**SUSTAINABLE DEVELOPMENT WORKING GROUP PROJECT PROPOSAL (hereinafter – SDWG)**

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| **Project Title:**  ***"Gas hydrates: Environmental and Economic Impact on Sustainable Development and Climate-driven Transformation of the Arctic (hereinafter referred to as GH4Arctic and/or the Project)*** | **Lead Country/ GН4Arctic Project leader(s):**  Russian Federation/  Federal State Autonomous Educational Institution of Higher Education "National Research University “Higher School of Economics" (hereinafter referred to as the HSE) (the leading organization)  - V. I. Il`ichev Pacific Oceanological Institute of the Far East Branch of the Russian Academy of Science (RAS);  - Non-profit partnership "Technology platform “Technologies of Ecological Development" that unites more than 80 research organizations and 76 educational institutions of the Russian Federation |
| **Total Cost of Project:**  The Project management state / project manager(s) provide the funding for supporting the permanent Secretariat.  The Project management state / project manager(s) and participants will seek opportunities to co-finance joint research programs (f hereinafter  research) from their own funds, resources of concerned national organizations and international financial institutions in accordance with the coordinated action plan of the Project implementation. | **Relationship to other AC Working Groups:**  The GН4Arctic Project is a unique one. The coordination with other Arctic Council Working Groups is required on certain aspects of the Project implementation including Arctic Monitoring and Assessment Program (AMAP), Emergency Prevention, Preparedness and Response (EPPR), and Protection of the Arctic Marine Environment (PAME). |

**Criteria for assessing project proposals submitted to SDWG**

In the Declaration adopted in 1996 in Ottawa (Canada) which established the Arctic Council, the signatory countries unanimously declared “...their desire to protect the Arctic natural environment, including the health of Arctic ecosystems…”.

The Environmental Protection Strategy notes: “…the Arctic also exerts an important influence on the global environment…” [1]. This implies the relevance of studying positive and negative feedbacks between natural and anthropogenic processes that determine the functioning of the Arctic climate system.

The United Nations Framework Convention on Climate Change emphasizes: “…that steps required to understand and address climate change will be environmentally, socially and economically most effective if they are based on relevant scientific, technical and economic considerations and continually re-evaluated in the light of new findings in these areas…”, as well as the fact that the parties to the Convention «… promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change…».

**Taking into account the above-mentioned priorities, the main goal and objectives of the GН4Arctic Project are formulated:**

***Project Objective***

Overall goal of the project is to develop a set of measures to prevent and / or reduce damage to the Arctic ecosystem at local and global scales) as well as an international system for assessing, forecasting, monitoring and informing about the risks associated with the massive release of greenhouse gases into the atmosphere, emitted from gas hydrates.

***Tasks:***

1. To identify the mechanism of gas hydrates destabilization in the Arctic seas.

2. To evaluate the distribution and stability violations of natural gas hydrates in permafrost, prospects for their industrial development.

3. To assess environmental risks and their demographic consequences in case of degradation of gas hydrates because of climate changes in the Arctic.

4. Mapping of underwater permafrost (hereinafter referred to as UP) and to identify its inter-annual dynamics in areas of massive discharge of bubbly methane to quantify methane emissions from bottom sediments into the water column and atmosphere.

5. To develop a system for monitoring, forecasting and managing the risks of uncontrolled natural release of greenhouse gases into the atmosphere from offshore gas hydrates and other geological reservoirs (pools) of methane as well as quantitative assessment of their massive emissions.

6. To develop a new generation of models for UP degradation and destabilization of shelf hydrates in the context of identifying and evaluating the strength of positive feedback in the climate-cryosphere-greenhouse gas emissions-climate system.

**GН4Arctic Project Rationale:**

The project is proposed to be implemented in 2020-2023 during the period of the chairmanship in the Arctic Council of Iceland (2019-2021) and Russia (2021-2023).

The importance of methane research is confirmed by establishing an expert group of the Arctic Council in 2017, initiated by Finland, to promote the implementation of the framework document for action on enhancing the reduction of black carbon and methane emissions (EGBCM).

At the Project preparation stage, representatives of a number of universities in the Arctic Council member-states reported their interest in participating in its implementation, including the University of Science and Technology, Trondheim (NTNU), Norway; the University of Illinois at Chicago (UIC), USA; Stockholm University (SU), Sweden, and the University of Alaska Fairbanks (UAF), USA.

**Background:**

The studies of gas hydrates around the world have been carried out quite actively in recent decades. Special programs and plans for their study were adopted in such countries as the United States of America, Japan, Canada, India, China, and others. Interest in studying them was primarily related to the possibility of using gas hydrates as a potential source of natural gas extraction to meet the global demand for energy. According to various estimates, more than 70% of the world's natural gas reserves are located in gas hydrates, which is more than half of all energy hydrocarbons on the planet. This fact drawn the attention to the exploration of gas hydrates located primarily in cold seas and its extraction from the sea floor that is considered as a promising technology for new source of energy production.

