SEMINÁRIO Geotecnia em Obras Marítimas – Aprender com a Experiência
Auditório Infante D. Henrique (APDL - Porto de Leixões)
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Identification of suitable sites for the development of offshore renewable energies from a technical and economic point of view – the Portuguese case

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- *LNEG*

Organização
CPGT Comissão Portuguesa de Geotecnia nos Transportes
CPMT Comissão Portuguesa de Melhoramento de Terrenos
Sociedade Portuguesa de Geotecnia
APDL Administração dos Portos Douro • Leixões • Viana

Planning the installation of offshore wind farms

- A spatial planning methodology for offshore projects can be defined by:

- Set of information and georeferenced information that defines the set of operating restrictions managed by a geographic information platform capable of connecting and relating the spatial information normally designated as “layers”.

- **Results:** areas / regions suitable for the implementation of offshore wind farms and information on sustainable offshore wind potential available for a region of interest - a country or a specific area.

Planning the installation of offshore wind farms

- The necessary data are divided in two categories:

1. Wind resource mapping.

    1. Technology – reference equipment to install is mandatory

2. Conditions/Restrictions to the installation of wind turbines

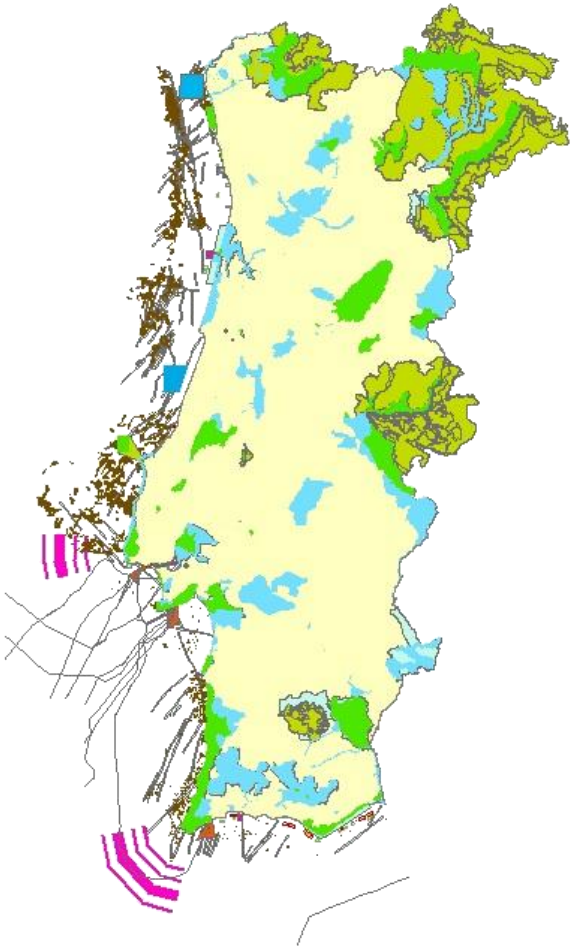
    1. Environmental
    2. Physical
    3. Socio-economic (mainly locations where other activities on the sea are taking place)
    4. Economical assessment (for most situations this is performed only at the project level)

Planning the installation of offshore wind farms

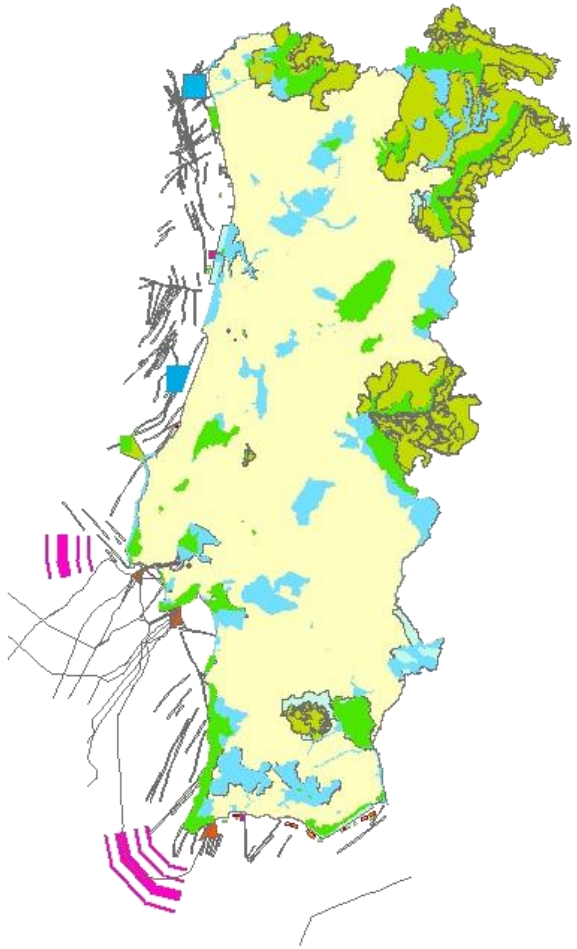
1. Wind resource mapping.
   - Obtained based on numerical modeling - mesoscale (extensive regions> 100km2), and measured wind data (validation).
   - They must include energy produced by a given model of wind turbine (reference model)
   - necessary to identify sites with adequate wind resources
   - It allows to identify the sustainable / available potential in regions of interest

- 2. Conditions/Restrictions to the installation of wind turbines
   - Existence of databases with information on existing restrictions at sea in the study area are crucial for introduction into a GIS.
   - Examples of restrictions - environmentally protected areas, navigation channels, submarine cables, seismic faults, among others.
   - Restrictions related to distance can be considered (definition of minimum value of distance to the electric grid, ports and shipyards).

