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No. (14)-D8(E)-

REGARDING THE STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT OF THE ENGINEERING INFRASTRUCTURE DEVELOPMENT PLAN FOR RENEWABLE ENERGY DEVELOPMENT IN THE BALTIC SEA

Lithuania wishes to inform you about Strategic Environmental Assessment (SEA) of the Engineering Infrastructure Development Plan for Marine Areas of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea, Designed for the Development of Renewable Energy (EIDP). The SEA report is currently delivered for the Lithuanian national authorities for the review.

According to the SEA of the EIDP it is highly unlikely that the implementation of a plan will have any significant transboundary environmental impacts. However, we are taking a precautionary approach and would like to provide you with the information.

If you have any queries or wish to participate in transboundary consultations regarding the SEA, please do not hesitate to contact us no later than 11th of October, 2021.

Please find attached the summary of the SEA report in English.

Vice-minister Darius Kvedaravičius

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ATTACHMENT: Conclusions and Summary of the Strategic Environmental Assessment of the Engineering Infrastructure Development Plan for Marine Areas of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea, Designed for the Development of Renewable Energy, 48 p.

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CONCLUSIONS AND SUMMARY OF THE STRATEGIC ENVIRONMENTAL ASSESSMENT OF

THE ENGINEERING INFRASTRUCTURE DEVELOPMENT PLAN FOR MARINE AREAS OF LITHUANIA'S TERRITORIAL SEA AND/OR THE EXCLUSIVE ECONOMIC ZONE OF THE REPUBLIC OF LITHUANIA IN THE BALTIC SEA, DESIGNED FOR THE DEVELOPMENT OF RENEWABLE ENERGY

2021 m.

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1. PLANNED AREA

The Development Plan provides for a planned area, i.e., a *potential area for development of renewable energy*, which is defined in the technical infrastructure drawing of the Comprehensive Plan of the Territory of the Republic of Lithuania[1] (2015), supplemented with the part "Marine Territories". A total area of the territory is 644.33 km^2.

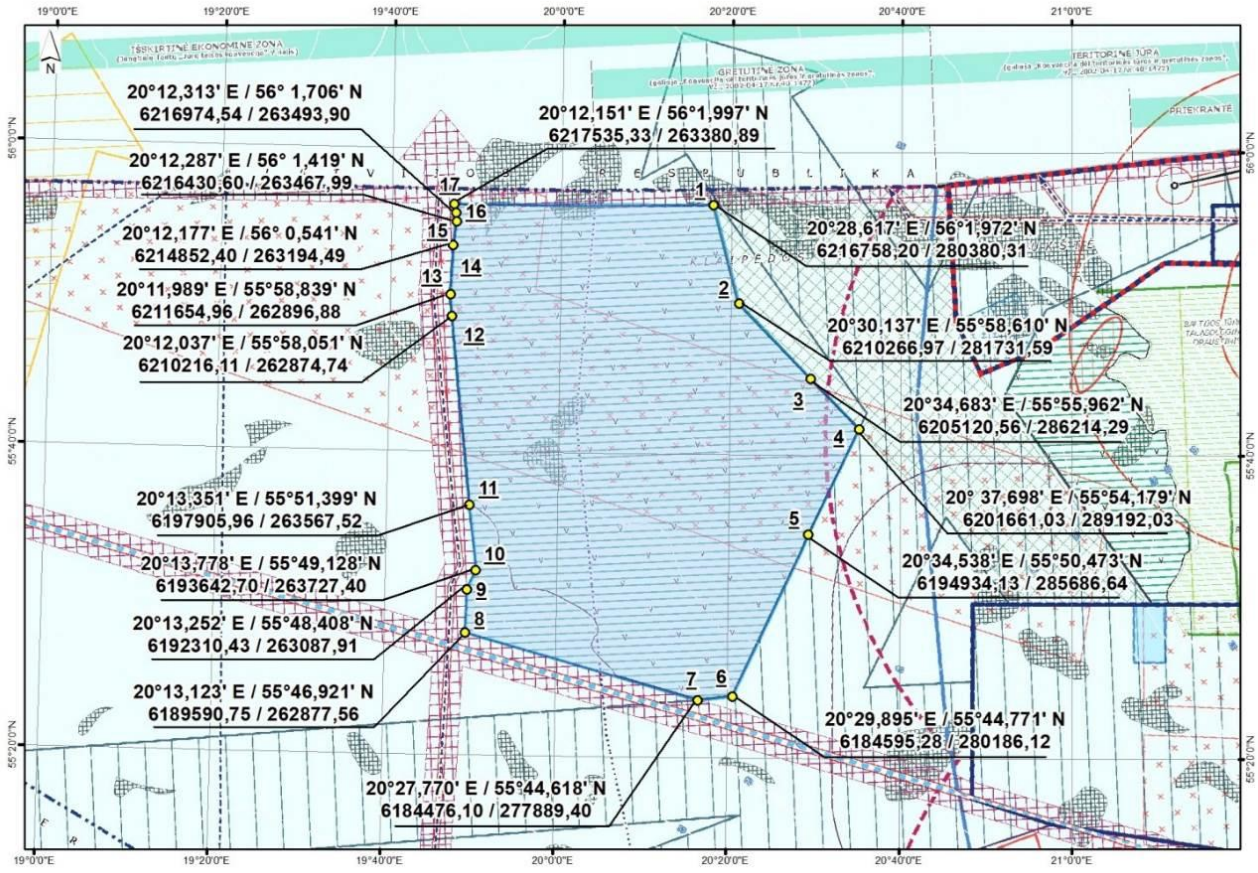

Fig. 1. Planned area - a *potential area for development of renewable energy*, as defined by the Comprehensive Plan of the Territory of the Republic of Lithuania.

2. BASIS FOR PLANNING

The basis for preparation of the Development Plan is:

- Resolution of the Government of the Republic of Lithuania No. 697 of 22 June 2020 "On the Identification of the Priority Parts of Lithuania's Territorial Sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea Where a Tender (Tenders) for the Development and Operation of Power Plants Using Renewable Energy Sources is (are) Expedient and on the Measurement of the Installed Capacities of Such Power Plants".

[1] Resolution of the Seimas of the Republic of Lithuania no. XII-1781 as of 11 June 2015 "On the Approval of the Part "Maritime Territories" of the Comprehensive Plan of the Territory of the Republic of Lithuania

- Order of the Minister of Energy of the Republic of Lithuania no. 1-253 as of 17 August 2020 "On the Start of the Preparation of the Engineering Infrastructure Development Plan for Marine Territories of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea Allotted for the Development of Renewable Energy and on the Setting of the Planning Objectives".
- The Development Plan Planning Programme approved by Order of the Minister of Energy of the Republic of Lithuania no. 1-306 as of 23 September 2020 "On Approval of the Programme on the Planning of the Engineering Infrastructure Development Plan for Marine Territories of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea Allotted for the Development of Renewable Energy and on the Setting of Planning Objectives."

3. OBJECTIVES AND TASKS OF PLANNING

Key Objectives of the Development Plan:

- To create conditions for energy production from wind power in the Baltic Sea.
- To create conditions for increasing a share of renewable energy sources in Lithuania's domestic energy production and total final energy consumption, thus reducing dependence on imported fossil fuels, and increasing capacities of local electricity generation.

Tasks of the Development Plan:

- To identify specific areas where the development and operation of offshore wind farms will be implemented in phases, including an assessment of a current situation, and taking development of wind farms in phases into account.
- To develop a concept of connecting wind farms to a transformer substation in the Baltic Sea (hereinafter – the offshore transformer substation) (at least 2 alternatives) and solutions in accordance with the planning conditions issued, with preliminary sites for connecting the wind farms to the offshore transformer substation cables and offshore transformer substation based on the prepared alternatives.
- To specify solutions of the research and concept for field studies in the sites of installation of offshore transformer substations and connection of the wind farms to the offshore transformer substation cables based on the prepared alternatives.
- To reserve areas for wind farm park boundaries, connection cables, construction, and service corridors, as well as other infrastructure facilities inside the Infrastructure Development Plan territory.
- To set special conditions for the use of the area, requirements for conditions of use, management, protection of the planned territories, development of activities in those territories, and other requirements.
- To prepare an infrastructure Development Plan for the wind farms in the Baltic Sea.
- Following the Procedure for Strategic Environmental Assessment of Plans and Programmes approved by Resolution of the Government of the Republic of Lithuania no. 967 as of 18 August 2004 "On the Approval of the Procedure for

Strategic Environmental Assessment of Plans and Programmes," to conduct the Strategic Environmental Assessment of the Infrastructure Development Plan (hereinafter – SEA) in accordance with the established procedure.

4. CONCEPT ALTERNATIVES UNDER CONSIDERATION

Preparation of the Development Plan Concept and the SEA, provided for a division of the area planned under the Development Plan, which is defined in the technical infrastructure drawing of the Comprehensive Plan of the Territory of the Republic of Lithuania (2015), supplemented with the part "Marine Territories", into separate areas, where the development of wind turbines will be carried out in phases. Key criteria for the division into areas are as follows:

- Size of the area planned under the Development Plan (644.33 km2) and its geometric shape.
- Geographical location and geometric shape of the area to be developed in the phase I (Fig. 3).
- Infrastructure corridors provided for in the Harmony Link Plan and the Comprehensive Plan of the Territory of the Republic of Lithuania.
- The task to evenly distribute the nominal capacity of wind farms and to attain ~700 MW for each area.
- The option of taking a high voltage cable out of the farm without crossing another farm.
- Localisation of potential oil fields.
- Natural aspects.

The following aspects have been examined in the selection of possible alternative transformer substation (TS) sites:

- Infrastructure corridors provided for in the Harmony Link and the Comprehensive Plan of the Territory of the Republic of Lithuania.
- A national security-sensitive territory where the construction of wind farms is prohibited[2];
- Technical feasibilities (possible typical solution) of localising two 700 MW TSs at the same point.
- Possible installation of transformer substations in the centre or on the outskirts of the generation facility.
- Optimisation of investment costs and electricity losses in the cable network through the TS positioning.

[2] The territory is defined on the map approved by Order of the Commander of the Lithuanian Armed Forces No. V-217 of 22 February 2016, "On the approval of the map of the territories of the Republic of Lithuania where design and construction of wind turbines (high-rise buildings) may be restricted"

https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/52fb4fc1d58011e59019a599c5cbd673?jfwid=-fxdp80pu

4.1. Factors determining the allocation of WT areas, cabling solutions, localisation of transformer substations, etc.

Key parameters of wind turbines

The Lithuanian offshore wind farm (OWF) is expected to use modern wind turbines which will generate the highest amount of energy per unit area in an average wind (according to preliminary data, an average wind speed is 9 m/s).

- Offshore wind turbine (WT) models with a capacity of 10-14 MW are available on the market now. WT technology is constantly and rapidly advancing. So, much more powerful models may appear on the market at the end of the construction. In the absence of measurements or any accurate data on winds in the planned area, the most probable Haliade-X 12 MW wind turbine[3] model with the following basic parameters was selected in the preparation phase of the Development Plan in order to choose specific OWF areas and to make preliminary measurement of the possible WT capacities to be installed therein: capacity: Pn-12 MW; diameter of the rotor: D-220 m; height: h-248 m; wind class[4]: IB.

In the technical design phase, based on the developer's data and clarified wind speed parameters, the most suitable wind turbines will be selected as well as physical and technical parameters of the wind farm, including their power.

Wind turbine location options in the planned area

When planning the preliminary sites for wind farms, possible locations for wind turbine installation were selected using a simplified method that meets the objectives of the concept, i.e., geometrically, based on the rotor diameter of the planned wind turbine (D):

- wind direction 12xD.
- perpendicular to the wind direction 5xD.

It the technical design phase, according to either the methodology provided by the developer or one of the turbulence impact models, locations of wind turbines' installation and their quantity will be specified.

The area of the Development Plan and the areas where the phased development of OWF is planned are not rectangle in the direction of prevailing winds. To use the entire territory most

[3] https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine. This specific wind turbine was used for preliminary assessment only

[4] Wind class IB (wind speed index I (10 m/s) and turbulence category B (medium)) was chosen as the most suited for conditions of the wind farm. Turbulence category C would only be acceptable for individual wind turbines. It is not advisable to use the mentioned manufacturer's wind turbines of the same size but more powerful in the plans, because an average wind speed hardly reaches speed index for a lower-capacity wind turbine [according to the standard LST EN IEC 61400-1]. An average wind speed must be clarified by making additional measurements.

efficiently, peripheral wind turbines are planned to be built at the cable protection zone (100 m)[5] from the boundaries of the area, by planning the entire power plant layout grid, accordingly.

Methods of wind turbine interconnections and connections to the substation

A network of medium and high voltage power lines, step-up transformers and substations is needed for the transformation and transmission of the produced energy to the mainland electricity networks (managed by LITGRID AB in Lithuania). No offshore reserve interconnection of the wind farms, developed in the phase I, and later perspective wind farms (sites A, B, and C) is scheduled due to the likely different electricity transmission technologies and likely different wind farm operators. The connection of the offshore substation to the onshore one is not provided for in this planning document.

There are underwater cables used to transport energy offshore. A 66 kV network would enable to consistently connect 6 to 9 wind turbines in groups. A 66 kV closed switchyard with the capacity to connect 2-3 cable lines must be installed in the wind tower. An exact number of WTs and cable lines in each of them must be determined during the technical design. In the design phase, OWF developers must specify cable line corridors provided for in the planning document.

Cable laying technology

Cables are usually laid using vessels. The cables, which connect wind farms to each other and wind farms to a transformer substation are usually recessed 1-2 m into the seabed (a trench is dug using special plough or a jet of compressed water). Under difficult geological conditions, cables are also laid on the seabed and covered with massive concrete slabs or rocks. The laying depth of high voltage cables may reach 3 m. An exact method of cabling will be selected during the preparation of the technical design, which will provide a decision of whether and/or which sections will require additional protection against physical flushing/exposure.

Before laying cables, the seabed must be inspected to avoid unsuitable cabling conditions (various matters, slopes). As well, various obstacles and debris (e.g., ship anchors, chains, steel nets, etc.) must be removed from the seabed.

During the preparation of the Development Plan, voltage and type (direct or altering current) of cables are not specified and will be selected during the preparation of construction technical specifications.

Offshore transformer substations

The technical design will provide the specification of the need for step-up (intermediate) transformer substations and the electrical network connection scheme. A transformer substation (s) is intended to collect the power generated by the entire wind farm, to transform it, and to transmit electricity further to electricity transmission networks. A substation is usually built in the centre of the generated power or in another location suitable for bringing medium and high voltage cable lines.

[5] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.416425

The choice of substation location is determined by:

- Sea depth – construction is more cost efficient in shallower waters.
- Lengths of medium-voltage cables and energy losses in them; most cost-efficient location to build a substation is the centre of generating sources.
- Proposed high-voltage connections with onshore and other wind farms.
- Additional wind turbulence caused by a substation as a structure.

Alternatives of the Development Plan Concept provide for preliminary locations for transformer substations. During the technical design, taking the above criteria into consideration, the location of the TS of the selected alternative under the Development Plan Concept may alter.

The size and performance of an offshore substation is influenced by a cable connection to an onshore substation in Lithuania or to an international hub interconnecting offshore OWF. Subject to the type of connection (HVDC[6] or HVAC[7]), an offshore transformer substation must have different equipment.

A substation is planned to be equipped with a required number of medium-voltage line cells, two power transformers, high-voltage sectional connection, and cells for high-voltage cable connections.

During the technical design, parameters of medium voltage network and generated reactive power shall be calculated, as well as technical specifications for the capacity of wind turbines to use or to generate reactive energy shall be formulated.

The main components of an offshore power substation are power transformers, switchgear, backup generator, staff rooms, water tanks, power cables, control/monitoring system, and more. Substations may weigh between 500 and 2,000 tons and are usually installed on a similar foundation as wind farms. A platform is elevated approximately 25 m above the sea level, the area may reach up to 800 m^2. One standard substation is sufficient to serve a wind farm of up to 700 MW capacity. Yet, to ensure more efficient electricity transmission, more than one substation can be installed per farm.

4.2. OWF development areas and phasing

Based on the principles and assumptions listed above, four areas have been identified (Fig. 2): The Area under development in Phase I, Area A, Area B, and Area C, in which the development and operation of offshore wind farms are planned.

