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FOLATING SOLAR PHOTOVOLTAIC AS A SOURCE OF CLEAN ENERGY AND CHALLENGE FOR MARITIME SPATIAL PLANNING AND SECURITY ENVIRONMENT

ABSTRACT

The civilizational development has been linked to energy sources and ways of obtaining them. Countries with access to low-cost energy sources usually enjoyed years of rapid development and period of prosperity. Today, the environmental impact of energy production is playing an increasingly important role. There is a rise in the share of energy produced from renewable sources: water, wind and solar. Photovoltaic panels are becoming more and more popular: progressively cheaper, lighter and easier to use. However, the development of solar panels has its limits. They cannot be installed on all surfaces, in any location and, most importantly, they take valuable space that could be used for other purposes. Recently, technological development allowed to produce floating solar photovoltaic (FSPV) that creates a new quality in this area. Solar energy can be sourced ecologically, close to the areas of greatest demand, and not blocking valuable land space. However, new floating installations generate new challenges in terms of not only maritime spatial planning, but also the maritime safety environment and, in long term perspective, global security.

Keywords: Floating solar photovoltaic, FSPV, maritime security, maritime spatial planning

INTRODUCTION

For centuries seas were considered as great potential for expanding possibilities of human civilization. Despite the fact that for most of humankind history seas were used solely either for transport or fishery, dreams were always big. Not only writers or futurologists were foretelling about cities floating on the sea surface, or established on its bottom, as well as other sophisticated
devices. In fact we are on the edge of fulfilling those brave prophecies, although it is now more about “other devices” than cities, which still remain in the phase of ambitious pilot projects, such as Saudi Arabia’s floating city called Oxagon (Bobstock, 2021).

Humankind’s dependence on energy would endure and there are no indications that something is going to change that in the foreseeable future. Nevertheless, throughout history ways of energy production have been changed with more shifts yet to come. Nowadays, it is relatively easy to generate energy, but the challenge is to make its production less carbon intensive, more safe and ecological. In broader look, managing risk of global warming takes both shift in methods of energy production and the use of land. The latter would eventually need to be adapted. Fore sure changes will enclose not only stopping deforestation, but will encompass retrieving some of already deforested land back to the nature (rewilding) (Carrol, Noss, 2020). Such circumstances put much more emphasis on wise spatial planning, both in terms of land and sea.

Producing energy by solar panels has been, for years, considered as ecological. Indeed the amount of energy produced from sunlight has been skyrocketing for almost a decade. It is assessed, that in 2011 solar panels worldwide generated 66 TW out of 4401 (1,5%) TW total renewable energy produced, and only ten years later solar panels produced respectively 1033 TW out of 7931 TW (13,0%) (Ritchie, Roser, Rosado, 2020). This means, that solar energy production almost doubled every second year. Nevertheless, it is assessed that the potential is even bigger. This is not only for the green transformation, but mainly for the accessibility of solar panels, their decreasing costs and better availability. Installing panels is cost and time effective, easier than beforehand, but still solar panels have some drawbacks. First of all, production of energy is dependent on the direct exposure to sunlight, insolation and temperature. All that makes the volume of energy produced uncertain and variable – depending mostly on weather, climate and day length what is directly connected to the geographic location and seasons of the year. If unfavorable weather conditions happen the yield might be seriously decreased, or even reduced to zero levels. Similarly, in winter, the time of exposition to sunlight is reduced the more, the closer the place is to the North Pole (or South in summer, on Southern Hemisphere). If the outside temperature rises too much, the efficiency of solar panels could be much decreased. Recently it happens not only in traditionally hot places, but more and more often, as series of heat waves spread across, in countries with mild climate. Finally, contrary to conventional energy, it has almost infinite sources, but require supplementary energy production. Whereas solar energy can form a substantial part of total energy generation, it needs to be supplemented by other flexible and more reliable energy production sources (eg. gas, or nuclear).
Secondly, solar panels need a lot of space. Producing substantial amounts of energy requires a vast area for solar photovoltaic panels. In such case the roof surface area usually is not enough. Solar panels could be easily installed on land but, in many circumstances, that comes with certain concerns. As far as installing solar panels on arid lands, or wastelands (such as deserts) seems to be in line with wise usage of limited farmable areas and might be beneficial to flora, building them on arable land may be considered as a waste of valuable space. The worst case scenario is when they are installed on a deforested land. Thus, in some circumstances, creating vast fields of solar panels on land is in clear contradiction with the use of land for farming, or wild ecosystems purposes. Moreover, it is counterproductive to the efforts of retrieving back the land for planting trees, or forestation. A good solution seems to be installing solar panels on rooftops and walls, but that has its limits as not all buildings’ surfaces are capable of holding them. Installing solar panels is also not possible in scenic, historic areas as well near landmarks, places of cultural, or architecture significance – as they deteriorate the landscape. In some cases their installation is also not possible near airfields, or air force bases for safety reasons as they might be a source of reflections dangerous for manned air assets. In such conditions, in not-so-long-term perspective, further increase in energy production from land-based solar panels is limited, especially if the electricity transmission is connected with a substantial waste.