Planning the installation of offshore wind farms



Bottom Fixed Technologies



Floating Technologies

Restrictions to the Installation of Marine RES

- Environmental Protected Areas
- Electrical cables
- Military Zones
- Seismic Faults
- Natura 2000 Areas
- Aquaculture Areas.
- Pilot Zones
- Navigation Channels
- Rocky seabed
- Biosphere Reserved Areas
- Protected Areas
- Other Aquaculture Zones
- Portuguese Pilot Zone for Marine Renewables R&D
- Reef areas
- (…)

Planning the installation of offshore wind farms

Wind resource conditions to establish:

Offshore Wind Atlas
Map of anual energy production with a reference WT (MWh)
Nominal power and characteristics of the WT selected model (MW)
Minimum NEPs (h/year) – for economic viability analysis
Equivalent energy losses (%, or MWh)

Additional facts to consider:

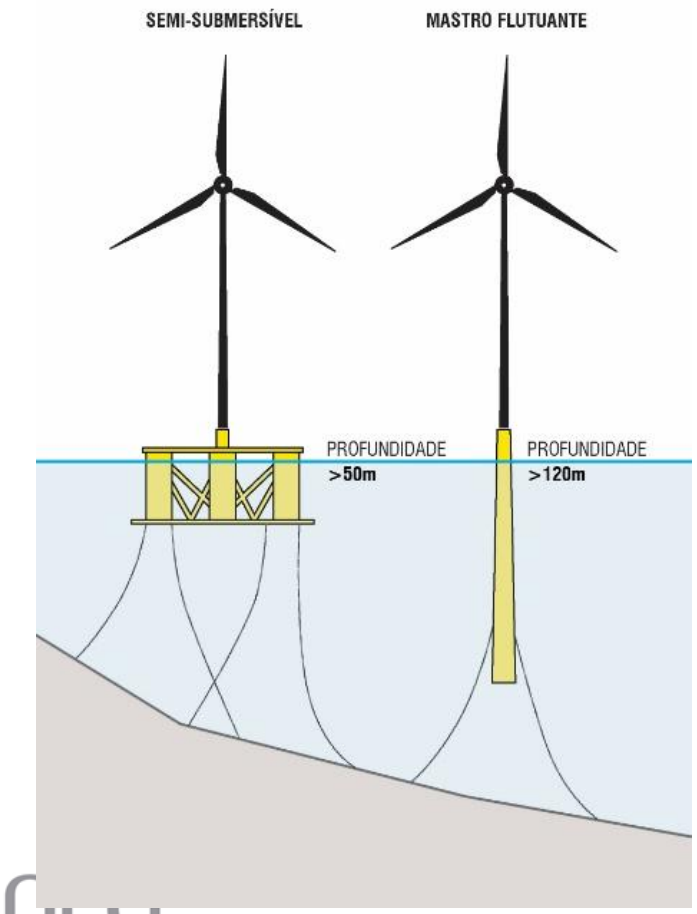
Electric losses: 3%;

- Energy losses due to wake effects: 5%
- Energy losses due to operational unavailabitlity: 3%;
- *curtailment*: 5%.

Miscelaneous conditions:

Type of restriction	Description
Bathymetry	Depth/Slope
Environment	Protection áreas (sea and coastal)
Economic activities	Fisheries, aquaculture and other activities
Connection to the electric grid	Available capacity to connect to the grid, curtailment (if applicable),
Accesses	Ports, coastal área, visibility área, distance to coast, etc…
other	Military zones, seismic faults, types of seabed, navigation channels, submarine cables,…

Planning the installation of offshore wind farms – Technology selection



	Bottom fixed foundations		Floating foundations	
Name:	Monopile	Jacket	Windfloat	Hywind
Type of foundation:	-	-	Semi-Submersible	Spar-Buoy
Mooring system:	-	-	Catenary System (3 cables)	Catenary System (3 cables)
Depth (m):	10 - 30	25 - 50	> 50	> 100
Development phase:	Comercial	Comercial	Pre-Comercial (2019)	Pre-Comercial (2017)

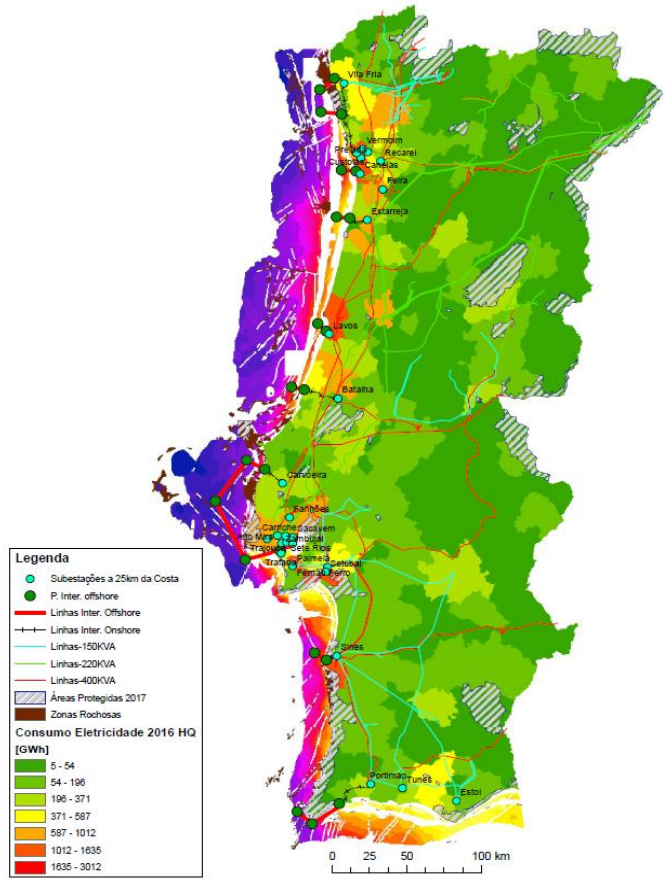
Planning - Conditions

Conditions for the definition of possible configurations for the future Wind Power plants (2020-2050) (example from OffshorePlan project*):

- Energy resource available – >3000h/year (fixed tech), >3500 (Float. Tech)
- Proximity to RNT substations - ~25 km to the coast.
- Proximity to consumption areas (considered coastal and near-coast municipalities).

