Sustainable Green H_2 Atlas for Mainland Portugal

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REPÚBLICA PORTUGUESA
AMBIENTE E AÇÃO CLIMÁTICA

The work rested on the contribution of several organizations to whom much is thanked

The final results here presented, as well as any failures or omissions, are LNEG's sole responsibility

GALP
GGND

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REPowerEU: Joint European Action for more affordable, secure and sustainable energy

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REPowerEU: Joint European Action for more affordable, secure and sustainable energy

"**Member States should swiftly map, assess and ensure suitable land and sea areas that are available for renewable energy projects**, commensurate with their national energy and climate plans, the contributions towards the revised 2030 renewable energy target and **other factors such as the availability of resources, grid infrastructure and the targets of the EU Biodiversity Strategy**. The Commission will propose in the upcoming nature restoration law proposal that Member States should, when preparing their national plans to meet restoration targets, take into account limited and clearly defined areas as particularly suitable ('go-to' areas), while avoiding as much as possible environmentally valuable areas..."

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A108%3AFIN

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The Sustainable Green H_2 Atlas does not avoid a detailed analysis of the projects to be implemented under the applicable legislation.

The main objective is to support the rapid transition to the H_2 economy in Portugal by creating a basis for visualization of what would be its materialization over the Portuguese mainland territory.

Introduction

This presentation presents the work developed for mapping the best areas for locating green H_2 production plants in Portugal. These are obtained through the application of a new composite index with a high spatial resolution that allows the assessment of the suitability for implementing green H_2 projects in Portugal mainland. This new index was developed by LNEG.

The composite index results from several subindexes:

i. Water input subindex
ii. Energy input subindex
iii. Market conditions subindex

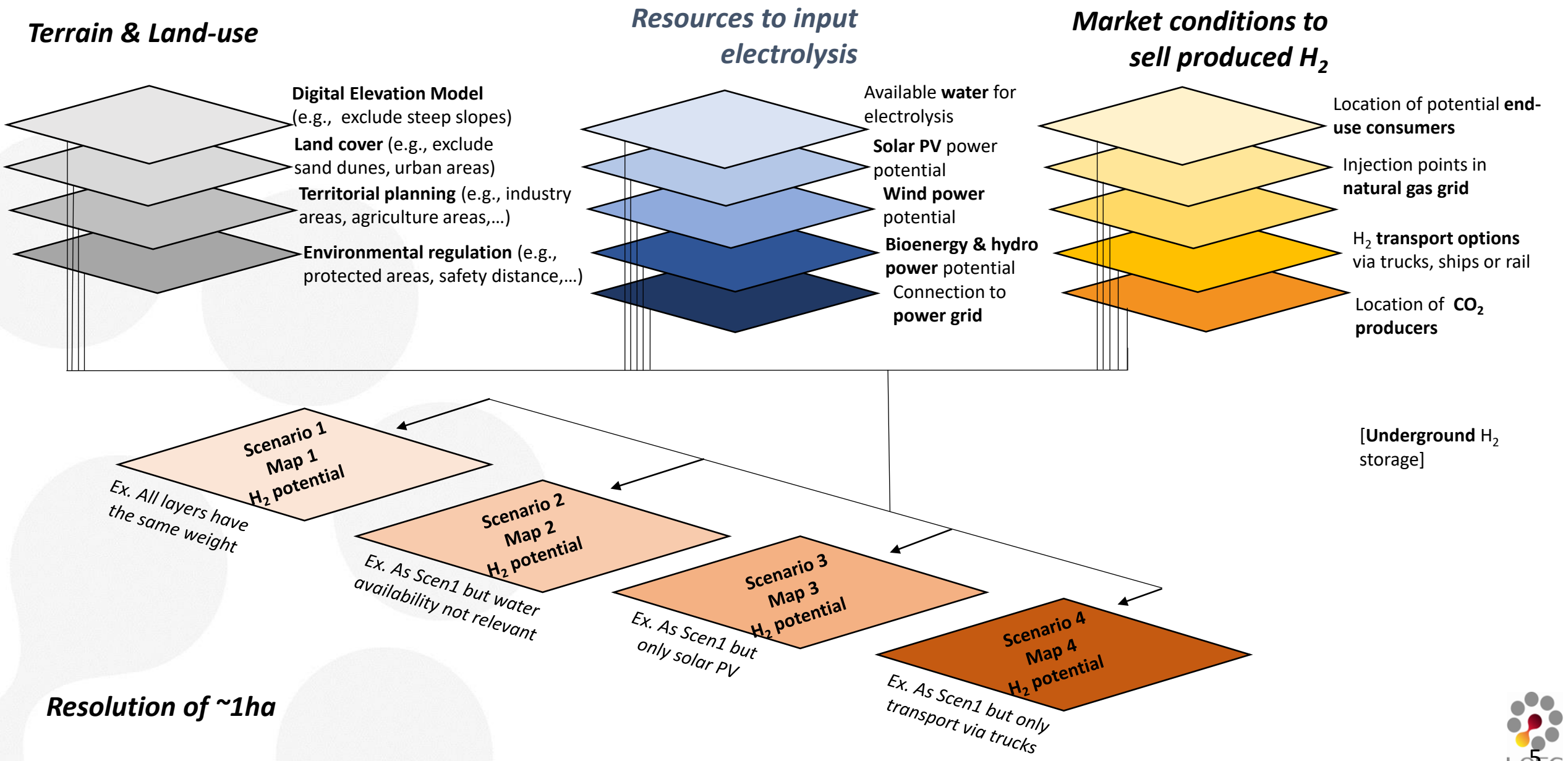
Each of these subindexes is, in turn, composed of several indicators that correspond to different criteria (and GIS – geographic information system - layers) considered in the assessment of the suitability of an area (or GIS polygon) to implement a green H_2 production plant.
The performance of each polygon is evaluated and classified according to predefined classes, which constitute adequacy thresholds for each indicator/criterion.

The maps presented here were obtained considering four scenarios, varying the relative importance of each sub-index and each indicator within the three subindexes.

How the National Sustainable Green H_2 Atlas is developed?

- methodology-

Conceptual scheme of the composite H_2 location index



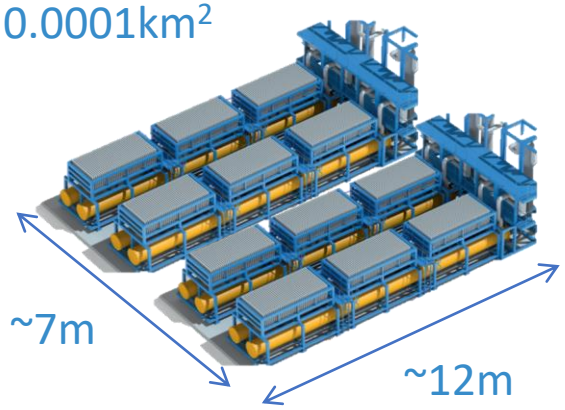
Resolution of ~1ha

Area occupied by a 50MW H_2 green production unit

The electrolysers are modular - green H_2 production units will have varied dimensions.

As such, it was not considered a minimum or maximum reference area – projects with a large area (including renewable electricity production) and others of small sizes, located with small consumers and powered by the electricity grid, may arise.

For 50 MW and only for the electrolyser area:
~84m² | 0.0001km²



https://ucpcdn.thyssenkrupp.com/_binary/UCPthyssenkruppBAISUhdeChlorineEngineers/en/products/water-electrolysis-hydrogen-production/alkaline-water-electrolysis/link-thyssenkrupp_Hydrogen_Water_Electrolysis_and_green_chemicals.pdf

We considered 100 m x 150 m (15 000m² / 1.5 ha) as a total area for the production unit, which includes:
- "cell house"
- Water storage
- H_2 storage
- other auxiliary equipment
- access routes (area will vary with delivery option)

(here are not considered possible additional area requirements due to the need to comply with municipal soil waterproofing indexes)

50 MW eletrolyser and others ~0.015 km² /1.5 ha

50 MW wind ~0.93 km² /93 ha

50 MW solar PV 0.95 km² | 95 ha

Composite index of H_2 green production units

Calculated for all polygons for a given scale in Mainland Portugal:

$$[(Kw1 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Surface water}}) + (Kw2 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Wastewater WWTP}}) + (Kw3 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Water supply grid}}) + (Kw4 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Ground water}}) + (Kw5 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Sea water}}) + (Kw6 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Multipurpose irrigation}}) + (Kw7 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Water scarcity index}})] = \underset{\text{Scale: 0 to 3}}{\text{Water input index}}$$

$$[((Kp1 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Solar exposure}}) + (Kp2 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Onshore wind speed}}) + (Kp3 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Offshore location}}) + (Kp4 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Bioenergy power generation}})) + (Kp5 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Hydropower generation}}) + (Kp6 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Power grid}})] = \underset{\text{Scale: 0 to 3}}{\text{Power input index}}$$

$$[(Km1 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Gas grid}}) + (Km2 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Potential } H_2 \text{ consumers Transport}}) + (Km3 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Potential } H_2 \text{ consumers industry}}) + (Km4 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Potential } H_2 \text{ feedstock consumers}}) + (Km5 \times \underset{\text{Scale: 0 , 1, 2, 3}}{\text{Large } CO_2 \text{ producers}})] = \underset{\text{Scale: 0 to 3}}{\text{Market index}}$$

$$[((Kh1 \times \underset{\text{Scale: 0 to 3}}{\text{Power input sub-index}}) + (Kh2 \times \underset{\text{Scale: 0 to 3}}{\text{Water input sub-index}}) + (Kh3 \times \underset{\text{Scale: 0 to 3}}{\text{Market sub-index}})) \times (\underset{\text{Yes = 0 or No = 1}}{\text{Constrained location?}})] = \underset{\text{Scale: 0 to 3}}{\text{Green } H_2 \text{ sustainable location index}}$$

Scenarios are defined by changing values of "K"

Indicators considered: classified into 4 Classes (“0” inadequate, “1”poor, “2” fair and “3” good)

Water input subindex

1. **Surface water bodies**
2. **Wastewater from WWTP**
3. **Water supply grid**
4. **Groundwater**
5. **Sea water**
6. **Multipurpose irrigation**
7. **Water scarcity index**

Energy input subindex

1. **Solar exposure**
2. **Wind resources onshore**
3. **Wind resources offshore**
4. **Bioenergy power generation**
5. **Hydropower generation**
6. **Connecting to power grid**

Market subindex

1. **Injection points in natural gas grid**
2. **Potential H_2 consumers transports**
3. **Potential H_2 consumers industry**
4. **Potential H_2 feedstock consumers**
5. **Large CO_2 producers**