It is predicted that in the coming years the biggest cities are going to grow yet more rapidly, consequently their energy demand. Most of the big cities are already facing difficulties with air pollution, poor air quality. Authorities are seeking ways to promote more renewable energy and ecological solutions in order to reduce contamination. Among them the implementation of electric cars was supposed to be the right answer. In fact, this solution only augments the electricity demand and puts even more strain on the power supply grid. Solar panels should come to relief this problems. Nevertheless, there are many limitations considering installation of solar photovoltaic panels in urban areas. Having in mind that around 80% of the big cities are located near, or by the coast, the natural shift for search of energy supply should be towards the waters, including seas located nearby urban agglomerations.

Maritime areas, especially littoral, surrounding ports are already very congested with traffic and many installations both on surface and submerged. Among them there are 11 major categories such as maritime constructions (eg. wind farms), maritime agriculture, cables and pipelines, fishing, dumping and protected (due to cultural, or historic issues) areas, or those used for nature preservation, sand and gravel extortion, military practice, or maritime traffic – all of them have functions which concur, partly-concur, and non-concur with each other (Pajak, 2019). Adding to that floating solar photovoltaic installations would further complicate the matrix of potential usage of the maritime areas.
and make the management of maritime spatial planning even more challenging. Nevertheless, the increasing consumption of energy leaves not many other options.

**FLOATING SOLAR PHOTOVOLTAIC (FSPV)**

Vast fields of solar panels, due to their preconceived belief of somehow fragile construction, have not been so far widely considered to be built at sea. Their characteristics are believed to make them vulnerable to sea conditions which could be in fact very unfavorable: waves of varying heights, strong wind, briny sea breeze and corrosion caused by both salt and water. Not so long ago first prototypes of floating solar panels entered lakes and man-made reservoirs. In the meantime the technology advancement allowed to build floating solar panels at seas and to change the deeply entrenched opinions that photovoltaic is not suitable for maritime areas. Hence, some experts started to highlight the great potential this technology might have and already a few promising researches have been conducted.

Floating solar panels could be and are often already installed on reservoirs (large natural, or man-made lakes) used for agriculture, hydroelectric energy production, or flood prevention. There are hundreds of big artificial lakes worldwide. The biggest were constructed in: Egypt, Sudan, Ethiopia, Zambia, Ghana, Canada, US, Venezuela, Uzbekistan, Kirgizstan, Tajikistan, Russia, China, and many other. Most of the above use water from rivers to amass it in manmade lakes. A number of them play also an important role in depleting downstream water because of the large-scale evaporation of upstream water reservoirs. Floating solar panels covering much of the water surface reduce extensive evaporating what is an important feature especially in hot climate. It is also of significant importance if we take into account the ongoing climate change and scarce of water not only for the agriculture, but also to households. Having this in mind manmade lakes e.g. in central Asia, or Africa could avoid excessive evaporation if more floating panels are installed on them. Thus, more water from rivers could be preserved enabling it to reach final destinations such as inland lakes and in this way helping them not to dry out. Beside that floating solar photovoltaic may not only improve production of energy, but also help managing the problem with water in semi-arid, or desert areas.