Definition of the “routing” of submarine transport cables from offshore generation to RNT, with the following conditions:

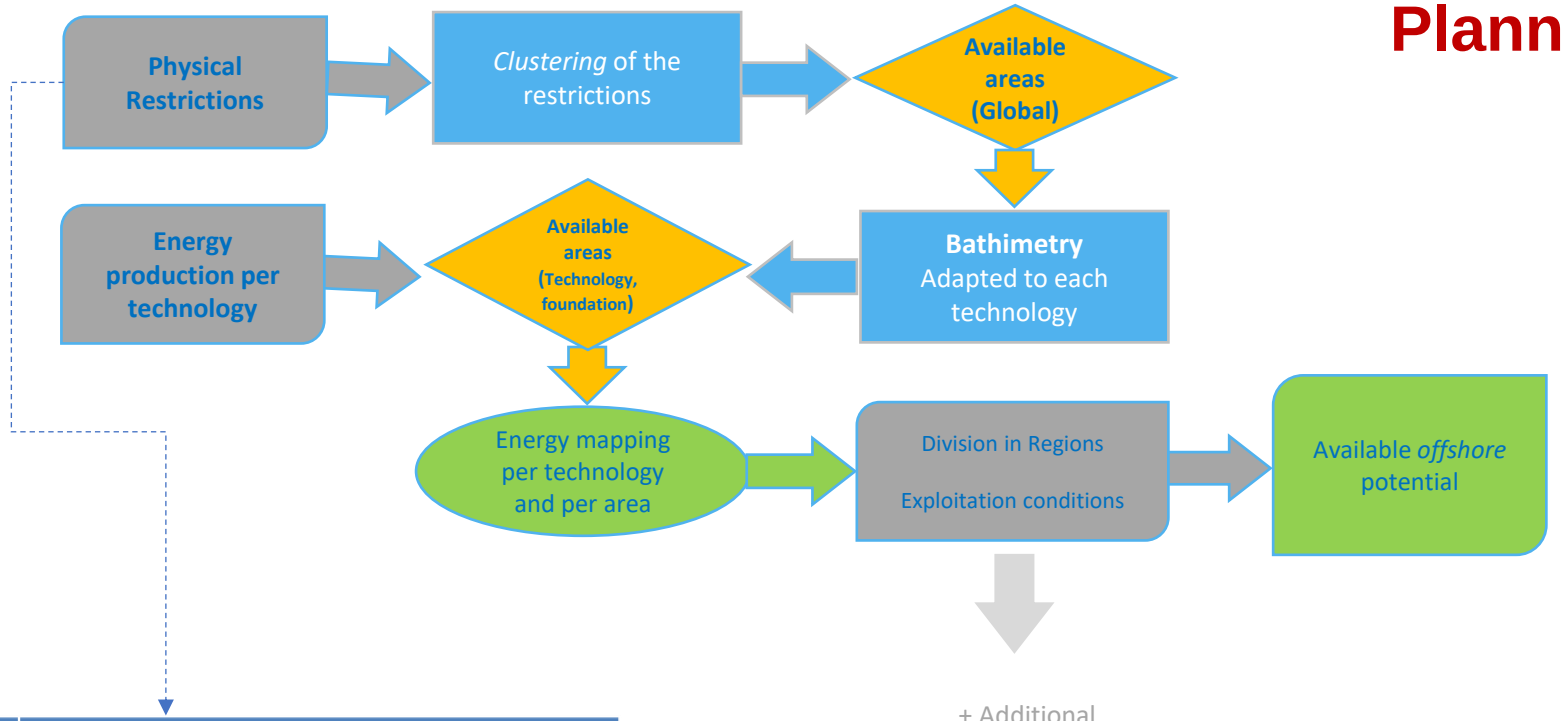
- Submarine cables along the coast must be submerse to a depth of 50 meters
- Avoid environmental protected areas and seabed with rocks.



Areas of interest for offshore renewable energy development and identification of near coast consumption centers

* OffshorePlan ((POSEUR – 01-1001-FC-000007), co-financiado pelo Programa Operacional de Sustentabilidade e Eficiência no Uso de Recursos (POSEUR), através do Portugal 2020 e do Fundo de Coesão),

