A Revelatory Case Study for the Emergence of Powerships: The Floating Power Plant Innovation for Rural Electrification

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The existence of energy is essential to countries striving to survive, both socially and economically. In this context, countries establish different types of power plants and use alternative energy resource,s such as solar and wind power, to meet their energy needs. Establishing power plants and using alternative energy resources are tough for some regions, such as Middle Eastern, African, and Asian countries. Thereby Powerships have been developed due to the consideration that these countries suffer from energy deficiency and encounter difficulties in building land power plants. In this study, the emergence of Powerships, providing electricity to energy-deficient countries and the successful launch strategies, are investigated. A single revelatory case study concept is used to understand what exactly the Powerships are, where they operate, positive and negative situations encountered during operation, as well as economic benefits compared to other systems. In this context, together with the intensive literature review, semi-structured interview questions are prepared for several company officials and former employees and detailed evaluations are described in the Powerships operation process. Semi-structured interview questions results are evaluated and discussed with a view to understanding how the company has successfully launched its innovative product to the energy market. This article will, we hope, represent a significant resource for experts, academics, and companies working on floating energy power plants in the future.

KEY WORDS
~ Electricity
~ Powerships
~ Single revelatory case study
~ Innovation
~ Energy demand

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doi: 10.7225/toms.v11.n01.w10

Received on: Jun 28, 2021 / Revised on: Dec 22, 2021 / Accepted on: Jan 24, 2022 / Published online: Feb 20, 2022

1. INTRODUCTION

The increasing energy demand causes a great challenge in Middle Eastern, Asian and African countries. The high implementation costs of local power plants and renewable power stations create a reluctance on governments or investors (Mitsubishi Heavy Industries, 2017). The time required to build land-based power stations also poses a barrier against urgent power demands. Besides, considering the so-called regions, the size of the population that is going to be served (Willige, A, 2017), as well as safety issues, may hinder the long-term energy production investments for specific regions. The rural areas, like island countries, also suffer from an energy shortage. Transferring the energy from the mainland via subsea cables is a complex and costly operation to be invested in (Willige, A, 2017). Mainland grid lines are most likely to be separated from the island grids. In this case, local power plants should be built on the island, or renewable energy resources should be used, which are mostly not viable because of the investment costs, reliability issues, energy efficiency concerns, and limited accommodation areas (Lin et al., 2013). The first floating plant "Jacona" was introduced in 1931 to support the power demand of the cities and towns along the New England Coast for emergency cases. The USA also utilised non-self-propelled power barges, including nuclear reactors for power generation, during World War II. The latest non-self-propelled floating power plant designs were introduced with gas turbines, steam boilers and turbines, nuclear reactors, and mostly with reciprocating internal combustion engines (Acuner and Helvacıoğlu, 2017). The floating power plant industry was carried one step further by producing the first floating energy fleet in the world in 2009, which are patented as "Powerships" by the same company (Karadeniz Energy, 2017). Unlike the traditional floating power plants, these innovative Powerships can be propelled with their propulsion systems. Preparation of the plants can be completed within a couple of months after the contract agreement. They can be berthed or moored at a suitable coastal station wherever the interconnection to the main grid is available. The generated power can be fed to the main grid from the onboard high-voltage substation, therefore no land acquisition and minimal onshore infrastructure are required. The fuel demand of the onboard high-capacity generators of the Powerships are supplied via pipeline or through bunkering according to the capability of the on-shore facility. In addition, fuel flexibility on the use of low sulphur HFO, LNG and LPG is provided with the utilisation of dual-fuel engine technologies for power generation. When the contract is over, towing is not required to navigate through where the next customer is located. Compared to land-based power plants, the same amount of power can be obtained in a much smaller area with Powerships. High capital costs for project financing are also eliminated with all-in-one solutions given by the company (Karadeniz Energy, 2017).

In this study, the successful launch strategies during the innovation process of Powerships are discussed. According to the key findings in the literature, semi-structured questions are prepared to be asked of several Powerships officials and former employees. Considering the difficulty of collecting the data, this process constitutes the most tough part of the article. On the other hand, New developments and new project regions about powerships are constantly emerging. Problems that have not been experienced before may arise in new regions, which creates a research gap. Finally, the results are discussed in the next section to understand how the company has successfully launched its innovative product to the energy market. Despite the development of technology, some countries still suffer from energy poverty. This study, as no other in literature so far, examines Powerships that provide a notable advantage for countries in their effort to overcome the energy poverty. The lack of detailed work on this type of ships further enhances the importance of this article. In the first stage of the article, a detailed literature review is made on floating power generation systems. A revelatory case study is used to fully explain all the details about Powerships as a methodology. The amount and duration of the electricity provided from Powerships have been described regionally. Furthermore, semi-structured interview questions, observations, document, and archives results have been obtained and discussed in detail. Installation factor, no need for free space, security factor, fuel flexibility, temporary or seasonal energy demand factor, as well as external source problem, constitute the main topics when the results obtained are evaluated. Consequently, revelatory case analysis on the emergence of Powerships innovation is performed during the process in terms of benefits and difficulties. The academic literature gives very little information on Powerships. Researchers might have hesitated regarding the subject because of the data collection difficulties and the patent issue of the Powerships concept. In this context, the literature review has been carried out on electrical energy production in floating systems. The related literature review, obtained from the search in WOS (Web of Science), is expressed in Table 1. Goswami et al. (2019), conducted a study that compared the advantages of floating solar power plant (FSPV) and conventional land-based PV system. FSPV systems do not cause decreasing agricultural areas and water evaporation, whereas also having more benefits in the angle of the life cycle, economic and emission compared to the conventional ones. The energy obtained by this FSPV power system equals the use of 92945.95 million tons of coal in total, so that FSPV system will prevent 340801.74 tons of CO2 emission. FSPV is economically feasible, considering the