Shallow seas have been already contributing to ecological energy production – mainly through offshore wind power plants. Although energy produced by such plants is considered to be green, windmills themselves are seen not so eco-friendly. This is not only for the sake of collisions of birds with rotor blades, but also for the emitted infrasound that may harm humans and fish spawning in shallow water. Hence, new wind power plants are no longer erect-
ed on territorial seas but are planned mainly in exclusive economic zones – far away from seashore. The main advantage of wind power plants is that they are very resistant to harsh weather conditions at sea, but their ability to produce energy constantly, both in case of no wind and to strong gales, is limited. Among the biggest disadvantages are high costs and complexity in installing.

The main concern was that installing solar panels at sea might be much less efficient, in terms of energy production, due to being unable to be permanently positioned with the best angle towards the sun, but also because of the impact of waves, wind, pivots, and contact with salt water. Recent research, conducted at Utrecht University, revealed that solar panels at sea, or more professionally called floating solar photovoltaic (FSPV), may have a bright future. Solar panels installed at sea showed to be almost 13% more effective than panels installed on land (Golroodbari, 2020). Finding that, a next riddle needed to be solved: what makes this effect? The first thing is water temperature, which is usually more stable (lower than the temperature of air in hot climate and warmer than the air is in cold), makes electrical losses in the photovoltaic material smaller, what results in improved yields. Secondly, both sea water and whitecaps on waves reflect sunlight which eventually insulates solar panels more making the overall installation more effective, eventually the most favorable conditions were determined with the speeds of wind faster than 7.6 metres per second (about 27 km/h) making whitecaps form on the waves (Golroodbari, 2021). It is worth mentioning that it was even found out that clouds which shall lower solar panels efficiency do not necessary do it over water as they rebound quite a big percentage of sunlight reflected from the water back to the sea surface.

The above findings open vast inland water and maritime areas to be covered by large solar panel installations. Nevertheless, this task is not easy and has many restrictions. First of all, solar installations should not interfere with other sea functions including sea farms, fishing areas, waterways, marine reserves, or extraction or dumping areas, and naval training areas for maritime forces. Secondly, large solar installation shall be located in vicinity of energy consumption areas as energy transmission is never without losses. In such conditions hybrid forms of wind and solar installations could be implemented. Wind power plants are usually located in areas where other sea activities are not possible and the distance between them are just enough to fit floating solar panel installations. The advantage of such solution is also that sea wind farms are already connected to the mainland by electrical transmission lines what may save some costs of erecting such installations. A big plus is that floating solar panels installations are relatively quick to construct, silent to run, do not endanger fish spawning and require no land levelling (Aneso 2020). Moreover floating solar panels reduce evaporation what is not so important at sea, but
has a great potential on freshwater reservoirs, especially those located in hot and semi-arid climate zones.

THE RACE: THE FASTEST, THE BIGGEST

As future of solar panels installed at seas seems to be promising some competitors have already rushed out of the starting blocks. The stakes are very high: solar and wind energy share in global electricity generation exceeded 10% in 2021 and solar energy generation has rose by 23% (EMBER 2022). It is expected that this growth will be sustained, but much of that could be produced at seas. At present some 60 countries are developing FSPV and it is estimated that around 350 FSPV systems in 35 countries are operational, producing a total of 2.6 GW of renewable energy (Haugwitz 2020).