Remove areas affected by land-use restrictions

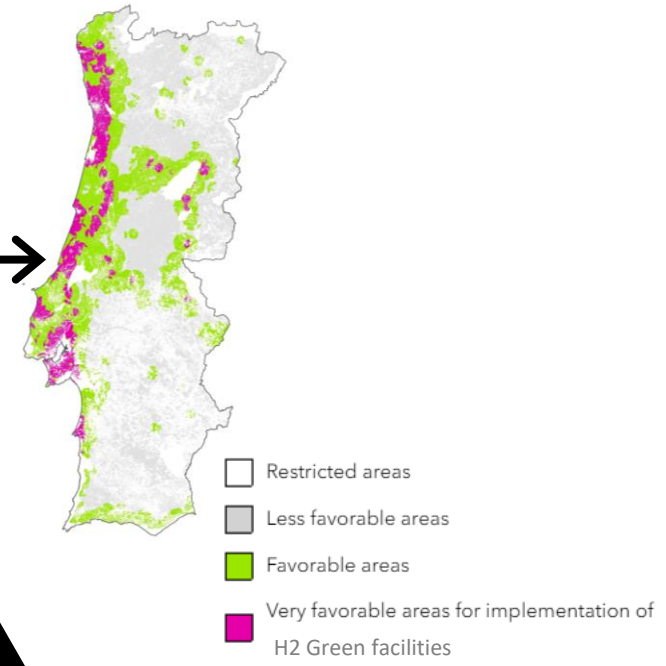
i. **Nature protected areas:**
   i. National protected áreas network (ICNF)
   ii. Natura 2000 network

ii. **Excessively steep slopes (>30%)**

iii. **Inadequate terrain conditions:**
   i. Artificial polygons (residencial, services, transport, infrastructure, landfills, water treatment, mines, quarriers, parking, tourism, sports, golf courses, camping, leisure, …)
   ii. Bare rock
   iii. Beaches and sand dunes
   iv. Wetlands (marches,morasses, intertidal zones)
   v. Surface water bodies (salt pans, natural-water courses, artificial/modified-water courses, natural lakes and ponds, artificial lakes and ponds, hydropower reservoirs, reservoirs of dams or weirs, ponds, aquaculture, coastal lagoons, rivermouths, ocean)

iv. **Potentially protected land use types:**
   i. Protected agriculture and nurseries
   ii. Orchards
   iii. Olive groves
   iv. Cork trees agroforestry zones (SAF)
   v. Holm oak (azinheira) trees agroforestry zones (SAF)
   vi. Stone pine (Pinheiro manso) trees agroforestry zones (SAF)
   vii. Stone pine (Pinheiro manso) and Holm oak (azinheira) trees agroforestry zones (SAF)
   viii. Cork trees forests
   ix. Homl oak forests
   x. Other oaks forests
   xi. Chestnut forests
   xii. Other hardwood forests
   xiii. Stone pine forests

Sustainable Green H_2 Atlas



It was not possible to exclude RAN (National Agricultural areas) and REN (National Valuable Ecological areas)

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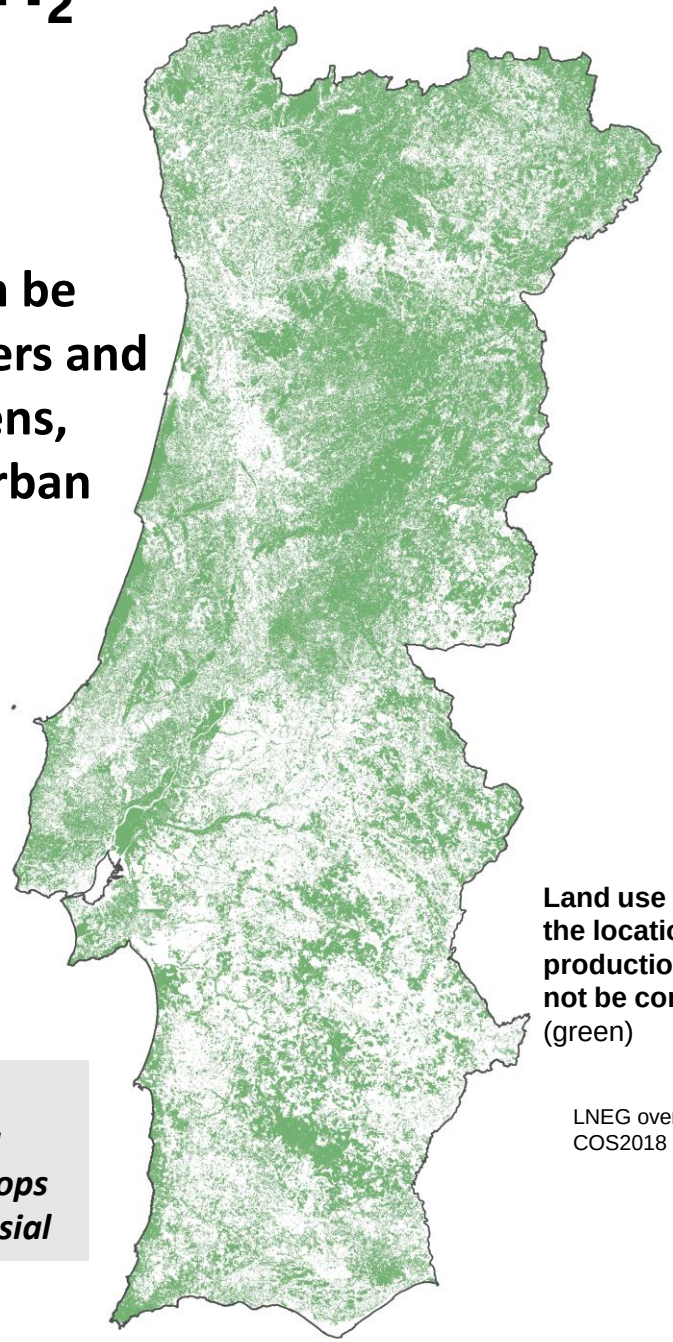
Land Use classes and potential location for H_2 production units

1. Polygons with culturally complex plots
2. Agriculture with natural and semi-natural areas
3. Improved pastures
4. Spontaneous pastures
5. Sparse vegetation
6. Temporary rainfed and irrigated crops
7. Agriculture and protected nurseries
8. Rice paddies
9. Vineyards
10. Orchards
11. Olive grove
12. Temporary crops and/or improved pastures associated with vineyards
13. Temporary crops and/or improved pastures associated with orchards
14. Temporary crops and/or improved pastures associated with olive groves
15. Cork trees agroforestry zones (SAF)
16. Holm oak trees agroforestry zones (SAF)
17. Agroforestry surfaces of other oaks (SAF)
18. Stone pine (Pinheiro manso) trees agroforestry zones (SAF)
19. Agroforestry surfaces of other species (SAF)
20. Stone pine (Pinheiro manso) and Holm oak (azinheira) trees agroforestry zones (SAF)
21. Other mixed agroforestry areas (SAF)
22. Cork trees forests
23. Holm oak trees forests
24. Other oaks forests
25. Chestnuts forests
26. Eucalyptus forests
27. Forests of exotic species
28. Other deciduous forests
29. Pine forests
30. Stone Pine forests
31. Other resinous forests
32. Bushlands

Some of these classes can be located in urban perimeters and even correspond to gardens, urban parks/ forests or urban gardens!

Ex: sparse vegetation



Land use classes where the location of H_2 production units should not be controversial (green)

LNEG over DGT COS2018

Classes in green – location should not be controversial
Classes in orange - potentially controversial location, including Bushlands, Resinous Forests, Agroforestry areas, Temporary crops
Classes in red – location should be potentially highly controversial

Classified Areas

it is not possible to locate production units

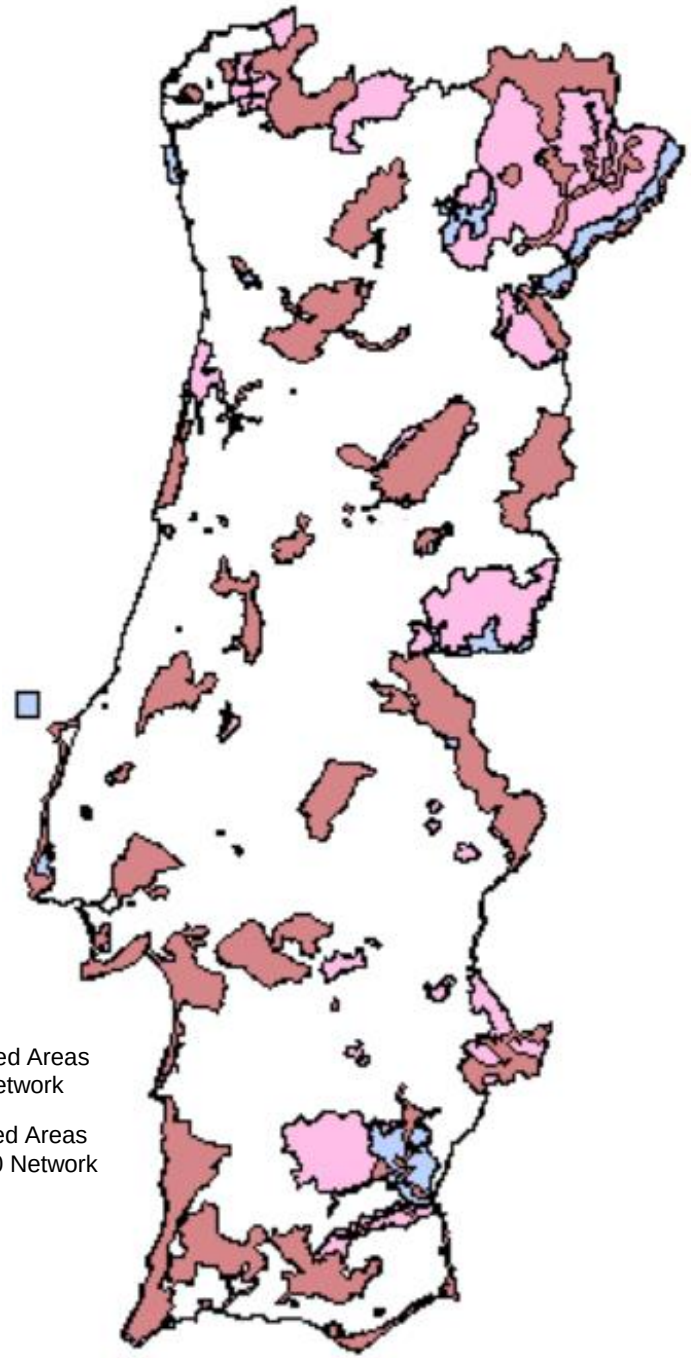
> **Protected Areas**

RNAP and Natura 2000 Nerwork

> **Others**

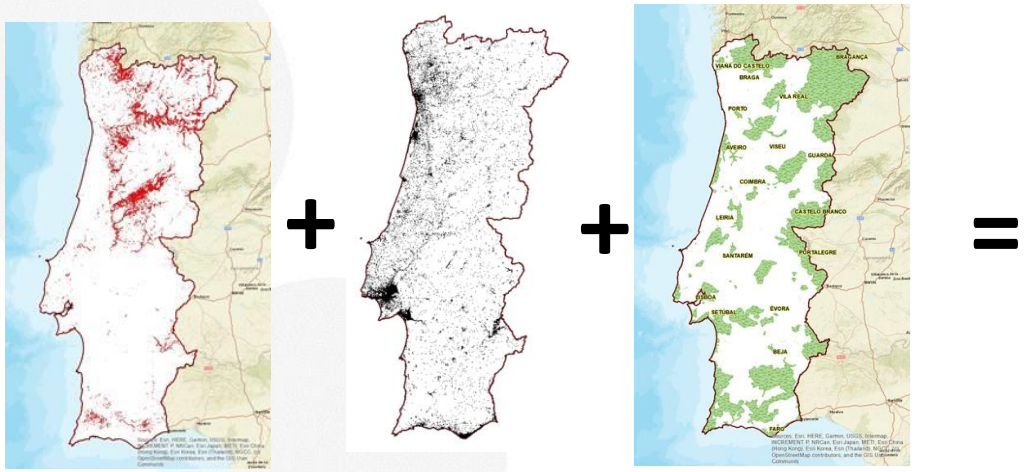
UNESCO biosphere reserves

Not considered
Geoparks
RAMSAR Sites
Municipal ecological structures



Areas affected by exclusion conditions for project location

Land uses Classes where H_2 production units cannot potentially be located are excluded: areas with slope>30%, technically inadequate terrain and all classified areas