tariff reduction on floating power systems. Examining the studies on floating photovoltaic (FPV) power generation, units Ranjbaran et al. (2019) describe the gains of the FPV system in detail, as well as the system'a main achievements: efficient power generation, reliability and durability, preventing water evaporation, lower operational and maintenance costs and greenhouse gas emission. Renewable energy sources should be used to meet the increasing energy demands, without harming the environment. Thus, Stiubiener et al. (2020) propose a sustainable hydro-solar model to solve the increasing energy demand in the form of renewable energy sources. The hydro-solar model has been on Hydro-Electric Power Plant (HEPP) because HEPP reservoirs contain an expressive amount of flooded areas. This system makes a significant contribution towards meeting the amount of energy with the use of 10 % of these flooded areas at intervals where the amount of solar irradiation is at its peak.

Hu et al. (2020), proposed installing a hybrid system to provide power for the floating offshore structures, also showing the gains on wind platform and multiple heave-type WECs in different wind and wave flow conditions. Uniform wind field, a steady wind field with wind shear, and a turbulent wind field were investigated by Li et al. (2018), and tested for power generation on offshore floating wind turbines. Wind shear and inflow turbulence have a significant effect on wind turbine performance. The existence of inflow turbulence causes an unsteady power generation and thrust force. Moreover, inflow turbulence and wind shear lead to deformation on the wing roots of wind turbines. To reduce emissions from ships, Platzer and Sarigul-Klijn (2018), proposed autonomous sailing ships that use wind energy for power generation. In this study, a small-scale autonomous hydrofoil boat construction is demonstrated for proposed technology testing. In an effort to increase efficiency in power generation by utilisation of nonlinear roll-pitch coupling on a ship, Yerrapragada et al. (2017), used a small-scale ship to describe the advantages of this system in detail. Reis and Gallo (2018), described power production from waste heat by an organic Rankine cycle, aimed at increasing the thermal efficiency and minimising greenhouse gas emissions. A gain of 22 % has been achieved in fuel consumption and carbon dioxide emissions. This system, defined on FPSO (floating production storage and offloading), used for oil exploration in offshore waters, provides a 22 % gain in fuel consumption and carbon dioxide emissions. In addition to meeting the heat demand needed, waste heat recovery system contributes 21 % by approaching electricity generation. Konur et al. (2020), proposed a heat exchanger network designed for a ship to produce power from main engine waste heat sources. Since main engines are used on navigation and generators in harbour mode to produce electrical power, it follows that ships may benefit from organic Rankine cycle systems for increasing the efficiency for burned unit fuel.

Table 1.
Literature Review (Yerrapragada et al., 2017; Platzer and Sarigul-Klijn, 2018; Reis and Gallo, 2018; Goswami et al., 2019; Ranjbaran et al., 2019; Stiubiener et al., 2020; Hu et al., 2020; Li et al., 2020; Konur et al., 2020).

Author	Technologies	Site	Methods/Analysis	System Savings
Yerrapragada et al., 2017	Wave power generation	On ocean waves	Increase power production efficiency	Increased efficiency
Platzer and Sarigul-Klijn, 2018	Generating energy via wind power	Oceans	Multipole systems analysis	Emission reduction, Renewable energy resources
Reis and Gallo, 2018	Waste heat recovery system for Power production by organic Rankine cycle	Brazil	Economic Analysis	Emission reduction, Increased thermal efficiency
Goswami et al., 2019	Floating solar photovoltaic (FSPV)	Neel-Nirjan Dam of Bakreswar Thermal Power Plant (India)	FSPV system compare with the land-based PV system	Cost, Emission, Life cycle, Agricultural areas, Water
Ranjbaran et al., 2019	Floating photovoltaic power generation	Describe all studies on FPV	Highlights the pros and cons of FPV	Water, Cost, CO2 reduction, Efficiency, Reliability and Durability
Stiubiener et al., 2020	Generating energy from PV panels without occupying large land extensions	Brazil (Southeast/ Midwest; South; Northeast and North)	Analyze the feasibility of changing the hydro-thermal model by the hydro-solar model	Agricultural fields, Water quality, Cost, Natural life
Hu et al., 2020	Floating offshore wind platform Multiple Heaving Wave Energy converters (WECs)	Shandong province, China	A numerical model was developed for systems optimization	Power generation Using renewable energy resources
Li et al., 2020	Power generation on three different wind conditions	China	Aero-hydro-servo coupled analysis	Power generation with three comparative wind fields
Konur et al., 2020	Waste heat recovery system for Power production by organic Rankine cycle	All available waters for shipping	Pinch point analysis; Thermodynamic analysis; Exergy analysis	Electrical power production, Increased thermal efficiency, optimal waste heat recovery