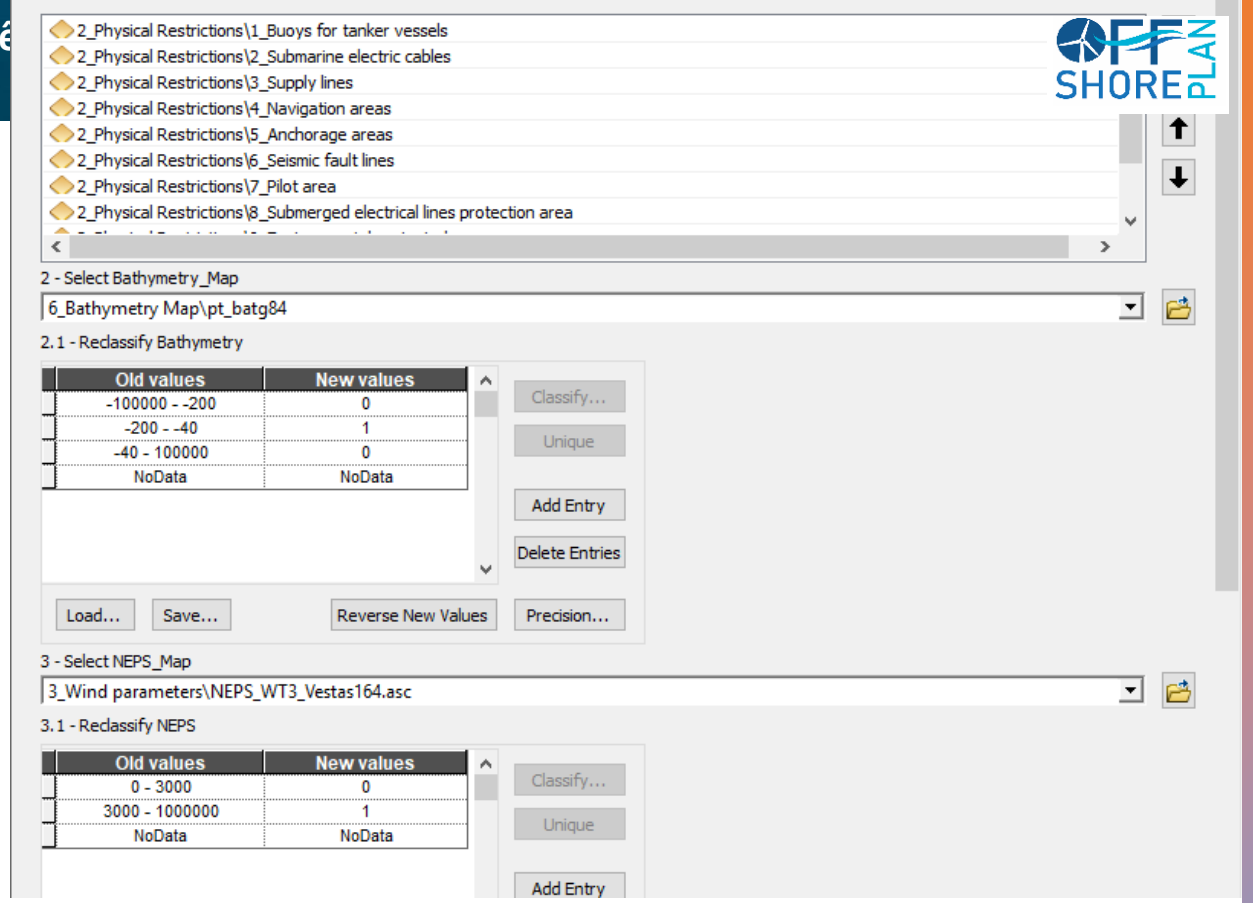
Planning – Methodology and GIS

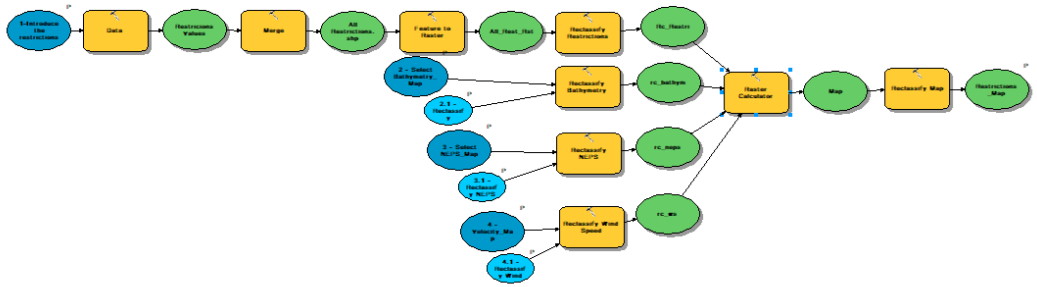


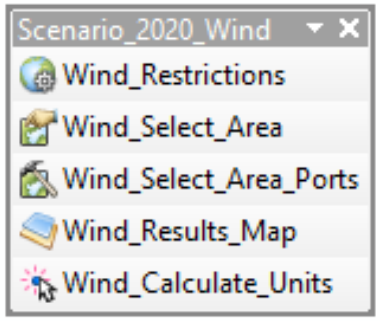
Tipology	Description
Bathymetry	Depth/slope
environment	Marine and coastal protected áreas
Economic activities	Fisheries and other economic activities
Grid connetion	Available grid connection, tension levels, other relevant issues
Accesses	Ports and shypyards, coastal zone, visibility área, …
Miscelaneous	Miitary zones, seismic faults, type of seabed, navigation channels, buoys, submarine cables, …

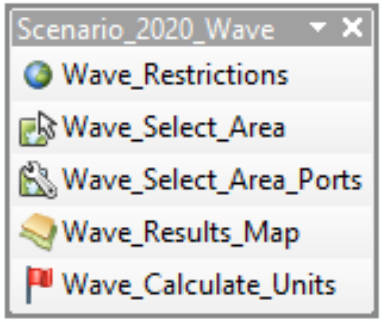
Planning - Conditions

- Implements restrictions in the ressource maps according to the selected technology.
- Trhough several spatial operations, enables to build na atlas with all the selected restrictions (one or many).
- First view of the suitable áreas to be considered in the Portuguese EEZ.
- Identification of the available potential according to input data and selected technology