The first big FSPV was built by the company Sungrow Power Supply in 2017 in Anhui, China near the city of Huainan on a manmade lake. The solar farm was to produce 40 MW of energy being able to power 15,000 homes (Daley 2017). Nowadays, this magnificent 5-year old Chinese FSPV field is not even among the 7 biggest constructions underway. In terms of energy yields it has been bested at least by 10 bigger FSPV, 7 of them able to generate more than 100MW power (Kumar 2021):

1. Saemangeum floating solar energy project, South Korea – 2.1GW
2. Omkareshwar Dam floating solar farm, India – 600MW
3. Hangzhou Fengling Electricity Science Technology’s solar farm, China – 320MW
4. Three Gorges New Energy’s floating solar farm, China – 150MW
5. Cirata Reservoir floating photovoltaic (PV) power project, Indonesia – 145MW
6. NTPC Kayamkulam solar project, India – 105MW
7. NTPC Ramagundam solar power plant, India – 100MW
8. CECEP’s floating solar project, China – 70 MW
9. Sembcorp’s Tuas floating solar project, Singapore – 60MW
10. Hapcheon Dam floating PV power plant, South Korea – 41 MW

It needs to be underlined that the above mentioned projects, despite being major breakthrough, are not usually seaborne. Nevertheless, some first brave attempts have been already done. The best example is the Saemangeum floating solar energy project which is located near Saemangeum Seawall on the coast of the Yellow Sea. It is installed with more than five million solar modules over an area of 30km² and is well visible from space. The vast area covered by groups of solar panels create literally floating fields that need to be considered whenever sea activity is performed. Such big fields of solar panels at sea need to be
challenged with severe weather conditions, among which the wave and stormy wind seem to be the biggest obstacle. For this reason first installations in such a big scale were built on shallow waters. Nevertheless, we may expect that in the near future that greater depth will not be a big obstacle, similarly as it is not impeding construction of offshore wind turbines, or oil rigs.

Picture 1. Satellite view of Gunsan Islands, South Korea. Well visible floating fields of solar panels around the central and eastern part of the archipelago.

Source: Google Maps https://www.google.co.uk/maps/ [17.09.2022]

PROSPECTS FOR THE FUTURE

As floating solar farms seem to be a tailored installation for clean and effective energy generation, without the need to block the usage of land, it shall be analyzed what might the future look like when this technology breaks free of its niche perception. As the incoming change might be substantial it is important to undertake the effort of analyzing how would FSVP alter the spatial
planning of maritime areas and finally what implications they would have on maritime security environment.

First of all, we may assume that when the number of floating solar farms increases they will start to generate significant amount of energy, soon becoming the third pillar of the solar PV sector (Haugwitz 2020). We may, with high probability, predict an outburst of floating solar farms in the coming years. First they will cover inland and manmade lakes, internal waters (such as lagoons, semi-enclosed bays etc.) as FSVP located there would not need such a big endurance and resistance to unfavorable weather conditions. Nevertheless, expansion to the seas, especially littoral areas, seems to be unequivocal. The first seaborn step would be into shallow maritime areas, including gulfs, parts of the sea partly covered by peninsulas, or chains of islands. Shallow water would not boost their cost and some protection from variety of land forms would decrease weather impact on FSVP. The second step shall be installing FSVP on deeper waters (blue waters) what requires many more technological solutions to meet environmental demands. Among them the biggest ones would be mooring floating solar fields to the sea bottom and making them resistant to even extreme weather conditions including high oceanic wave. Finally, in more distant future we may imagine vast fields of FSVP drifting with the currents in the oceans, similarly as nowadays do autonomous floating systems which collect ocean waste (Dickie, 2021). Drifting FSVP could have batteries attached to store generated energy that could be used to recharge electric ships undertaking transoceanic voyages. They could also produce hydrogen by electrolysis. Hydrogen could be stored in interchangeable tanks which would be collected from time to time. It is possible that those drifting fields of FSVP could even have propulsion in order to divert their course although they would rely mostly on the currents.

Summing up, the spread of FSVP at seas shall be divided in 4 major phases: inland, littoral, blue water, and drifting (oceanic) installations, where the last 3 are seaborn. Each one will need suitable technological development and will bring certain implications. Among them we may find implications on maritime spatial planning, maritime security environment, and global security. Those consequences would be analyzed below. We need also to bear in mind that development of FSVP may be stopped quite suddenly if a better, cheaper, and more ecological source of energy is invented.