The identity of Powerships according to IMO (International Maritime Organization) regulations was discussed (Ataergin, 2015). Powerships were described as floatable power structures which have been transformed from a ship. It has been stated that only Annexes IV, V and VI of IMO's MARPOL Convention show them to be fully applicable to Powerships. Although Powerships are treated as ships within the ship industry's approach, some definitions need to be regulated, as the rest of the annexes show the only relation to the navigability of the vessels.

2. METHODOLOGY

2.1. Single Case Study Structure

The case study method allows researchers to examine the data closely in a specific context. In general, a case study method refers to a small field of study and a limited number of people (Zainal, 2007). In this approach, work design is flexible and data collection and analysis are largely determined by the subject and certain procedures are decided when the work is in progress (Fidel, 1984). The researchers must decide whether to use a single case or multiple case study before any data collection when performing case study designs. There are two types of single case studies. One of them is represented by holistic case studies and the other is embedded case studies. Holistic case studies are examined under five headings, and these are: "Critical Case" "Extreme Case or a Unique Case", "Representative or Typical Case", "Revelatory Case" and "Longitudinal Case" (Yin, 2014). The revelatory case is used when a researcher has the opportunity to observe and analyse a phenomenon that was previously unavailable for social science research (Yin, 1994). The study aims at giving a deep knowledge about the Powerships, especially operating the energy poverty regions. A detailed literature review has been performed on Powerships and floating power production systems. The information obtained on the floating power production systems, using renewable energy, has been given in the literature review section, there being not much more academic information on Powerships, A revelatory case study was carried out using semi-structured interview questions on administrative and technical stuff, observations and documents. Evaluating the data obtained from powerships, six significant factors (installation factor, challenges of installatıon area, security factor, fuel flexibility, temporarily or seasonal energy demand factor, external source problem) have been highlighted. All stages are reviewed on the flowchart and a conclusions section has been created. The flowchart of the article is indicated in Figure 1.

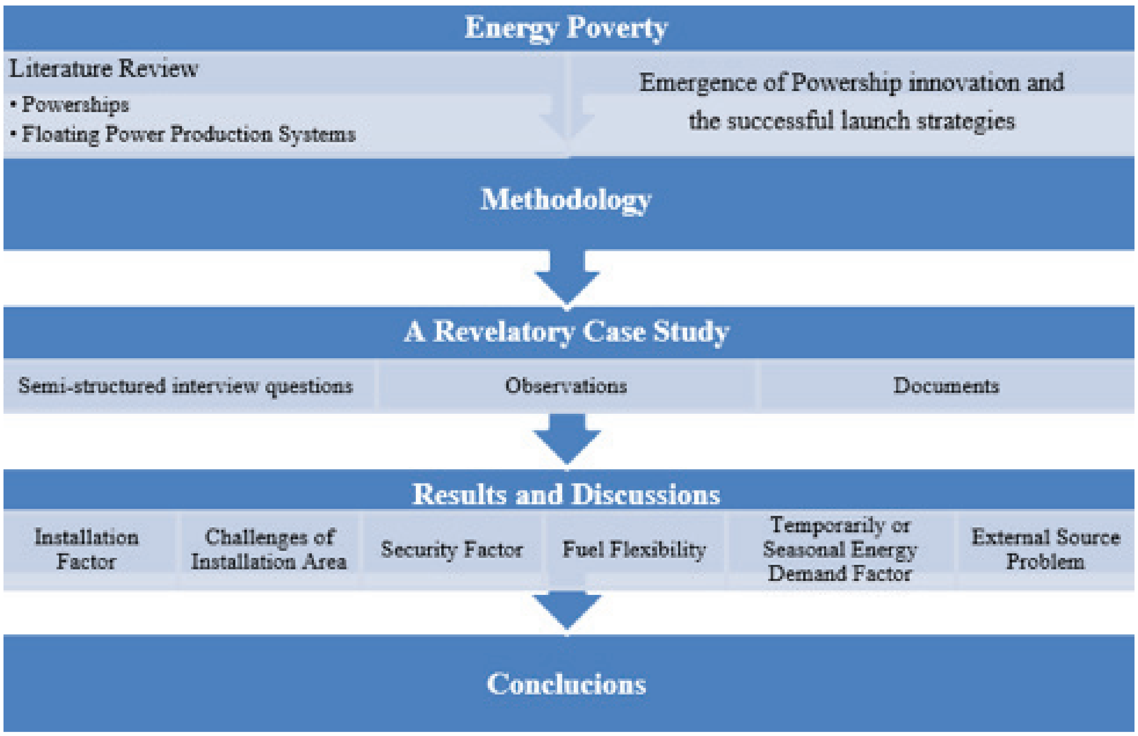

Figure 1.
The flowchart of the article.