[6] HVDC – High voltage direct current

[7] HVAC – High voltage alternating current

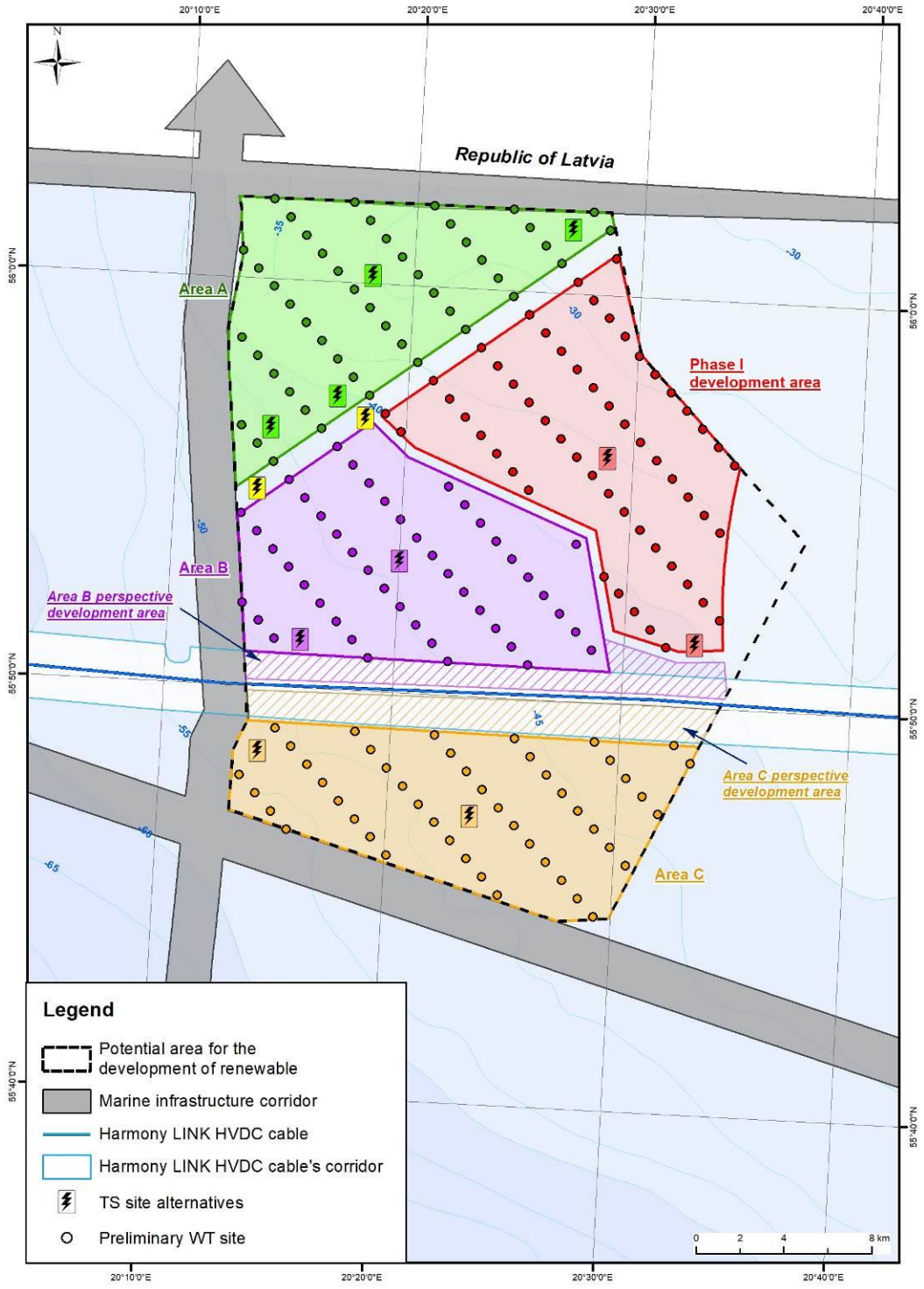

Fig. 2. A summarising scheme of the concept: location of the planned OWF areas and TS site alternatives.

The Phase I development area is within the dedicated OWE development zone approved by the Resolution of the Government of the Republic of Lithuania no. 697 of 22 June 2020 "On the Identification of the Priority Parts of Lithuania's Territorial Sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea Where a Tender (Tenders) for the Development and Operation of Power Plants Using Renewable Energy Sources is (are) Expedient and on the Measurement of the Installed Capacities of Such Power Plants." It will be built up with a wind farm of 700 MW installed capacity (Fig. 3). The total area of this territory is 137.5 km^2.

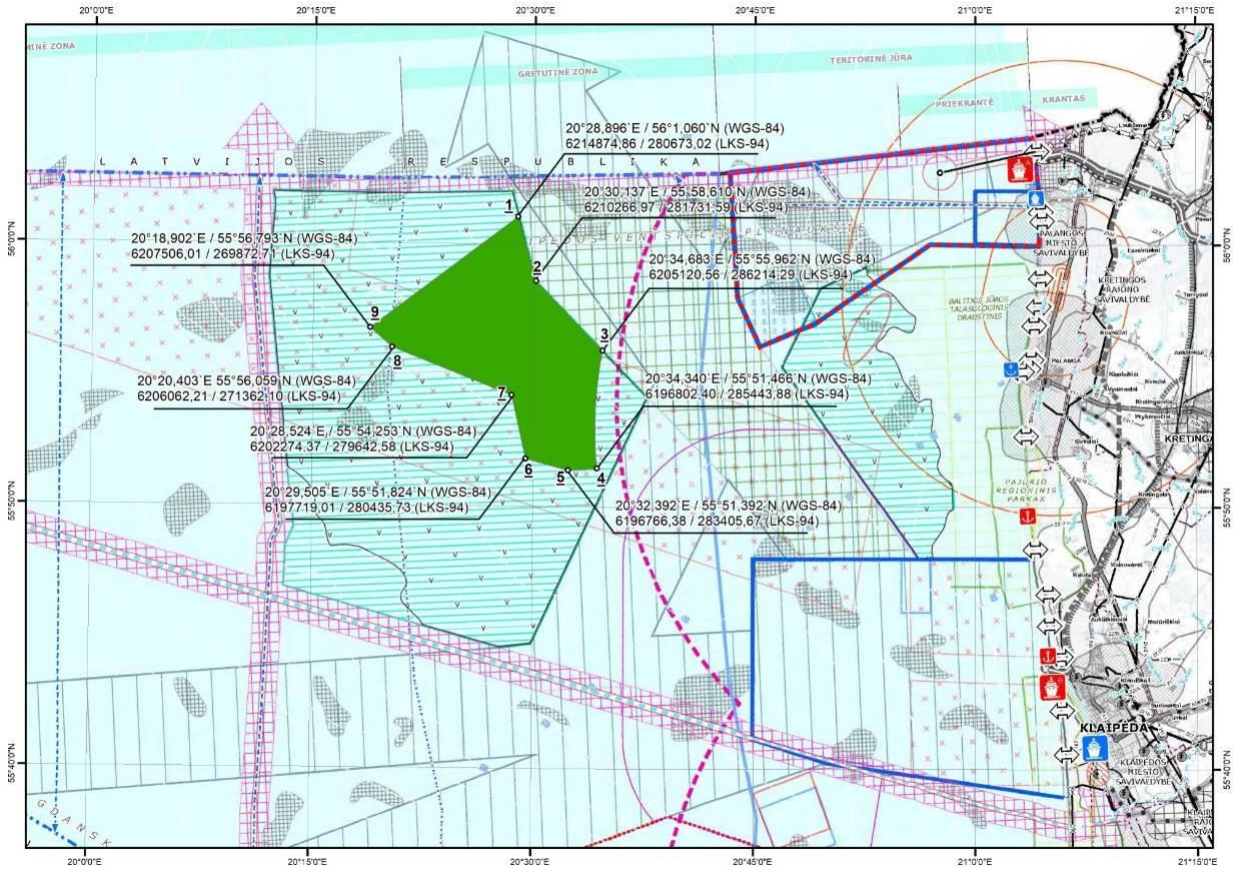

Fig. 3. The area under development in Phase I

The area intended for the development of renewable energy under the Development Plan is crossed by the future Harmony Link route. For the latter, an engineering infrastructure Development Plan for the special state importance energy system synchronisation project "Construction of Harmony Link Connection and 330 kV Distribution Centre "Darbėnai"" was developed. The explanatory notes[8] thereof specifies that due to the limitations caused by cabling technology, it is not possible to accurately identify the planned location for the underwater cable of the Harmony Link at the Development Plan. Therefore, a corridor of up to 3000 m is planned in the offshore part. The location of the underwater cable is planned to be specified after the

[8] https://www.litgrid.eu/uploads/files/dir570/dir28/dir1/17_0.php

seabed surveys during the technical design. Before the commencement of works, the contractor will re-survey the seabed and determine even more precise coordinates in the 300-500 m wide seabed corridor[9] under study to avoid inappropriate cabling conditions. Following the construction of the Harmony Link and pursuant the Law on Special Land Use Conditions, the underwater cable protection zone will be 100 meters on either side of the outer boundaries of the cable engineering structure of this line (in the absence of a cable engineering structure – edge cables of this line). The water above this line will free up a section almost 2.8 km wide. To make best use of the full potential of the renewable energy development area, it is planned that with the exactly known location of the Harmony Link underwater cable route, the vacated areas might be used for wind energy development, by preserving a 1.1 km wide corridor for cables, communications, construction, and maintenance. Such areas are demarcated as perspective development territories Area B and Area C.

Within the area of the Infrastructure Development Plan, two 1.1 km wide corridors in the east-west direction shall be preserved between the demarcated areas for the connection cables, communication, construction, and maintenance of wind farms: 1) between the Area A and Area B / area under development in Phase I; 2) At the Harmony Link corridor location. For the use of the planned area, a narrower corridor is planned, 0.5 km wide, in the north-south direction, between the area under development in Phase I and Area B. The basis for the choice of corridor widths is average distances between the geometrically laid out WTs and the space for ships to move.

Pursuant to Resolution of the Government of the Republic of Lithuania no. 697 as of 22 June 2020 [10], the OWF will primarily be constructed in the area under development in Phase I. In other sites, the development of WT is planned in later phases. Their implementation feasibilities will depend on capacities of the Lithuanian electricity transmission network to receive produced energy or on cross-border agreements on transfer of produced energy to other countries' networks, as well as on research findings under the Development Plan.

4.3. Directions for routing high voltage cables from selected areas

In the foreseeable future, the Lithuanian electricity transmission network managed by LITGRID AB will have limited possibilities to receive and distribute energy flows in the high-voltage network. Therefore, this put for consideration the following alternatives of the Development Plan Concept: direct connection of one or two OWF (areas) to the planned Darbėnai transformer substation with a high voltage cable; connection of remaining OWF (areas) to the planned international Lithuanian, Polish and Swedish OWF power hub (hereinafter – the Hub), which is planned in the Study on Baltic offshore wind energy cooperation under BEMIP[11].

[9] The engineering infrastructure development plan for the special state importance energy system synchronisation project "Construction of Harmony Link Connection and 330 kV Distribution Centre "Darbėnai."" Strategic Environmental Assessment. 2020. JSC Infraplanas. U-1415-00-SP-SPAV.AT - 01

10 Resolution of the Government of the Republic of Lithuania no. 697 as of 22 June 2020 "On the Identification of the Priority Parts of Lithuania's Territorial Sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea Where a Tender (Tenders) for the Development and Operation of Power Plants Using Renewable Energy Sources is (are) Expedient and on the Measurement of the Installed Capacities of Such Power Plants"

11 Study on Baltic offshore wind energy cooperation under BEMIP. *Final Report ENER/C1/2018-456 June 2019*

Upon forming concept alternatives, the Development Plan presumes *a priori* that a shallower area will be developed in the Phase II. Therefore, the second connection of OWF to the Lithuanian transmission networks is planned from Area A. Subject to the results of studies provided for in the Development Plan, the area under the development in the Phase II and the direction of the high-voltage cable routed therefrom may change.

When forming alternatives of the concept, in the absence of approved plans on receiving more than 1,400 MW from OWF to Lithuanian electricity transmission networks, it is planned to connect the remaining farms to the Hub. When it is possible to accept higher energy flows, the Development Plan will not restrict such possibilities.

4.4. Alternatives of the Concept

There have been four main alternatives (Fig. 4–7) formed for the connection of wind farms to the transformer substation in the Baltic Sea, with two sub-alternatives for each transformer substation installation site:

- Alternative I of the Development Plan Concept provides for the connection of the area under development in Phase I and Area A to the Lithuanian electricity transmission networks through the perspective Darbėnai TS, while areas B and C might be connected to the Hub. In this alternative to the DP Concept, two directions are chosen for connection to Darbėnai TS: the Harmony Link corridor and the Lithuanian-Latvian border utility corridor.
  - Alternative I-(1) provides for that transformer substations are installed in WT farm centres.
  - Alternative I-(2) provides for that transformer substations are installed on the borders of WT farms as close as possible to the high-voltage electricity transmission corridor (direction).

- Alternative II of the Development Plan Concept provides for connection of the area to be developed in Phase I to the Lithuanian electricity transmission networks through the perspective Darbėnai TS, while areas A, B and C might be connected to the Hub. In this alternative to the DP Concept, the direction chosen for connection to Darbėnai TS is the Harmony Link corridor.
  - Alternative II-(1) provides for that transformer substations are installed in WT farm centres.
  - Alternative II-(2) provides for that transformer substations are installed on the borders of WT farms as close as possible to the high-voltage electricity transmission corridor (direction).

- Alternative III of the Development Plan Concept provides for the connection of the area to be developed in Phase I to the Lithuanian electricity transmission networks through the perspective Darbėnai TS, while areas A, B and C might be connected to the Hub. In this alternative to the DP Concept, the direction chosen for connection to Darbėnai TS is the Harmony Link corridor, and the same location of transformer substations is selected for farms A and B (for merging parks and/or development thereof in the same phase).

- Alternative III-(1) provides for that transformer substations are installed in OWF (or merged farms') centres.
- Alternative III-(2) provides for that transformer substations are installed on the borders of OWF (or merged farms) as close as possible to the high-voltage electricity transmission corridor (direction).

- Alternative IV of the Development Plan Concept provides for the connection of the area to be developed in Phase I and Area A to the Lithuanian electricity transmission networks through the perspective Darbėnai TS, while areas B and C might be connected to the Hub. In this alternative to the DP Concept, the direction chosen for connection to Darbėnai TS is the Harmony Link corridor.
  - Alternative IV-(1) provides for that transformer substations are installed in OWF centres.
  - Alternative IV-(2) provides for that transformer substations are installed on the borders of OWF as close as possible to the high-voltage electricity transmission corridor (direction).

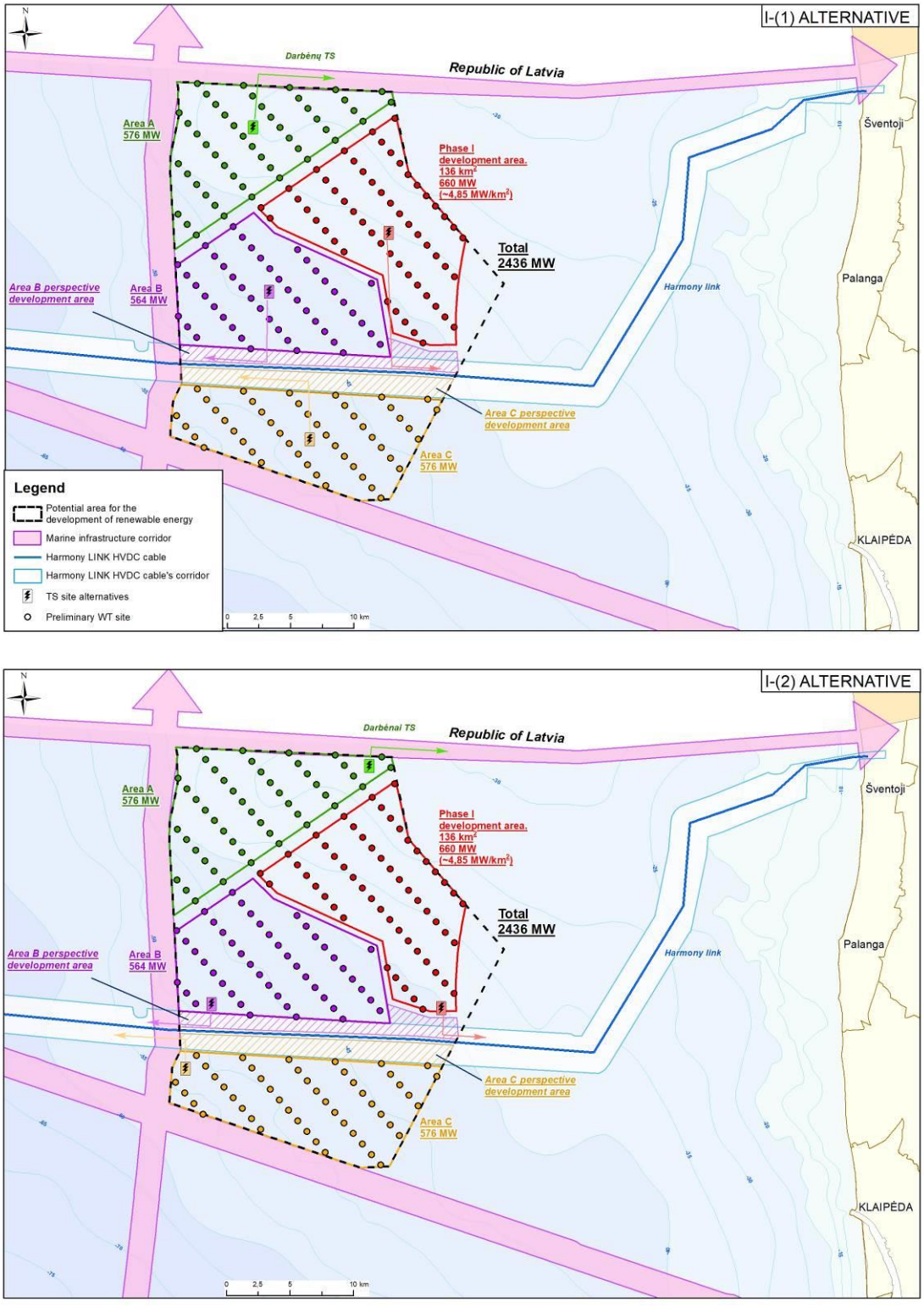

Fig. 4. Alternative I and its options 1 and 2 (sub-alternatives).