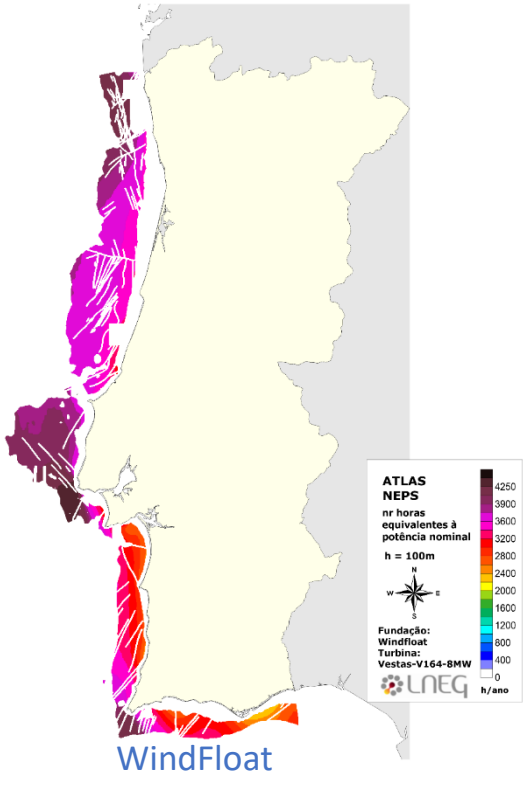




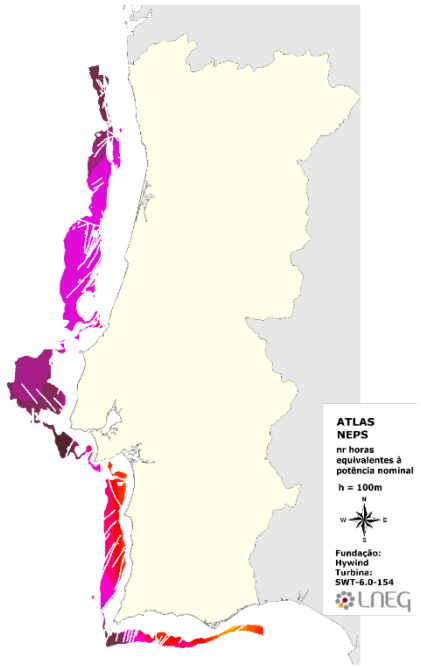




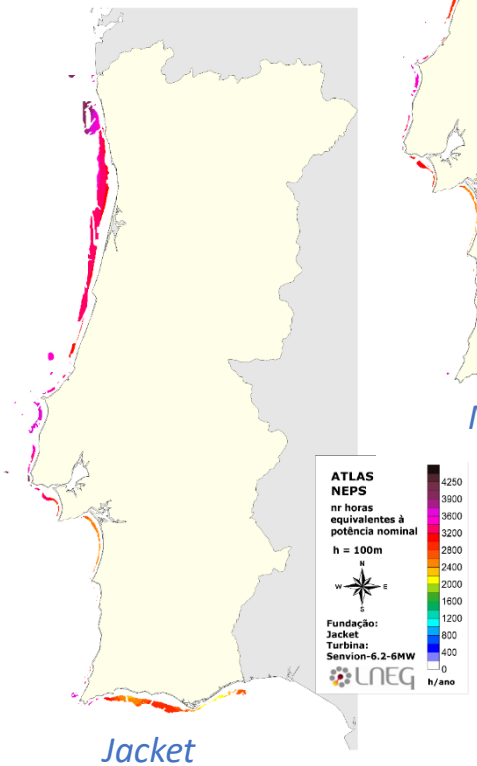
Planning – Results



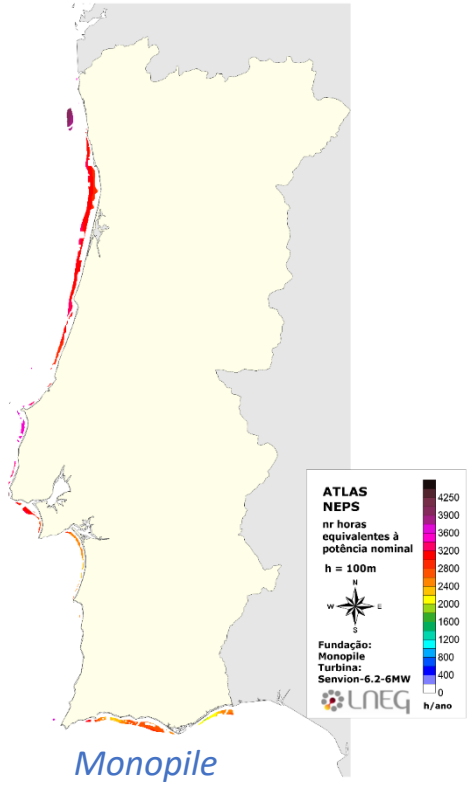
WindFloat



Hywind



Jacket



Monopile

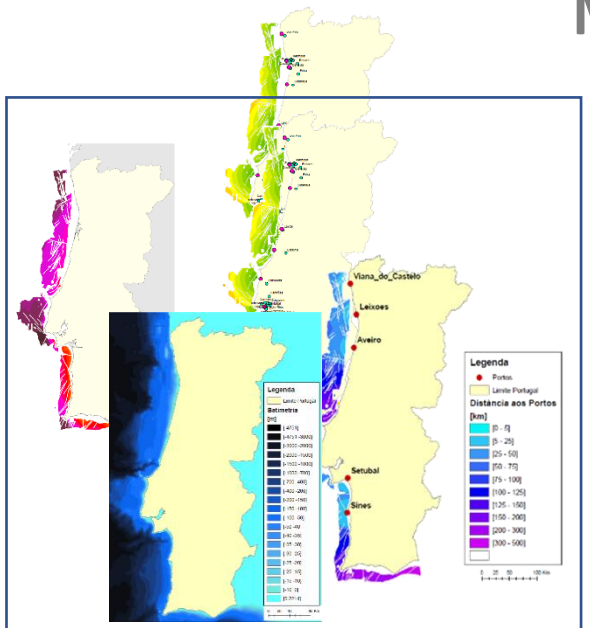
MarinePlan – Platform for technical and economic planning of systems for renewable marine energy exploitation

This work was co-financed by the Operational Program for Sustainability and Efficiency in the Use of Resources (POSEUR) through Portugal 2020 and the Cohesion Fund (OffshorePlan Project - POSEUR - 01-1001-FC-000007)

MarinePlan – Platform for technical and economic planning of systems for renewable marine energy exploitation

Objetive: Provide an economic technical planning platform to support the development of marine renewable energy projects.

Methodology and data flux



Input data:

- Maps (energy resource, bathymetry, ports location, National Transport Network,…)
- Investment Costs, O&M costs, …

$$VAL = -I_0 + \sum_{k=1}^{n} \frac{FC_k}{(1+d)^k}$$

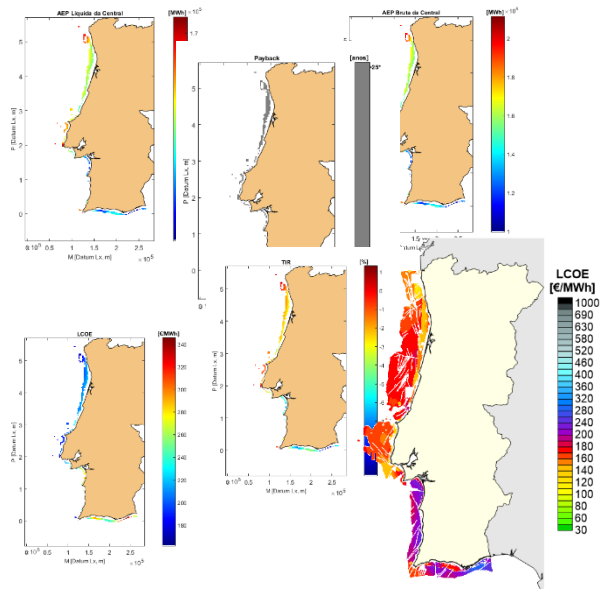
$$\sum_{k=1}^{Tr} \frac{FC_k}{(1+d)^k} \geq I_0$$

$$LCOE = \frac{\sum_{k=1}^{n} \frac{CA_k}{(1+d)^k}}{\sum_{k=1}^{n} \frac{ECR_k}{(1+d)^k}} \times 1000$$

$$-I_0 + \sum_{k=1}^{n} \frac{FC_k}{(1+TIR)^k} = 0$$

Economic indicators:

- IRR
- NPV
- LCOE
- Payback

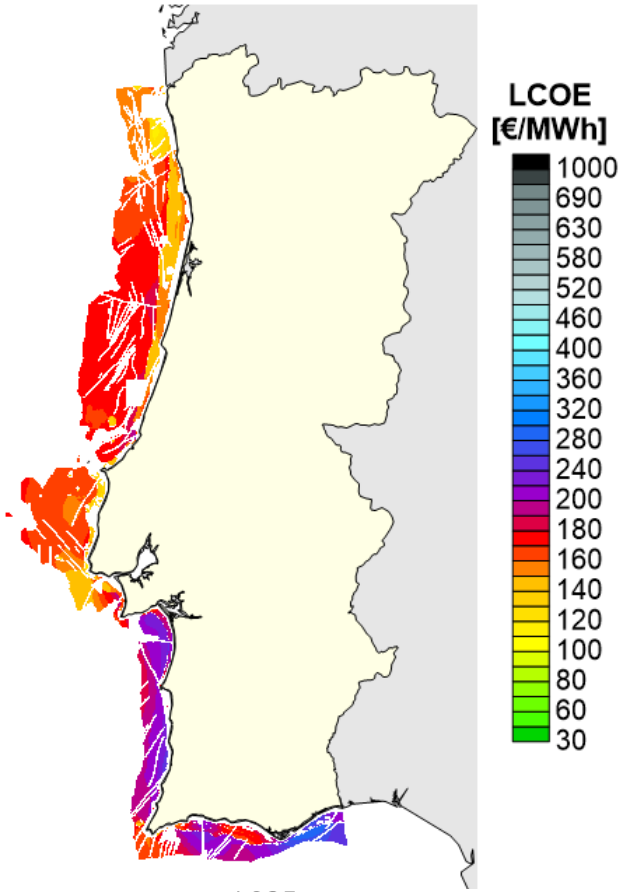


Results:

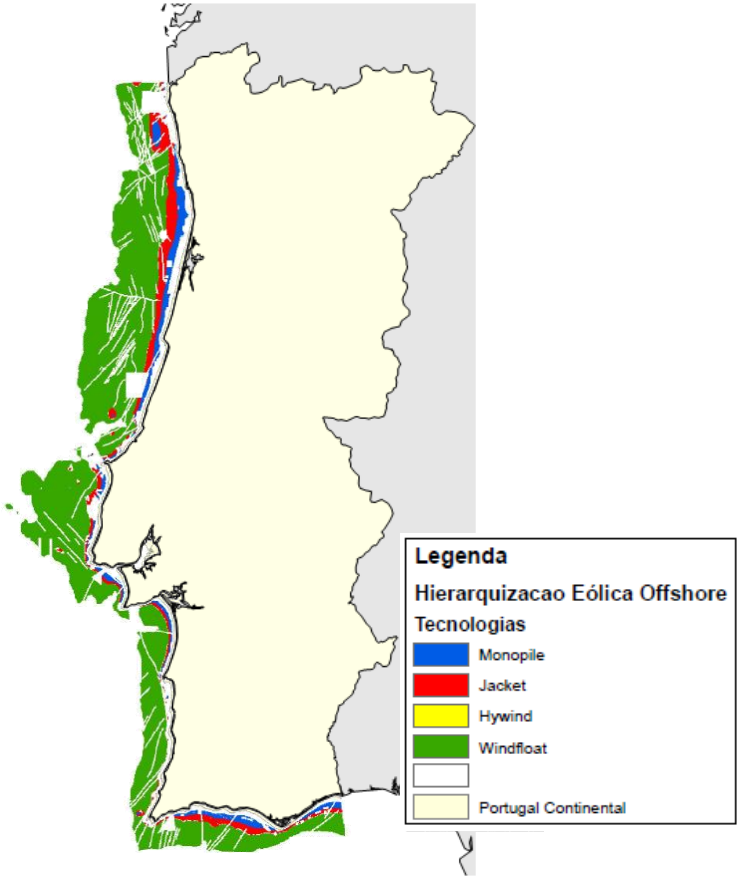
- Maps or single values for the economic indicators
- Hierarchy of technologies

MarinePlan – Results

Hierarchy of LCOE – offshore wind technologies



LCOE



Hierarchy of technologies

What was done in Portugal for the Offshore Development Plan

Facing the targets In September 2022, the Government created a working group for the planning and operation of power plants based on renewable energy sources of origin or oceanic location (Order n. 11404/2022, of September 23), to identify the best available areas for the installation of Offshore Wind Power Plants and to prepare a timeline and business plan for their deployment.

- **SG1, coordinated by DGRM** – General Directorate for Maritime Resources: propose specialized areas for the development of offshore renewable energy projects; indicate points of interconnection to the RNT and indicative powers, as well as the temporal sequencing of the areas;

- **SG2, coordinated by DGEG** - General Directorate for Energy and Geology: propose the model for the allocation of capacity reserve titles (TRC) for electricity injection in RESP and private use of maritime space (TUPEM) associated to electroproducer centers based on competitive procedures;

- **SG3, coordinated by APP** –Association of Ports of Portugal: evaluate the development needs of port infrastructures, in support of the construction of electroproducer centers, and in the development of a national industrial chain of offshore renewable technologies