CONSEQUENCES OF FSVP SPREAD TO MARITIME SPATIAL PLANNING

With aforementioned perspectives drawn one shall ask a question what changes shall FSPV bring to maritime spatial planning. First of all, it needs to be
stated that FSPV would undoubtfully need to be included in the process of spatial planning as it covers vast areas of the sea space. Having noted that, an analysis is needed in order to answer a question what other functions of the maritime areas are concur, partly-concur, and non-concur with FSVP. Among analyzed functions the 11 major were specified, that were mentioned at the onset of this paper. To present the relations of FSVP and other functions a matrix was created. In order to better visualize the compatibility with other functions a set of 4 colors was used: green for concur, yellow for partly concur, and red for non-concur whereas black was used, in cases of combability with oceanic FSVP, where certain maritime function would not be able to be used in the open ocean.

Table 1. Matrix depicting compatibility of FSVP and other functions of maritime areas.

<table>
<thead>
<tr>
<th>Functions of maritime areas</th>
<th>Compatibility with Litoral/blue water FSVP</th>
<th>Compatibility with oceanic FSVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maritime traffic</td>
<td>non-concur</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>non-concur</td>
<td></td>
</tr>
<tr>
<td>Wind farms</td>
<td>partly-concur</td>
<td></td>
</tr>
<tr>
<td>Constructions</td>
<td>partly-concur</td>
<td></td>
</tr>
<tr>
<td>Cables and pipelines</td>
<td>partly-concur</td>
<td></td>
</tr>
<tr>
<td>Fishing</td>
<td>non-concur</td>
<td></td>
</tr>
<tr>
<td>Nature preservation</td>
<td>concur</td>
<td></td>
</tr>
<tr>
<td>Military practice</td>
<td>non-concur</td>
<td></td>
</tr>
<tr>
<td>Dumping sites</td>
<td>non-concur</td>
<td></td>
</tr>
<tr>
<td>Protected areas</td>
<td>non-concur</td>
<td></td>
</tr>
<tr>
<td>Sand and gravel extortion</td>
<td>non-concur</td>
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</tbody>
</table>

As it is easily visible above that littoral/blue water FSVP is not interfering with only one maritime function of the sea – nature preservation. Consequently, it has only one concur function. As indicated before FSVP, once installed, with a high degree of probability, does not cause any harm to the nature. Moreover, many artificial anchors, mooring chains, or lines may create very beneficial environment conditions for maritime fauna. Thus maritime so-
lar fields may create favorable habitats. The minus is that those floating constructions are catching floating derbies including plastic particles what usually leads to its accumulation both inside and around them.

Littoral/blue water FSVP is partly concurrent with 3 maritime functions: wind farms, constructions, and cables and pipelines. That means in some circumstances the existence of wind farms, submerged cables, or pipelines and other constructions may coexist with FSVP. It is worth noting that maritime solar panels are joined into groups which are separated from each other. This specific characteristic allows to place between separated groups of FSVP wind turbines, or other constructions. It is also possible to locate floating solar panels near submerged cables, or pipelines. The only requirement is that the anchors are placed in a safe distance and FSVP is not located directly above sea cables, or pipelines.

FSVP is not compatible with all other maritime functions: maritime traffic, agriculture, fishing, military practice, dumping sites, protected areas, sand and gravel extortion. In fact this is a majority of them, what makes littoral, or even blue water FSVP one of the least compatible maritime functions.

In terms of large drifting solar panels four maritime function in the open oceans would not be used at all (due to big depth): agriculture, wind farms, constructions, sand and gravel extortion, as well as cables and pipelines. Contrary to littoral FSVP, oceanic one would be compatible not only with nature preservation, but also dumping sites and protected areas. Big depth to the bottom of the sea and lack of anchors would render those functions fully compatible. Finally, large, drifting FSVP would not be capable, similarly as littoral, for the same reasons, with maritime traffic, fishing and military practice.