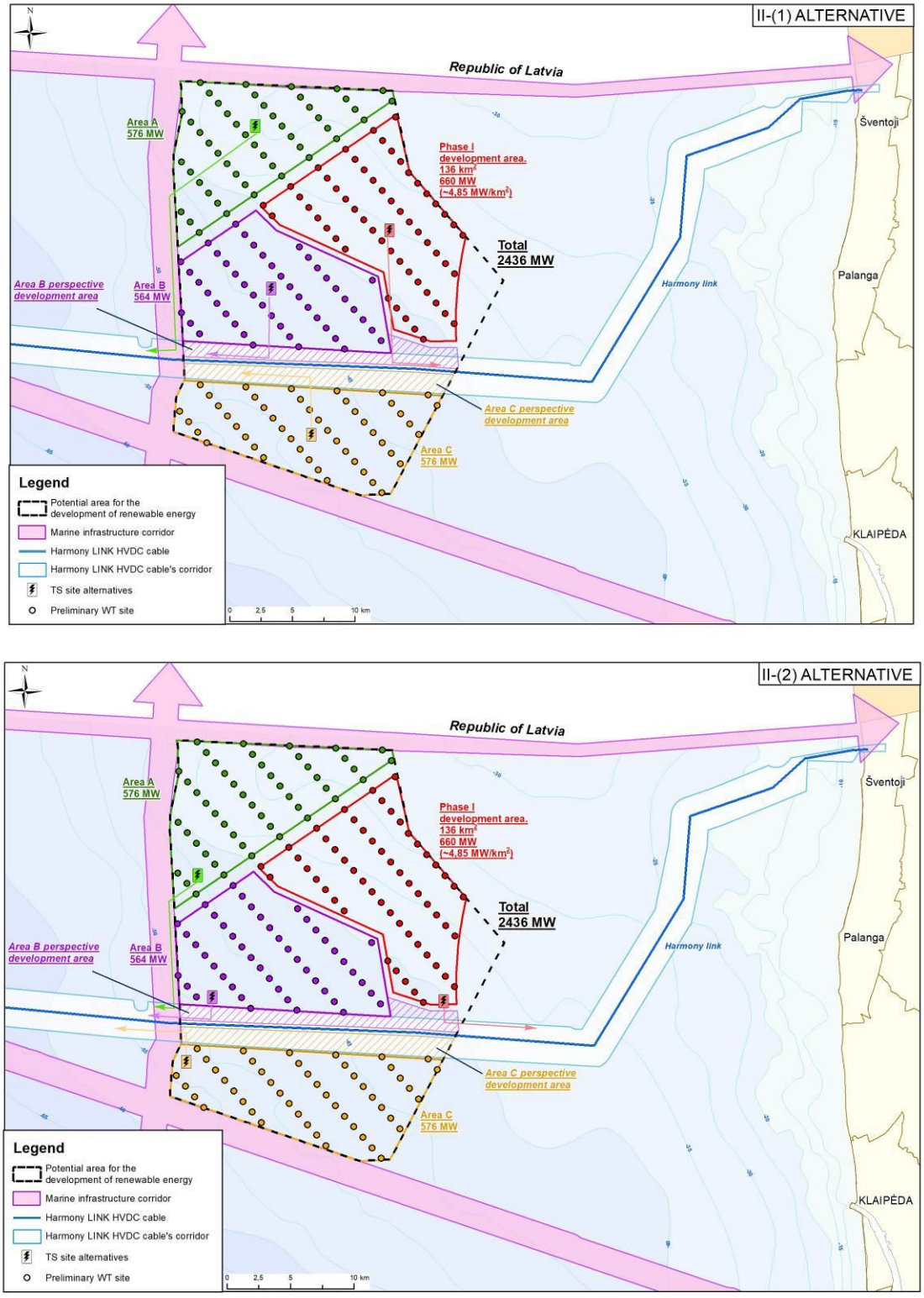

Fig. 5. Alternative II and its options 1 and 2 (sub-alternatives).

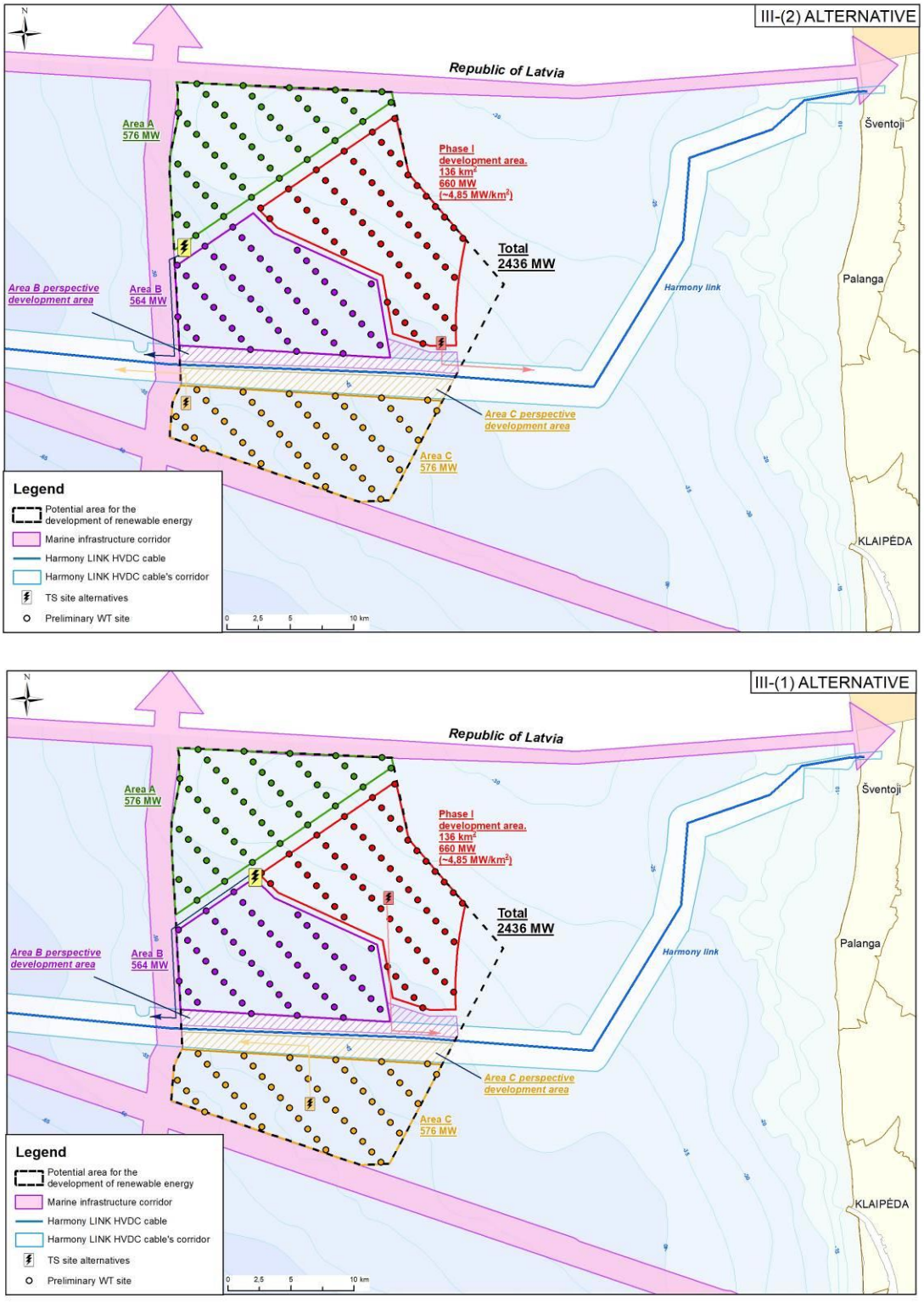

Fig. 6. Alternative III and its options 1 and 2 (sub-alternatives).

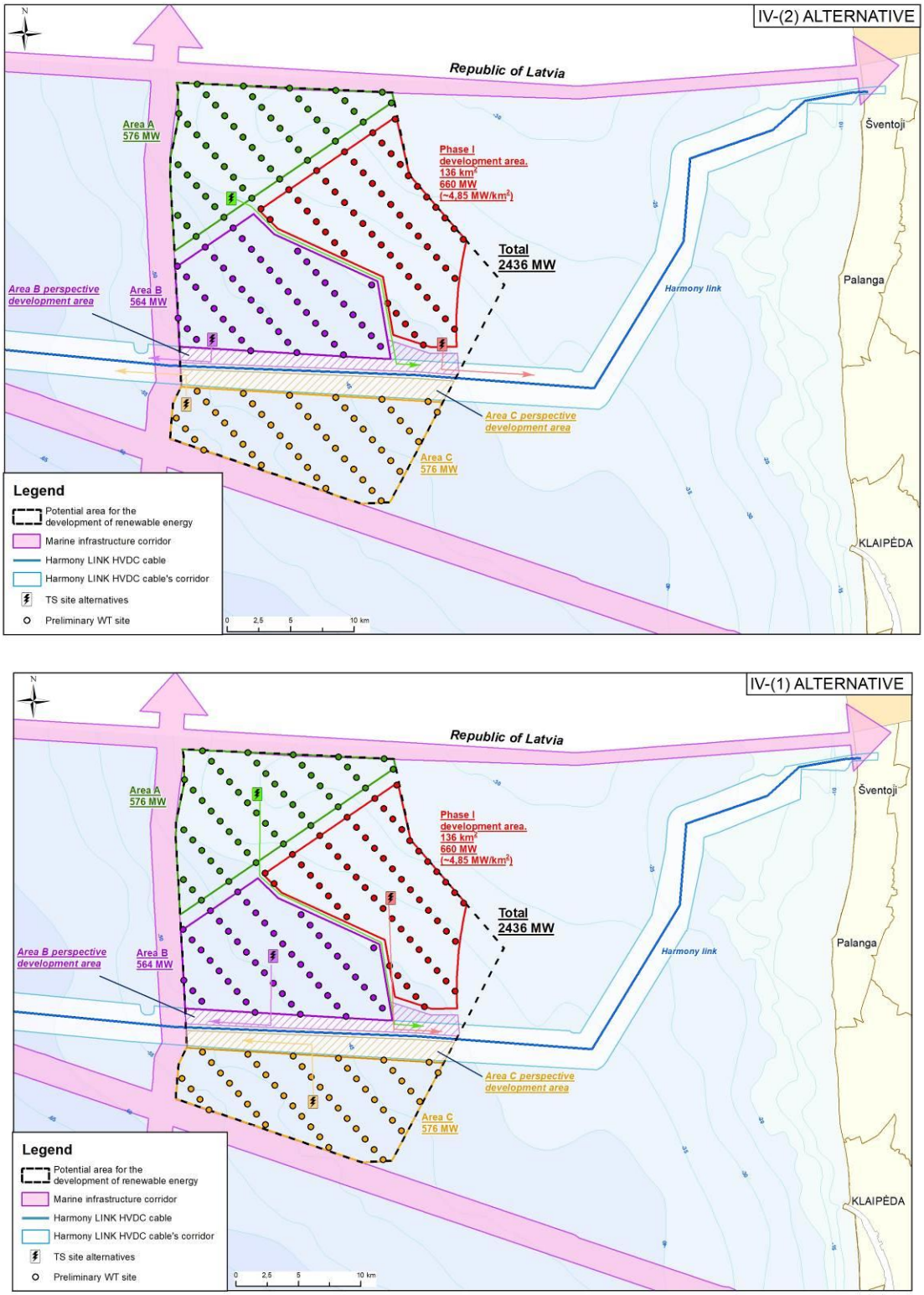

Fig. 7. Alternative IV and its options 1 and 2 (sub-alternatives).

5. SHORT DESCRIPTION OF AREAS WHICH MAY BE SIGNIFICANTLY AFFECTED

Geographical and administrative situation of the planned area

The area of potentially renewable energy development, which occupies a part of the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea (Fig. 1), is far from the shoreline and coastal municipalities of Klaipėda city, Klaipėda district and Palanga. The shortest distance from the planned area to the town of Palanga is about 26 km. The distance from the planned area to the Latvian EEZ is about 1 km, to the Swedish EEZ – about 69 km, to the Russian Federation EEZ – about 23 km.

Seabed characteristics, relief, depths

The potential wind energy development area is located on the Klaipėda-Ventspils Plateau. The Klaipėda-Ventspils Plateau in the northern part of the Lithuanian marine area starts at the Gulf of Riga, stretches along the shore, and in the latitude of Liepaja turns southwest, to settle between the Gotland and Gdańsk depressions. There are more prominent sea floor elevations at this location. One of them is known as Klaipėda bank, located in the north-western part of the Exclusive Economic Zone of the Republic of Lithuania. The sea depth in some places of this area reaches 47 m. Westwards, the slopes of the Bank descends into the Gotland Basin.

Based on foundation technologies, the best conditions for the installation of farms are seabed areas with a depth of 20 to 40 m (installation of parks in the nearshore, up to 20 m is practically infeasible due to environmental constrains) (Fig. 8). At present, there are technological capabilities to install power plants at depths of up to 50 m, and, with the undergoing development of the concept of floating power plants, sea depth may be not the key criterion.

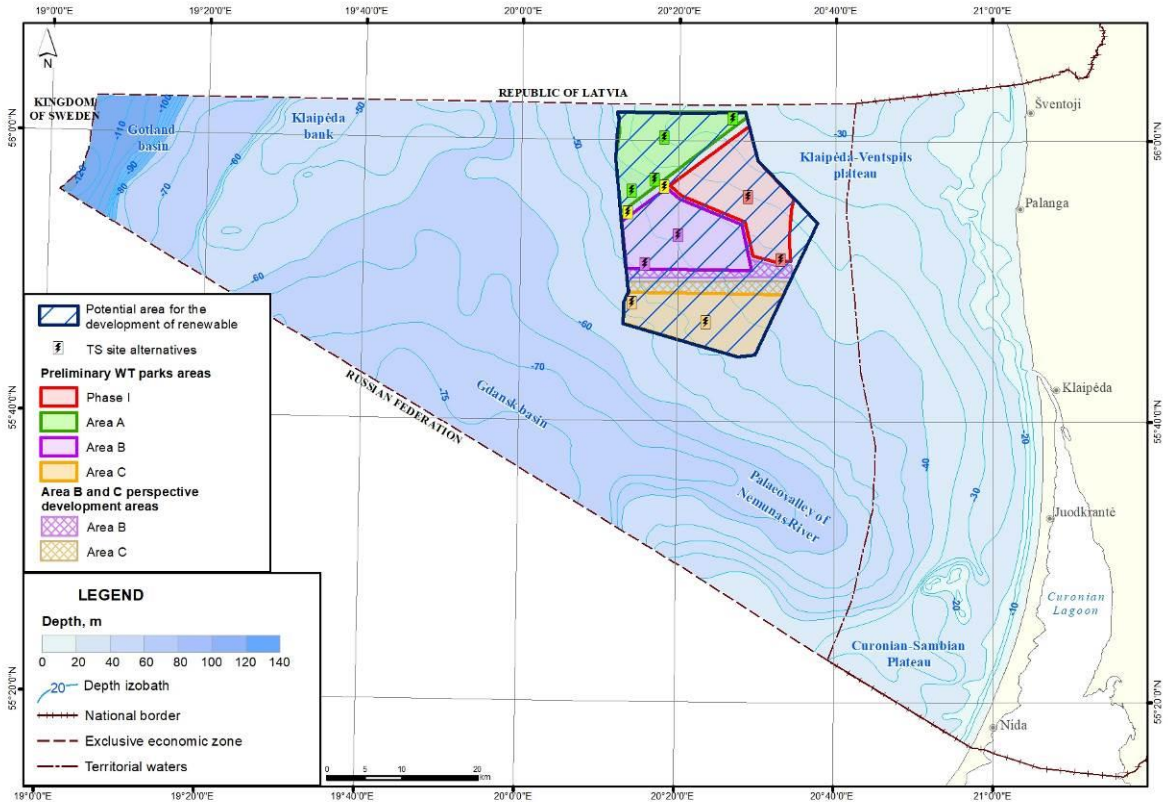

Fig. 8. Sea depth scheme.

Current sea use

There are several traditional maritime activities that have evolved to meet the needs of the state and are legally regulated and mapped, e.g.: fishing, shipping, port and marine activities, protection of natural and underwater cultural heritage, military exercises, and other restricted areas, dredging of soil, extraction of sand for beach nourishment, utility infrastructure, and recreation.