Slope >30%

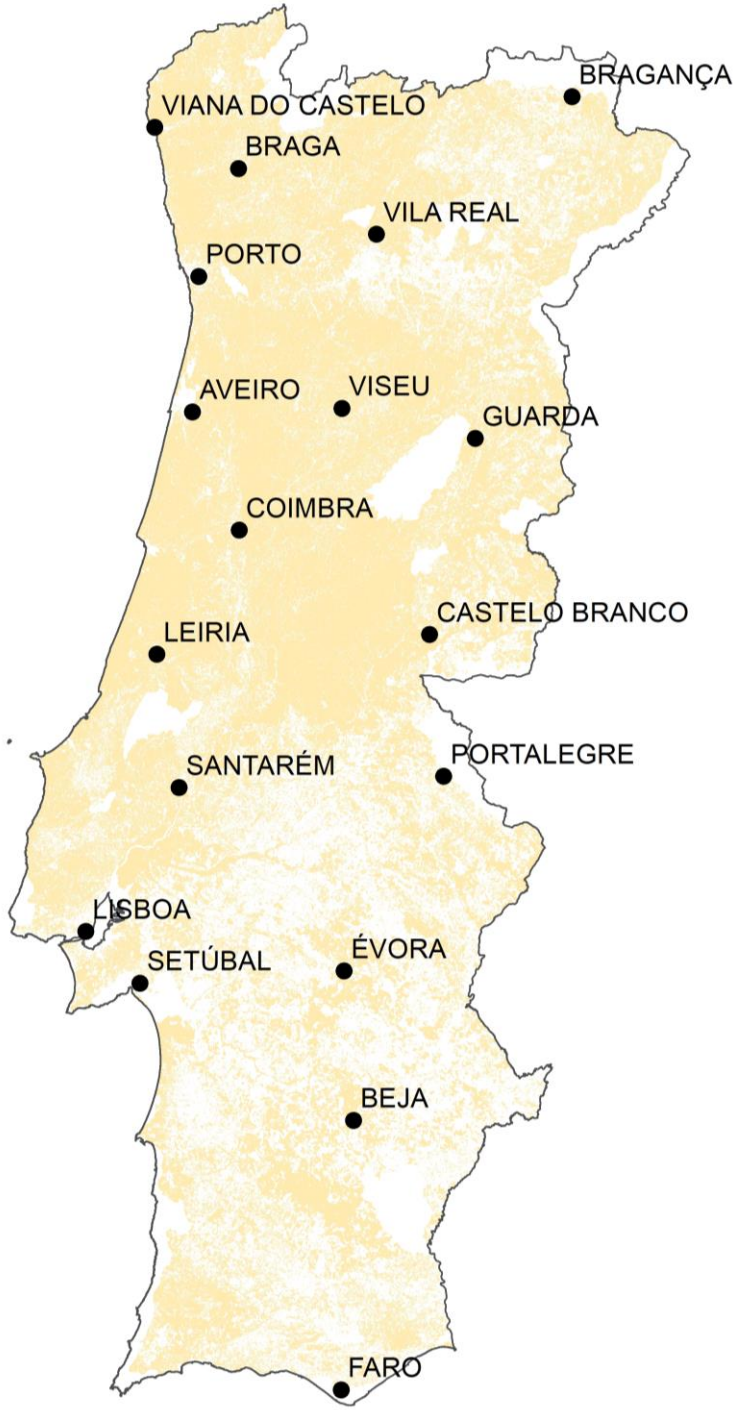
LNEG (over EU Digital Elevation Map)

Land use Classes where H_2 production units cannot potentially be located (black)

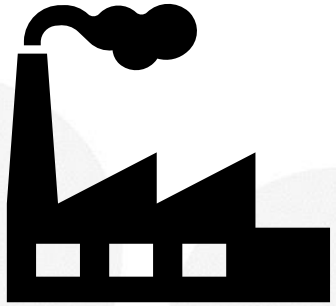
DGT COS2018

Classified áreas (National Network of Protected Areas (RNAP) + Natura 2000 Network + Biosphere Reserves)

LNEG over ICNF



What potential H_2 consumers are considered ?



- Glass, chemical and ceramic industry;
- Cement and lime industry;
- Mining industry;
- Paper industry and paper pulp;
- Agri-food industry;
- Power plants and oil refineries

Data source:

apa agência portuguesa do ambiente

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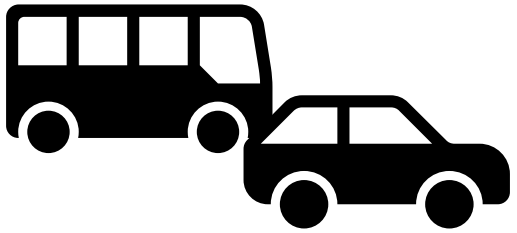
REPORTES AMBIENTAIS
PRTR – REGISTO DE EMISSÕES E TRANSFERÊNCIAS DE POLUENTES



- Terminals of road passenger transport companies;
- Access to the main road freight routes, including the A1, A6 and A25 motorways and intersecting national roads within a 20km range;
- Fuel stations of the national Emergency Network of Fuel Stations (REPA), which can be converted to H_2

LNEG

What potential consumers of H_2 as a feedstock are considered ?

- Sociedade Portuguesa do Ar Líquido "ARLIQUIDO", LDA - CPE
- ADP Fertilizantes S.A - Unidade Fabril do Lavradio
- Omya S.A.
- Hychem - Complexo Fabril da Póvoa de Santa Iria
- Specialty Minerals Portugal, Especialidades Minerais, S.A.
- Sopac - Sociedade Produtora de Adubos Compostos, S.A.
- Bondalti Chemicals, S.A.
- Indorama Ventures Portugal PTA (Fábrica de PTA)
- Refinaria de Sines

Data source:

apa agência portuguesa do ambiente

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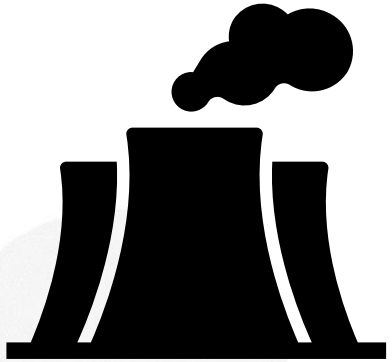
REPORTES AMBIENTAIS
PRTR – REGISTO DE EMISSÕES E TRANSFERÊNCIAS DE POLUENTES

LNEG

Which large CO_2 emitters are considered ?



- Clinkers
- Glass production
- Natural gas power plants of Lares, Ribatejo and (Pego)
- Refinery of Sines

Data source:

SILiAmb
Sistema Integrado de Licenciamento do Ambiente

REPORTES AMBIENTAIS
PRTR – REGISTO DE EMISSÕES E TRANSFERÊNCIAS DE POLUENTES

Indicators considered in the National Sustainable Green H_2 Atlas

Water input subindex

1. Surface water bodies
2. Wastewater from WWTP
3. Water supply grid
4. Groundwater
5. Sea water
6. Multipurpose irrigation
7. Water scarcity index

Energy input subindex

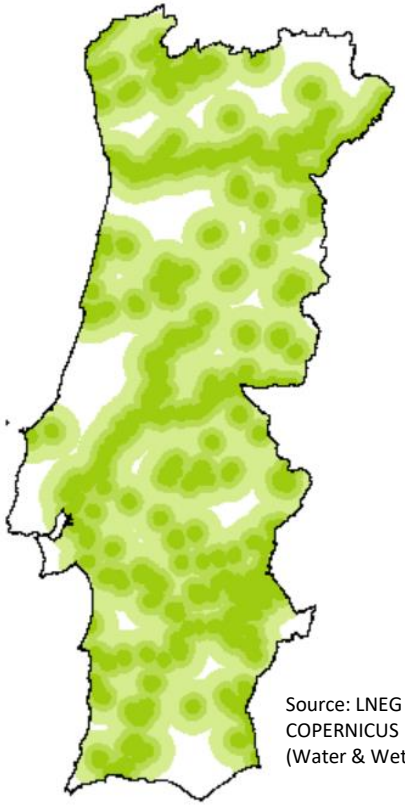
1. Solar exposure
2. Wind resources onshore
3. Wind resources offshore
4. Bioenergy power generation
5. Hydropower generation
6. Connecting to power grid

Market subindex

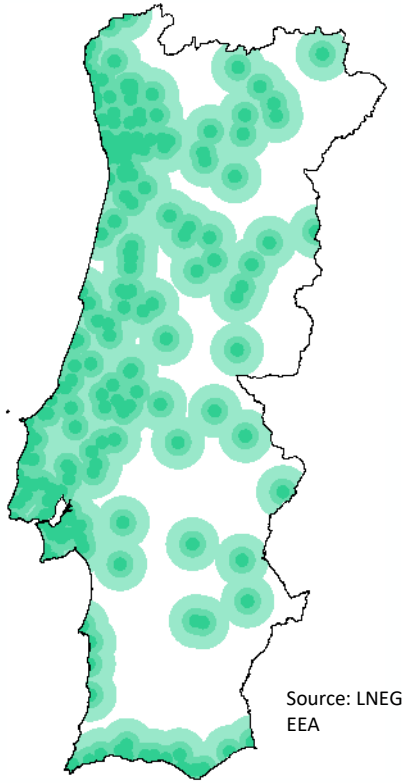
1. Injection points in natural gas grid
2. Potential H_2 consumers transports
3. Potential H_2 consumers industry
4. Potential H_2 feedstock consumers
5. Large CO_2 producers

LNEG

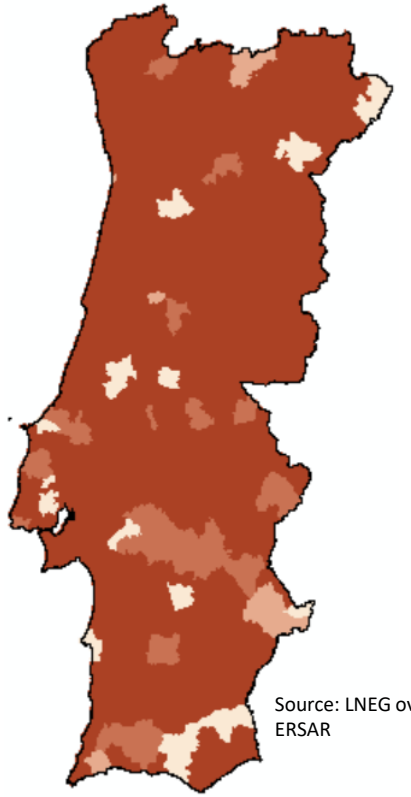
Indicators of the Water input subindex (I)



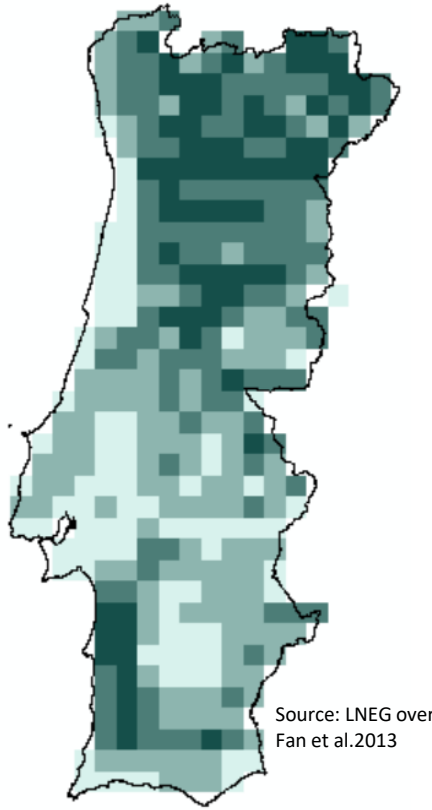
Source: LNEG over COPERNICUS (Water & Wetness)



Source: LNEG over EEA



Source: LNEG over ERSAR



Source: LNEG over Fan et al.2013

Surface water bodies

Class	Description
3	<5km for a water body with a capacity ≥ 2540m^2
2	10-15km for a water body with a capacity ≥ 2540m^2
1	10-20km for a water body with a capacity ≥ 2540m^2
0	> 20km for a water body with a capacity ≥ 2540m^2

Wastewater from WWTP

Class	Description
3	<5km for a WWTP with a capacity > 10 000 p.e.
2	10-15km for a WWTP with a capacity > 10 000 p.e.
1	10-20km for a WWTP with a capacity > 10 000 p.e.
0	> 20km for a WWTP with a capacity > 10 000 p.e.

