation, in addition to the value of all revenues produced, is the NPC of a device throughout the course of a project's whole duration. When determining whether the battery should be charged by renewable sources during times of low net load or by a diesel generator during periods of high net demand, the mixed dispatch technique considers the total cost of ownership. As a direct consequence of this, you will have a reduced need to spend money on fuel.

Table 6. *Battery Storage*

Properties

Idealized Battery Model
Nominal Voltage (V): 600
Nominal Capacity (kWh): 4.22E+03
Nominal Capacity (Ah): 7.03E+03
Roundtrip efficiency (%): 90
Maximum Charge Current (A): 1.76E+03
Maximum Discharge Current (A): 1.76E+03

Gas turbine is most cost-effective way to generate electricity on offshore oil platform, but it has negative environmental impact due GHG emissions. So, to reduce the emissions, there is a need to design a hybrid system with RES. Signal Power group 3MW, is used in this case. The generator works with natural gas with 0.96 g/m3 emissions of CO2. Below, table 7 shows the values of some other parameters.

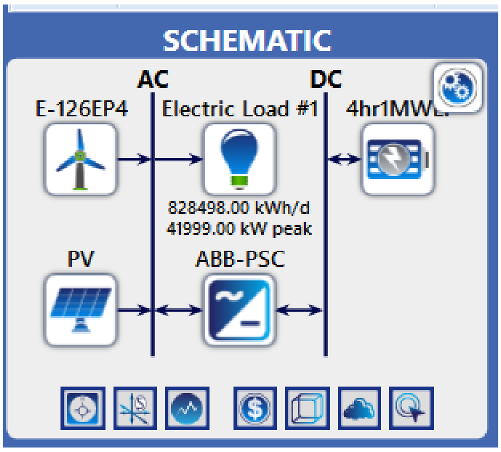
Table 7. *Gas turbine parameters*

Component	Description	Source
Name	Signal Power group 3MW	HOMER pro
Fuel	Natural gas	HOMER pro
Capacity	3000kW	HOMER pro
Fuel curve intercept	184m3/hr	Manufacturer
Fuel curve slope	0.322m3/hr/kW	Manufacturer
CO2 emission	0.96 g/m3	Manufacturer
Fuel price	$ 1 - $ 1.5 /litre	Manufacturer
Initial cost	$1800000	Market price

Chapter 5. Discussion and interpretation of findings

In this research, two simulations were conducted in the software. The model was designed with the assumptions of floating wind and solar PV, including battery storage. All the components are presented on figure 10. To design this model, the electrical bus which connect the energy sources to the electric load, are in AC mode, because of the constant demand of electricity of the platform. If the DC mode is selected, that cause some delay in the transmissions of energy.

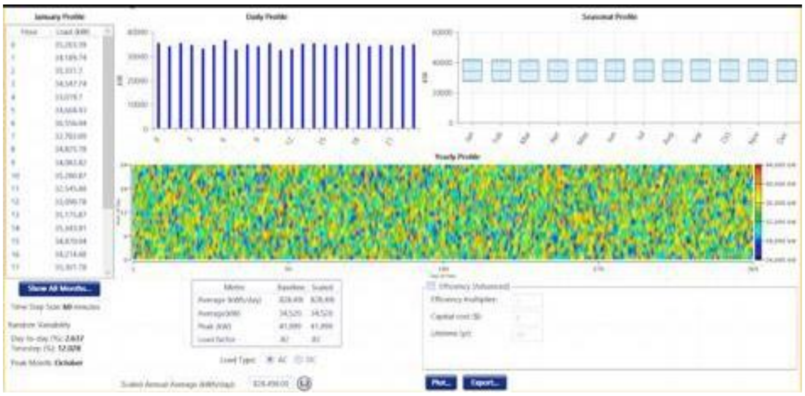
Figure 10*. Schematic RES*



However, there is a need for the battery storage to make sure that the platforms will always have electricity. And for that reason, the DC bus and convertor or inverter were added to the system, the combination of all the components gives more realistic result. The increased dependability of inverters, which has resulted in the industry practice of extending considerably longer warranties, is partly responsible for the decreased O&M expenses, which may be credited in significant part to this improvement. Increasing the leakage current and minimizing the series resistance of inverters, in addition to providing superior environmental protection for the running electronics, might prolong the life of inverters to 25 years.