2.2. Semi-structured Interview Questions for Revelatory Case of Powerships Emergence

Building a floating power plant and temporarily submitting it to the region is a project that contains many details and needs attention, despite its many advantages. However, success can be achieved as a result of meticulous planning. Technical and administrative evaluations, concerning the reasons for the need for these ships, and how the idea of building these ships and producing electricity has emerged, are explained in Table 2, by interpreting the expert opinions.

The most important factor that makes this project important and makes it so difficult to implement is that, even though ships have the same equipment and infrastructure, the difficulties and risks they may encounter in each region they go to are different from each other. Sometimes the biggest challenge is the geological structure of that region, sometimes the political and sometimes economic difficulties can be encountered. You can see the answers we have received in Table 2, with the questions we asked to cover all possible problems questions answers.

Table 2.
Selected excerpts from the answers to interview questions.

Interview Questions	Administrative Stuff	Technical Stuff
How did the "Powerships" idea come about?	"The idea is basically not new. There are small power plants installed on barges to be used on-demand near the riverside regions." "Considering the chaotic order in Iraq/Basra region, energy demand was wanted to be covered by a mobile power plant."	
Why are the Powerships being preferred?	"Powerships maintain their presence according to geological difficulty and socio-economic underdevelopment factors of the countries."	"A floating and transitory power plant is more economical and more secure than land-based power plants."
How economical are the Powerships compared to other systems?	"Powerships can bring profit from time and money with the ability to transfer all the equipment at once." "The demanding countries may produce energy from solar power in a cleaner and more economical way. However, this situation is related to the world's political vision."	"Powerships are more economical in a way that can provide more power in a limited area." "There is no need for cabling to rural areas because the ship arrives directly to the demanding location."
How are the fuel contracts made (by whom, what kind of fuel is used)?	"The fuel demands of the projects have been met locally by this time. HFO is most likely to be used. These conditions depend on the agreement."	"HFO and natural gas can be utilized. Fuel has generally been supplied by the contacted government."
Do you have security problems (both staff and plant)?	"According to the specifically created security procedure for each project, secure space is created with the help of the related unit of government." "It is natural to be the targets of rebel groups in chaotic regions because the agreements are made with the governments. The security is provided with highly qualified security procedures."	"Floating feature gives an advantage to Powerships in the case of security compared to land-based power plants."
The number of the crew working on the ship and their sufficiencies?	"The crew consists of operation and maintenance crew, life supportive staff, and the crew required for being a ship."	"There has Bangladeshi personnel to do the cleaning duties. Also, local people have been working as engineers and electricians according to the agreement with the government."
Have you experienced a problem with the safety of the staff and the environment?		"I haven't experienced any environmental problem on the ship. MARPOL regulations are applied and necessary inspections are carried out by class society and port state."

What other difficulties do you face (Operationally and socially)?		"Some engines are stopped at nights because the energy need is reduced." "Operation of the engines might be hindered in bad weather conditions, because of clogged seawater filters."
How do you see the Powerships future, what are your plans?	"The Powerships will stay on market as long as the fossil fuel-based energy production continues in the world."	"The fleet will expand with the rising demand. Powerships are the fast-foods of the industry. The company gives the fastest option to provide energy. Who wouldn't want this?"

3. EVALUATION OF POWERSHIPS PROJECTS

The regions in need of energy and the Powership operations, as carried out in these regions, are expressed in detail in terms of the amount of energy provided. Old and new Powerships projects are explained in detail in Table 3. In the first stage Iraq, Lebanon, Pakistan, Ghana, Zambia, and Indonesia Projects are conducted. In addition to older projects, new ones are added for 2018 and, beyond for such projects, the ones in the Sudan, Sierra, Mozambique, Senegal, Guinea, Guinea-Bissau, Gambia and Cuba Projects.

Table 3.
Areas and details of the projects.