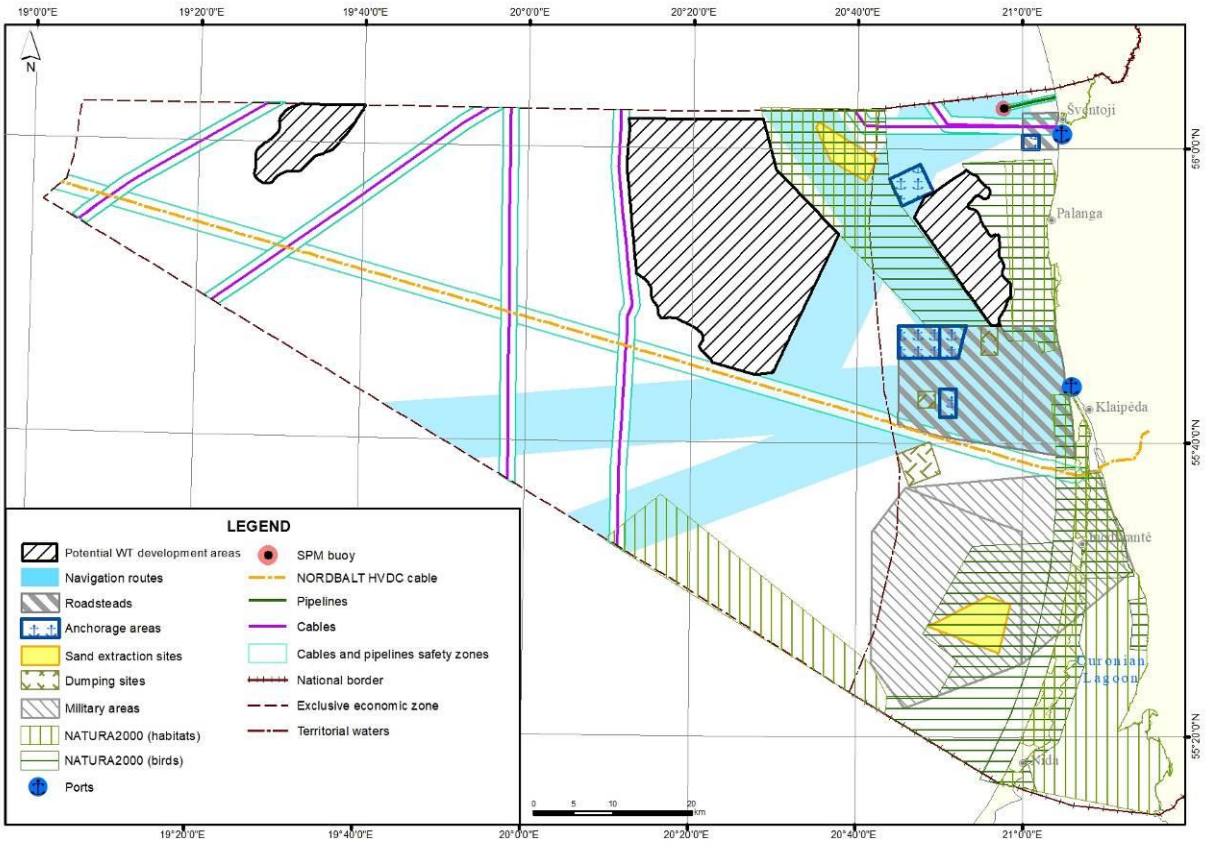

Fig. 9. Current use of the Lithuanian Baltic Sea region and potential wind energy development zones (based on solutions specified in the Comprehensive Plan of the Territory of the Republic of Lithuania of Y2015).

Solutions under the Comprehensive Plan of the Territory of the Republic of Lithuania, supplemented with the part "Marine Areas", as well as the Comprehensive Plan of the Territory of the Republic of Lithuania for 2030 under development highlight the priority of use of the planned area – renewable energy development.

Mineral resources

According to the information of the Lithuanian Geological Survey on the promising oil structures in the Lithuanian maritime part, the Lithuanian EEZ is supposed to store about 40-80 million tons of oil. The northern part of the planned area overlaps with the boundaries of oil-prospect structures (Fig. 10).

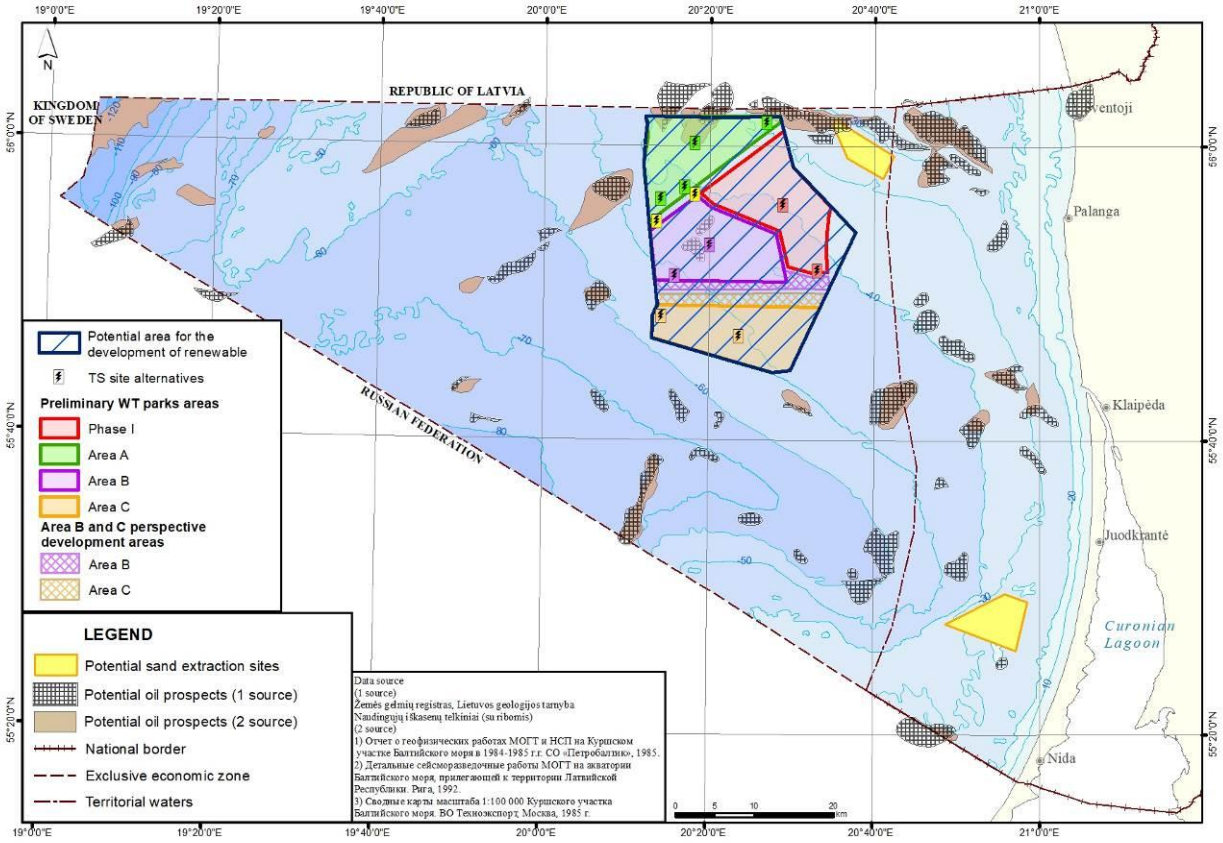

Fig. 10. Scheme of the location of the planned area in relation to the marine mineral resources.

Engineering infrastructure

In the Lithuanian marine area two types of engineering infrastructure have been identified - a pipeline complex with the Būtingė terminal buoy (SPM) and underwater electricity cables.

In the central part of the marine area, from Klaipėda via the Curonian Spit and further to the Swedish EEZ, a 450 km long 700 MW high-voltage DC underwater NORDBALT cable is laid ,

On 21 December 2018, CEOs of Lithuanian and Polish transmission system operators LITGRID and PSE signed an agreement, committing to undertake development activities in the preparation phase of the project of construction of new Polish-Lithuanian underwater electricity HVDC cable – "HARMONY Link." In January 2020, the study for the Baltic Sea route was developed. The corridor of the planned "Harmony link" route crosses the potential area intended for the development of renewable energy.

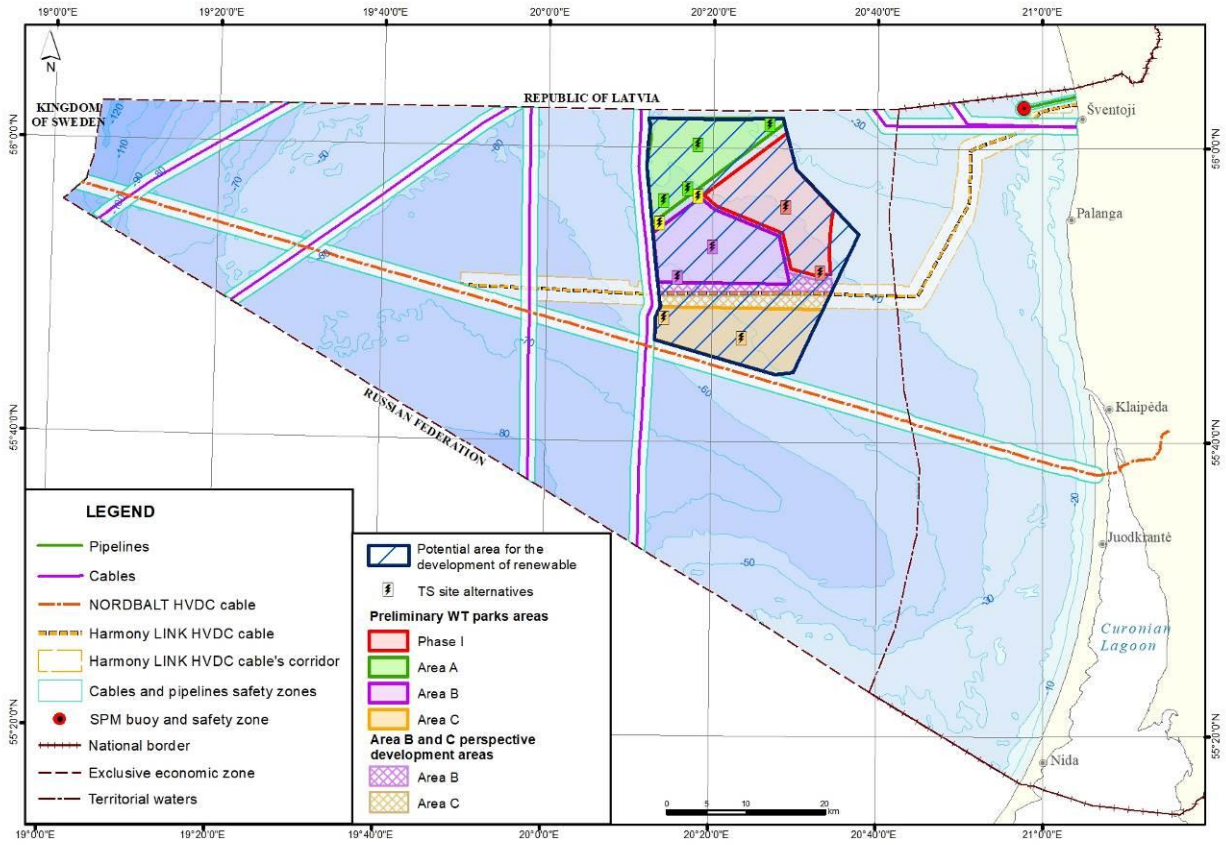

Fig. 11. Existing and planned engineering facilities in the marine area.

Restricted-use areas at sea. In the territorial waters of Lithuania and in the Exclusive Economic Zone, quite a large space is occupied by restricted-use areas: military training grounds, an area with sunken World War II munitions, former minefields.

In accordance with the national security criteria, a small eastern part of the area under the Development Plan falls into the areas where the construction of WTs is prohibited. No WTs will be installed in this part of the Development Plan area.

Protected and NATURA 2000 sites

In the Lithuanian marine waters, there are several protected areas and areas of the European ecological network "Natura 2000". The Klaipėda-Ventspils Plateau Biosphere Reserve, with areas important for the protection of birds and habitats, is closest to the planned area (borders with it).

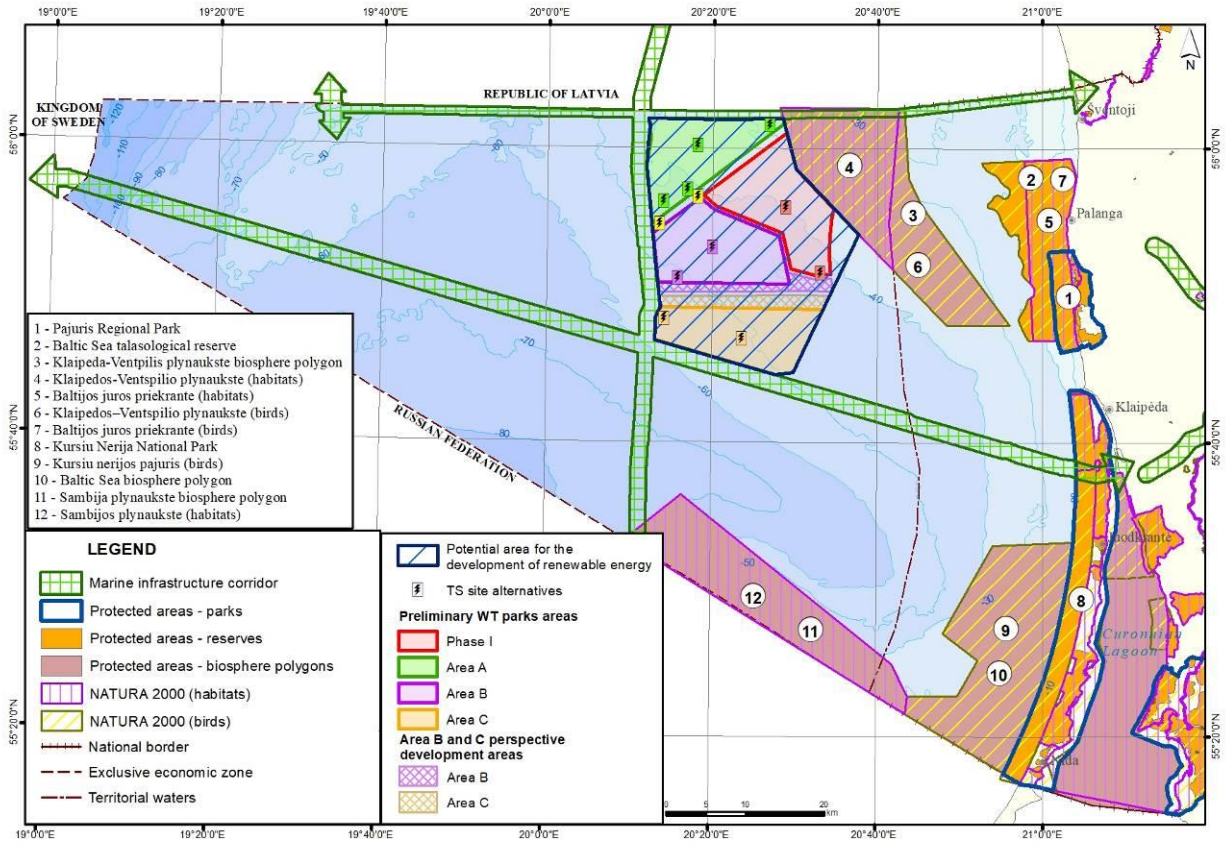

Fig. 12. Protected NATURA 2000 sites at sea and in the coastal zone.

Cultural heritage

According to the information from the Lithuanian Transport Safety Administration charts, several wrecks not included in the Cultural Heritage Register have been identified in the Lithuanian EEZ.

Most of the wrecks are industrial ships; though, the remains of scientifically highly valuable wooden ships were discovered, too. There were also several valuable habitats of cultural underwater seascape with natural relics and tree remains found.

National security requirements and restrictions

According to the National Security Strategy of the Republic of Lithuania (approved by Resolution No. IX-907 of the Seimas of the Republic of Lithuania of 28 May 2002 (as amended by Resolution No. XIII-202 of the Seimas of the Republic of Lithuania on 17 January 2017)), energy security is one of the primary interests of the national security of the Republic of Lithuania in the sustainability of the State's development.

According to the methodology of mapping the territories of the Republic of Lithuania where, given the national security requirements, restrictions on the design and construction of wind turbines may be applied (approved by Order of the Minister of National Defence of the

Republic of Lithuania No. V-921 of 22 August 2012 "On approval of the mapping methodology of the territories where, given the national security requirements, restrictions on the design and construction of wind turbines may be applied"), a map of the territories of the Republic of Lithuania where the design and construction works of wind turbines (high-rise buildings) may be restricted (approved by Order of the Commander of the Lithuanian Armed Forces No. V-217 as of 15 February 2016) has been developed.