In 2017, China announced the successful completion of the first offshore natural gas hydrate production test in South China Sea, producing 120 thousand m3 of gas hydrates containing 99.5% methane during the period from 10 to 18 May, 2017. China had duplicated Japan’s achievement of 2013, when the same amount of gas from the offshore methane hydrate was produced after almost 10 years of search in Aichi Prefecture. On March 26, 2020 the Ministry of Natural Resources of China reported world records by extracting 861.4 thousand m3 of gas hydrates from a depth of 1225 meters during the exploration of the so-called "fuel ice", while the average daily production volume reached 28.7 thousand m3.

These data indicate an increase in the activity for the development of technologies for industrial production of natural gas from gas hydrates and the economic feasibility of such production in the medium term. The scientific base in the field of studying the distribution and stability of permafrost and associated Arctic gas hydrates is becoming topical [2,3] that This is necessary to prevent geo-ecological disasters that may occur during exploration and industrial activities (uncontrolled releases of hydrate gas, etc.). The scale of the consequences of such disasters is clearly demonstrated by the accident in the Gulf of Mexico, however, in the Arctic the damage might be more drastic.

In addition, the relevance of the GH4Arctic Project implementation is proved by massive discharge of methane due to progressive degradation of UP [5,6], identified within the framework of the multi-year Russian-American-Swedish project “International Siberian Shelf Studies” (hereinafter-ISSS) [4]. At the same time, during the 5-year program of research drilling in the seas of the Eastern Arctic, it was found that over the past 30 years, the rate of vertical degradation of permafrost has doubled, compared to previous centuries, and reached 18 cm / year, which is an order of magnitude higher than previously accepted estimations [7].

Underwater permafrost in the seas of the Eastern Arctic has become warmer than ground permafrost by 8-10°C. This is quite close to the temperature of the phase transition, and in many places it has already undergone significant or complete degradation [8]. This means that huge reservoirs of natural gas (mostly methane) in free or hydrate form are already involved in the modern biogeochemical cycle, the intensity of which can vary by five orders of magnitude (from 10-3g/m2 to 102g/m2 per day) depending on the state of the underwater permafrost [9].

In addition, it should be noted that the study of underwater gas hydrates in recent decades has not provided a sufficient scientific base for systematic observations and data banks related to gas hydrates in permafrost on land, whose capacity in the Arctic region can reach 300-700 meters. The research conducted recently in Russia has revealed about 7 thousand bulges of heaving only on the Yamal Peninsula that may be of interest for further study in order to analyze their potential gas explosion hazard, as well as about three hundred lakes, at the bottom of which hundreds or even thousands of craters of gas emission are observed [2, 10]. For example, in the summer of 2014, an almost circular crater with a diameter of 20 meters and a depth of about 50 meters was found in the Central part of the Yamal Peninsula [11]. The studies and simulations have shown that the crater was formed as a result of cryovolcanism caused the release of gas due to processes associated with the degradation of permafrost. It is noteworthy that this is the first recorded phenomenon of cryovolcanism on Earth, which is not completely because of this process occurs quite rarely, but due to the insufficient knowledge and small population of the Arctic and cryolithozone as a whole. It should be noted that within the framework of the ISSS international project (since 2003), multiple submerged craters have been identified on the sea floor of the Eastern Arctic, the linear dimensions of which vary from meters to tens or hundreds of meters in diameter; this should be taken into account when planning infrastructure projects for the development of the Northern sea route. The release of methane from gas hydrates concentrated in perennial permafrost on land and in the Arctic seas can contribute to the increase in the greenhouse effect and accelerate climate change.

These processes make it necessary to conduct research on gas hydrate deposits and develop an international system for assessing, forecasting, monitoring and informing about the risks associated with the release and discharge of methane into the atmosphere from gas hydrates.

Identifying the climate role of the consequences of permafrost degradation and massive methane emissions caused, among other things, by the destabilization of Arctic shelf hydrates will be an important contribution to the assessment of the relationship between climate change, the state of permafrost and additional greenhouse gas emissions into the atmosphere.

**Activities and Outputs of GН4Arctic Project**

***Major Activities:***

1. Organizing and implementing the international research in the Arctic seas having more than 80% of the world underwater permafrost and associated with huge reserves of gas hydrates

2. Establishing systematic observations and data bank on gas hydrates in the Arctic, the state of gas hydrates in the permafrost on land, on the shelf and, in general, on the bottom of the Arctic seas.

3. Assessing the positive impact observed and expected climate changes on methane emissions from bottom sediments into the water column and atmosphere due to the degradation of permafrost and destabilization of hydrates, and the thawing the terrestrial permafrost.

4. Developing a methodology for early detection, monitoring and mitigation of threats to residents at higher risks related to increasing underwater permafrost degradation and hydrate destabilization as well as terrestrial permafrost thawing in the Arctic.

5. Identifying the environmental consequences of water acidification resulted from the oxidation of methane (to carbon dioxide) that entered the water environment due to unloading of deep geological methane from hydrates and other sources.