Areas	Project Details
Iraq Project	Energy supply company vessels operated with a total of 410 MW. In 2010, Iraq, the first country to send Energy ship, it also carries the title of the first country to order an extra energy ship and request extension to the contract.
Lebanon Project	In 2012, Powership signed a contract with the Lebanese Electricity Utility for 2 energy vessels with a total production capacity of 270 MW. In 2016, the capacity of Energy supply company ships has been increased. The capacity of Energy supply company vessels has started to operate in the country with production exceeding 370 MW and the contract period has been extended for another 2 years. In 2018, the contract period was extended for an additional 3 years. Powerships meets 25 % of Lebanon's total electricity needs.
Pakistan Project	Upon the agreement between Karpower Company and Pakistan, two Powerships belonging to Energy supply company started producing energy and feeding Pakistan energy systems. However, the Pakistani government in the period did not fulfil the contractual obligations, did not provide the necessary fuel for the energy production, nor gave the agreed money for the service provided.
Ghana Project	In the Ghana project, two Powerships have been supplying 225 MW of energy operating at the Port of Tema with the Ghana Electricity Administration. The Powership contract for the Ghana region was the first African country project to be signed, as well as a hub for the West African region. Ghana electricity purchase contract has been 5 plus 5 years, 10 years in total. Powerships have the advantage of dual-fuel flexibility that can provide low fuel costs. Moreover, Powership engines can both be operated by HFO (Heavy Fuel Oil) and natural gas. The first energy ship operated in December 2015 with a production capacity of 235 MW and the second with 470 MW capacity in 2017. This is the first project in Africa. is supplying 26 % of Ghana's total electricity needs.
Zambia Project	Zambia has agreed with Powership to support the defective power sector. Under this project, 100 MW of electricity has been supplied. The Turkish company supplies electricity with power ship called "Irem Sultan" to Zambia for two years. Zambia is a non-coastal country. For this reason, the ship anchored in Nacala port in Mozambique. The electricity is supplied to Zambia via cross-border interconnection lines through Mozambique and Zimbabwe. The transfer of the economically critical electricity on this route is also the first cross-border electricity transfer in the world with a single energy ship.

Indonesia Project	In 2015 and 2016, five contracts were signed with state utility PT PLN (Persero) to supply 1000 MW of electricity for 5 years with 5 Powerships at 4 Islands. It meets 30 % of North Sulawesi's, 55 % of East Nusa Tenggara's, 80 % of Ambon's, 10 % of Medan's total electricity needs.
Sudan Project	In April 2018, a contract was signed with Sudan Thermal Generator Company (STPGC) to supply 150 MW of electricity for 3 years. It meets 10 % of the total electricity need for Sudan.
Sierra Leone Project	In June 2018, a total of 3-years contracts were signed with the Sierra Leone national electricity company, the Electricity Distribution and Supply Agency (EDSA), the Ministry of Energy and the Ministry of Finance, 30 MW for 7 months and 5 MW for 5 months. In December 2018, an Addendum Agreement was signed to increase the capacity to 50 MW for 7 months and to 30 MW for 5 months. Powerships provide 80 % of Sierra's total electricity needs.
Mozambique Project	In 2018, a 125 MW electricity distribution agreement was signed with Mozambique's electrical services company Electricidade de Mozambique (EdM) for 10 years, provided that LNG fuel was used. It meets 10 % of Mozambique's total electricity needs.
Gambia Project	In February 2018, Powership, Gambia National Water and Electricity Supply Company Ltd. signed a contract to distribute a 35 MW Powership for 2 years. Powership meets 60 % of Gambia's total electricity needs
Cuba Project	In October 2018, Powerships signed a contract with Cuba's state power company Unión Eléctrica de Cuba (UNE) to distribute three Powerships of a total of 110 MW for 51 months. In November 2019, the capacity was increased to 184 MW with a new contract for the project where 3 ships are operating. Cuba is important as it is Powership's first project in the Western Hemisphere. Powerships meets 10 % of Cuba's total electricity needs.
Senegal Project	In August 2019, a 235 MW electricity distribution agreement was signed with the Electricity Authority of Senegal (SENELEC) for 5 years, provided that LNG fuel was used. 15 % of Senegal's electricity is provided by the Powerships that started operating in Dakar.
Guinea Project	In December 2019, a contract was signed with Guinea's national electricity company Electricité Nationale de Guinée to supply 105 MW of electricity for 1 year. It meets 10 % of the total electricity need of Guinea.
Guinea-Bissau Project	In January 2019, a contract was signed with Electricidade e Aguas da Guiné-Bissau (EAGB) to distribute 35 MW of electricity for 5 years. Powerships meets all of Guinea Bissau's electricity needs.

Powership projects, which started with Iraq, have expanded, successful results have been achieved, reaching a comprehensive structure as shown in Table 3. Preferring a Powership over an established power plant, although it is based on different reasons in each region, the only thing that did not change was the need for energy and, despite all the difficulties, these needs were met. Although the managers in these countries see Powerships as a temporary solutios to their energy needs, repeated contracts in many places have also shown that these projects are sustainable for many years. Countries that reach the energy gap, need more energy by increasing their production activities, and this can be met with more Powerships. The result creates a mutualistic profit cycle.

4. RESULTS AND DISCUSSION

According to our research about Powerships and experts answers to our semi-instructed interview questions, there are many factors to the successful launch of Powerships into the energy production and distribution sector. All of them are explained into six different headings in Figure 2.

The purpose of the emergence of Powerships to provide energy supply is indicated in Figure 2. Challenges of installation land-based power plant, security problems on areas, seasonal energy demand, having dual-fuel technology on Powerships, represent the main topics concerning the emergence of these ships. External source problem, such as bad weather conditions, creates an obstacle in generating electricity.

