International Legal Aspects on the Exploration and Use of Solar Energy in Outer Space

Irina Chernykh and Stanislav Kopylov[*]

Abstract

In the context of global energy crises related to the traditional energy sources, as well as in connection with modern challenges and threats caused by the instability of the world energy markets, there is a necessity to expand and use the objects of energy complex that use renewable energy sources like solar energy.
Such energy usage can be a reason for different interstate disputes due to the uncertainty in international legal regimes of space energy sources under international space law. Firstly, there is no legal definition of "space resource." Secondly, the current international space treaties contain only basic principles and norms for regulating this kind of space activity. Finally, there could be many issues related to the responsibility and liability for such a new kind of space activity. This paper will be devoted to the issues mentioned above and to other questions related to this problem.

1. Introduction

The global challenges facing all mankind over the past few years have forced us to pay attention to innovative ways of human development. The energy sector has not been spared this attention, where against the background of the crisis associated with traditional energy sources (oil and gas), various initiatives are emerging to use innovative renewable and alternative energy sources, such as hydrogen energy, bioenergy, geothermal energy, hydropower, Ocean energy, wind energy and solar energy, which can be extracted both on the surface of the Earth and in outer space.
The current large-scale crisis associated with the SARS-CoV-2 coronavirus pandemic, which has engulfed all sectors of the economy, primarily due to low demand for aviation fuel, as air traffic between states has almost stopped, also some space launches have been rescheduled,[1] causes the need

* Irina Chernykh, Department of International Law, RUDN University.
Stanislav Kopylov, Department of International Law, RUDN University.

1 Coronavirus pandemic forces US Space Force, SpaceX to delay GPS satellite launch, https://www.space.com/coronavirus-delays-spacex-space-force-gps-satellite-

not only to find the best ways out of this situation, but also to identify promising development directions to overcome contradictions and problems. For many states, which are directly dependent on stable prices for energy resources, this economic situation can be an impetus for the modernization of the energy sector in technical, conceptual terms with the implementation of innovative energy-efficient technologies of renewable and alternative energy sources.

The tense geopolitical situation and the desire of various States to diversify energy sources and suppliers of energy resources in the context of ensuring energy security justify the need to deploy and use energy facilities that operate on the renewable energy sources base. In this regard, a good example is the experience and initiatives of the European Union,[2] which systematically implements the decarbonization policy and links it specifically to ensuring energy security. Technological progress can help the decarbonization process, which will reduce dependence on fossil fuels and increase energy security by eliminating dependence on single suppliers. Another good example is China, whose rapid population growth and active economic development over the past decades has turned this state into the world's main energy consumer. Aware of the potential risks associated with dependence on fossil fuels, China has developed plans to meet its energy needs through science and technology,[3] which should introduce renewable energy sources into the overall energy grid and ensure the state's energy security.

1.1. Kinds of New Energy Sources

Renewable, alternative and innovative energy sources include green energy, which is replenished naturally but is limited by geographical location or technological development. Renewable resources are also usually determined by the lifespan of one generation of people.

The main types of renewable and alternative energy sources are: hydrogen gas, biomass energy, wind energy, tidal energy, biofuels, geothermal energy, nuclear energy, hydropower, geothermal energy and solar energy.

launch.html (accessed 29 September 2021); NASA Pushes Back Launch Date on Webb Space Telescope, Citing COVID-19, https://www.npr.org/2020/07/17/892179776/nasa-pushes-back-launch-date-on-webb-space-telescope-citing-covid-19 (accessed 29 September 2021); Coronavirus Delays Work on NASA's Moon Rocket and Capsule. URL: https://www.nytimes.com/2020/03/19/science/nasa-coronavirus-sls-rocket-moon.html (accessed 29 September 2021).

2 See: L.R. Morningstar, A. Simonyi, O. Khakova, I. Markina, European energy diversification: How alternative sources, routes, and clean technologies can bolster energy security and decarbonization, https://www.atlanticcouncil.org/wp-content/uploads/2020/01/Khakova-Energy-Diversity-IB-A4.pdf (accessed 29 September 2021).