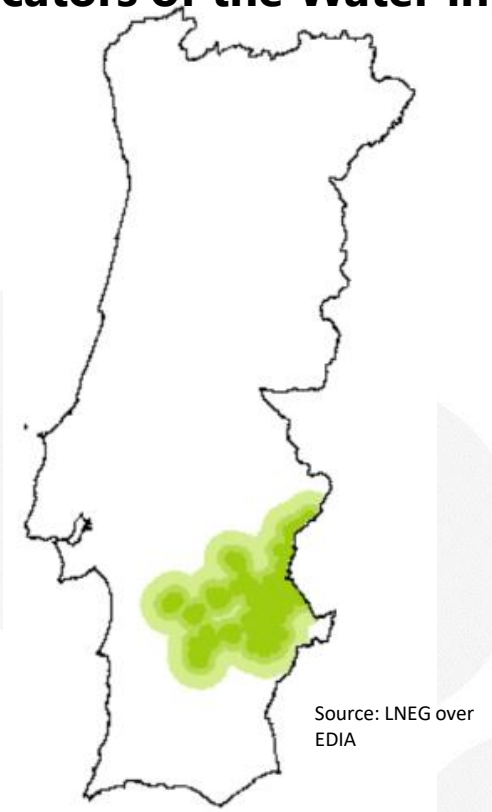
Water supply grid

Class	Description
3	number of supply failures =<1
2	number of supply failures between 2.5-1
1	number of supply failures between 4-2.5
0	number of supply failures >= 4

Groundwater

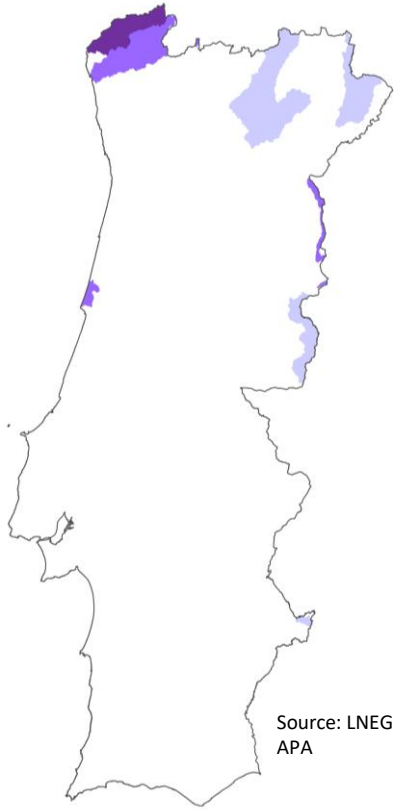
Class	Description
3	about at least 1 water abstraction point w/ depth =< 20 m
2	about at least 1 water abstraction point w/ depth 20-35 m
1	about at least 1 water abstraction point w/ depth 35-50 m
0	about at least water abstraction w/ point > 50 m

Indicators of the Water input subindex (II)



Source: LNEG over EDIA

Source: LNEG



Source: LNEG over APA

Multipurpose irrigation

Class	Description
3	multi-purpose irrigation less than 5km away
2	multi-purpose irrigation between 5-10km away
1	multi-purpose irrigation between 10-20km away
0	multi-purpose irrigation more than 20km away

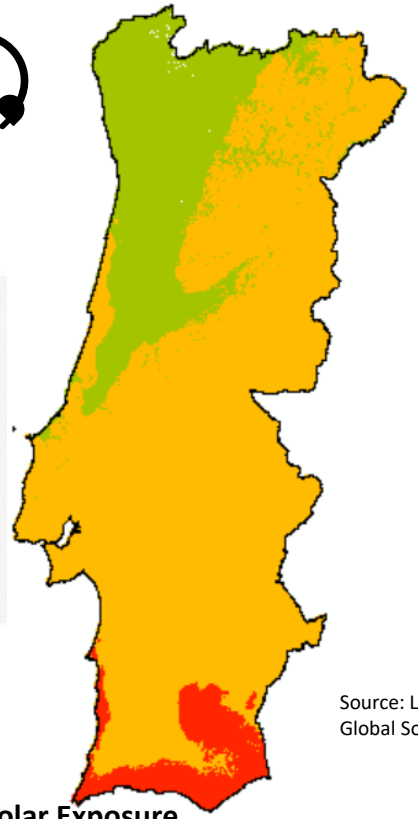
Sea water

Class	Description
3	sea water less than 5km away
2	sea water between 5-10km away
1	sea water between 10-20km away
0	seawater more than 20km away

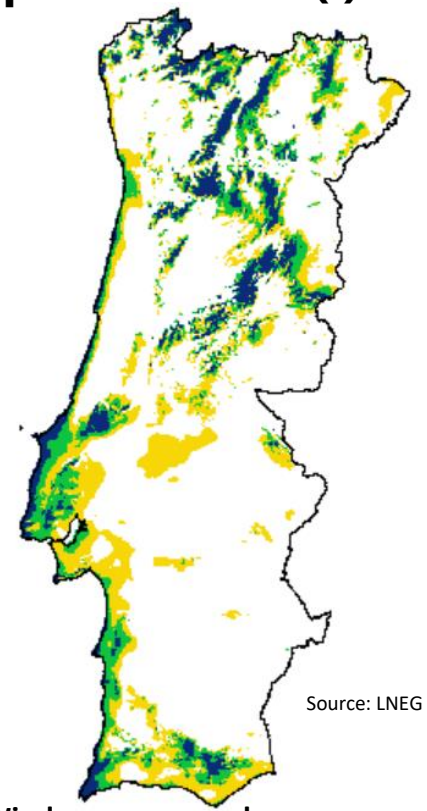
Water scarcity index

Class	Description
3	Sub-basin classified with scarcity index 0-10%
2	Sub-basin classified with scarcity index 10-20%
1	Sub-basin classified with scarcity index 20-30%
0	Sub-basin classified with scarcity index >30%

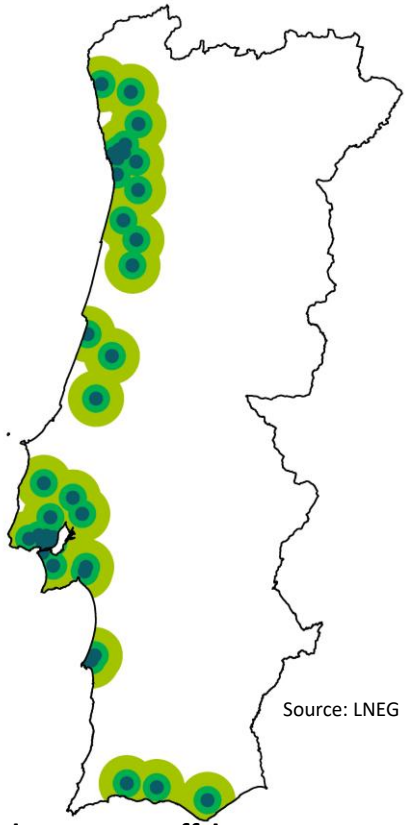
Indicators of the Energy input subindex (I)



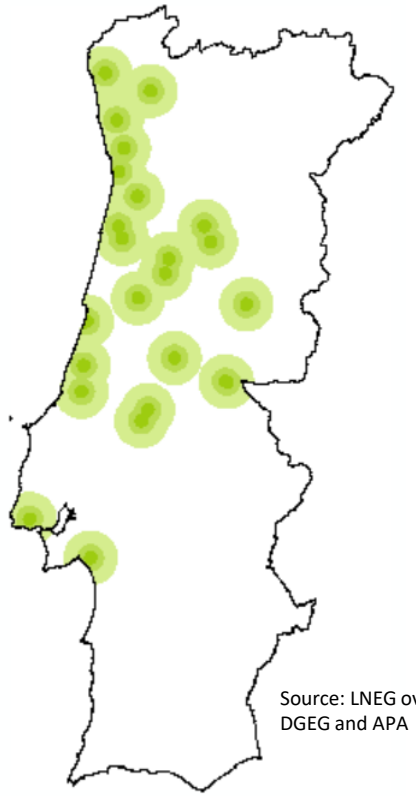
Source: LNEG over Global Solar Atlas



Source: LNEG



Source: LNEG



Source: LNEG over DGEG and APA

Solar Exposure

Class	Description
3	More than 1800 kWh/m^2 annual solar irradiation GHI
2	between 1600 kWh/m^2 to 1800 kWh/m^2 annual solar irradiation GHI
1	between 1400-1600 kWh/m2 to 1800 kWh/m^2 annual solar irradiation GHI
0	less than 1400 kWh/m^2 annual solar irradiation GHI

Wind resources onshore

Class	Description
3	>2500 h/year wind potential generation+ 300 incident power flow (W/m^2)
2	2300-2500 h/year wind potential generation+ 275-230 incident power flow (W/m^2)
1	2100-2300 h/year wind potential generation+ 250-275 incident power flow (W/m^2)
0	<2100 h/year wind potential generation+ 250 incident power flow (W/m^2)

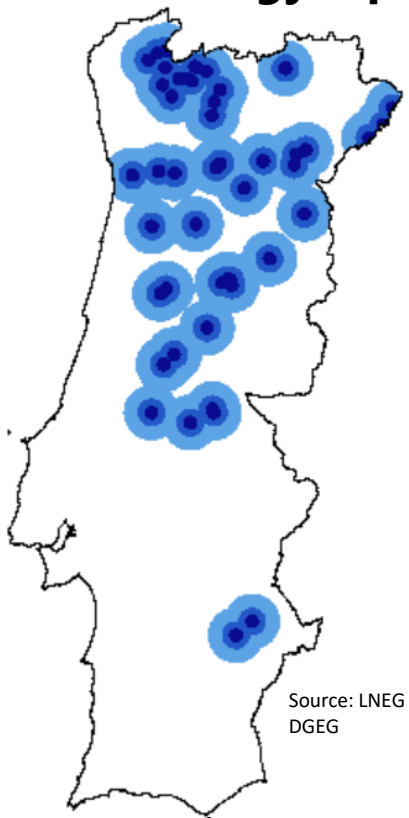
Wind resources offshore

Class	Description
3	Offshore wind farm interconnection point less than 5km away
2	Offshore wind farm interconnection point between 5-10km away
1	Offshore wind farm interconnection point between 10-20km away
0	Offshore wind farm interconnection point more than 20km away