In accordance with the national security criteria, a small eastern part of the area under the Development Plan falls into the areas where the construction of WTs is prohibited (Fig. 13). No WTs will be installed in this part of the Development Plan area. The implementation of the solutions under the Development Plan is crucial for achieving the goals of the National Energy Independence Strategy. Major area of the area under the Development Plan is a part of the areas where construction sites for wind turbines are subject to coordination provided that the producer of energy from renewable resources signs a contract with the Lithuanian Armed Forces on part of the investment and other costs.

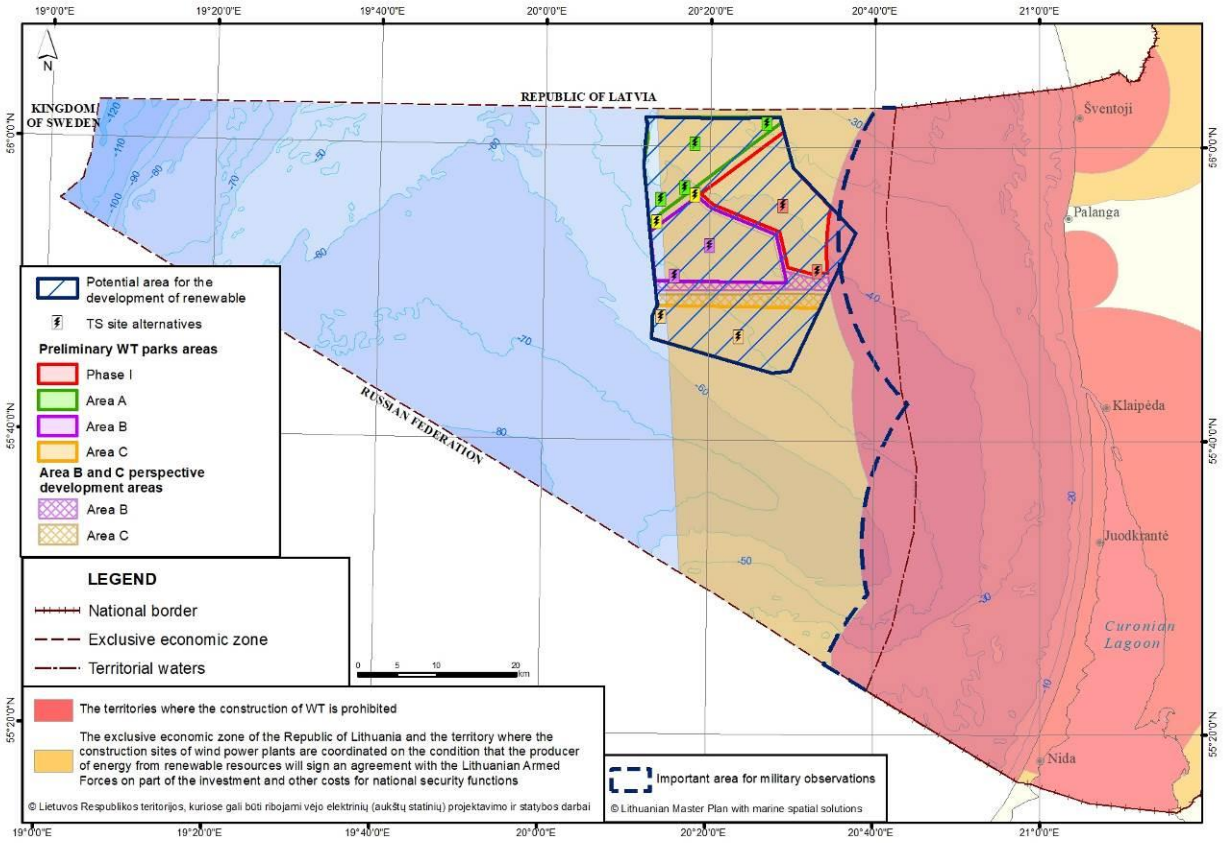

Fig. 13. Restrictions on the design and construction of wind farms in accordance with national security regulations.

6. Effects of Implementation of Development Plan Solutions on Environmental Components

6.1. Effects of the Implementation of the Development Plan Solutions on the Society and its Health

The effect of wind farms is relevant and usually studied in terms of the living environment up to 2 km from the planned wind farms. The effect of shadow flickering can be perceived at up to 1-1.5 km from WT towers. Electromagnetic fields are only generated in the immediate vicinity of a WT rotor or overhead power lines and usually grow weak to limit values at about 20-30 m from the cables. Infrasound is also typical for the natural environment, in particular, the marine environment due to the wind and waves.

Due to the long distance from planned offshore wind park to the nearest living environment, these factors are not relevant.

The planned area is more than 26 km away from the shoreline and the nearest residential, social, and recreational environment. The goals and objectives of the Development Plan do not cover or provide for possible solutions for electricity transmission to the shore. Effects of the residential, social, and recreational environment due to the physical impact of the Development Plan solutions are unlikely.

6.2. Effects of the Implementation of the Development Plan Solutions on Biodiversity

Offshore wind power development may have implications for biodiversity, both positively and negatively.

The main positive aspects are the establishment of invertebrate communities on WT poles and the restriction of fishing. This can make an OWF safe place for fish communities.

The main negative aspects for birds are:

- Site avoidance and loss of feeding grounds for seabirds.
- Barrier effect on migrating birds.
- Direct collision and death due to WTs.

Negative aspects for other marine animals should be mentioned and highlighted:

- noise during the construction of a OWF, which may cause adverse physiological effects (including damage to organ tissues), disrupt animal communication, influence behaviour (including eviction from their natural habitats or hunting areas).
- potential barrier and death effect on migrating bats.

Protected Areas. When implementing the solutions under the Development Plan, it is important to consider the values protected in the adjacent Natura 2000 sites (Klaipėda–Ventspils Plateau Important Birds Area (IBA) (LTPALB002)) and Klaipėda–Ventspils Plateau Biosphere Polygon, as well as their biodiversity (Fig. 12). These protected areas are designated for the protection of habitat type of EU importance – reefs (1170), place of velvet scooters regular aggregations and long-tailed ducks and razorbills wintering and migrating populations, as well as for ensuring a favourable preservation status of the above sites.

Analysis of effects of solutions under the Development Plan on the protected values shows that the highest probability is that the impact of displacement on the Klaipėda-Venspils Plateau during the wintering of seabirds (from the end of October to the end of March) will be observed. The eastern part of this area is bordered by the area of the Development Plan (Phase I area), which may cause displacement to the implementation of solutions under the Development Plan: birds may avoid the border of the protected area that is closest to the planned wind farms, without singling out any of the alternatives.

During the implementation of the solutions under the Development Plan, the consequences for the protected areas in the adjacent environment and the values protected therein, i.e., reefs, are possible during the installation of power transmission cables. Therefore, the location of protected seabed habitats must be considered when selecting the site for the offshore TS which the underwater power transmission cables will be routed to.

Seabed habitats. Only three habitat types are mainly common in the area of the Development Plan: the sandy bottom of the aphotic zone; bottom of various sediments and sublittoral sludge located occurs in a dead zone, too. The most valuable registered seabed biotopes in the area under consideration, which are biologically significant and classified as reefs according to the habitat types in Annex II of the Habitats Directive, are not abundant. From the geomorphological point of view, the main reefs are moraines with *Mytilus edulis trossulus* and *Balanus improvisus*, the location of which has also been found only in Lithuania's territorial sea near Palanga.

When implementing the solutions under the Development Plan, there are possible consequences for the seabed biotopes due to the destruction of seabed bottom during the installation of WT foundation and energy transmission cables. The total area of the destructed habitat depends on the selected WT models, foundation structures and number of WT. The physical destruction of the habitat due to the installation of WT foundation will be reversible, but only after the end of the operation period, after all wind farm structures are dismantled and removed. After their removal, the vacant bottom area will soon be covered by the predominant taxa of seabed biotopes.

Adjacent habitats may also be damaged during the installation (anchoring) and certain maintenance of wind farms; however, it is likely that they will recover soon; such local and short-term adverse effects are not significant and will not have any negative consequences for seabed habitats.

During the construction of WT underwater parts, the water turbidity is likely to increase. This may have a short-term adverse effect on seabed organisms. This effect is local and insignificant and will not have any negative consequences for seabed habitats.

The installed underwater structures of wind turbines will become a secondary (artificial) substrate suitable for the attachment of various sedentary aquatic organisms. This, in turn, will increase the diversity of habitats and seabed communities, increase biomass and number of species. The new substrate is expected to be colonised primarily by dominant species such as *Mytilus edulis*, *Balanus improvisus*, green algae, red algae, and other organisms. Based on monitoring reports of OWF in other countries, it can be stated that colonisation occurs more rapidly on higher parts of structures.

Fish. In total, 65 cyclostomes and fish species have been registered in Lithuanian waters of the Baltic Sea, including 21 freshwater, 33 marine, and 11 migratory. About 19 cyclostomes and fish species are protected under the Habitats Directive, Bern or CITES conventions (Convention on International Trade in Endangered Species of Wild Fauna and Flora), 5 of them are included in the Red Data Book of Lithuania, and 18 are considered very rare. Of all the species registered in Lithuanian waters of the Baltic Sea, 34 are caught annually and 14 – less than once in 10 years. Some fish species are very common, while other species (swordfish, anchovy, sea urchin) have only been recorded once or several times.

Potential adverse effects for marine fish are related to the construction of OWF, which may cause a great underwater noise, increase the turbidity of the water due to the installation of foundations and/or the laying of cable lines. During the operation of OWF, there are adverse effects possible due to interference caused by maintenance of OWF and cable-emitted electromagnetic fields.

The greatest effect of noise on fish is possible during pile driving – high sound pressure can kill or injure fish. Water turbidity and increased sediment concentration in the water column are caused by excavation and drilling works carried out during the installation of WT foundations. This can mostly endanger fish eggs or juvenile fish, which are the most vulnerable. Turbidity can not only complicate fish nutrition in the area but can also affect fish spawning grounds. However, suspended sediment remains in the water for quite a short period of time, and their spread area depends on the type of sediment and the regime of streams. The effects are expected to be local, short-term and have no significant consequences for the marine fish population.

Some of benthic habitats used for foraging by benthic fish can be destroyed during installation of wind farm foundations. Considering the relatively small area of the foundations of separate wind turbines and large distances between them, it can be stated that a negative local impact on the nutritional base of benthic fish will not be significant and therefore will not have significant adverse effects for the marine fish population.

An increase in the number of organisms living on hard bottoms is expected due to the emergence of new substrates suitable for habitats. This may have a positive impact on fish populations due to the proliferation of potential food items and the emergence of spawning-favourable habitats. Additional underwater objects may also attract fish that tend to spend part of their time in hiding places from predatory fish. The installation of wind farms can serve as an artificial reef for fish. Both diversity of species and fish number may increase in the site of these facilities.

The impact of noise caused by the operation of mechanisms depends on fish species and a distance to the noise source. Findings of previous studies show that this effect is minimal for almost all fish and, therefore, should not cause significant adverse effects on the marine fish population. Stress caused by this noise to fish and their reproductive properties has not been studied yet.

Electric current flowing in electric cables on the seabed causes electromagnetic fields. It is suggested that this field may interfere with fish migrations (disrupts orientation) or foraging (fish emit certain electrical impulses, too). Experimental studies have shown that, normally, the effects of electromagnetic fields on fish are minimal or their adverse effects have not been proved.

Marine mammals. There are 3 species of seals living and breeding in the Baltic Sea: the grey seal (*Halichoerus grypus macrorhynchus*), the ringed seal (*Phoca hispida botnica*) and the harbour seal (*Phoca vitulina vitulina*). The gray seal is included in the Red Data Book of Lithuania and is assigned Class 1 (E) (species on the verge of extinction). In the territorial sea of Lithuania, including the area of the Development Plan, seals do not live permanently, but only come together with migrating fish, therefore, an exact number of animals is not known. Based on the number of reports of seals observed, the number of seals (both live and dead) on the Lithuanian coast increased over the last decade.

The Baltic waters are home to two different populations of harbour porpoise. One of them breeds in the waters of the Belts, Zund, Kattegat, and Skagerrak. Another population is found beside the coasts of Germany, Poland, and eastern Sweden, in the central part thereof. The animals are characterised by seasonal migrations, i.e., they move south in winter. According to the research carried out under the international project "Sambah" in 2011–2012, the number of harbour porpoise in Lithuanian waters, including the area of the Development Plan, is very small in comparison with other water areas in the Baltic Sea.

Due to the small number of stray marine mammals, the implementation of solutions under the Development Plan in the Lithuanian exclusive economic zone is not expected to have significant adverse effects for marine mammal populations.

OWF may adversely affect marine mammals due to noise during the construction and operation phases. Installation of foundations, pile driving is the noisiest operations during the construction of WT. They may cause adverse effects on the hearing, behaviour, and distribution of marine mammals. The potential effect of sound on mammals is subject to the specific work, however, increased ship traffic and noisy work in WT areas force the animals to move to adjacent areas.

Other potential impacts of OWF on marine mammals are as follows:

- collisions with ships. They are possible during WT construction as well as during any operations in marine waters. Collisions are most likely to occur when a vessel is manoeuvring slowly or in places with high animal densities (Thompson et al., 2013).

- changes in available habitats. As marine WT structures become a new habitat for algal and benthic communities, they may attract fish and, thus, marine mammals. Besides, lower vessel traffic in WT areas, compared to the surrounding waters, may have a positive effect on the numbers of marine mammals.

According to the information on the impact of the construction and operation of existing OWF on mammals, the number of animals in the OWF areas decreases during construction; yet recovers during operation.

Birds. The locations of the rise of migratory birds observed on the Lithuanian coast and in the mainland may be in large areas of up to 1000 km. During spring migration, the start-off places for birds registered at the seaside are 500 km (maximum 800 km) between the south-western parts of the Baltic Sea, north-western and southern Lithuania, Kaliningrad, northern and central Poland, and southern Sweden.

Directions of bird migration on the Lithuanian coast depend on a location of the shoreline and can be marked along it. Migrations over the high seas are recorded almost all year round except in late spring and early summer. Autumn migration begins in summer when common scoters migrate in the southwest to moulting grounds. Later, in September, an intensive migration of passerine is observed, and in early autumn and early winter, large passages of sea ducks in the sea area are registered. During a winter, sea birds often migrate from one wintering location to another in the Baltic Sea area. In spring, intense flights to stopover sites in the northern and Arctic regions are recorded.

Despite long-distance bird flights may take many months, spring and autumn bird migrations are considered the main ones on the Lithuanian coast, as well as within the country. The start-off and route of seasonal bird migrations depend on meteorological conditions of a particular season.

The area of the Development Plan should not differ from other areas of Lithuanian marine waters in terms of migratory birds. Besides, WT areas are remote from the shore. So, there should be no impact on the birds which migrate mainly above land.

The most abundant wintering birds in Lithuanian territorial waters are velvet scoters, long-tailed ducks, mergansers, great crested grebes, red-throated and black-throated divers, and golden-eye. During ship-based surveys, most abundant seabird species were long-tailed ducks, velvet scoters, razorbills, guillemots, and divers. Yet, the main and most numerous species wintering in Lithuania are long-tailed ducks, velvet scoters and divers.

Bats. Intensive bat migration passes through the Lithuanian coast. Bats ringed in the Vente ornithological station are found wintering in Great Britain. This means that the mammals must fly through the English Channel to overcome this route. There were studies carried out in Germany, whereby ultrasonic microphones were placed on navigation buoys in both the North Sea and the Baltic Sea and recorded the intensity of bat passage during their migration in September. The most common species were Nathusius' pipistrelle, common pipistrelle, common noctule, lesser noctule. Those are also one of the most common bat species found in Lithuania.

There are no studies on migration over the Baltic Sea near Lithuania, Latvia or Poland conducted yet. There is, though, a likelihood that bats may try to fly over the Baltic Sea. However, it is not known at what distance from the shore they can do it; neither there is information on composition of species, flight altitude or intensity.

Once the solutions under the Development Plan are implemented, the effect of displacement, barrier effect, and direct collision with WT on wintering and migrating birds can be observed in the area.

The main negative aspects are as follows:

- Displacement effect, avoidance of area, and loss of feeding areas for seabirds.
- Barrier effect on migratory birds.
- Direct collision and death due to WT.

Direct collision/death for birds and bats. When flying, birds may fly into WT. Some birds may also be blown by air vortices caused by rotating WT blades and strong winds. Although

studies conducted and published in various parts of the world report low numbers of birds killed by operating WTs, given that waterfowl are long-living and low in productivity, even low additional mortality can be argued to contribute to declining populations of some species.

Displacement effect. Displacement, such as visual effects, noise, vibration, or intimidation by surveillance vessels may force birds to leave feeding or resting areas in or around OWF. Even a temporary departure may also be observed during the installation of WT. The intension of the displacement effect is subject to the features of a specific area and the species found there.

While birds avoid certain objects at one distance or another, they may lose areas suitable for their feeding or rest. In the Lithuanian marine waters, the planned WT will not have any impact on inland breeding birds, though, the areas may be essential for wintering or migratory birds. If the birds feed intensively, the remaining undisturbed areas will not be sufficient to meet their needs effectively.