3 See: Sarah O'Meara, China's plan to cut coal and boost green growth, Nature 584 (2020), https://doi.org/10.1038/d41586-020-02464-5 (accessed 29 September 2021).

1.2. International Conferences and Organizations on Energy Sources

International legal cooperation between States on the use of renewable energy sources and the implementation of relevant projects was initially made possible by the UN and the activities of its main organs. However, energy as well as environmental protection are not fully described in the UN Charter, but at the same time, if the UN's goals to maintaining international peace and security, developing friendly relations among nations and promoting social progress, better living standards and human rights, as well as coordinating the actions of Nations in achieving these common goals are broadly interpreted, then the UN is competent in energy and environmental issues, which are part of its work to solve economic and social problems. That is why it is not surprising that a number of organs within the UN system deal with energy issues.

The main UN organs have made a significant contribution to the regulation of international energy relations. On 14 December 1962, thanks to the UN General Assembly, Resolution 1803 (XVII) on the permanent sovereignty over natural resources was adopted.[4] Several other UN General Assembly resolutions that followed the United Nations Conference on Environment and Development (hereinafter – UNCED), Earth Summit in 1992 also addressed energy issues.[5] Since 1981, the UN General Assembly has periodically held various international conferences on renewable energy and adopted relevant resolutions based on their results.

The Economic and Social Council (hereinafter – ECOSOC), which started its work in this direction more than 60 years ago, also pays great attention to alternative and renewable energy. In 1959, thanks to the ECOSOC, such a term as unusual energy sources appeared for the first time. In 1960, this term was transformed into "new energy sources", which meant solar, wind and geothermal energy, and since the 1970s, the new term "new and renewable energy sources" has been used in the United Nations at the present time.

The idea of establishing a specific international organization for renewable energy sources was born in 1981 at the United Nations Conference on New and Renewable Sources of Energy,[6] held in Nairobi. The implementation of this idea took 30 years, which resulted in the creation of the International Renewable Energy Agency (hereinafter – IRENA) – an international

4 See: UN Doc. A/RES/1803 (XVII) "Permanent sovereignty over natural resources," https://undocs.org/en/A/RES/1803(XVII) (accessed 29 September 2021).

5 See: United Nations Conference on Environment and Development (UNCED), Earth Summit, Official website of the Department of Economic and Social Affairs in the context of Sustainable Development, https://sustainabledevelopment.un.org/milestones/unced (accessed 29 September 2021).

6 See: UN Doc. A/RES/35/204 "United Nations Conference on New and Renewable Sources of Energy," 1981 United Nations Conference on New and Renewable Sources of Energy, 35th sess.: 1980-1981, https://digitallibrary.un.org/record/18939 (accessed 29 September 2021).

intergovernmental organization that supports States in their transition to a sustainable energy future, and serves as the main platform for international cooperation, a center of excellence, and a repository of technologies, resources, and knowledges about renewable energy sources.

IRENA promotes the widespread and sustainable use of all forms of renewable energy, in the pursuit of sustainable development, access to energy, energy security, and low-carbon economic growth and prosperity. It should also be noted that according to the IEA Report for 2019 "The Critical Role of Buildings. Perspectives for the Clean Energy Transition", [7] increased investment in clean energy will ultimately lead to savings in the entire global economy and reduce by half the costs spent on providing households with energy. According to Global Energy Review 2021 of IEA, renewable electricity generation in 2021 is set to expand by more than 8% to reach 8300 TWh, the fastest year-on-year growth since the 1970s. Solar photovoltaic systems and wind are set to contribute two-thirds of renewables growth. China alone should account for almost half of the global increase in renewable electricity in 2021, followed by the United States, the European Union and India.[8]

1.3. Current Projects

In the context of one or another use of renewable energy sources, certain technical characteristics for the final region of use are required, and not all regions can implement such energy projects. As for solar energy, not all states have good characteristics on the map of solar resources, but they are still interested in implementing such projects. Moreover, despite the fact that recently there has been a decrease in the cost of implementing renewable energy projects, as well as an increase in efficiency from their use, there is still a serious problem with the constant supply of energy.