Development of the Offshore National Plan

Selecting the Areas

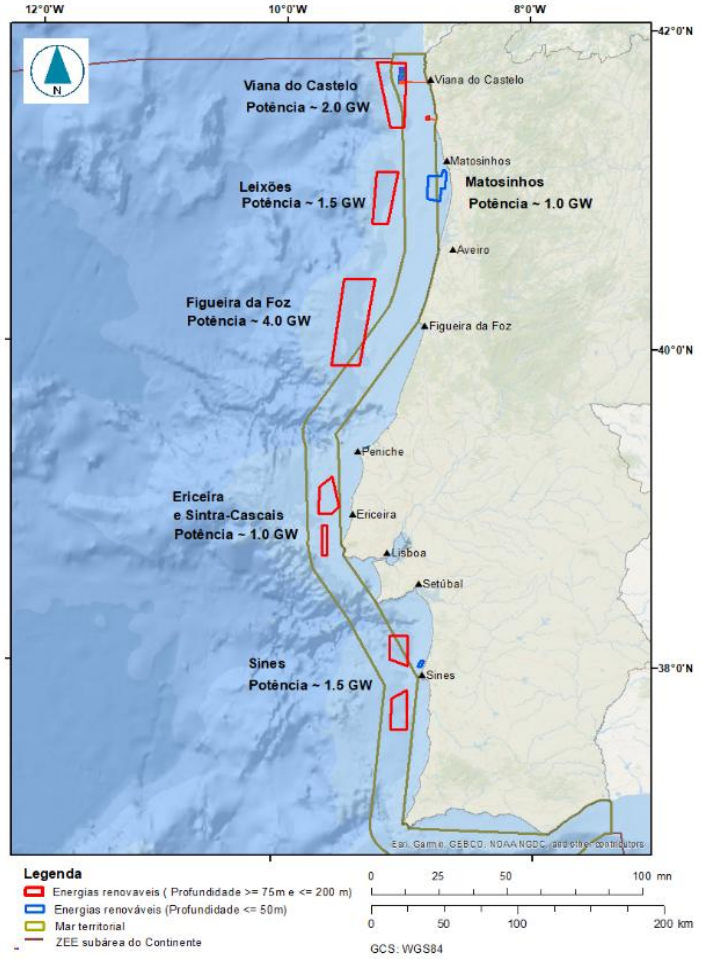
- **Methodology used in the spatialization of the areas**

❑ Use of GIS

❑ Input Data: **Geoportal DGRM:** PSOEM - National Maritime Spatial Planning Situation Plan and **Project OffshorePlan**: Atlas of the Wind Resource (h= 100 m) and the Atlas of the Wave Resource(h=0 m)

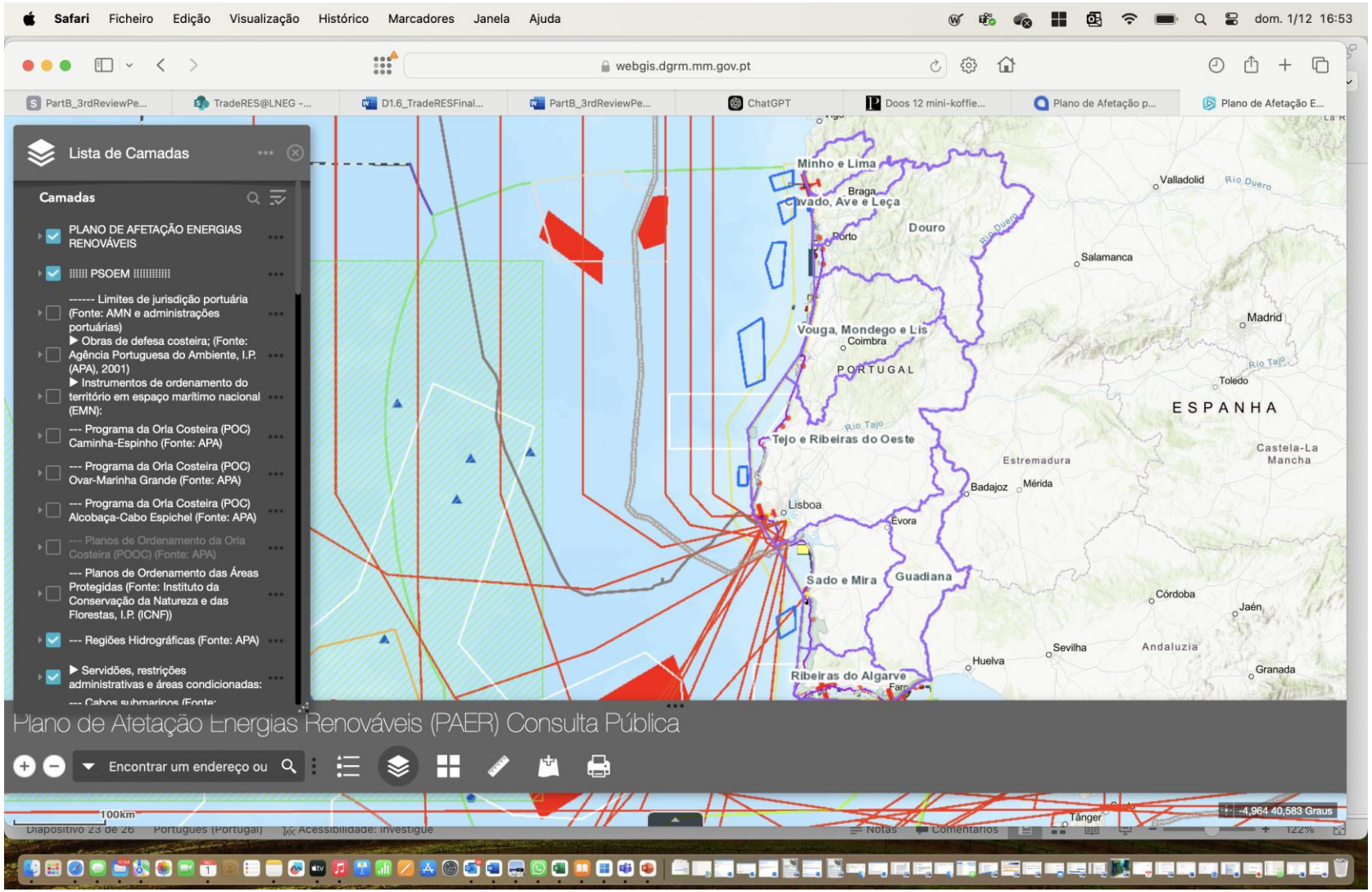
❑Selection was performed based on the establishment of compatibility with the different restrictions and activities.