Barrier effect. OWF can be a barrier to migratory or passage birds, yet, with the scale of this effect depending on the size of the OWF, the distances between individual WTs and their location in relation to the main flight paths of birds and the ability of birds to cope with their increased energy consumption. On the Lithuanian coast of Baltic Sea, bird migration directions are along the shoreline, with the most intensive seasonal bird migrations taking place at sea up to a few kilometres from the shore.

Change or loss of habitat. The construction of OWF can be conflicting in relation to birds due to the communities of benthic organisms therein that may be suitable for the feeding of sea ducks. However, WT installation depths, a structure of bottom communities, feeding mechanism of ducks, diving depths, and types of feeding objects should also be considered. The depth of the area under the Development Plan is 40 to 60 meters, that is, too deep for forvel vetscoters and long-tailed ducks to feed effectively. It is likely that neither do other bird species feed efficiently in the site of the planned economic activity. As the sites of the planned OWF are not the main feeding areas for waterfowl, all groups of birds will presumably have enough of other suitable feeding places in Lithuanian marine waters.

Based on the sensitivity indices of seabird species to OWF, black-throated and red-throated divers are the most sensitive in terms of flight parameters, susceptibility to displacement, flexibility to habitat change, protection status, etc. Less sensitive was found to velvet scoter. Piscivorous species like great cormorant, great crested grebe, auk, benthophagous common scoter are slightly less sensitive. Gull, common tern, and common guillemot are considered least sensitive.

To find the impact of WT on birds, detailed studies on all elements of the ecosystem are necessary, as changes in the number or distribution of birds in the area may not only be due to the emergence of WT.

Migrating bats can also be adversely affected if they migrate through the constructed WTs on the high seas. Such WTs may attract bats. And when they fly up, apart from the direct collision effect, the bar damage effect can also be observed, i.e., bats fly into the flow of thinned air and may die due to a sudden change in pressure in the lungs.

6.3. Effects of the Implementation of the Development Plan on Water

Under normal operating conditions, the operated OWF will not have any negative consequences for seawater quality. However, temporary changes in water quality are possible during construction, i.e., when installing foundations and laying cables due to a temporary increase in suspended particles (turbidity) in the bottom layers of water column.

The impact of the wind farm installation on the hydrodynamic conditions will largely depend on the planned method of attaching the wind turbines to the seabed and the size of the foundation. Single-pole structures with a normal foundation diameter of nearly 3 to 3.5 meters and with power plant towers more than 500 meters apart from each other usually do not have any significant effect on the change in water flow regime. In this case, the distance between the wind towers should be more than 500 m (in our case, about 1.1 km), therefore, the impact on the hydrodynamic conditions will be insignificant.

As OWF areas are planned at depths greater than 30 m, it is likely that frame or tripod foundation structures will be used for the installation, with a negligible impact on the hydrodynamic conditions given that they will be built offshore, in a stable geological environment (on solid moraine basis rather than on sensitive sandy one).

The installation of wind turbine foundations and underwater cabling during the construction will cause a short time increase in the number of suspended particles (turbidity) in the water column of the planned farm area. An increase in turbidity will only occur at the foundations and cable laying sites. Its impact can therefore be assessed as local (bottom layer) and short-term (during installation only), with no significant long-term impact on hydro-chemical water parameters or consequences for quality of the Baltic Sea water.

Potential additional chemical pollution of the aquatic environment is usually associated with accidental collisions of tankers with wind farms in adverse weather conditions. In this case, the main problem might be the spillage of oil products into the marine environment from the tanker involved in the accident. The areas of the OWF in question are outside the existing and planned shipping lanes, roadstead, and anchorage sites, therefore the risk of collision is minimal.

Smaller pollution by oil products is also possible due to the accidental spill of lubricants and coolant from wind turbine systems. Advanced wind turbines are designed to minimise the likelihood of potential spills. Under the gondolas, there are oil collectors of adequate capacity (depending on a WT model) equipped to prevent pollutants from entering the marine environment in case of an accidental spill due to turbine failure.

During the installation of wind turbines (cabling, installation of foundations), additional water pollution with chemicals (heavy metals, organic compounds) is possible during the resuspension of bottom sediments. According to the data of the State Environmental Monitoring of the Baltic Sea and the Curonian Lagoon for the period of 2014–2019 and in-situ observations, the chemical state of water and bottom sediments in the analysed part of the Baltic Sea area (monitoring station No. 65) was good and did not exceed the established limit values approved by Order of the Minister of Environment of the Republic of Lithuania no. D1-194 of 4 March 2015"On the approval of characteristics of good environmental state of the marine area of the Republic of Lithuania", i.e., they match the good environmental status.

6.4. Effects of the Implementation of the Development Plan Solutions on the Seabed

The area under in the Development Plan is mainly located in the northern part of the Lithuanian marine area, on the Klaipėda-Ventspils plateau and, partly, on the slope of the Gdańsk Depression. Sea depths herein range from 20 m, closer to the seashore to 50 m.

The layer of sedimentary cover in the Lithuanian marine areas is about 2 km thick. The upper part of the geological section consists of quaternary sediments. Their thickness greatly varies, i.e., from 5-10 m on plateaus to more than 100 m in paleoincisions. The Baltic quaternary stratum of the Lithuanian waters consists of three main lithostratigraphic complexes: Pleistocene glacial deposits (dominated by moraine loams and sandy loams), sediments (clays, sands) formed during various phases of Baltic Sea evolution (mud of Late Glacial and Holocene periods), as well as latter-day marine sediments (sand, silt, mud). Under the quaternary sediments, there occur formations as of the Middle and Upper Devonian (sandstone, siltstone, dolomite), Permian (dolomite limestone), Lower Triassic (clay, clayey siltstone, and marl), Middle and Upper Jurassic (argillite), and Lower and Upper Cretaceous (Terigenic clay, glauconitic-quartz sand) derivatives. In the area under consideration, quaternary sediments are about 20-30 m. Beneath them, there are usually the deposits of the Triassic, less often of the Permian period.

The Baltic Sea belongs tectonically to a relatively stable Eurasian lithosphere plate. In Lithuania, compared to neighbouring countries, seismic activity is relatively the lowest. It is influenced by glacio isostatic processes after glacier melting and partly by minor seismic events related to resonant vibrations of distant seismically active zones (up to magnitude 4 vibrations have been recorded). Vertical glacial-isostatic crustal movements can reach up to 2 mm per year. The horizontal compressive force generated by the retreat of glaciers is gradually declining; yet may still induce the activity of older fracture systems, especially in neighbouring Latvia and Estonia. In the study site, the fracture system (as well as zones of potential secondary seismic activity) is well reproduced by the location of potential oil structures, as oil structures are formed at the tectonic dislocations of oil rich layers.

The marine energy development zone is relatively least affected by tectonic activity (lowest deep fracture density). However, the north-western corner of the area and adjacent oil structures are relatively large and quite promising. Their more detailed seismic surveys may reveal a wider fracture network. According to available information of the Lithuanian Geological Survey on the promising oil structures in the Lithuanian maritime part, the Lithuanian EEZ is supposed to store about 40-80 million tons of oil. The northern part of the planned area overlaps with the boundaries of oil-promising structures. Potential oil storage sites (structures) in the Development Plan area, with expected resources of unknown value, were identified in previous years through the analysis of 2D seismic data. There and no oil exploration wells drilled out yet. A normal global practice of oil search and exploration works (typical of oil works in Lithuania, too) shows that the location, size, and other parameters of oil structures (storage sites), as identified based on exploration data, change significantly after more detailed 3D seismic exploration studies and, in particular, after well drilling. Research data can show not only other locations, size, and boundaries of identified potential oil structures (storage sites), but also facilitate a search for new potential oil structures (storage sites).

Main hazards and effects on seabed integrity are physical loss due to the installation of offshore temporary artificial structures and the installation of permanent structures on the seabed, dredging and removal of excavated soil; physical damage due to extraction and use of natural resources, bottom siltation at excavation sites (increase in the concentration of fine sediments). All these effects are relevant during the installation of WT.

Attachment of WT foundations to the seabed (subject to the type of structures selected) may cause a local-scale change in water current regime. This, in turn, may increase current turbulence, causing washouts around power plant foundations. Further, this will locally affect the stability of the bottom in the cable-laying routes, destroy the rocks, create conditions for the decay of surface sediments, and the emergence of locally widespread, rather loose sediment fields. Such seabed damage is considered as artificial fragmentation of the lithological integrity of the seabed, breakup into smaller areas of different lithological composition and properties (substrate). Such impact is not critical from a geological point of view, though, may affect the distribution of benthic communities, their quality, as well as feeding habits, spawning grounds, etc. of other associated living organisms.

6.5. Effects of the implementation of the Development Plan solutions on the landscape

The Development Plan area is located on the high seas, more than 26 km from the shoreline. Given the morphological zoning of the landscape, the natural landscape of large water areas predominates in the vicinity of the area under consideration. The area falls within the Eastern Baltic shallow sea section (A) South-East Baltic Sea underwater plateau area (I) Curonian-West Samogitia Baltic Sea coastal underwater plateaus and tributaries.

The implementation of the solutions under the Development Plan will result in emergence of expressive technogenic vertical dominances that will reduce the naturalness of the existing natural landscape of large water areas.

Potential consequences of the solutions under the Development Plan for the landscape are examined from the aspect of ecological and visual stability. The analysis of visibility of the planned OWF was included the assessment of the vertical viewing angle of WT.

Visual impact zones were identified, in view of the height of wind farms and rotor above sea level (the total height of WT was accepted for analysis - 250 m), to define the area of impact on the landscape. It should be noted that the identified visual impact zones do not reach the shoreline, including the Latvian coast (Fig. 14).

The assessment has shown that the future WTs, closest to the Lithuanian Baltic Sea coast, will be visible but insignificant, in the presence of highly transparent weather and good visibility conditions. High-intensity public beaches or viewing decks on the seaside will not fall to the visually significant impact area of the WT farms in the territories under the Development Plan.

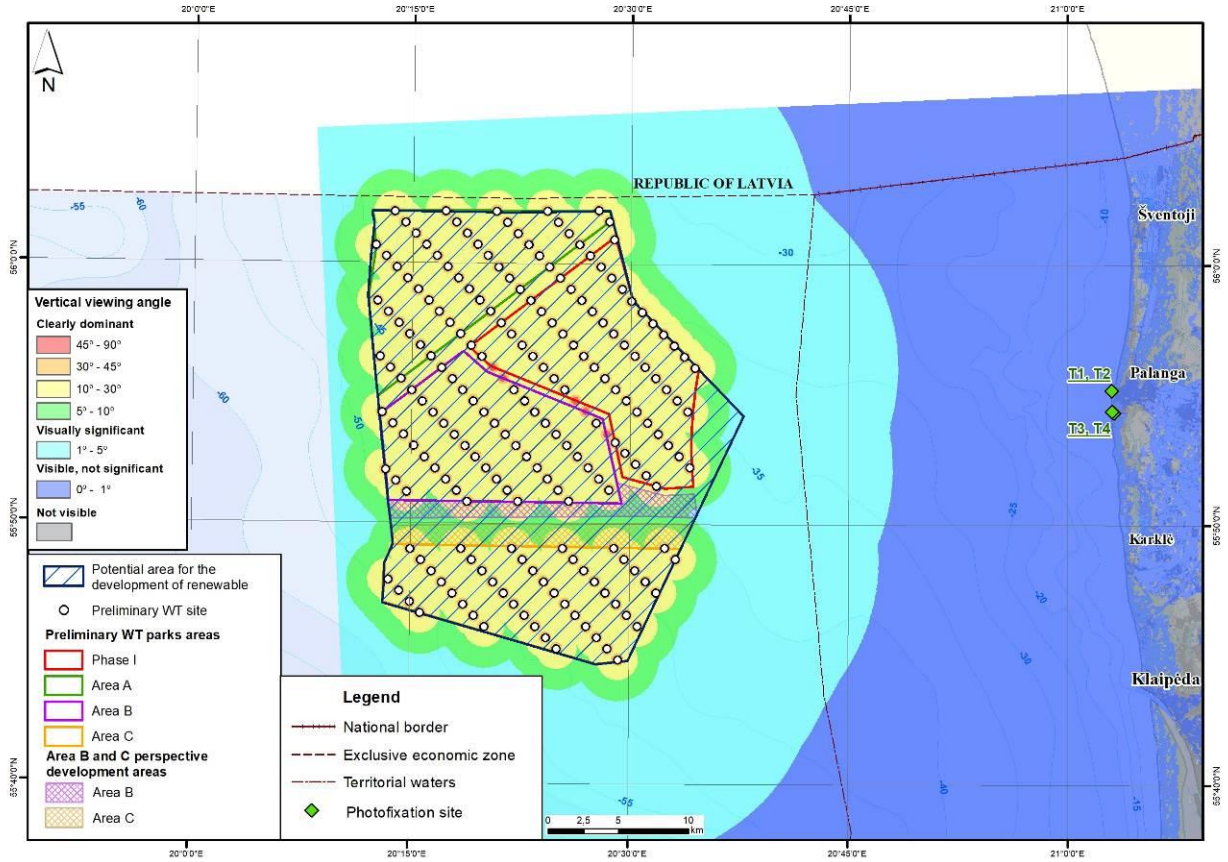

Fig. 14. Visual impact zones.

So that to implement the solutions of the Development Plan, wind turbines of another height (higher or lower) may be installed, as selected by the developer of the OWF. Prognostic results of the visual impact assessment show that to make visual impact of the OWF, to be installed in the area of the Development Plan, on the shore-based sightings more visually significant, i.e., in order for the vertical viewing angle to reach more than 1°, the overall height of WT turbines should exceed 500 m.

6.6. Effects of the implementation of the Development Plan solutions on the cultural heritage

There are no registered marine heritage values in the area of the Development Plan. The distance to the nearest registered cultural heritage object (code 38471) is about 20 km from the boundary of the Development Plan area, therefore, no adverse effects for registered underwater heritage objects are expected.

However, throughout the marine area, there may be underwater objects that are important for maritime cultural heritage. According to the information from the Lithuanian Transport Safety Administration charts, several dozen sunken objects not included in the Cultural Heritage Register have been identified in the Lithuanian EEZ. Most of the underwater objects are industrial ships; though, the remains of scientifically highly valuable wooden ships were

discovered, too. There were also several valuable habitats of cultural underwater seascape with natural relics and tree remains found. One discovery site is marked in the area of the Development Plan but does not fall within the preliminary boundaries of the territories intended for the installation of OWF.

During the implementation of the Development Plan solutions, installation of WT foundations and power transmission cable lines may have adverse effects on such objects and destruct their value. To avoid adverse effects, it is planned to conduct seabed surveys and identify potential objects with features of marine cultural heritage before the detail design works.

6.7. Effects of the implementation of the Development Plan solutions on the climate

The use of renewable energy sources is particularly welcome in the context of climate impact as a climate change mitigating measure. Wind energy is one of the renewable forms of energy, which reduces the use of fossil fuels and, together, the emissions of CO2 and other substances into the ambient air. The use of wind energy plays a major role in controlling climate change by reducing greenhouse gas emissions from the energy sector.

6.8. Effects of the implementation of the Development Plan solutions on physical assets and the socio-economic environment

The opportunities for developing offshore wind energy are directly related to other activities currently carried out in the sea area: shipping, shipping routes; fishing; mining sites for excavated soil, potential sites for sand excavation to replenish beaches; offshore engineering installations (electricity, communication lines, pipelines, etc.) and their safety zones; restricted use areas (exercise grounds used by the military, sunken ships, dangerous objects, cultural heritage values); marine areas for conservation purposes; other potential activities (mineral resource extraction areas). To rationally use marine areas and marine resources, it is important to coordinate traditional and planned interests between activities and sea users.

It is important to note that the installation of OWFwill significantly contribute to the implementation of the objectives of the Lithuanian Energy Independence Strategy. Assuming that 12 MW WT models might be used for the development of the wind farm, it is tentatively estimated that the total capacity of all offshore wind farms would be 2,436 MW. In the later phases of the implementation of the solutions under the Development Plan, wind speed measurements will be performed in the WT development territories and accurate WT models will be selected to form the OWFs, therefore, the final total installed capacity may change (likely to increase).

The study "Development 2050"[12] assumes that the main source of electricity generation in 2050 will be offshore wind farms, which will account for about 40% of the RES generation structure. The estimated total installed capacity of OWF for the three scenarios ranges from 1.6 to 2.0 GW in 2050. Thus, the objectives of the NEIS will be achieved by means of flexibility measures embedded. To this end, the most favourable alternatives of the Development Plan are I-(1), I-(2), IV-(1) and IV-(2), which provide for the connection of at least 2 phases/areas of the OWF to the Lithuanian onshore electricity transmission network. In order to ensure the

[12] https://www.litgrid.eu/uploads/files/dir564/dir28/dir1/15_0.php

fulfilment of the NEIS objectives, the alternatives of the Development Plan should provide for the connection of all phases/areas of the OWF to the Lithuanian electricity transmission network, provided that the network is supplied with sufficient capacity to receive the full amount of energy that can be generated.