Within the European Union, through the activities of the European Space Agency, dedicated to the study and exploration of outer space, active work is underway to explore the possibilities of using solar energy in space and to support the development of clean energy. This work is complex, ranging from the use of solar-powered parts of satellite systems to redirecting that energy to the Earth, the Moon and other planets. To this end, ESA has developed a platform to gather technical and conceptual information on various aspects of space solar power.[9]

7 See: The Critical Role of Buildings Perspectives for the Clean Energy Transition, Official website of the International Energy Agency, 2019, https://www.iea.org/reports/the-critical-role-of-buildings (accessed 29 September 2021).

8 See: Global Energy Review 2021, Official website of the International Energy Agency, https://www.iea.org/reports/global-energy-review-2021 (accessed 29 September 2021).

9 See: Clean Energy – New Ideas for Solar Power from Space, Official website of the European Space Agency. URL: https://ideas.esa.int/servlet/hype/IMT?

Similar initiatives also belong to the United States, which began a study in 2021 on the use of solar-powered vehicles for activities beyond Earth orbit. The National Aeronautics and Space Administration has developed the Solar Electric Propulsion project,[10] which should increase the duration of space research missions through energy-efficient technology and the use of solar energy.

China, for its part, announces plans to build a solar power plant in outer space by 2030, with a gradual increase in capacity from 1 megawatt to 1 gigawatt by 2049. These initiatives appeared as recently in 2019,[11] and in 2021, China announced a technological breakthrough in its quest to develop orbiting power plants capable of harvesting solar energy and transmitting it directly to Earth, and announced the beginning of testing the transmission of energy over massive ranges.[12]

These initiatives set certain tasks for the international community to solve the step-by-step problems of regulating this kind of activity to avoid potential conflicts and disputes between the interested space states.

1.4. Whether Sun Energy Is a Space Resource?

International space law now does not have any definition of space resources: the outer space treaties are silent about it. However, it is possible to find different notions of a general term 'resource' in the doctrine and in the national environmental legislation of some States.

A notion 'resource' could mean "*used and potential sources of meeting the needs of society, which can be broadly divided into material and energy (primary and secondary), intellectual, labor, information, financial, temporary, traditional and non-traditional*[13] or "*a source and means of obtaining benefits of various goods for the life of human society*"[14] At the same time 'mineral resources' are understood as:

documentTableId=4508762553030009 7&userAction=Browse&templateName=&documentId=514a8db636ea637f6e27069183966350 (accessed 29 September 2021).

10 See: Solar Electric Propulsion (SEP), Official website of NASA, https://www.nasa.gov/mission_pages/tdm/sep/index.html (accessed 29 September 2021).

11 See: D. Cyranoski, China sets sights on first solar power stations in space, Nature 2019. https://doi.org/10.1038/d41586-019-00629-5 (accessed 29 September 2021).

12 See: D. Tang, China embarks on space race for solar power, The Times, August 17, 2021. https://www.thetimes.co.uk/article/china-embarks-on-space-race-for-solar-power-2hvkdhlcx (accessed 29 September 2021).

13 See: Russian standard P 52104-2003 "National standard of the Russian Federation. Resource saving. Terms and definitions" (approved by the Resolution of the Gosstandart of the Russian Federation of 03.07.2003 N 235-st), as amended on 30.11.2010, http://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=EXP&n=527970#02953920050425354 (accessed 29 September 2021).

14 Mining: Terminological Dictionary, K.N. Trubetskoy, D.R. Kaplunov (Eds.), Gornaya Kniga Publishing, Moscow: 2016, p. 416.