The initial installation costs of the power plants are quite high. These costs can increase exponentially, especially considering geopolitical positions and infrastructure competencies in the regions where they are established. Table 4 shows how high these costs are, even for a developed country like the US, according to the power plant variety. Economic costs are the cost of a typical facility for each electricity production technology before adjusting to regional cost factors. Overnight costs do not include the accrued interest. Technologies with limited commercial experience, technology research, and development software include a technological optimism factor to take into account the assessment of underestimating the full engineering and development costs for new technologies. All technologies demonstrate a variety to some extent in cost based

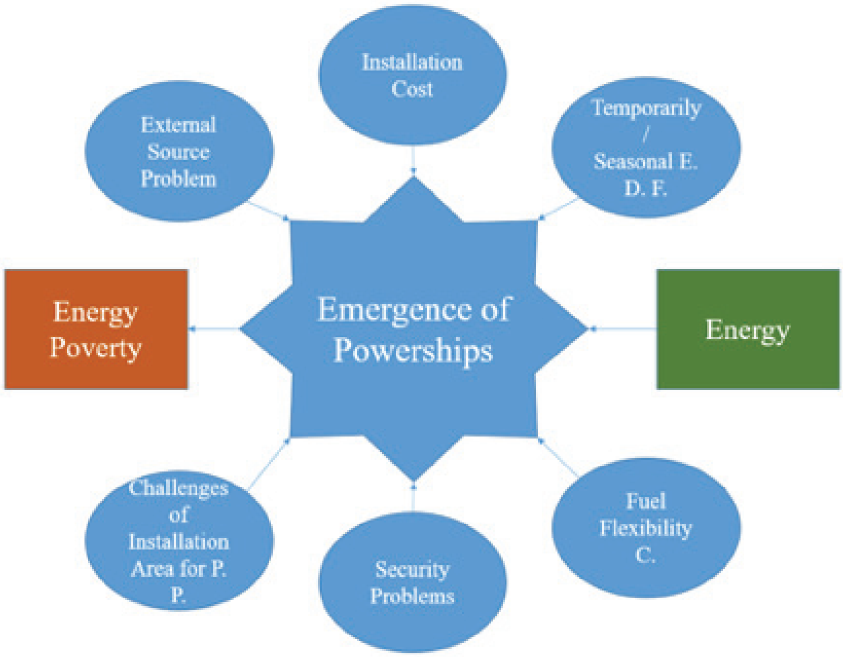

Figure 2.
Factors leading to the emergence of Powerships.

on project size, location, and access to key infrastructures, like grid connections, fuel supply and transportation. The cost

advantage of the lowest cost regions combines the underlying variability of the regional cost and makes a significant difference between unadjusted costs and capacity-weighted average national costs. (EIA, 2017).

As can be seen from Table 4, the recovery period is four years for gas/fuel alternating power generation facilities, providing a wide range of fuel usage flexibility. When examined in this context, the investing company must have much longer contracts to be profitable. When the contract expires, a very small portion of the investment can be taken back. If you are planning to roll back, it is likely to encounter a cost of close installation, sometimes even greater.

Energy supply company Chief Executive Orhan Karadeniz has said that, in the emergence of a Powership, an investment of 1.5 Million Euros is needed for every MW (Fırat, 2014). But once a ship is built, it can be used many times in different regions, following maintenance and transportation costs that may be relatively small. That gives Powerships an advantage to move to regions that are more profitable at the end of their contract. However, in the case that if a reduction of power is needed in a region because of an unpredictable reason, the Powerships might be the first choice to be disconnected from the grid lines. The investment made by governments to economically viable land-based power plants can also decrease the need for a floatable power plant near the region.

Table 4.
Cost and performance characteristics of new central station electricity generating technologies (EIA, 2017; 2021).

Technology	First available year	Size (MW)	Lead time (years)	Base overnight cost ($/ kW)	Technological optimization factor	Total overnight cost ($/ kW)	Variable operation and maintenance ($/MWh)	Fixed operation and maintenance ($/kW-year)	Heat rate (Btu/kWh)
Ultra-supercritical coal (USC)	2023	650	4	3.661	1.00	3.661	4.48	40.41	8.638

USC with 30 % carbon capture and sequestration (CCS)	2023	650	4	4.539	1.03	4.652	7.05	54.07	9.751
USC with 90 % CCS	2023	650	4	5.851	1.03	5.997	10.93	59.29	12.507
Gas/Oil combined cycle - Single shaft	2022	418	3	1.079	1.00	1.079	2.54	14.04	6.431
Gas/Oil combined cycle - Multi shaft	2022	1.083	3	954	1.00	954	1.86	12.15	6.370
Combined cycle with 90 % CCS	2022	377	3	2.470	1.04	2.569	5.82	27.48	7.124
Internal combustion engine	2021	21	2	1.802	1.00	1.802	5.67	35.01	8.295
Combustion turbine – aeroderivative	2021	105	2	1.170	1.00	1.170	4.68	16.23	9.124
Combustion turbine – industrial frame	2021	237	2	710	1.00	710	4.48	6.97	9.905
Fuel cells	2022	10	3	6.671	1.04	7.339	0.59	30.65	6.469
Advanced nuclear	2025	2.156	6	6.016	1.05	6.317	2.36	121.13	10.461
Distributed generation - base	2022	2	3	1.555	1.00	1.555	8.57	19.28	8.946
Distributed generation – peak	2021	1	2	1.868	1.00	1.868	8.57	19.28	9.934
Battery storage	2020	50	1	1.383	1.00	1.383	0.00	24.70	N/A
Biomass	2023	50	4	4.080	1.01	4.104	4.81	125.19	13.500
Geothermal	2023	50	4	2.680	1.00	2.680	1.16	113.29	9.156
Municipal solid waste – Landfill gas	2022	36	3	1.557	1.00	1.557	6.17	20.02	8.513
Hydropower	2023	100	4	2.752	1.00	2.752	1.39	41.63	N/A
Wind	2022	200	3	1.319	1.00	1.319	0.00	26.22	N/A
Wind offshore	2023	400	4	4.356	1.25	5.446	0.00	109.54	N/A
Solar thermal	2022	115	3	7.191	1.00	7.191	0.00	85.03	N/A
Photovoltaic	2021	150	2	1.331	1.00	1.331	0.00	15.19	N/A