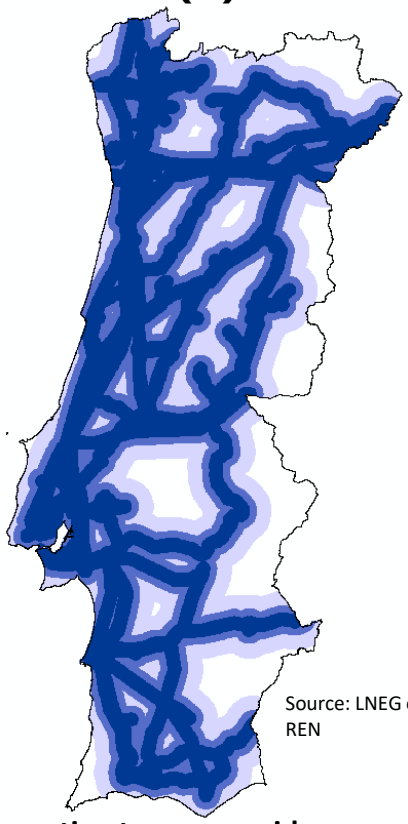
Bioenergy power generation

Class	Description
3	<5km distance from bio energy power plant =>2,5 MW
2	10-5km distance from bio energy power plant =>2,5 MW
1	10-20km distance from bio energy power plant =>2,5 MW
0	>20km distance from bio energy power plant =>2,5 MW

Indicators of the Energy input subindex (II)



Source: LNEG over DGEG



Source: LNEG over REN

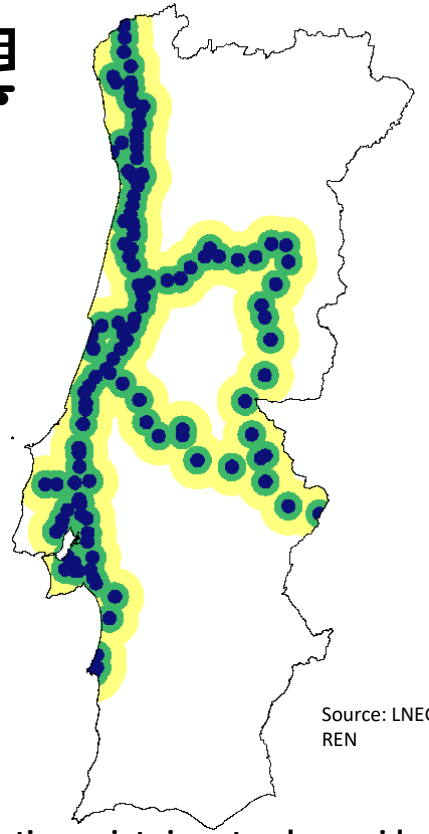
Hydropower generation

Class	Description
3	<5km distance from hydropower plant =>10 MW
2	10-5km distance from hydropower plant =>10 MW
1	10-20km distance from hydropower plant =>10 MW
0	>20km from hydropower plant =>10 MW

Connecting to power grid

Class	Description
3	<5km distance to the power grid
2	10-15km distance to the power grid
1	10-20km distance to the power grid
0	> 20km away to the power grid

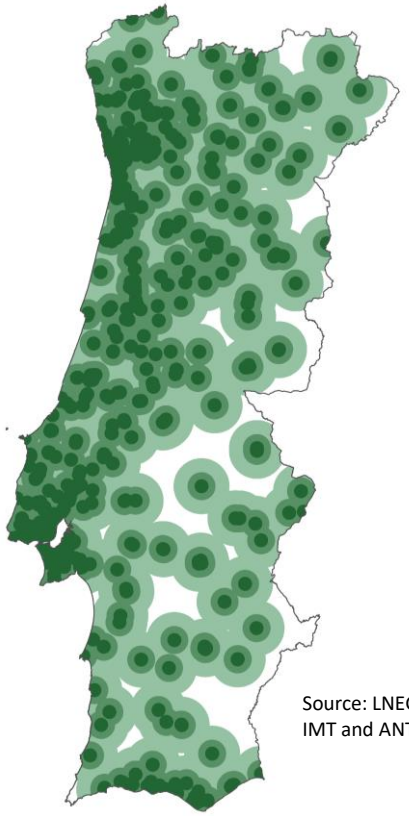
Indicators of the Market subindex (I)



Source: LNEG over REN

Injection points in natural gas grid

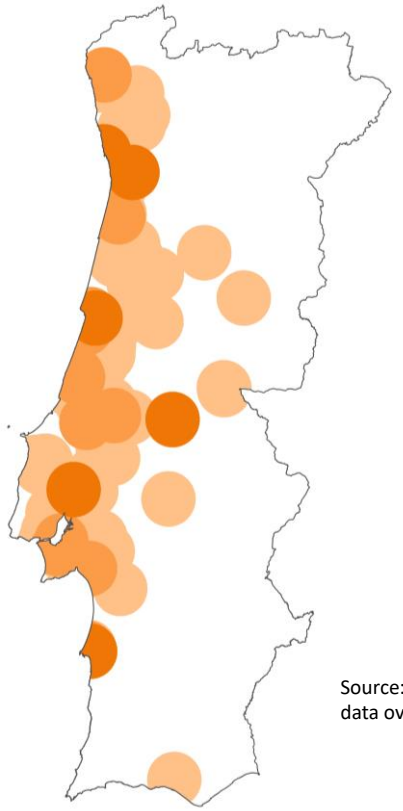
Class	Description
3	<5km distance to the injection point (JCT/GMRS) of the natural gas network
2	5-10km distance to the injection point (JCT/GMRS) of the natural gas network
1	20-10km distance to injection point (JCT/GMRS) of natural gas network
0	>20km distance to the injection point (JCT/GMRS) of the natural gas network



Source: LNEG over IMT and ANTRAM

Potential H_2 consumers - transports

Class	Description
3	<5km distance from a potential consumer
2	5-10km distance from a potential consumer
1	20-10km distance from a potential consumer
0	>20km distance from a potential consumer

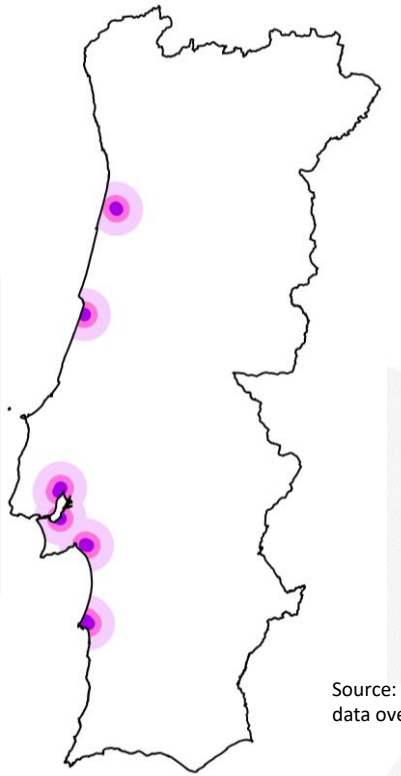


Source: LNEG (few data over APA)

Potential H_2 consumers - industry

Class	Description
3	<20 km distance from a potential consumer with CO_2 emissions >500 kt
2	<20 km distance from a potential consumer with CO_2 emissions between 50-500 kt
1	<20 km distance from a potential consumer with CO_2 emissions <50 kt
0	>=20km distance from a potential consumer for any mass of CO_2 emissions

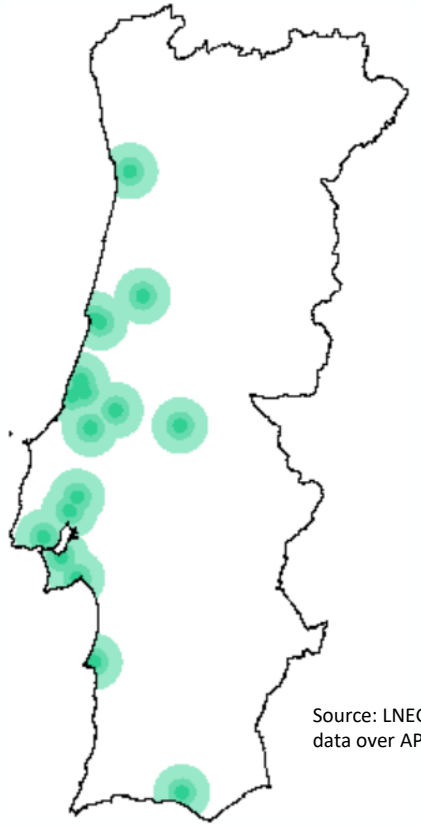
Indicators of the Market subindex (II)



Source: LNEG (few data over APA)

Potencial H_2 feedstock consumers

Class	Description
3	<5km distance from a potential consumer
2	5-10km distance from a potential consumer
1	20-10km distance from a potential consumer
0	>20km distance from a potential consumer



Source: LNEG (few data over APA)

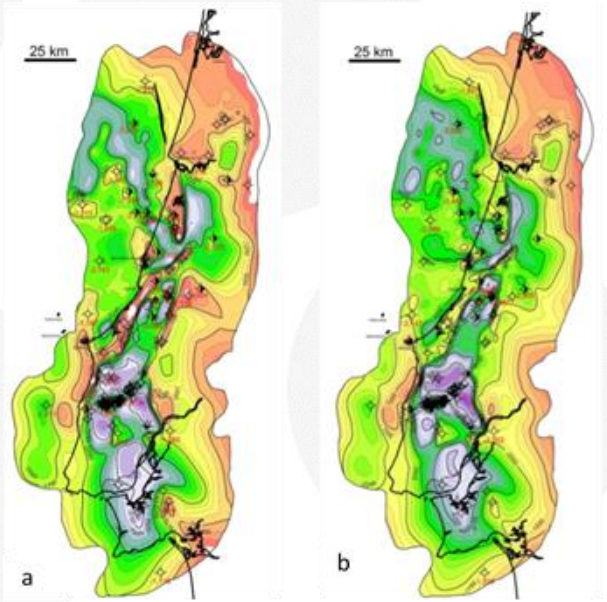
Large CO_2 producers

Class	Description
3	<5km distance from a large CO_2 emitter
2	5-10km distance from a large CO_2 emitter
1	20-10km distance from a large CO_2 emitter
0	>20km distance from a large CO_2 emitter