Summing up, it is easily visible that floating solar panels occupy the surface and consume much space, the same space where most of the maritime activities take place. Consequently, FSVP is very little compatible with other surface maritime functions. What is more, as FSVP has a big density of anchors attached to the bottom of the sea, they are non-concurrent with all functions which utilize the seabed, or water space. In terms of large drifting solar panels it is quite different. The biggest change is that drifting FSVP would not need anchors, hence it is much more compatible. Combining all facts presented, it shall be stated that FSVP, both littoral, or surface, is not very much compatible with other maritime functions. In fact, they are much non-compatible.

Taking into account the recent robust expansion of photovoltaic energy on land and the growing demand of energy, especially in big cities, which majority of them is located nearby costs, we may predict a rapid expansion of FSVP in the nearest future. Knowing that FSVP is not compatible with most of the other functions of the sea, we may expect that it will make maritime spatial planning even more complex.
Having in mind that the first step of expansion of FSVP into the seas would be territorial waters and Exclusive Economic Zones (EEZ) of developed countries one would find that those maritime areas are already covered by spatial planning. Knowing also that areas suitable for FSVP installation would be very limited, at the beginning, a special attitude toward maritime spatial planning should be implemented. Restricted shallow areas should be even more wisely planned in order to leave necessary space to FSVP. This shall be not an easy task as most of the littoral areas of developed countries are already fully booked with almost all already existing maritime functions. In this situation it may turn out that those countries which did not start maritime spatial planning and possess big undeveloped maritime areas could be in a better starting position to install FSPV than the countries with well-organized and developed maritime areas. Nevertheless, both of them would face a major dilemma: not only how to settle the presence of FSVP and other functions of maritime areas, but also how to set up as much FSPV as possible so they could yield more energy.

Summarizing, increasing presence of FSPV would greatly congest maritime spatial planning, leaving even less area, especially near shore, or big agglomerations, to basic functions of the sea, such as maritime traffic, fishery, or nature preservation. Installing FSPV on littorals, or blue waters will interfere with much of maritime functions, such as: maritime traffic, agriculture, fishing, military practice, dumping sites, protected areas, sand and gravel extortion. Supposedly, FSVP would find bilateral advantage when installed near wind farms, or other maritime constructions erected at seas. As FSVP impact on nature is probably marginal, the important question is whether, and if so, to what scope, FSPV shall be allowed to be located within, or in vicinity of areas reserved for nature preservation. Nevertheless, as every construction either anchored, or mounted to seabed, FSPV may enrich maritime life creating new habitation areas. Anticipating an imminent increase in marine floating waste, FSPV fields may cause trash trapping, leading to creation of local islands of floating litter. Even if this may be helpful in terms of collecting the floating trash from water, probably it will be ill-perceived. Nevertheless, those aspects would not be able to stop the spread of FSVP nor prevent it from playing an important role in generating energy in the future.

CONSEQUENCES OF FSVP SPREAD TO MARITIME SECURITY ENVIRONMENT

In long term perspective building FSPV at seas on a lavish scale would start affecting the way of conducting maritime activities and even leave a solid mark on the way the naval warfare is conducted. As FSVP consumes much space near shores it would further channel maritime traffic, leaving only nar-
row lanes for ships in some areas. This phenomenon is not new, as already in
countries where maritime areas are covered by spatial planning for a long time,
maritime traffic is often limited to narrow lanes. Nevertheless, implementing
FSVP would intensify this process further congesting maritime traffic, what
would make maintaining maritime safety even more complex.

For sure spread of FSVP would affect naval operations – both surface
and underwater. First of all, it would restrict the area ships could be used and
consequently change the location where maritime naval warfare would be con-
ducted. Secondly, it would restrict the range and ability of weapons usage and
might also reduce target detection ranges. Most probably, FSVP would play an
important role in conducting surface warfare creating not only restrictions, but
also deeply complicating the usage of detecting devices (e.g. radars, infrared
sensors), guns, missiles, as well as antisubmarine warfare. Very large fields of
solar photovoltaic, including the drifting ones, in terms of surface warfare,
would have big influence both on tactical and operational level.