The impact of the OWF on GDP can be divided into three types: direct, indirect, induced. The direct impact arises from the wind energy industry itself, while the indirect impact is generated within other industries that are involved in the development of the OWF. Sectors that generate the biggest indirect contributions to GDP include electrical equipment, machinery, metal, construction industries, as well as engineering services, rubber and plastic products, and real estate. Induced effects refer to the rise in the consumption of goods and services caused by investments in the development of the OWF and the creation of new job opportunities. In the long run, investments in research and innovation in wind energy also have the potential to create added value.

The installation of offshore wind farms will require the transportation of ship crews, installation and technical maintenance of turbines, laying of cables. Ship owners and ports will look for optimal solutions in this process. Klaipeda port is currently contributing to the development of wind energy in Lithuania and other countries. Stevedoring companies handle all components of onshore wind farms, which are delivered by ship, unloaded and then delivered to installation sites by road.

The key commercial fishing areas in the Lithuanian waters are at the seacoast, the area near the Russian border, and the area near the Swedish zone. The Development Plan area falls into the designated fishing divisions 504 and 534, containing a trawling area in which fishing intensively takes place using all fishing gear (bottom, pelagic trawls, and cod nets) in January-April and September-December. The impact on the fishing business is expected due to the emerging fishing restrictions in the areas of OWFs. Some commercial fishing areas in the OWF areas will be lost or subject to certain fishing restrictions during construction and operation. According to the available data, the most suitable area for trawling falls into the area under the phase I of the OWF Development Plan and into a part of the B Area. Once the solutions under the Development Plan are implemented, trawling will not be allowed in these areas due to the risk of damaging the power transmission cables laid at the seabed.

It should be noted that the area of the Development Plan occupies fishing areas on the high seas that are not allocated to individual companies. Therefore, due to restrictions during the construction and operation of the OWF, fishing will be possible in adjacent areas and fishermen will not suffer losses. However, offshore fishing companies can also claim compensation for lost fishing grounds, especially for trawling areas, which are not very large. Pursuant to Article 7 (1) of the Law on Fisheries of the Republic of Lithuania (adopted on 27 June 2000 No. VIII-1756, valid consolidated version of 01/01/2020 to 31/10/2021) "Users of fish stocks shall have the following rights: (...) to receive compensation for losses where fishing opportunities are lost (also for a fixed period) due to the economic activities of the authorities, state or municipal enterprises or agencies, including the economic activities carried out on their behalf (...)." Paragraph 2 of the same article states that "The procedure and rates for calculating the losses incurred in marine waters shall be established by the Ministry of Agriculture." Should fishermen file a claim for

compensation for losses related to the loss of fishing grounds, the procedure for compensation for losses shall be established by the Ministry of Agriculture.

The implementation of the solutions under the Development Plan and the establishment of OWF may also have indirect positive consequences for fish stocks. WT foundations can function as artificial reefs and attract many fish species. At the beginning of the operation of the OWF, fish are attracted from adjacent areas to the foundation of the WT, but in the long run there is a possibility of an increase in fish productivity in the OWF itself if the park is large enough and the fishing capacity is low. Wind farms sites usually create favourable conditions for the formation of fish nutrient base and spawning and can increase biodiversity – together with the restrictions on fishing, this can contribute to the conservation and enhancement of fish stocks. A balanced approach to the conservation and enhancement of fish stocks and the resulting constraints and compensation can substantially reduce the adverse effects for the fishing industry and the potential for conflicts between the fishing industry and wind energy.

According to the information from the Lithuanian Geological Survey on the promising oil structures in the Lithuanian maritime part, the Lithuanian EEZ may cover about 40-80 million tons of oil. The northern part of the planned area overlaps with the boundaries of oil-promising structures. Despite strategic goals, offshore oil exploration has not started. To avoid barriers to the implementation of the Oil Exploration and Production Strategy in Lithuania, i.e." expansion of oil exploration and exploitation of new fields," it is essential to ensure that potential oil fields in the area of the Development Plan and adjacent to it are thoroughly studied in the geophysical exploration phase before the commencement of design works.

OWFs may become a tourist attraction, where boat trips might be organised. Ships and boats, which now take tourists from Klaipeda port to trips on the Baltic Sea coast, would be perfect for the tours to the Lithuanian OWFs.

The integration of OWF will require both internal development of the transmission network and offshore infrastructure. The connection of OWF (700 MW) parks under development in Phase I (planned until 2030) to the 330 kV network does not require additional 330 kV PT development on land, it will be needed only at sea. As the ownership boundary is planned at the Darbėnai switchyard on the end coupling, all offshore infrastructure (underwater cable and platform) as well as some part of the terrestrial cable will be owned and developed at the expense of the producers, as required by the current legislation.

The connection of OWF (+700 MW) parks under development in Phase II (after 2030) to the 330 kV network may require additional development of 330 kV transmission network (TN) both at sea and on land. There are 2 feasible alternatives for the connection of Phase II-developed OWF to the Lithuanian transmission network:

Alternative I – strengthening the interconnection with Latvia (i.e., reconstruction of the 330 kV OL Darbėnai-Grobinė, with additional changes in the territory of Latvia). At the same time, strengthening the offshore infrastructure (second underwater cable and platform), as well as part of the terrestrial cable). If this Alternative is chosen, the consent of the Latvian transmission grid operator will also be required.

Alternative II – onshore TN development required. The following options are considered:

Option 1. Where new 330 kV PPLs are laid at Darbėnai-Telšiai-Mūša and Mūša-Panevėžys.

Option 2. Where new 330 kV PPLs are laid at Darbėnai-Varduva-Mūša and Mūša-Panevėžys.

As in Alternative I, offshore infrastructure (second underwater cable and platform) will be required as well as some part of the terrestrial cable.

3rd-party investments in OWF and related projects, both onshore and offshore, will be carried out at the initiative and at the expense of the OWF developers, as laid out in the current legislation. The infrastructure required for OWF will not depend on and will not be operated by LITGRID.

The energy system development scenarios presented in the study presume that at least 2 offshore wind farms, each 700 MW, are planned to be connected to the Lithuanian electricity transmission network; therefore, the alternatives I and IV for offshore WT connection are to be considered.

Where the most technologically appropriate location of the substation in each phase is the centre of the respective farm phase, then the alternatives I-(1) and IV-(1) should be considered.

The criteria for choosing between the above two alternatives might be the length of the Area A shore cable and the cost of the cable route studies.

The Alternative I-(1) is obviously more attractive in terms of cable length.

The Alternative IV-(1) is more attractive because most of the high-voltage cable route would overlap with the Harmony Link route.

The locations of geometrically localised offshore wind farms presented in the report will be specified at the technical design preparation phase and will be subject to technical specifications of the selected wind farm model and the results of the seabed research works. After a detailed assessment of the natural and economic aspects, the locations of transformer substations can also be reviewed. The main difference among the concept alternatives under consideration is the length of the needed underwater cables. Therefore, the report compared the differences among the cable lengths and their installation costs to compare the concept alternatives under consideration in economic terms.

The comparison of the above alternatives suggests that the positioning of the transformer substation in the centre of the OWF is more economically justified than on the edge of the farm (Note: the calculations do not consider depths and related TS construction costs).

When comparing the costs of cabling, it is obvious that cabling in the northern utility corridor provided for in the Comprehensive Plan of the Territory of Lithuania would be cheaper than cabling using the Harmony Link corridor. This, however, does not include indirect costs or obstacles that may arise due to the proximity to the state border or potential oil fields on the northern side, additional site surveys may require both extra costs and time, moreover, political / legal obstacles are possible as well.

When laying a high-voltage cable in the Harmony Link cable corridor, previous seabed surveys can be referenced in order to reduce surveying costs.

7. MEASURES TO AVOID, REDUCE, OR RESTITUTE MAJOR ADVERSE ENVIRONMENTAL EFFECTS OF THE IMPLEMENTATION OF DEVELOPMENT PLAN SOLUTIONS

Environmental component	Environmental effect mitigation measures
Protected areas and their values	It is recommended to build offshore transformers away from the boundaries of protected areas. Shipping around the OWF should be arranged in such a way that service vessels do not sail in the protected area during the wintering of seabirds, and the traffic should be arranged to disturb the wintering birds are as little as possible.
Biodiversity	Prior to the implementation of solutions under the Development Plan, seabed biotopes must be investigated, and existing seabed biotopes must be identified at the locations of cable routes at offshore TS and OWF. To reduce an adverse effect of solutions under the Development Plan on birds and bats, the following mitigation measures are recommended: • To plan the layout of WT towers in the areas planned for the development of OWF in such a way that the distance between separate WTs is as small as possible (as far as the technical specifications allow), thus reducing the number of corridors potentially dangerous for migrating birds. • Before developing technical designs, it is recommended to carry out sea observations of wintering and migrating birds and bats, findings of which might be used, as needed, to identify the distances of safe buffer zones for birds from the adjacent NATURA 2000 IBA (important bird area) Klaipėda-Ventspils Plateau. • To arrange traffic of the vessels serving the OWF during the winter, i.e., November to April, so that the routes do not pass through the protected areas. • To reduce the effect on wintering birds on the coast, noisy wind farm installation (pile driving) and dismantling works should not be carried out in November-April (inclusively). To reduce an adverse effect of solutions under the Development Plan on animals, the following mitigation measures are recommended: • Before developing a technical design, it is recommended to carry out recording of marine mammals, which would allow to select the most appropriate measures to reduce an effect of the construction of OWF. • Where pole foundation is chosen during the installation of WT to reduce an effect on marine animals, following special mitigation measures are recommended: - A warning method is recommended for pile driving where animals are driven away from the area before the commencement of noisy operations. For this purpose, warning sounds are continuously broadcast in the area before the start of work, the volume of which gradually increases up to the start of work. - use an air bubble curtain to protect against possible hearing loss around the pile driving point, which reduces the driving sound.
Water	During the phases of construction, operation, and decommissioning of the OWF, it is necessary to comply with the Law on Protection of the Marine Environment of the Republic of Lithuania and

Environmental component	Environmental effect mitigation measures
	international treaties on safe shipping and marine pollution. To properly select technological solutions for the development of the wind farm and to assess an effect of the planned wind power structures on the hydrodynamic environment, it is recommended to measure the velocity and direction of currents before the start of construction works (background assessment) and after completion of construction works. During the installation of the OWF, more intensive shipping may cause local and temporary effect on water quality due to additional water pollution with chemicals (heavy metals, petroleum hydrocarbons, polyaromatic hydrocarbons). To assess the compliance of pollutant concentrations with the values of good environmental status, it is advisable to include pollutant studies in the environmental monitoring programme and to ensure the execution thereof before construction works (background concentrations), during construction (foundation installation, cabling), and upon completion of construction works (3-6 months after completion of works).
Seabed and subsoil	To reduce environmental effects of the Development Plan, the following preventive conflict reduction measures are planned: - Before planning the WT construction, to conduct a seismic geophysical survey of the planned and adjacent territories for likely/potential oil structures to avoid a conflict between the two strategic energy sources in the future extraction. - To ensure that changes in the surface lithology of the seabed are controlled at the development site of the OWF, thus enabling the monitoring of whether the OWF does not adversely affect an integrity of the seabed or related quality of biological and mineral resources. - To use existing/planned infrastructure corridors for power cabling, thus reducing seabed fragmentation with trenches. - To establish safety zones both for individual wind turbines, substations and for the OWF area under development to ensure safe shipping, to reduce the risk of accidents (collisions), and to avoid bottom trawling at power cable laying sites.
Landscape	Following the implementation of solutions under the Development Plan, the natural landscape of Lithuania's Baltic Sea will be supplemented with technogenic objects in large water areas. The emergence of new expressive vertical dominants in the seascape may cause public dissatisfaction. Therefore, information campaigns are necessary to shape public attitudes towards the renewable energy and to raise public awareness of direct and indirect benefits of offshore wind farms. To make sure that the implementation of solutions under the Development Plan will have no visual adverse effects on the seascape, prior to the technical design of OWF installation, an assessment of the environmental effect of WT models selected by WT park developers and the location of the WT in the planned area must be conducted. The height of WT models must be limited, as appropriate, so that the turbines closest to the coast do not have a significant adverse visual effect on the onshore viewing decks.
Cultural heritage	To avoid adverse effects, underwater seabed surveys are planned to be carried out prior to WT design works, at the sites of installation of offshore transformer substations and the connection of wind farms to the offshore transformer substation cables. Where the objects are found during the surveys that might match or be identified as potential underwater heritage sites, the layout of TS, WTs and cable lines is to be adjusted.

Environmental component	Environmental effect mitigation measures
Socio-economic environment	The implementation of solutions under the Development Plan may have consequences for fishing businesses due to emerging fishing restrictions in the OWF areas. Pursuant to Article 7 (1) of the Law on Fisheries of the Republic of Lithuania (adopted on 27 June 2000 No. VIII-1756, valid consolidated version of 01/01/2020 to 31/10/2021) "Users of fish stocks shall have the following rights: (..) to receive compensation for losses where fishing opportunities are lost (also for a fixed period) due to the economic activities of the authorities, state or municipal enterprises or agencies, including the economic activities carried out on their behalf (..)." Paragraph 2 of the same article states that "The procedure and rates for calculating the losses incurred in marine waters shall be established by the Ministry of Agriculture." Where fishermen file a claim for compensation for losses related to the loss of fishing grounds, the procedure for compensation for losses shall be established by the Ministry of Agriculture. To avoid barriers to the implementation of the Oil Exploration and Production Strategy in Lithuania, i.e. "expansion of oil exploration and exploitation of new fields," it is essential to ensure that potential oil fields in the area of the Development Plan and adjacent to it are thoroughly studied in the geophysical exploration phase before the commencement of design works. In accordance with the national security criteria, a small eastern part of the area under the Development Plan falls into the areas where construction of WTs is prohibited. No WTs will be installed in this part of the Development Plan area. The area under the Development Plan is a part of the areas where construction sites for wind turbines are subject to coordination provided that the producer of energy from renewable resources signs a contract with the Lithuanian Armed Forces on part of investment and other costs. At an early planning phase, it is pursued for cooperation with national defence authorities so that constraints on the development of the OWF are well explained and understood, and mitigation measures are discussed and agreed upon together. Part of Lithuania's Baltic Sea territory has been recognised as dangerous. Former minefields are identified as potentially dangerous. It is possible to carry out economic activities in these territories, however, a prerequisite is to carry out comprehensive seabed surveys in search of hazardous objects and, if necessary, to carry out decontamination thereof before starting the WT design works.

8. DESCRIPTION OF THE SELECTED ALTERNATIVES OF THE DEVELOPMENT PLAN

8.1 Comparison of the alternatives to the Development Plan Concept based on the principle of sustainable development

To measure am impact of the Development Plan on the national development, alternatives of the concept are assessed in terms of sustainable development, i. e., with regard to consequences for the natural, social, and economic environment.

The consequences were assessed with consideration to their significance and weight, in percentage (significance) of the criterion in question. The significance of consequences is judged based on quantitative parameters and qualitative aspects.