Underground H_2 storage

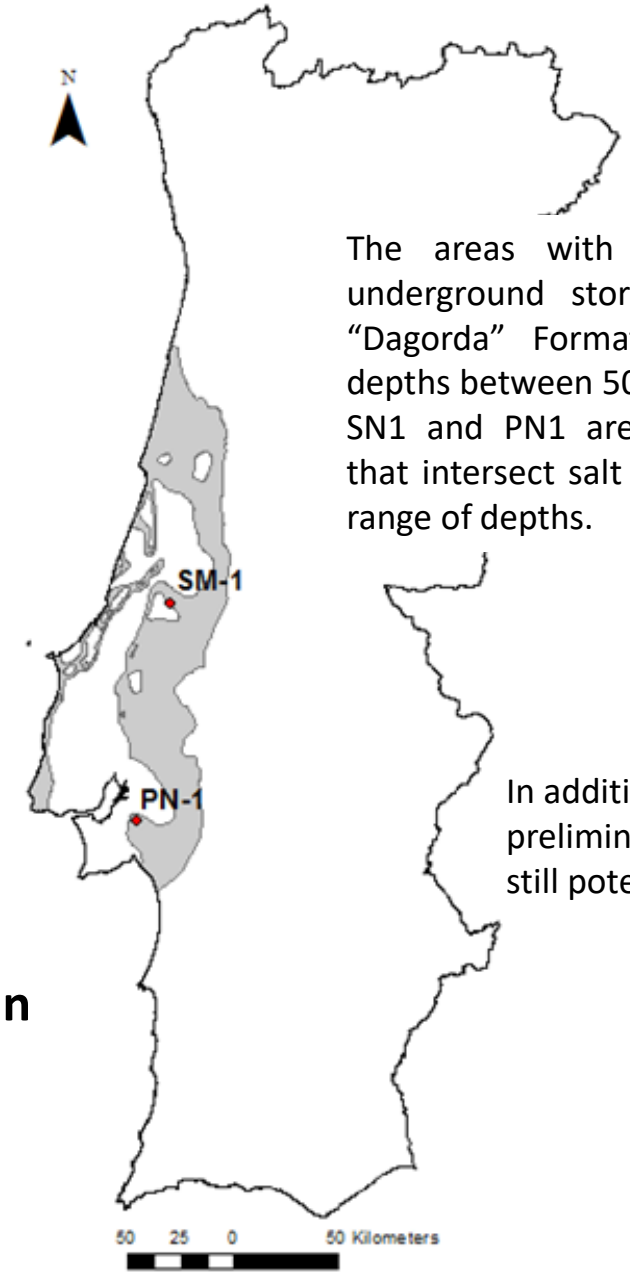
LNEG is working on identifying salt formations (diapiros) where H_2 can be stored – preliminary data indicate potential in "Dagorda Formation"

Using data from geophysical surveys of oil companies (data at DGEG), depth and thickness maps were drawn up within the "Dagorda Formation"



- Calibration of seismic profiles with deep probes
- Application of other criteria (reservoir depth and thickness)

Not considered at this stage in the H_2 Atlas - UNCERTAINTY



The areas with potential for underground storage of H_2 in "Dagorda" Formation occur at depths between 500 and 1750 m. SN1 and PN1 are deep probes that intersect salt masses in this range of depths.

In addition to this preliminary area, there is still potential in Algarve

National Sustainable Green H_2 Atlas

4 scenarios

Diversified

Drought + Gas and Transport Network

Drought + Gas Consumers

Prospective

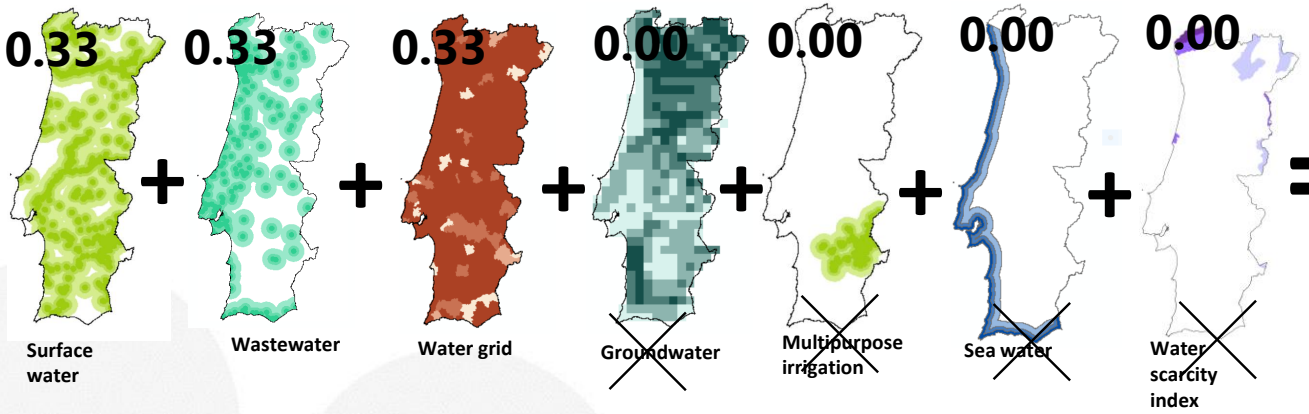
4 scenarios to identify the "best" areas for H_2 production:

Weight of each subindex (Kh)	Scenario A	Scenario B	Scenario C	Scenario D
Water input subindex	0.25	0.40	0.40	0.25
Energy input subindex	0.25	0.10	0.10	0.25
Market subindex	0.50	0.50	0.50	0.50
	1.0	**1.0**	**1.0**	**1.0**

NOTE: by providing a higher value for the "k" factor (weight), we are indicating that a certain local with higher values of that indicator/subindex is better for H_2 production. By allocating a high weight to wastewater, for example, the result would be that sites with access to wastewater would be classified as "better" to produce H_2.

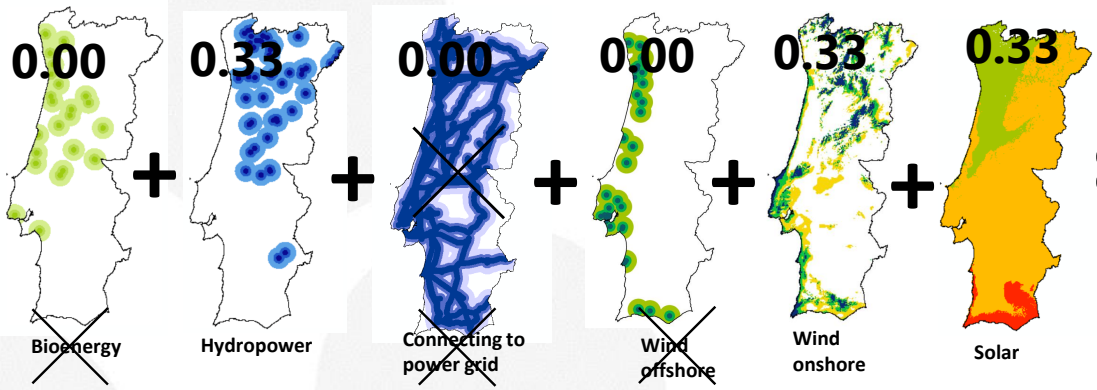
Index /indicator	Weight	Scenario A "Diversified"	Scenario B "Drought + Gas and Transport Network"	Scenario C "Drought + Gas Consumers"	Scenario D "Prospective"
Land cover (terrain)					
Slope					
Land cover (COS2018)					
Planning tools					
Protected areas					
RAN (not considered yet)					
REN (not considered yet)					
Water input subindex (7 indicators)	**Kh1**	**1.00**	**1.00**	**1.00**	**1.00**
Surface water bodies	Kw1	0.33			
Wastewater from WWTP	Kw2	0.33	0.50	0.50	0.30
Public water grid	Kw3	0.33			0.10
Groundwater	Kw4				
Sea water	Kw5		0.50	0.50	0.20
Multipurpose irrigation	Kw6				0.20
Water scarcity index	Kw7				0.20
Energy input subindex (6 indicators)	**Kh2**	**1.00**	**1.00**	**1.00**	**1.00**
Solar exposure	Kp1	0.33	0.33	0.33	0.20
Wind resources onshore	Kp2	0.33	0.33	0.33	0.20
Wind resources offshore	Kp3				0.20
Bioenergy power generation	Kp4				0.10
Hydropower generation	Kp5	0.33			0.10
Connecting to power grid	Kp6		0.33	0.33	0.20
Market subindex (5 indicators)	**Kh3**	**1.00**	**1.00**	**1.00**	**1.00**
Injection points in natural gas grid	km1	0.25	0.70		0.20
Potential H_2 consumers transports	km2	0.25	0.30		0.20
Potential H_2 consumers industry	km3	0.25		0.70	0.20
Potential H_2 feedstock consumers	km4	0.25		0.30	0.10
Large CO_2 emitters	km5				0.30

Scenario A "Diversified"