5. CHALLENGES OF INSTALLATION AREA

There are some difficulties in establishing a power plant for small island countries and large scattered islands, which do not have large land areas. Because the land is so precious in these countries, even creating the necessary space to build a power plant is causing very high costs. Although governments try to create politics against it, they cannot be said to be very successful in this matter, as is the case in Indonesia (Jullaga, 2015).

However, the transfer of the generated energy between islands is also a separate problem. The cables that will be passed over the sea will increase the cost of installation, also bringing security problems and increasing the cost of maintenance. Powerships can solve all these problems without having to occupy almost any land component by sharing the necessary energy with the required number of ships and operating from different regions.

5.1. Security Factor

The security factor is one of the most important factors that distinguishes the Powerships from other energy production facilities. Giving power to rural settlement areas and underdeveloped countries brings a potential risk of security to the investment because of lacking in education, hunger or poverty among people, terrorist activities, rebels, wars, etc. The idea of Powerships has come from electrifying the rural areas wherever needed. The business area, comprised in this idea, contains even the war zones, severely in need of power. That is the reason why the security issue is accepted as a natural factor to be taken into consideration by the administration. Countries like Lebanon and Iraq have been suffering from war for years. Their land-based powering options have been reduced since most of the power plants stay inside the war zones. The people and the governments have been strictly in need of power for keeping their food fresh and getting through the economic recovery. Terrorist activities, piracy, and rebel groups have created a major problem in underdeveloped countries. These activities have made the people and the governments poorer. They could not attract foreign investors. The lack of infrastructure in those countries has also caused a step back. Undoubtedly, economic development starts with energising the country. However, it poses a risk, even for regions that are considered to be relatively safe because the energy sector is the preferential target of terrorist organisations. Moreover, since agreements are made with governments, merchants do not welcome them and this risk is further increased through unstable management processes.

The Powerships are born with some advantages compared to land-based power options in the case of security issues. When security problems become uncontrollable, the ability to quickly move to a safer place alone can be enough to explain how the Powerships have entered the energy supply sector so quickly and strongly.

Powerships can comply with fast-changing conditions and provide fast mobility. According to the interview questions, it is deduced that the technical staff of the Powerships feel safer to work in a floating vessel. However, the floating feature is not self-sufficient for providing security. Since the agreements are made with the governments, it is very likely that the rebel groups in chaotic regions can select the Powerships as a target. Highly qualified security protocols need to be created for each individual project according to the specific territorial conditions of the countries. A secure space for the Powerships and the power supply lines are provided in coordination with the government and the security protocols.

5.2. Fuel Flexibility

The use of gaseous fuels is quite common in internal combustion engines with spark ignition, however modern dual-fuel reciprocating internal-combustion diesel engines can provide high fuel efficiency with the use of liquid diesel fuels as well as gaseous fuels. The liquid fuels can range from light fuel oil (cleanest fossil fuel) to heavy fuel oil (cheapest fossil fuel), while bio-oils can also be used. Gas fuels may have different properties and calorific values, ranging from biogas to natural gas. In all cases, care should be taken that the engine is set to match the type of fuel used (Klimstra, 2016). Moreover, studies are carried out to use biofuels in ship main engines and suitable ones are manufactured. On the other hand, it is difficult and costly to meet all the existing needs through new machines and biofuels. Biofuels are heated and used on existing diesel engines, but this station can lead to unexpected effects on machine performance (Hoang, 2018).

Dual-fuel engines allow you a seamless and smooth transition from gas fuel to liquid fuel processing (and vice versa), so you get full fuel flexibility. Powerships with dual-fuel engines can work with gas, diesel, biofuel or heavy fuel oil (HFO). If it becomes difficult to obtain a fuel type, or if the prices become too high to be reached, our dual-fuel engines can simply be turned into another fuel source. This allows you to take advantage of gaseous fuels, even if the gas supply is not certain (MAN, 2020).