It has been examined how well the HES rough size corresponds to the ideal system size as established by the simulations carried out by HOMER Pro. Because of this, the energy mix in such HES is often consistent, which indicates a connection between the temporal variations of the different types of energy sources. When a system is powered only by renewable energy sources, the ideal energy mix is one that is very similar to the energy mix that was specified when the system was first sized. According to the findings, the most NPC-efficient solution only utilizes 67% renewable resources. At the moment, the efficiency of ESS is higher than that of solar PV, which means that ESS is the most economically feasible option. A wind turbine with this kind of configuration requires a swept area coefficient (SoC) of 20% and a hub height of 30.5 meters. Towers of varied heights will need to be used if there is any hope of mitigating the wave that will be produced by the wind turbine cluster. ESS The System-on-Chip (SoC) is a sensitivity variable due to the fact that the selected dispatch mode often puts less focus on the collection of energy and the smoothness of the power output in order to reduce the amount of money spent on operating and maintenance costs. Future work will focus on optimizing power management strategies by utilizing the ESS SoC, conducting a sensitivity analysis of the tower's height, and designing the electrical system to include a hybrid linked AC-DC bus.

***Figure 11**. Consumption overview*



The energy need of the platforms were estimated to be 40MW, the value was based on existing platforms consumption. Figure 11, gives us an overview of the electricity consumption. The daily profile is quite constant, which can be explain by the fact that the number of equipment working and people on bord do not change often. And the Seasonal profile follows the same pattern. Even if the global demand of electricity changes during the year, the production capacity of offshore structures remind the same during the year.

Homer pro make the simulation using initial cost, replacement cost of all added in the model. So, in the model the optimum solution was to combine solar, wind and batteries. On table 8, it shows that the system needs 89 batteries, 23 wind turbines and 2.3 GW for solar power and the NPV is $243M. the fact that the NPV is lower, the project is more attractive for investors. There in not emissions in this model, because only RES systems were installed. However, we have to add a permeant generator in the model. The generator source will be Gas turbines, and they are commonly used on oil production facilities.

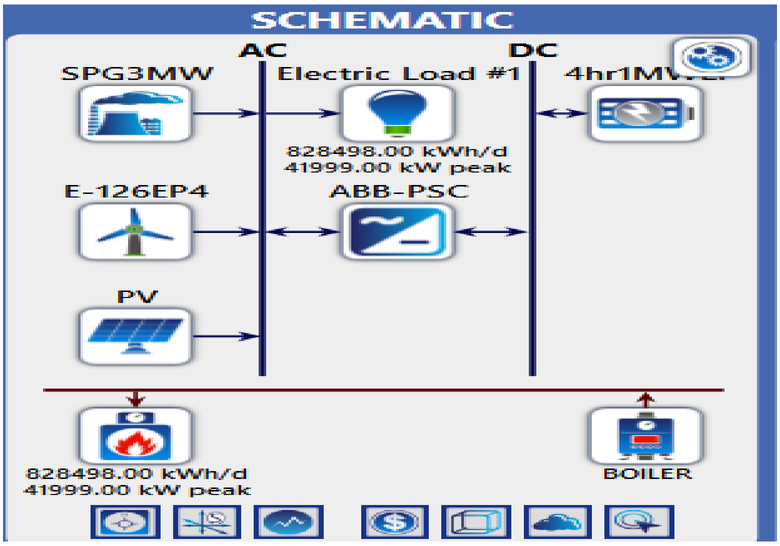
Table 8. *Optimization results*

Architecture					NPC ($)
PV (kW)	E-126EP4	4hr1MWLI	ABB-PSC (kW)	Dispatch	NPC ($)
2,339,436	23	89	43,830	CC	$243M
	35	119	44,957	CC	$282M

Second simulation with gas turbine:

In this second simulation, gas turbine and boiler were added to the project to have hybrid RES and thermal solution, as showed on figure 12. The integration of thermal source increases the overall cost of the project and cause GHG emissions as well. In table 9, we can see that the best solution for the simulation is selecting 20 turbines, 96 batteries, 748,7MW solar power and the NPC is $705M. in this simulation gas turbine, the NPC is four times higher than the model with only RES. The reasons for this extra cost can be link the thermal source initial cost and the boiler installation. The Cost of Energy (COE) produced by second configuration, which makes exclusive use of diesel generators, is more than twice as expensive as that produced by the hybrid design, which is the design that is the most efficient all around. It seems like the first model is more benefic for business point of view, but in reality, wind and solar together produce half of the energy demand. So, in order for the RES to fulfill all the electricity need, we have to triple the size the system, and in term the cost will be higher.

***Figure 12**. Schematic with gas turbine*



In order to better highlight the NPC value that may be attained when the amount of solar PV and wind is equal to or less than the value anticipated by the preliminary sizing, a new configuration, has to added to be take into account. The largest quantity of energy, 88.3%, is produced from sources that are not conventional or that are beneficial to the environment. The only design that is comprised entirely of renewable energy sources is design, which receives 75.36 percent of its electricity from wind, 20.54 percent from solar.