In terms of subsurface warfare, SFVP would much restrict submarines’
operational area. On the other hand FSPV fields with their multiple anchors
(being a source of weak hydroacoustic sound, but a bigger hydroacoustic obsta-
cle) may create a kind of vertical barrier which could, in some situations, make
detection of submarines more difficult. In such circumstances planning effec-
tive submarine operations would become more complicated. Without up-to-
date intelligence vast areas of FSVP would push submarine operations away
from the shores. It is also possible that submarines in the future would need
devices that would enable them to maneuver among fields of FSVP anchors, as
well as torpedoes that could run between them.

Large FSPV fields, due to big sizes, shall be considered as a quite vulner-
able target for a potential terrorist attacks. Hence it may need naval presence,
monitoring, or even a kind of protection. This might include barriers in the wa-
ter, or monitoring systems – both surface and submerged. Most of them shall be
operated remotely, unmanned, or with minimum personnel engaged. In case of
unlikely terrorist, or even military attack destruction of FSPV, for the big sizes
and subdivision into smaller, separated groups, shall remain unlikely.

CONSEQUENCES OF FSVP SPREAD TO GLOBAL SECURITY

If at least 3 out of 4 of the previously mentioned steps of the spread of
FSVP are introduced on a big scale, it is likely that FSVP would be able to create
a new quality in terms of global security. In such a situation, provided with suf-
ficient investment and maritime spatial planning, maritime areas, itself, may
become a source of clean energy production. In such a situation countries that
would have access to maritime areas suitable for FSVP building may become energy producers. If energy generated by FSVP could be stored (e.g. in the form of hydrogen) those states could become energy exporters. Therefore, maritime areas would make the table turn in the global economy for one more time, leaving oil and gas extortion much less needed. Consequently, oil and gas producing countries would lose much of their income and could be deprived of their global significance. As a result of this process the global centers of gravity could be changed to some extent, what would alter global distribution of wealth, importance of certain regions and sea lines of communication. For some countries it would open great opportunities. Nevertheless, one shall remember that implementation of new technology on a big scale is always expensive, so some of the poorer countries, without external investors, could not profit on that change even if they might have suitable maritime areas.

CONCLUSIONS

Floating solar photovoltaic would probably soon become relatively cheap, easy to install, silent to run, and requires no land levelling, or removal of vegetation. Floating solar panels at sea could benefit in preserving the landscape, as well as freeing up valuable space on land to help combat climate changes. They would open the possibility of unleashing great opportunities the seas still holds for the human kind. Some important projects have been already done and many steps have been taken to develop this forward-looking and promising concept. When it sets off, floating solar photovoltaic could have an important role in not only energy supply, but also would affect maritime spatial planning, as well as the way human kind exploits seas. In more distant future drifting fields of FSPH could help recharge electric oceanic ships, or become a source of hydrogen. If the spread of FSVP is larger it would alter the energy markets, and would create new areas where energy is produced and from where it could be exported. In long term perspective floating solar photovoltaic could have impact on capabilities of countries to produce energy and could have a significant impact on the foundations of international geostrategy. They could be a gamechanger in terms of energy producing centers and once again prove that the countries which have access to vast littoral maritime areas might be very beneficial. Consequently, shallow, littoral, or even blue water areas could become a resource of strategic potential. Finally, FSPV could alter the conditions of maritime safety and security, as well as way of conducting naval warfare and affect the way warships and submarines are designed and armed.

As FSVP technology has a great potential it’s full influence on the future is still hard to forecast. Nevertheless, there are many indicators it could be
groundbreaking, in terms of maritime spatial planning, maritime security environment, and global security.

**BIBLIOGRAPHY**


STRESZCZENIE


Słowa kluczowe:
pływające panele fotowoltaiczne, bezpieczeństwo morskie, planowanie przestrzenne obszarów morskich.