Table 1. Assessment of concept alternatives in terms of sustainable development

No.	Component	Description of comparison of alternatives
Natural environment		
1	Biodiversity: seabed habitats	When implementing solutions under the Development Plan, there are possible consequences for seabed biotopes due to the destruction of seabed bottom during the installation of WT foundation and energy transmission cables, as well as an increase of water turbidity. This physical destruction of the habitat will be reversible at the end of operation period. During the operation phase, adverse effects on seabed habitats are insignificant. The installed underwater structures of wind towers will become a secondary (artificial) substrate suitable for attachment of various aquatic organisms. This, in turn, will increase diversity of habitats and seabed communities, increase biomass and number of species. Given a ratio of destructed to newly created artificial substrate areas, it can be stated that OWF will have no significant adverse effects on seabed biotopes and benthic organisms. In the Alternative I of the Concept, the choice of a northern utility corridor to run a power transmission cable ashore would be likely to have a greater effect for seabed habitats due to the possible loss or fragmentation of crossed reef habitats. In the Concept's alternatives II, III and IV, given a ratio of the areas of destructed to newly created artificial substrate, OWF are estimated to have insignificant both negative and positive effects for seabed habitats and benthic organisms. To compare, in case of Alternative I, a little more significant adverse effects are likely for natural reef habitats.
2	Biodiversity: ichthyofauna	Potential adverse effects for marine fish are related to the construction of OWF, which may cause a great underwater noise, increase water turbidity due to the installation of foundations and/or laying of cable lines. During the operation of OWF, there are adverse effects possible due to interference caused by the maintenance of OWF and cable-emitted electromagnetic fields. The greatest effect of noise on fish is possible during pile driving - high sound pressure can kill or injure fish. In general, during any construction or installation operations, fish may react to the noise caused at up to 1 km and move away from the danger area, therefore, the probability of death is low. Upon the completion of installation, the fish come back. So, no significant long-term effects for the marine fish population are expected. Increased water turbidity may complicate fish nutrition in the area and affect fish spawning grounds. However, suspended sediment remains in the water column for quite a short period of time, and their spread area depends on the type of sediment and the hydrodynamic regime. The effects are expected to be local, short-term and have no significant consequences for the marine fish population. During the operation of the OWF, a positive impact is expected due to the anticipated increase of organisms living on hard bottoms in the farm territories due to the emergence of new substrates suitable for habitats. This may have a positive impact on fish populations due to the proliferation of potential food items and the emergence of spawning-favourable habitats. In this respect, the consequences of all the concept alternatives under consideration are seen as insignificant, though, equally negative, and positive.
3	Biodiversity: marine mammals	There are not many marine mammals in the area of the Development Plan. The implementation of solutions under the Development Plan (though it may have an adverse effect on individuals) is therefore assessed to have no significant adverse effects for marine mammal populations.
4	Biodiversity: birds and bats	Following the implementation of solutions under the Development Plan, the effect of displacement, obstruction, and direct contact with WT on wintering and migrating birds can be observed in the area. Migratory bats may also be adversely affected if they migrate by the

No.	Component	Description of comparison of alternatives
		constructed offshore WTs. Such WTs may attract bats. And when they fly up, apart from the direct collision effect, the barotrauma effect can also be observed. In the absence of detailed bird and bat migration studies in the planned area, the potential consequences are moderately significant for all of the alternatives.
5	NATURA 2000 territories are also protected in the Republic of Lithuania	The area of the Development Plan borders with the protected NATURA 2000 territories of the Republic of Lithuania. Analysis of effects of solutions under the Development Plan on the protected values shows that the highest probability is that the impact of displacement on the Klaipėda-Venspils Plateau during the wintering of seabirds (from the end of October to the end of March) will be observed. Birds may avoid the border of the protected area that is closest to the planned OWF, without singling out any of the alternatives. In the Concept Alternative I (both I-(1) and I-(2)), where the cable is to be laid along the Northern utility corridor, the preparatory cabling and cable digging works will affect physical environmental changes, which may lead to a decrease in the natural habitat 1170 Reefs and/or fragmentation thereof. In this context, adverse effects on Protected Areas and their protected values are assessed to be significant (Alternative I) or moderately significant (Alternatives II, III, and IV).
6	Water	Under normal operating conditions, the operated OWF will not have any consequences for seawater quality. However, temporary changes in water quality are possible during construction, i.e., when installing foundations and laying cables due to a temporary increase in suspended particles (turbidity) in the bottom layer of the water column. As the territories of OWF are planned at depths over 30 m, the impact of foundation structures on the hydrodynamic environment is insignificant, given that they are planned to be built far from the shore, in a stable geological environment. The increase in turbidity will only occur at the foundations and cable laying sites. Its impact can therefore be assessed as local (bottom layer) and short-term (during installation only), with no significant long-term impact on hydro-chemical water parameters or consequences for quality of the Baltic Sea water. In any of the concept alternatives, there are no adverse effects for water quality or hydrodynamic processes expected.
7	Sea bottom	A potential impact of a wind farm on the sea bottom will depend on the method of attaching the turbines to the seabed and the size of the foundation. Single-pile structures, with a foundation diameter typically between 3 and 3.5 meters and with wind towers spaced apart by 500 m (about 1.1 km in our case), usually do not have any significant effect on the changes in hydrodynamic regime. However, it has a direct intervention on the seabed, by locally damaging its integrity and possibly inducing erosive processes. The planned site for the installation of OWF is far from the major sediment transport routes, the main sediment flow is observed in 1–1.5 km part of the coastal area. Therefore, the installation of the WTs is likely to have no significant impact on the nearshore sediment transport patterns or the stability of sensitive sandy coasts of Lithuania. The impact of the installation of power cables connecting the WTs with a power substation is assessed as local (at the site of a trench). Trenches are made to a maximum depth of 3 m (subject to the equipment used). Where a cable-laying plough is used, the effect is considered as short-time, because the trench is buried at the same time and with the same sediments that were excavated when laying the cable. The change in bottom sediments will only be related to the loosening of the original rocks (which were solid, cemented before excavation) at the excavation site. In all the alternatives, the effects on the seabed are considered to be insignificant.
8	Landscape	Following the implementation of solutions under the Development Plan, the natural seascape

No.	Component	Description of comparison of alternatives
		of the Lithuanian Baltic Sea in large water areas will be supplemented with technogenic objects. The assessment shows that the future WTs closest to Lithuania's Baltic Sea coast will be visible in extremely clear weather and good visibility conditions. However, high-intensity public beaches or viewing decks on the coast will not be included in the visual impact zone (based on the prognostic results of the visual impact assessment, in order for the visual impact of WT parks on coastal sightseeing areas to become visually significant, i.e., for the vertical angle of vision to reach more than 1°, the total height of the WT should be more than 500 m; no WTs of such a height are produced, neither will they be installed). In that regard, adverse effects for the landscape are estimated to be negligible in all the alternatives.
9	Climate	The use of renewable energy sources is particularly welcomed in terms of climate impact as a climate change mitigating measure. Wind energy is one of the renewable types of energy, which reduces the use of fossil fuels and, together, the emissions of CO2 and other substances into the ambient air. The use of wind energy plays a major role in controlling climate change by reducing greenhouse gas emissions from the energy sector. In this respect, the climate impacts of all the concept alternatives considered are significantly positive.
Social environment		
1	Restriction of traditional maritime activities in the areas of OWF and power transmission cables	The area under the Development Plan is a part of the areas where construction sites for wind turbines are subject to coordination provided that the producer of energy from renewable resources signs a contract with the Lithuanian Armed Forces on part of the investment and other costs. The area under the Development Plan is located outside the existing shipping lanes, roadstead, and anchorage sites, therefore, the implementation of the solutions will not have any significant impact on shipping. The Development Plan area falls into the designated fishing divisions 504 and 534, containing a trawling area in which fishing intensively takes place using all fishing gear (bottom, pelagic trawls, and cod nets) in January-April and September-December. The impact on the fishing business is expected due to the emerging fishing restrictions in the areas of OWF. Some commercial fishing areas in the OWF areas will be lost or subject to certain fishing restrictions during construction and operation. According to the available data, the most suitable area for trawling falls into the area under the phase I of the OWF Development Plan and into a part of the B area. Once the solutions under the Development Plan are implemented, trawling will not be allowed in these areas due to the risk of damaging the power transmission cables laid at the seabed. In the event of a claim by fishermen for compensation for loss of fishing grounds, the Ministry of Agriculture will have to establish a procedure for compensation. In this context, the consequences for traditional maritime activities are adverse and moderately significant for all alternatives of the concept.
2	Cultural heritage	There are no registered marine cultural values in the area of the Development Plan, therefore, no adverse effects for the registered underwater heritage sites are expected. However, throughout the marine area, there may be sunken objects that are important for maritime cultural heritage. During the implementation of solutions under the Development Plan, such objects may have adverse effects as installation of the WT foundations and laying of power transmission cable lines may destruct their value. To avoid adverse effects in the later phases of the Development Plan (before or during the design works), it is planned to conduct seabed surveys and identify potential objects with features of marine cultural heritage. The implementation of solutions under the Development Plan will have no consequences for the registered or unregistered cultural heritage.
3	Reserves of useful resources	To avoid barriers to the implementation of the Oil Exploration and Production Strategy in Lithuania, i.e. "expansion of oil exploration and exploitation of new fields," it is essential to

No.	Component	Description of comparison of alternatives
		ensure that potential oil fields in the area of the Development Plan and adjacent to it are thoroughly studied in the geophysical exploration phase before the commencement of design works. In the Alternative I, the choice of a northern utility corridor for laying a power transmission cable to the shore is likely to have greater consequences due to potential restrictions on oil exploration. No validated or potential sand deposits have been identified in the planned area; therefore, it is estimated that the conditions for sand extraction for coastal management purposes in the WT installation area will not be affected. In this context, the solutions under the Development Plan are assessed to have no or insignificant (Alternative I) consequences for the exploration of useful resources and exploitation thereof in the future.
4	Recreation	The solutions under the Development Plan will not affect the existing recreation. OWF may become a tourist attraction, where boat trips might be organised. Ships and boats, which now take tourists from Klaipeda port to trips on the Baltic Sea coast, would be perfect for the tours to the Lithuanian WT farms. In this respect, minor positive effects for recreation are expected.
5	Social impact at the national and Baltic level due to energy security	The implementation of solutions under the Development Plan will create preconditions for the increase of energy production from renewable energy sources, which is directly in line with the objectives of the National Energy Independence Strategy (NEIS). The study "Development 2050" assumes that the main source of electricity generation in 2050 will be OWF, which will account for about 40% of the RES generation structure. The three scenarios provide for that a total installed capacity of OWF will range from 1.6 to 2.0 GW in 2050. Thus, the objectives of the NEIS will be achieved by means of flexibility measures embedded. To this end, the most favourable alternatives of the Development Plan are I-(1), I-(2), IV-(1) and IV-(2), which provide for the connection of at least 2 phases/areas of the OWF to the Lithuanian onshore electricity transmission network (Lithuanian TN). In this respect, positive effects are significant or moderately significant.
Economic environment		
1	Investments and job creation for the Lithuanian labour market	The implementation of solutions under the Development Plan will have a direct, indirect, and induced impact on GDP due to the development of the wind energy industry and other industries, development of engineering services and, in the long run, potential investment in wind energy studies and innovation. Lithuania's share of added value and new jobs will depend on what share of the value chain will be developed locally. A greater positive economic effect is estimated when connecting more OWF directly to the Lithuanian TN. In this respect, positive effects are expected to be significant or moderately significant.
2	Construction costs	The integration of offshore OWF into Lithuanian transmission networks (TNs) will require both internal TN development and offshore infrastructure. The costs of pursuing the NEIS objectives are, therefore, inevitable. To compare the alternatives of the Development Plan Concept, the main difference is in the cost of cabling. The preliminary calculations assume that the lowest cost for laying cables is when the transformer substation is installed in the power generation (OWF) centre. The Harmony Link corridor is most favourable for the connection of the area under development in Phase I to the electricity transmission networks in mainland Lithuania (when connecting via the northern utility corridor from the central TN, a length of a high-voltage cable is quite similar; and, when using the Harmony Link corridor for connection, the seabed surveys might be resorted to). For the connection of Area A to the

No.	Component	Description of comparison of alternatives
		electricity transmission networks in the mainland part of Lithuania, it would be most cost-efficient to use a northern utility corridor (alternative I-(1) of the concept) regarding the cable length.
3	Energy independence	The NEIS provides for that by 2050, 100% of the total final energy consumption of the country consists of local electricity generation. To ensure the achievement of the NEIS objectives, Alternatives I and IV, which provide for the connection of at least two OWF areas to the Lithuanian electricity transmission networks, are assessed more favourably. In terms of energy independence, it is estimated that the solutions under the Development Plan will have positive significant (Alternatives I and IV) and moderately significant (Alternatives II and III) effects.

Conclusion: The most favourable alternatives of the concept in terms of sustainable development are IV-(1) and I-(1).

8.2 Comparative analysis of alternatives of the Development Plan Concept

During the SEA of the Development Plan, four alternatives of the concept have been examined, with natural, social, and economic aspects taken into consideration.

Each alternative has two options (sub-alternatives):

- Option where offshore TSs are planned in the centre of the OWF.
- Option where offshore TS are planned as close as possible to the utility infrastructure corridor proposed for the connection of parks to the electricity transmission system.

Preliminary calculations of cable prices show that the localisation of the transformer substation in the centre of the OWF is more economically based.

In terms of assessing environmental effects of implementation of the Development Plan, major attention should be paid to the long-term potential consequences, including impacts on biodiversity (displacement, habitat alteration), landscape (permanent visual change), socio-economic environment, and extraction of underground mineral resources (potential oil resources).

In terms of consequences for the natural environment, biodiversity and landscape, the introduction of OWF will have an equal impact for all concept alternatives under consideration, as well as their options, due to the identical area and similar engineering solutions for the installation of basic engineering infrastructure. A slightly more significant difference is expected due to the high voltage cable route.

It should be noted that effects for such environmental components as water or ambient air would be short time, partially restored, and only perceived during the construction of facilities.

Social aspects and the current use of the sea area are of particular importance when implementing solutions under the Development Plan. The solutions under the Development Plan must be implemented in coordination with the interests of the fishermen operating the area. To avoid barriers for the implementation of the Oil Exploration and Production Strategy in Lithuania, it is essential to ensure that potential oil structures, provided in the area of the Development Plan and adjacent to the boundaries of it, are thoroughly studied in the geophysical exploration phase before the commencement of design works. In accordance with the national security criteria, a small eastern part of the area under the Development Plan falls into the areas where the construction of WTs is prohibited. No WTs will be installed in this part of the Development Plan area. The implementation of the solutions under the Development Plan is crucial for achieving the goals of the National Energy Independence Strategy.

The economic effects are closely related to the potential for the development of OWF to generate added value and create both direct and indirect jobs. Lithuania's share of added value and new jobs will depend on what share of the value chain will be developed locally, i.e., the need for local labour, raw materials, infrastructure, and equipment in different parts of the value chain, the capacities of existing industries, port facilities, etc. Given the technological differences among the concept alternatives and the expected socio-economic benefits, priority should be given to the concept alternatives IV-(1) and I-(1). The criteria for choosing between the above two alternatives might be the length of the Area A shore cable and the cost of the cable route studies.

The Alternative I-(1) is obviously more attractive in terms of cable length, though, in the northern part of the Lithuanian EEZ, the planned cable route would pass through potential oil structures and cross the boundaries of protected areas.

The Alternative IV-(1) is more attractive because most of the high-voltage cable route would overlap with the Harmony Link route, where seabed surveys have already been accomplished (the results are currently being processed), thus reducing the cost of cable route surveys and using existing utility infrastructure corridors. This alternative is more favourable as the high voltage cable does not cross the natural habitat of the 1170 Reefs.

It should be noted that:

1. The Development Plan cannot define exact locations of wind turbines, transformer substations, or cables – this work is done during the development of the technical design, with the available findings of other studies under the Development Plan and by making more precise engineering and economic calculations. The Development Plan defines the territories (areas) to be developed in phases and reserves corridors amongst them for infrastructure and shipping.
2. The Development Plan presumes *a priori* that a shallower area A will be developed in the phase II. Subject to the results of the studies provided for in the Development Plan, the area under the development in the phase II and the direction of the high-voltage cable taken from it may change.
3. Areas B and C are planned to cover additional perspective development territories, to be adjusted (defined) after installation of the Harmony Link underwater cable

crossing the Development Plan area, by saving a 0.55 km wide bar on both sides of the cable axis for cabling, construction, and utility service corridor.

4. Upon receipt of connection terms from the Lithuanian network operator LITGRID AB, more than two areas defined in the Development Plan may be connected to Lithuanian electricity transmission networks on the mainland.

DETALŪS METADUOMENYS	
Dokumento sudarytojas (-ai)	Lietuvos Respublikos aplinkos ministerija, A. Jakšto g. 4, 01105 Vilnius
Dokumento pavadinimas (antraštė)	Information regarding SEA procedure for Renewable energy development plan in the Baltic Sea.
Dokumento registracijos data ir numeris	2021-09-14 Nr. (14)-D8(E)-5788
Dokumento specifikacijos identifikavimo žymuo	ADOC-V1.0, GEDOC
Parašo paskirtis	Pasirašymas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	DARIUS KVEDARAVIČIUS, Aplinkos viceministras
Parašo sukūrimo data ir laikas	2021-09-14 11:09:12
Parašo formatas	Parašas, pažymėtas laiko žyma
Laiko žymoje nurodytas laikas	2021-09-14 11:09:29
Informacija apie sertifikavimo paslaugų teikėją	ADIC CA-B
Sertifikato galiojimo laikas	2020-12-22 - 2023-12-22
Parašo paskirtis	Registravimas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	Regina Žemaitienė, Vyr. specialistė
Parašo sukūrimo data ir laikas	2021-09-14 11:13:37
Parašo formatas	Trumpalaikis skaitmeninis parašas, kuriame taip pat saugoma sertifikato informacija
Laiko žymoje nurodytas laikas	
Informacija apie sertifikavimo paslaugų teikėją	RCSC IssuingCA
Sertifikato galiojimo laikas	2021-01-07 - 2023-01-07
Pagrindinio dokumento priedų skaičius	1
Pagrindinio dokumento pridedamų dokumentų skaičius	0
Programinės įrangos, kuria naudojantis sudarytas elektroninis dokumentas, pavadinimas	Elektroninė dokumentų valdymo sistema VDVIS, versija v. 3.04.02
El. dokumento įvykius aprašantys metaduomenys	
Informacija apie elektroninio dokumento ir elektroninio (-ių) parašo (-ų) tikrinimą (tikrinimo data)	El. dokumentas atitinka specifikacijos keliamus reikalavimus. Visi dokumente esantys elektroniniai parašai galioja. Tikrinimo data: 2021-09-14 11:22:23
Elektroninio dokumento nuorašo atspausdinimo data ir ją atspausdinęs darbuotojas	2021-09-14 atspausdino Regina Žemaitienė
Paieškos nuoroda	