❑Visibility from the coast in touristic areas and fisheries was a concern, as well as environmental issues.



Development of the Offshore National Plan

Example of input data from Geoportal DGRM



Development of the Offshore National Plan

Compatibility Analysis

Evaluated the incompatibility degree with other activities and sensitive áreas:
Compatible with strong restrictions; with moderate restrictions; with few restrictions and with no restrictions;

Different Technologies for wind offshore and waves were evaluated and assessed in what concerned:

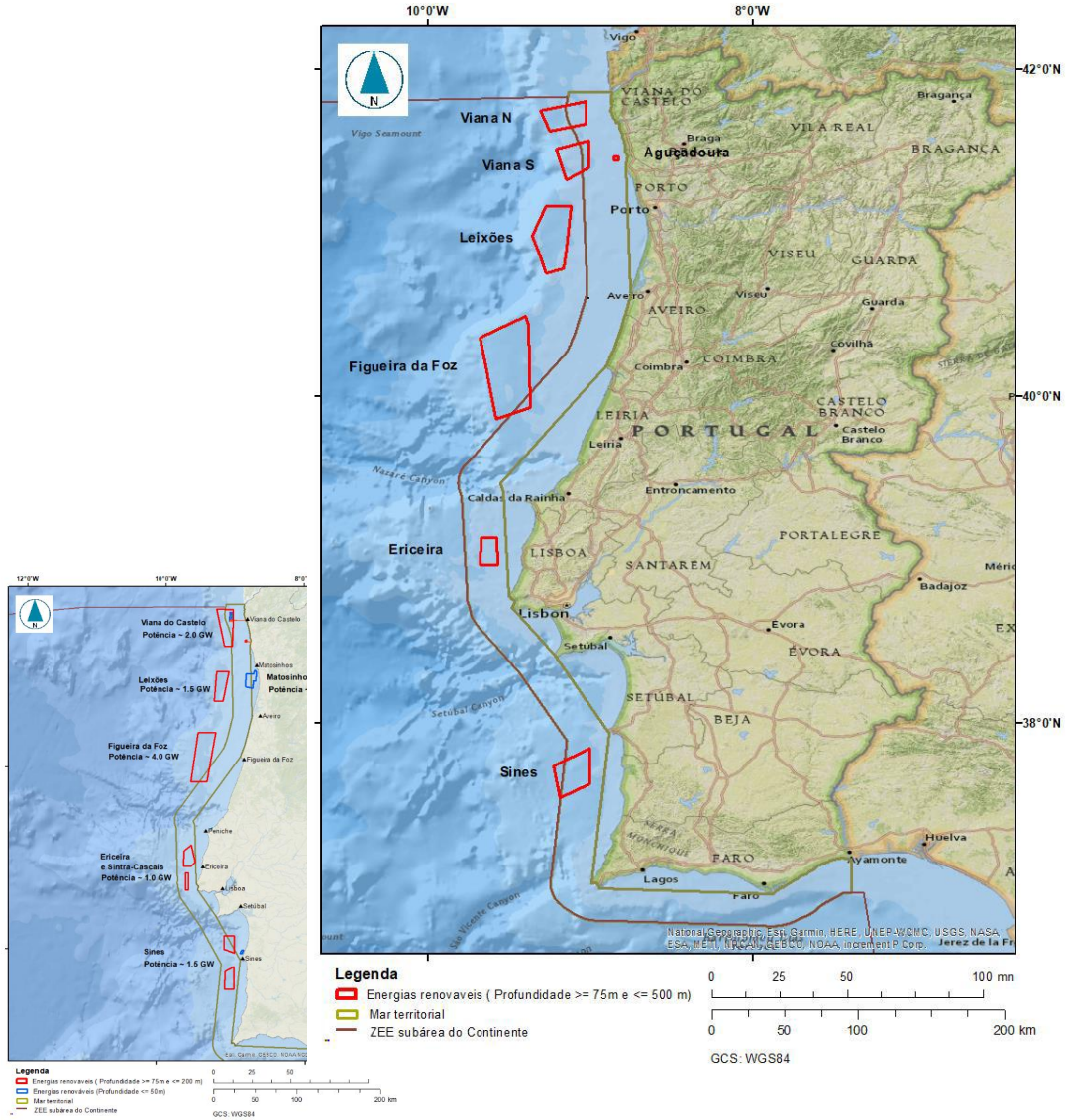
- Easements and Common uses – Fisheries (general, Drag,...), R&D and Academia activities, tourism and others

- Easements and administrative restrictiuons – Nature conservation, National defense, Port navigation, subwater cultural patriminoy, and other

Development of the Offshore National Plan

Selecting the Areas – Phase 2

- ❑ First design was subject to public consultation
- ❑ After this period and several meetings with relevant intervenients in the process, the areas were adjusted.
- ❑ Second round of public consultation (results are not public yet)



Summary

- **MSP is crucial for the offshore sector** and the involvement of several organizations is mandatory for its success.

- The methodologies used for the development of the plans was based on the use of **GIS and a large amount of information**, from different sectors.

- **Wind resource maps can be obtained on the Offshore Wind Atlas (LNEG), Global Wind Atlas, or simulated,**

- **Socio-economic component is a difficult part** and demands interaction with a large number of entities.

Sources of information

Thank you!

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DGRM Geoportal for this topic:

https://webgis.dgrm.mm.gov.pt/portal/apps/webappviewer/index.html?id=f108701225c24cca935b97e1d6180c4a

Public reports:
https://www.lneg.pt/wp-content/uploads/2023/07/20230531-GTOffshore_RelatorioFinal_vfinal.pdf
https://participa.pt/pt/consulta/plano-de-afetacao-para-energias-renovaveis-offshore-paer

OffshorePlan project:
https://offshoreplan.lneg.pt