Table 9.*Optimization with gas turbine*

Architecture						
PV (kW)	E-126EP4	SPG3MW (kW)	4hr1MWLI	ABB-PSC (kW)	Dispatch	NPC ($)
748,761	20	3,000	96	40,973	LF	$705M
2,432,412	25		88	43,649	CC	$711M
	35	3,000	124	41,010	LF	$742M
	35		120	44,755	CC	$749M

Oil and gas extraction necessitates energy-intensive procedures that emit pollutants into the atmosphere. One of numerous alternatives for reducing CO2 emissions from offshore oil and gas installations on the Norwegian continental shelf is to electrify them. However, there is a continuing discussion about how increased electricity use would affect CO2 emissions in the power sector, both in the short and long run (Riboldi et al, 2019). In our simulation, the CO2 emission value is around 95829kg/year, the Sulfur Dioxide (SO2) is 237kg/year and Nitrogen Oxides (NOx) is 328kg/year. This result in table 10 significant reduction in GHG emissions.

Table 10. *GHG emissions result*

Quantity	Value	Units
Carbon Dioxide	95,829,787	kg/yr
Carbon Monoxide	83.6	kg/yr
Unburned Hydrocarbons	1.94	kg/yr
Particulate Matter	0	kg/yr
Sulfur Dioxide	237,178	kg/yr
Nitrogen Oxides	328	kg/yr

So, it is clear that the hybrid model is one way the cut down air and environment pollution. Reduce CO2 emissions from oil and gas activity by connecting to the shore and using offshore wind, among other possible measures.

Chapter 6: Conclusion and Recommendations

A big number of important companies are doing research to assess if offshore platforms can use wind or solar power in light of the many opportunities that are now available. Research goals included determining ways to reduce greenhouse gas emissions from offshore platforms, optimizing the energy consumption, and transforming them into much more energy-efficient platforms. One driver to use RES to electrify offshore rigs, can be economical and financial. Solar and wind are available for free, it is will result in money saving on electricity bills. So, oil and gas companies can directly use marine energy to produce electricity on their platform and at the same time they will save many among of fuel or gas. However, RES project come with high initial investment cost, and in particular offshore floating wind and solar are very expensive compare to onshore installation. In the long term, RES will be cost effective for investors and with all the studies and the technology development in Marine energy, many innovative solutions will make RES more efficient and they will create more opportunities in the future. In addition, socio-political and environmental issues motivate the used of RES for oil platforms. In fact, high demand of energy for the population is opening doors for offshore structures, which in term will creative new jobs in related to Maritime energy. Moreover, green energy comes with positive impact on the planet by reducing GHG emissions. Nevertheless, Big fossil energy producers are making the energy transition more difficult, because they don't want loose money in the business. The lake of international regulations in offshore oil and gas platform activities, is another barrier to full implementation of green solution in high seas. In the recent years many oil companies started investing offshore energy, and their platform can be used for producing green hydrogen. The hybrid system also has less benefits for the environment if it supports the non-polluting ways (Hu et al., 2020; Ishraque & Ali, 2021). So, for saving the environment from pollution offshore wind technologies have developed even for deep sea. In that way, they will contribute in the green transition with positive impact on the environment and human health.

In this research, the modelling software known as HOMER Pro is used. The projected size of the hybrid energy system RES and GAS was compared to full green one. Homer pro is one of the best options when it comes RES simulation, and gives to the user a clear view about the system configuration, cost benefit and the GHG reduction possibility.

However, instead of all of the implications and significance of the study, there are some limitations to it as well. First of all, the study has covered very limited amount of data for the purpose of carrying out case study-based research. In fact, many assumptions were made the electricity consumption, price of energy source component, which is due to fact that there is no real model of the solution in the industry right now. Moreover, the time constraints have also refrained the researcher from doing extensive research which can also be considered by the future researchers in similar studies. So, the future researchers can be done on the Hywind Tampen from Equinor in Norway. Furthermore, electrification of offshore oil platform with wave or tidal power is another way to explore and the hybrid solution with wind, solar and wave should be analyzed too. To make the system more efficient and optimal, some studies look how digitalization solutions can be apply to integration of hybrid RES in to offshore platform. Artificial Intelligence (AI) and digital twins are options to apply, because they can predict and forecast future demand of energy base weather, model simulation data and decision-making tools. Recent developments in predictive analytics have resulted in a decrease in the number of plant problems and an improvement in plant efficiency. An increasing number of businesses are working to optimize the deployment of marine energy. The plant's efficiency has increased as a consequence of investments in new cleaning equipment and scheduling software, which he says have contributed to the improvement. The combination of digital and hybrid energy system will lead better energy saving, the market will be more attractive for investors and ghg emissions will be reduce significantly.

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