> *solid, liquid, gaseous minerals, energy resources and cavities of natural and man-made origin in the bowels, among which mineral deposits are distinguished; dumps of overburden and enclosing rocks, waste heaps of coal mines, dumps and warehouses of off-balance minerals; wastes from mining and metallurgical industries; deep springs of fresh, mineral and thermal waters; internal heat of the Earth's interior; natural and man-made cavities in the rock mass.*[15]

The term 'natural resources' means:

> *environmental components, natural objects, natural and man-made objects that are used or may be used in the implementation of economic and other activities as a source of energy, the production of products and commodities and have consumer value.*[16]

International law of the seas has the notion of a 'resource' that means "*all solid, liquid or gaseous mineral resources in situ in the Area*[17] *at or beneath the seabed, including polymetallic nodules*" (Art. 133 of the United Nations Convention on The Law of The Sea (hereinafter – UNCLOS).
Presumably, space resources are similar natural resources that are found in space.
The Hague International Space Resources Governance Working Group (hereinafter – the Hague Working Group) in its Building Blocks for the Development of an International Framework on Space Resource Activities offers the following definition of 'space resource':

> *an extractable and/or recoverable abiotic resource in situ in outer space, considering that outer space includes mineral and volatile materials, including water, but excludes satellite orbits; radio spectrum; and energy from the sun except when collected from unique and scarce locations.*[18]

The abovementioned analysis shows that collected solar energy could be referred to as a space resource.

15 Mining: Terminological Dictionary, K.N. Trubetskoy, D.R. Kaplunov (Eds.), Gornaya Kniga Publishing, Moscow: 2016, p. 416.
16 See: Federal Act dated January 10, 2002 N 7-FZ (revised July 31, 2020) "The Environmental Protection Federal Act", http://www.consultant.ru/cons/cgi/online.cgi?req=doc&ts=76810928302459945257290 65&cacheid=7F80784CEE70969B1652C04D72E1D058&mode=splus&base=LAW&n=358870&dst=100027&rnd=2A0585EED43C23A8C4AD76802D783F58#v6qwcduyvs (accessed 29 September 2021).
17 Means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction (Art. 1 of the UNCLOS (1982)).
18 See: Building Blocks for The Development of an International Framework on Space Resource Activities, November 2019. URL: https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht--en-ruimterecht/space-resources/bb-thissrwg--cover.pdf (accessed 29 September 2021).

1.5. International Legal Regime of the Use of Solar Energy

Solar energy as a kind of space resources of course is regulated by all principles and norms of international space law. The main sources in this regard will be the Outer Space Treaty 1967 as it includes specialized principles of international space law on the exploration and use outer space and other celestial bodies. Below there will be underlined the most important principles.

The Outer Space Treaty states: "*Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means*" (Art. II).

It means that usage of solar energy comes within this rule. At the same time Art. I of the Outer Space Treaty stipulates that: "*Outer space, including the Moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality*".

These provisions establish the base for the usage of space resources: States can use it considering the interests of the other States-participants of space activity.

Unfortunately, international space law does not have any specialized international legal regime for the usage of solar energy as space activities are different in practice and it is problematic to draft special international treaty for every type of it. However, international space law has some specialized regimes of space resources' exploitation and use like celestial bodies and orbital frequency spectrum, which will be analyzed in short.

1.5.1. International legal regime of celestial bodies and its resources

Firstly, international legal regime of celestial bodies and its resources is based on the principles of space law, which are enshrined in the Outer Space Treaty 1967.

Secondly, specialized international legal regime is established by the Moon Agreement 1979. However, the international legal regime of the use of the lunar natural resources has not been established yet. It should be established, including appropriate procedures, to govern the exploitation of the natural resources of the Moon as such exploitation is about to become feasible in accordance with the Moon Agreement (Art. 11). Nowadays States-Parties to this Agreement did not do it.

Due to this fact all interested persons in the future exploration and use of different celestial bodies, first of all, the Moon and its lunar resources have started to promote different initiatives and projects.