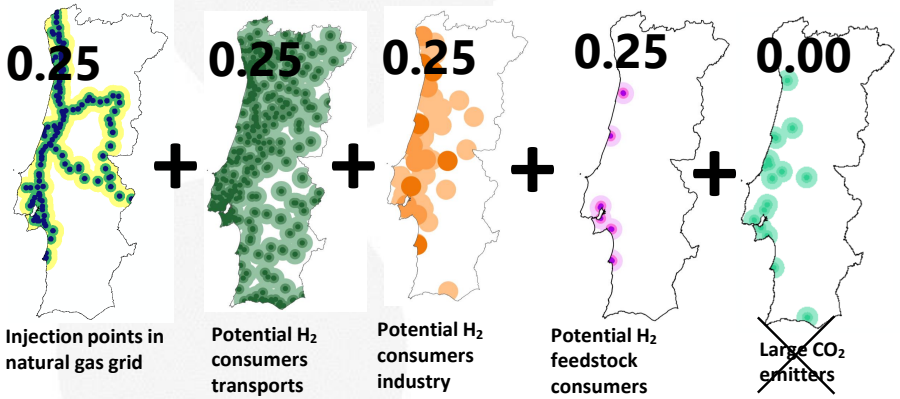
Water input subindex

0.25



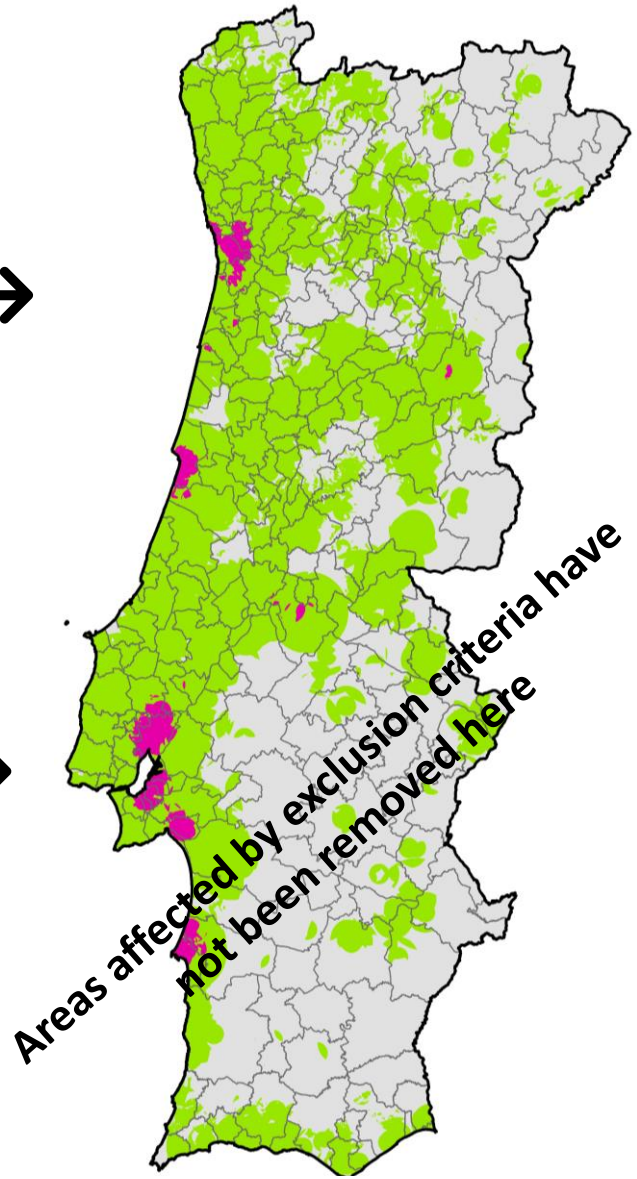
Energy input subindex

0.25

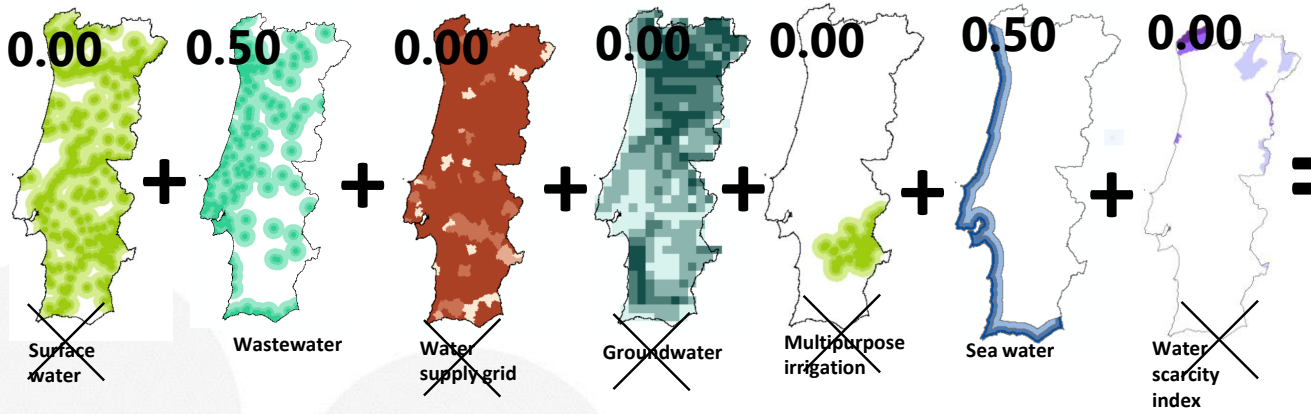


Market subindex

0.50

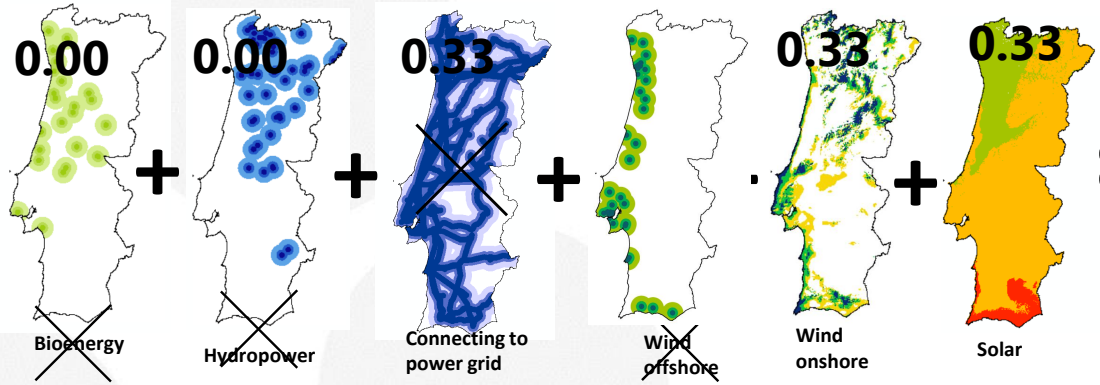


Scenario B “Drought + Gas and Transport Network”



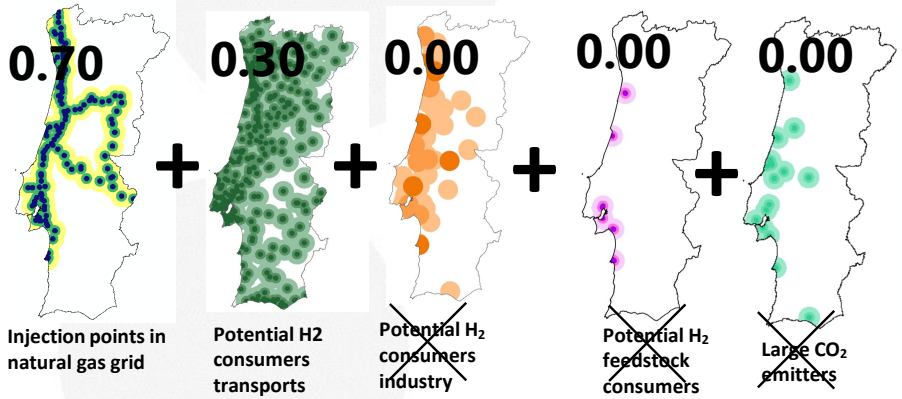
Water input subindex

0.40



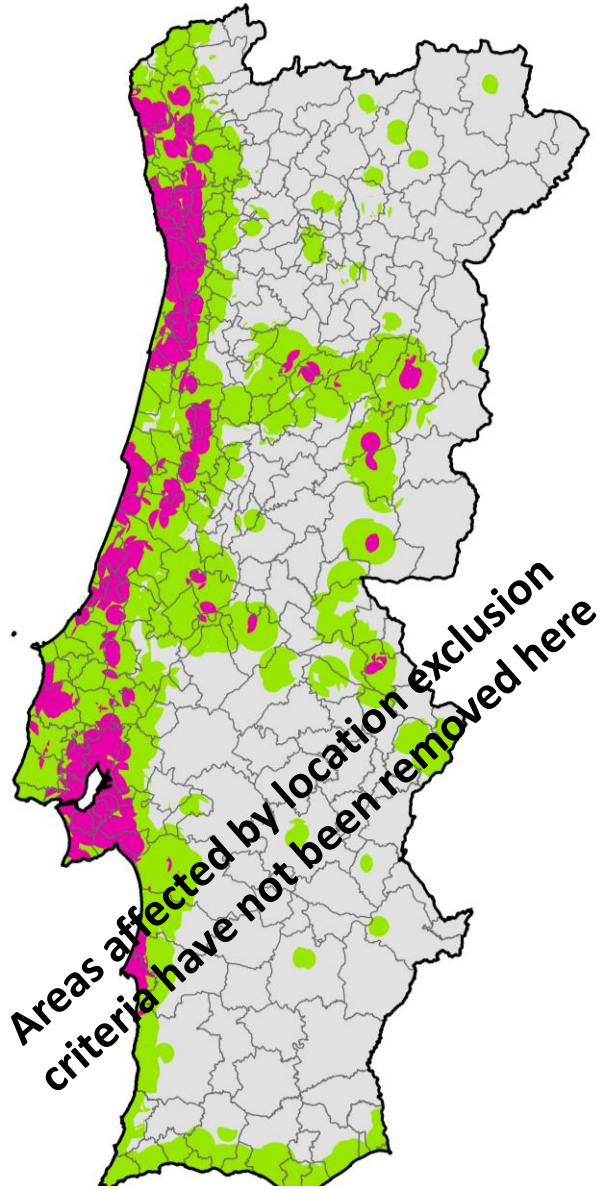
Energy input subindex

0.10



Market subindex

0.50



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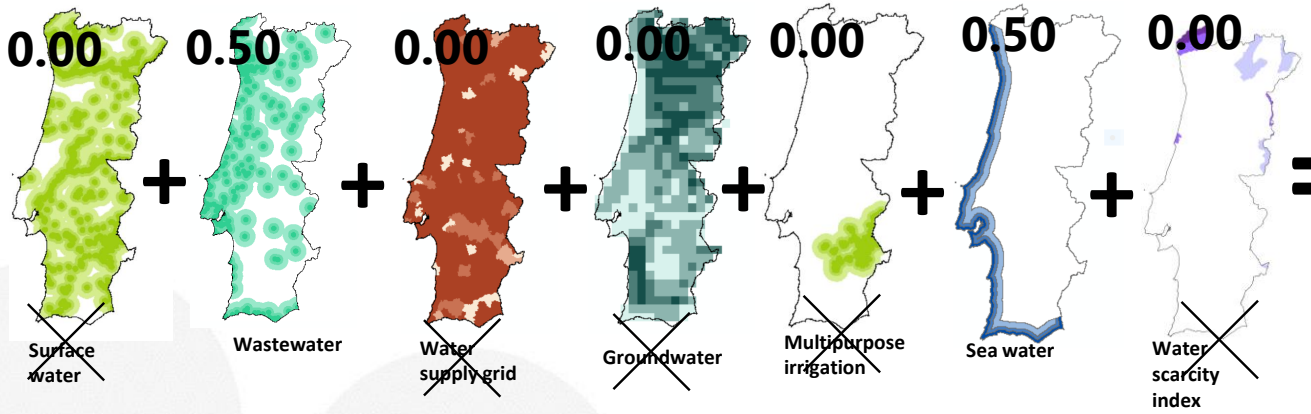
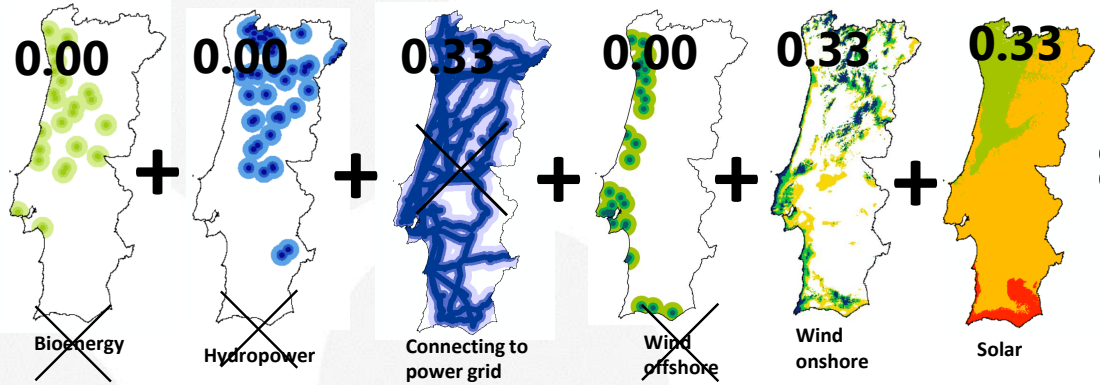
Scenario C “Drought + Gas Consumers”