6. Developing a model for assessing and forecasting environmental risks caused by the dynamics of the release volume power and frequency of massive emissions of greenhouse gases from gas hydrates into the atmosphere and the waters of the Arctic seas.

7. Analyzing and characterizing the main risk factors for violations of the stability of Arctic ecosystems and negative impact on public health associated with climatic degradation of gas hydrates. Development of methodological recommendations to justify practical measures aimed at reducing them.

8. Developing the main provisions of the information system for early detection, monitoring and risk assessment of geo-ecological disasters in the Arctic.

9. Developing the policy for informing state authorities, municipal self-government and the population on the risk prevention in the field of geo-ecological safety.

***Expected Outputs:***

1) advanced knowledge aimed at reducing the risks of adverse consequences of geo-ecological disasters and their impact on the morbidity and mortality rates of the population living in potentially dangerous areas, the state of the Arctic natural environment, the health of Arctic ecosystems and the global climate in general;

2) methodology of early detection and counteraction to threats related to the high rate of degradation of permafrost, melting and heaving of permafrost on land in state monitoring systems;

3) recommendations to improve geo-ecological safety in the member-states of the Arctic Council in order to reduce environmental and human health risks for the population living in the Arctic;

4) information system for early detection, monitoring and assessment of risks of geo-ecological disasters in the Arctic;

5) guidelines for training and knowledge management in the field of geo-ecological safety in the Arctic;

6) international plan for managing risks to the Arctic environment and climate change related to the state of gas hydrates; recommendations for decision-making by the authorized bodies of the member-states of the Arctic Council on interregional and interstate coordination in solving the problem of managing these risks.

Representatives of concerned organizations are invited to participate in the Project on behalf of the member-states of the Arctic Council, its permanent participants and observers.

The overall implementation of the project, including the coordination of all participants, and the submission of interim and final reports to the SDWG will be provided by a Task force consisting of the most experienced experts in the field of research including the greenhouse gas emissions caused by the degradation of underwater and ground permafrost; geo-ecological safety; public health and sustainability of ecosystems. In order to coordinate the practical activities, HSE (Russia) will establish a Project office in cooperation with the Ministry of Natural Resources and Environment of the Russian Federation, Ministry for the Development of the Russian Far East, Ministry of Education and Science of the Russian Federation, official Russian and foreign participants of the Project.

**Integration of Traditional and Local Knowledge**

Integration of traditional and local knowledge will help to achieve better results in the implementation of the Project by using them in the Project activities, in particular, in the field of monitoring the environmental situation and the state of gas hydrates in places where indigenous people live in the Arctic. The main beneficiaries of the new knowledge gained as a result of the Project will be indigenous Arctic residents who lead a traditional way of life.

**Timetable and Completion OF the GН4Arctic Project**

***The Project will start*** in September 2020.

The project involves 4 stages of implementation.

***Stage 1*** (September 2020 - March 2021) - Analysis of available information on gas hydrates in the Arctic region, including the state of gas hydrate deposits in perennial permafrost on land, on the shelf and in genera at the bottom of the Arctic seas; programs for their study and experimental development; the availability of research infrastructure. Development of recommendations for updating the database of systematic observations and data bank on gas hydrates in the Arctic region (interim report to SDWG).

***Stage 2*** (April 2021 - December 2021) – Assessment of the impact of observed and expected climate changes on the dynamics of continuous greenhouse gases emission from gas hydrates into the atmosphere and into the waters of the Arctic seas as well as the relationship between the dynamics of growth of greenhouse gas emissions from this source and climate change (interim report to SDWG).

***Stage 3*** (January 2022 - December 2022) – Development of a concept to minimize adverse effects on the Arctic environment and global climate caused by high rates of degradation of underwater permafrost, melting and heaving of perennial permafrost in the Arctic; development of a methodology for assessing, forecasting and monitoring geo-environmental risks (interim report to SDWG).

***Stage 4*** (January 2023 - September 2023) – Development of recommendations for the creation of an international system for informing public authorities, local governments and the public about risks in the field of geo-ecological safety; development of an international plan for managing risks to the population and the environment of the Arctic as well as the global climate related to the state of gas hydrates in the Arctic region (final report to the SDWG, including a draft report to Senior officials of the Arctic Council).

During the implementation of all stages of the Project (2020-2023), it is planned to organize and to carry out complex marine expeditions to the seas of the Eastern Arctic in order to implement the main activities related to field observations and to publish a series of articles in leading publications quoted in the Web of Science.

***The Project will be completed in September 2023.*** Holding a special scientific session on the results of the project at the General Assembly of the American Geophysical Union (AGU) and/or the European Geophysical Union (EGU). Publication of a specialized monograph in Russian and in English.

**Communications:**

As part of the task of developing a policy for informing state authorities, municipal governments and the public on the prevention of risks in the field of geo-ecological safety, an appropriate communication strategy will be developed that will make it possible to convey information about the goals and objectives of the Project, the final results of its implementation and practical recommendations to the general public of the member-states of the Arctic Council.

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