The first project belongs to the Leiden University, where it was decided to create the Hague Working Group. Such group was established in 2014. It began to develop the main structural elements of the legal model for regulating activities in the field of space resources, which were summarized in the Draft Building Blocks for the Development of an International Framework on Space Resource Activities on September 13, 2017.

In 2019, the Hague Working Group by consensus adopted the so-called 'building blocks' for the development of an international framework for activities in the field of space resources, consisting of 19 components that States, international organizations and non-governmental entities are encouraged to consider and use pending the adoption and the operationalization of the international framework.[19]

The second project is the Moon Village Principles drafted by the Moon Village Association, which has been recently created as non-governmental organization based in Vienna. The First Draft Principles were published on 21 December 2018. In February 2020, the Principles were revised to ensure that the Principles are consistent with international law, the UN Guidelines for the Long-Term Sustainability of Outer Space Activities (2019)[20] and the Building Blocks (2019). The Principles consists of 15 principles.[21]

Apart from these projects some researchers suggest drafting an operating agreement to the Moon Agreement pursuant to the paragraph 5 of the Article 11.

Other variants are discussed in the framework of the UN COPUOS Legal Subcommittee under the agenda item "General exchange of views on potential legal models for activities in the exploration, exploitation and utilization of space resources" and will be discussed in the framework newly established in 2021 Working Group under this agenda[22].

It should be noted that the Moon Agreement is applicable not only to the Moon and its resources but at the same to other celestial bodies like asteroids, exploitation of which has already started. Article 1 of the Moon Agreement states that:

> *this Agreement relating to the Moon shall also apply to other celestial bodies within the solar system, other than the Earth, except insofar as specific legal norms enter into force with respect to any of these celestial bodies.*

19 Building blocks for the development of an international framework on space resource activities. Working paper submitted by Luxembourg and the Netherlands. A/AC.105/C.2/L.315. 2020-03-02 https://www.unoosa.org/oosa/oosadoc/data/documents/2020/aac.105c.2l/aac.105c.2l.315_0.html, p. 1.

20 See: I. Chernykh, International Legal Aspects on Sustainable Development of Outer Space Activities: combine Safety and Effectiveness in the long-term, Proceedings of the International Astronautical Congress, Bremen, Germany, 2018, pp. 1-11.

21 See: Moon Village Principles (MVP) Issue 2., https://moonvillageassociation.org/wp-content/uploads/2020/03/MV-PRINCIPLES-Issue-2-Draft.pdf (accessed 29 September 2021).

22 UN Doc. A/AC.105/1243 "Report of the Legal Subcommittee on its sixtieth session, held in Vienna from 31 May to 11 June 2021," p. 30-33 (accessed 29 September 2021).

1.5.2. Orbital Frequency Spectrum Regime

A comprehensive international legal regime was established on the question of the orbital frequency spectrum usage too.[23] It is formalized in the provisions of the International Telecommunication Union's Constitution and Convention 1992 (edited in 2019) and in its Radio Regulations. The basic provisions permit the usage of the different types of orbits including the geostationary one. The most important provision – the Art. 44 of the ITU Constitution – stipulates that:

> *Radio frequencies and any associated orbits, including the geostationary-satellite orbit, are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulations, so that countries or groups of countries may have equitable access to those orbits and frequencies, taking into account the special needs of the developing countries and the geographical situation of particular countries.*

At the same time Art. 45 of the ITU Constitution bans harmful interference:

> "*All stations, whatever their purpose, must be established and operated in such a manner as not to cause harmful interference to the radio services or communications of other Member States...*"

Moreover, the UN COPUOS has already drafted some "soft law" documents in this regard. On the 8th of December 2000, it has adopted annually resolution 55/122 "International cooperation in the peaceful uses of outer space", Paragraph 4 of which dedicated to the "Some aspects concerning the use of the geostationary orbit."