The primary purpose of the Powerships is to ensure that the countries that are inadequate to produce the energy they need can provide the energy in the desired amount in the most economical way. However, the emissions they produce must comply with the legal restrictions in the countries in which they operate. Natural gas, which is the most effective fuel for lowering emission values, is cheaper compared to diesel fuels. However, for natural gas, an alternative fuel requirement must be included so that energy production can continue uninterrupted when factors such as continuous availability and storability in suitable conditions are taken into account. The most effective solution in this context is dual-fuel technology.

With the rise in fuel prices, regulations that are designed to prevent environmental pollution are getting more serious every day, therefore, new studies are being conducted on alternative propulsion systems. Significant gains have been achieved, especially with electrical propulsion systems, also in putting energy efficiency in a very important position on marine and power plants. A piston engine is still and shortly the most efficient way to convert liquid or gaseous fuels into energy. The most effective way to convert liquid or gaseous fuels into energy is an internal combustion piston motor. However, there are differences in the efficiency achieved after using different fuels. Natural gas is the most efficient burning fossil fuel, and conversion of an existing liquid-fueled engine to gasification has been tried many times, resulting in significant economic and environmental benefits (Mcmahon, 2015; Wartsila, 2013; Nguyen et al., 2020).

The use of gaseous fuel for energy production has several advantages. There is a serious price difference between natural gas and oil, which usually makes natural gas an attractive alternative.

The exhaust emissions produced by gaseous fuels are considerably lower than those produced by liquid fossil fuels. On the other hand, many new methods are being developed to reduce SOx and NOx emissions, so that ships can be operated in emission control areas by polluting the environment at a minimum level. It is an effective alternative in oreder to both harmonise with the environmental laws that governments apply and to protect the health of the people living near the power generation facilities. With the burning of the cleanest natural gas of fossil fuels, almost no sulphur dioxide or ash or particulate matter is formed. Nitrogen oxide emissions, one of the most dangerous emissions for nature, are also reduced by 90 % compared to petroleum. In addition, natural gas produces 20 % less carbon dioxide and 95 % less sulphur oxide than petroleum. There is plenty of natural gas in the land. According to IEA estimates, today's natural gas reserves represent approximately 182 trillion cubic feet, which means that gas is available for about 60 years, based on current natural gas consumption. This estimate does not contain significant reserves of natural gas that are believed to exist but have not been explored yet (Engie, 2015; IEA, 2017; Pham and Hoang, 2019).

5.3. Temporarily or Seasonal Energy Demand Factor

The benefits provided by the company's technology are not limited to producing energy for undeveloped countries and providing energy to countries experiencing difficulties in producing energy. Energy supply company Chief Executive Orhan Karadeniz said: “Britain is among the target countries, amid concerns there that the closure of coal-fired plants could leave it without (enough) power,” he said. “There could be a seasonal or periodic need for power ships in places like New York”. In developed countries, this system is not intended to be a general energy deficit, but rather to solve the rising energy needs in the most cost-efficient and most practical way, and create a solution that will not draw on any workload or a financial burden when the need arises. It may also be preferred as a transition system or as a system to cover periodic gaps, particularly in countries, who intend to change the source of energy production and intend to direct cleaner renewable resources, like the British example given by Orhan Karadeniz. In some underedeveloped countries, there may be an increase in seasonal energy needs. It would be much more logical to have a ship that can meet the energy needs of the rest of the year rather than a high capacity land power plant to meet this high energy requirement, which covers only certain times of the year. As in the example of Sierra Leonne, agreements can be made with higher energy production capacity at certain times of the year. In Sierra Leonne, there is an energy supply agreement that varies according to the months due to the increase in the freezing capacity of the fish, which is an important export product, to keep the fish intact (Yackley, 2013).

5.4. External Source Problem

Weather conditions are very significant in the Powerships operation. In case of bad weather conditions in the area where the Powerships were found, ship seawater filters are more polluted than good weather condition, so that engines of Powerships used to generate electricity cannot operate properly. Therefore, power production becomes very difficult to meet the electricity needs of countries. Moreover, various natural disasters, such as tsunami, can affect power ships electrical production system. However, these problems are described as very minor when compared with land electricity installations

6. CONCLUSION

Emergence of Powerships innovations, which were introduced and implemented by the Turkish Origin Energy supply company, are described as successfully launch strategies in the energy market exhaustively. Most particularly, Powerships provide very fundamental profits in energy production for countries that have challenges in establishing land-based power plants. Therefore, the supplied energy production is spread to other countries and also the existing contract terms are extended in the sense of installation cost and challenges, security and safety problems, fuel flexibility, seasonal energy demand, and other issues. Moreover, providing employment to the citizens, supporting educationally intelligent students and other positive feedbacks, ensure the adoption of Powerships by many countries. Our results describe that the Powerships provides more benefits compared to land-based power plants for energy needing countries. Energy cuts are almost completely eliminated and continuous production is ensured. Furthermore, energy is not only vital for production, but also necessary for facilitating and contributing towards the social life of people. This study, we hope, will be a substantial source for researchers, energy supply companies and employees, since a sufficient number of studies cannot seem to be found in the existing literature.

CONFLICT OF INTEREST:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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