Finally, on the permanent bases Member States of the UN COPUOS discuss in the framework of its meetings the agenda item titled "Matters relating to the definition and delimitation of outer space and the character and utilization of the geostationary orbit, including consideration of ways and means to ensure the rational and equitable use of the geostationary orbit without prejudice to the role of the International Telecommunication Union".

1.6. Liability for the Damage Caused by Solar Energy in Outer Space

One of the most interesting issues with solar energy is the liability for damage caused by it. The use of solar energy can damage space objects of other space actors and cause damage to the surface of the Earth. To date liability issues on space, activities are regulated by art. VII together with Art. VI (responsibility for national space activities) of the Outer Space Treaty 1967 and Liability Convention 1972.

23 See: A. Abashidze, I. Chernykh, How to Explore Further the Geostationary Orbit: Current Status from The International Legal Perspective, Proceedings of the Second IAA/AAS SciTech Forum on Space Flight Mechanics and Space Structures and Materials, RUDN University, Moscow, Russia, 25-27 June 2019.

Art. VII of the Outer Space Treaty 1967 states that a State Party:

> *that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies.*

This provision from the point of collecting of solar energy in outer space means that if a space object (specialized satellite or 'solar space power station") will cause any damage, the so-called "launching state" will be internationally liable. Also, there could be damage on the surface of the Earth. The Liability Convention 1972 is the second international treaty that contains provisions dedicated to the liability for space activities. Art. 2 enshrines the absolute liability if damage caused "*on the surface of the Earth or to aircraft in flight*". Art 3 is dedicated to the fault-based liability for damage caused elsewhere than on the surface of the Earth. It is interesting that both articles could be applicable in the case of the solar energy collected in outer space and delivering to the surface of the Earth.

The first scenario could be when transmitted solar energy will be a cause of indirect damage occurring on the surface of the Earth or aircraft in flight. The second variant – if solar energy will cause damage in outer space. The difference between these two scenarios is a type of future international liability that depends on a place of damage.

In these circumstances prof. Ram S. Jakhu and D. Howard define two types liability: liability of space based solar power as a space object and liability for electric transmissions, that includes interference to radio services and adverse effects on human health and property.[24]

For proof of international liability, it will be necessary to demonstrate several interrelated elements: breach of international obligation(s), a causal link, and damage. The most difficult issue will be to prove that solar energy itself was a cause of the damage (like in a situation with nuclear power sources).

3. Theory

Some aspects of the use of energy in space and its international legal regulation were discussed in early works on space law and economy in 1970-1980. For instance, some authors suggested to prepare in that context the Space Energy Convention.[25] In those times there have already been different

24 Ram S. Jakhu, D. Howard, Safety and Liability Aspects of Solar Power Satellites, 62nd Colloquium of the Law of Outer Space, Cape Town, South Africa, 2011, 3-7 October, pp. 362-367.

25 See: E. Fasan, Space Energy Law and the Hierarchy of Norms, 19th Colloquium of the Law of Outer Space, Anaheim, California, USA, 1976, 12--15 October, pp. 119-123.

projects in the usage of solar energy in space.[26] The most famous projects were U.S. outer space energy research programs and the USSR research on pollution-free energy from outer space.[27] The key approach in all these projects was to collect solar energy on solar space power stations (the Arthur D. Little concept[28] and the Boeing concept[29]), convert sunlight to low-density microwaves and finally to beam it to the Earth. On the surface of the Earth microwaves would be converted to ordinary electricity. For these purposes it was necessary to build ground receiving antennas (approx. 5 miles in diameter).[30] Another suggestion was to use laser beam.
Also, there were suggested different locations for such solar stations: Lagrange Points (as they had/have sufficient regulatory basis) or geosynchronous orbit (where it was supposed to deploy large orbital stations like colonies (USSR project)).
Authors in that regard rase the question of potential problems in that field like following to the principle of non-appropriation or liability questions,[31] as well as legal problems on the terrestrial use of solar energy.[32]
It was assumed that solar space power stations would start to be used in 1985, 1995 or 2050.

4. Results and Discussion

The necessity of the international legal regime for the solar energy and its use is not discussed today, because this type of energy is not so popular or required in comparison with the use of lunar resources or asteroids.
The possible models for international legal regime of solar energy includes: 1) the Antarctic Treaty (1959) regime, which provides the freezing of all territorial claims to a given territory as well as declaring the Antarctica as a

26 See: E.R. Finch, Energy – Ecospace, 19th Colloquium of the Law of Outer Space, Anaheim, California, USA, 1976, 12-15 October, pp. 124-134; H. Berger, International Law and Solar Energy Satellites, 20th Colloquium of the Law of Outer Space, Prague, Czechoslovakia, 1977, September 25-October 1, pp. 149-156.
27 I. Zorich, Energy from Outer Space, Week Newsletter, No 20 (948), p. 11.
28 It was supposed to collect solar heat by solar cells.
29 It was supposed to collect solar heat by a heat engine converter including usage of large mirrors which would collect sun energy, concentrate it and use for water heat creating steam. Steam would turn a turbine connecting with an engine converter which would produce current. The second variant was to use magnetohydrodynamic generator.
30 See: E.R. Finch, Energy – Ecospace, 19th Colloquium of the Law of Outer Space, Anaheim, California, USA, 1976, 12-15 October, pp. 124-134.
31 See: L.I. Tennen, International Law and the Use of Outer Space for the Production of Solar Energy, 20th Colloquium of the Law of Outer Space, Prague, Czechoslovakia, 1977, September 25-October 1, pp. 456-472.
32 See: E.R. Finch, Energy – Ecospace, 19th Colloquium of the Law of Outer Space, Anaheim, California, USA, 1976, 12-15 October, pp. 124-134.

"nature reserve for peace and science" in according with the Protocol on the Protection of the Antarctic Environment to this Agreement;[33] and the UNCLOS's regime, which establishes a regime for the development of resources in the Area (Part XI of the UNCLOS 1982). This Area and its resources in accordance with Art. 136 are the common heritage of mankind. Such activity is monitored by the International Seabed Authority located in Jamaica. The resources of the Area may only be alienated in accordance with the provisions of the 1982 UNCLOS and the rules, regulations, and procedures of the Authority.

However, if the experience of the international law of the sea could be used for solar energy, the Antarctic Treaty's approach is considered to be as subsidiary, i.e. in the event that the exploitation of solar energy is carried out in violation of the principles and norms of international law, which will lead to the need to suspend this type of space activity for some time.

5. Conclusion

Thus, we can conclude that solar energy is a space resource that allows States to get energy benefits in the future through the usage of special space energy platforms or space crafts. The exploitation and use of this type of energy should be compliant with basic principles and norms of international law, especially international space law.

Unfortunately, international space law does not contain any specialized international legal regime for solar energy but presumes special regime for mineral resources of celestial bodies and has the regime of the orbital frequency spectrum under the umbrella of the ITU.

In this case Public international law suggests the similar regimes which could be used for the establishing of the solar energy's usage regime such as the international legal regime of the Area (international law of the sea) or the regime by Antarctic Treaty System.

Concerning the damage from the use of solar energy, there we have similar problems in the context of the fault-based liability and indirect damage including damage on the surface of Earth. Disputes concerning damage from collecting solar energy satellites (direct damage) will be covered by the basic provisions of the Outer Space Treaty and the Liability Convention.

33 Protocol on Environmental Protection to the Antarctic Treaty, 4 October 1991, https://ats.aq/e/protocol.html (accessed 29 September 2021).

Acknowledgements

The article is published in framework of the grants of the President of the Russian Federation for state support of young Russian scientists – candidates of science (Competition - MK-2021) project "Problems of the exploration and utilization (including exploitation) of space resources: international legal and comparative legal analysis" MK-2118.2021.2.
This paper has been supported by the RUDN University Strategic Academic Leadership Program.