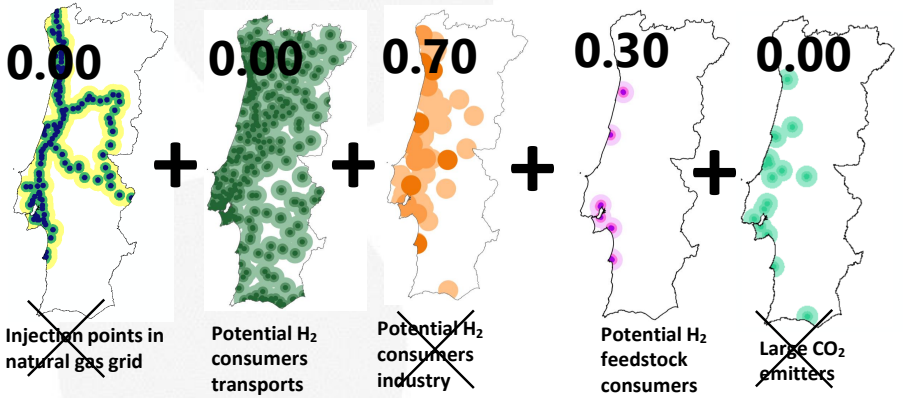
Water input subindex

0.40



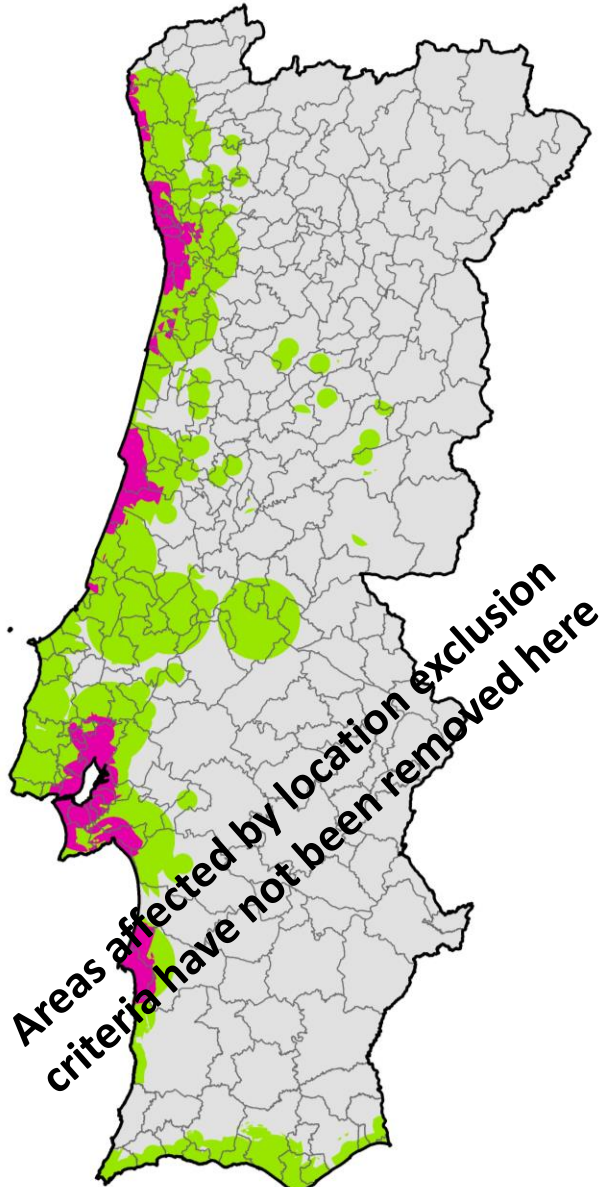
Energy input subindex

0.10



Market subindex

0.50



Areas with no potential

Less favorable areas

Favorable areas

Very favorable areas for implementation of H2 Green facilities

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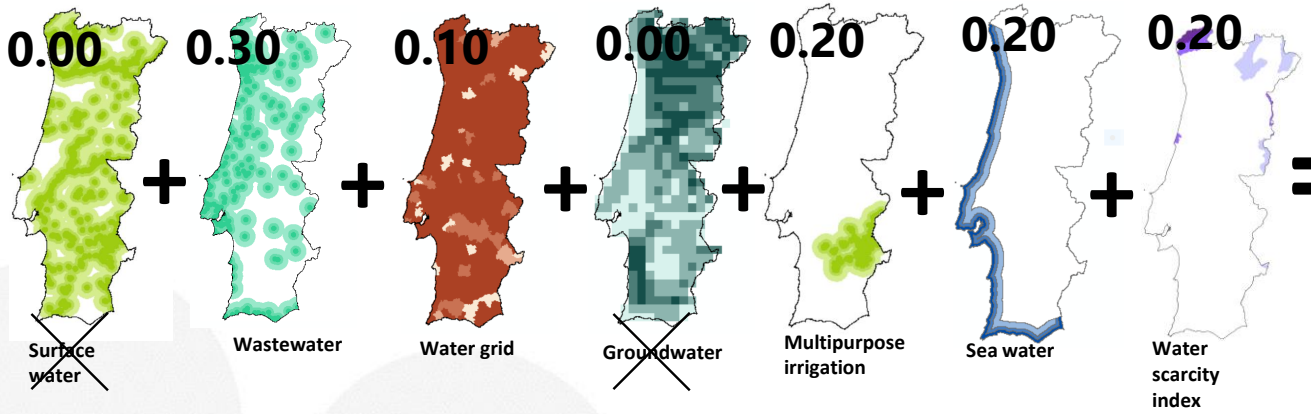
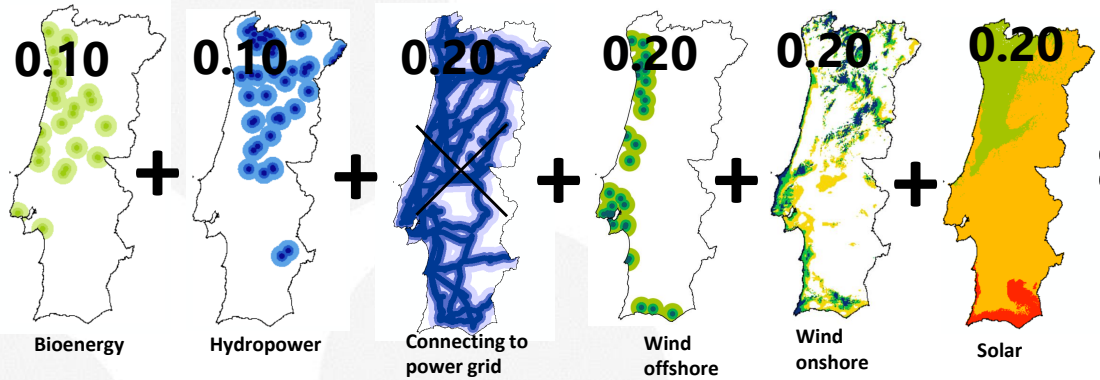
Scenario D “Prospective”



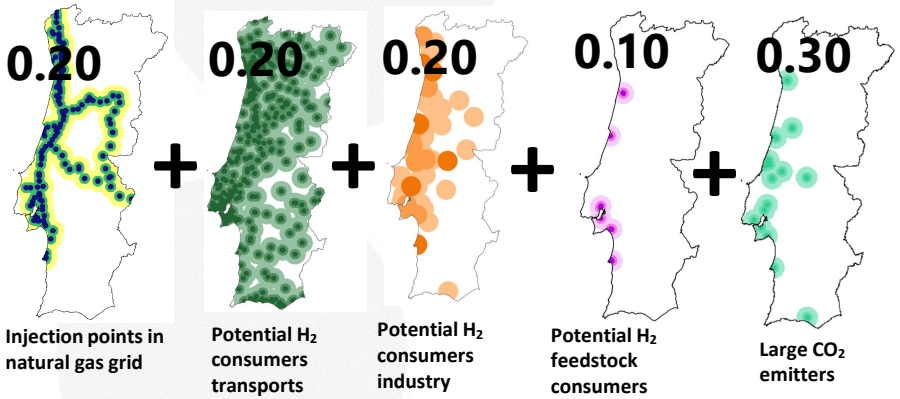
Water input subindex

0.25



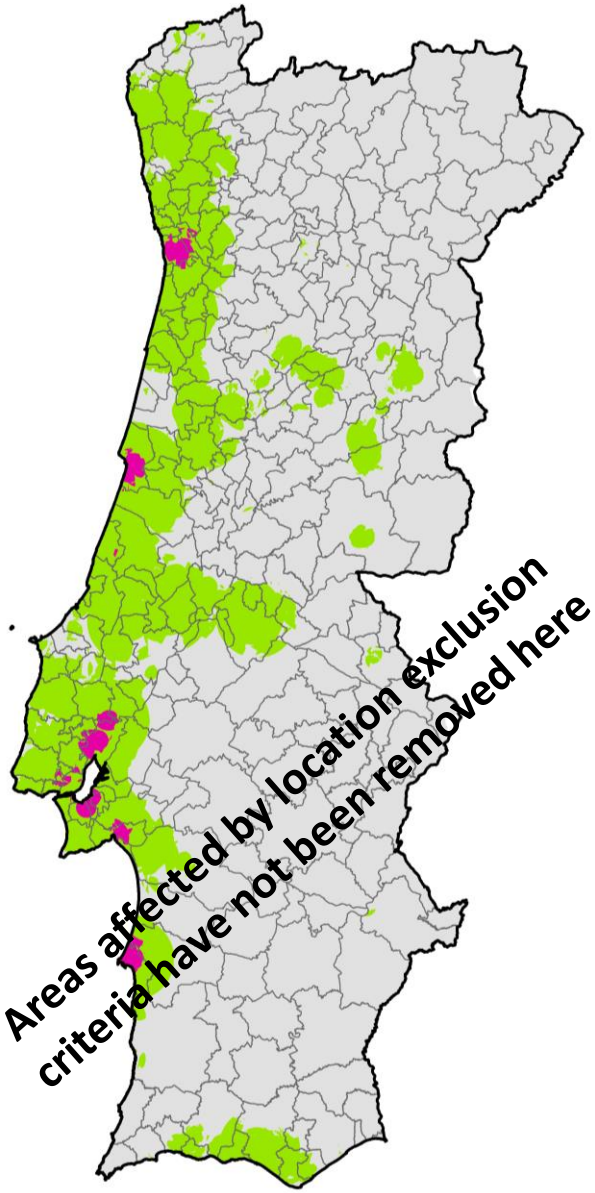
Energy input subindex

0.25



Market subindex

0.50



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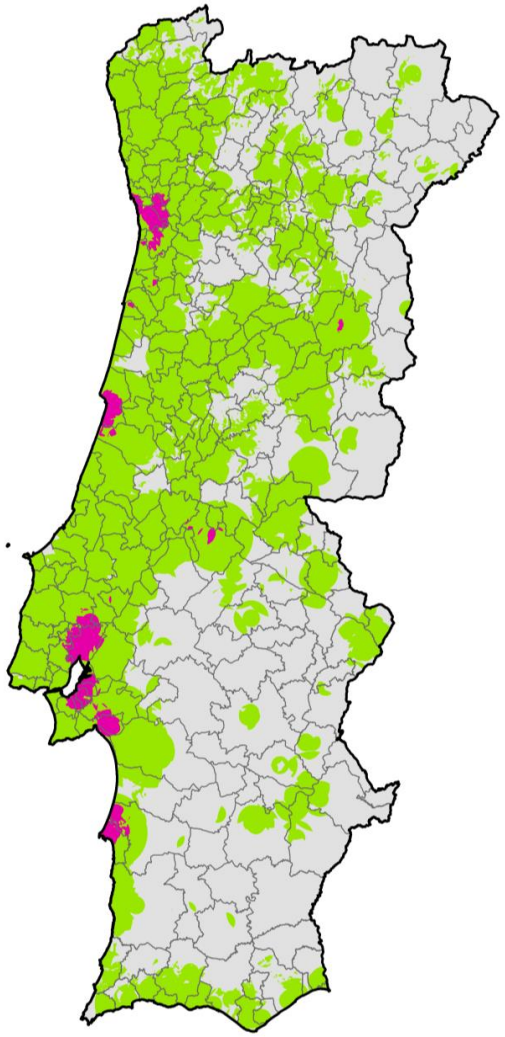
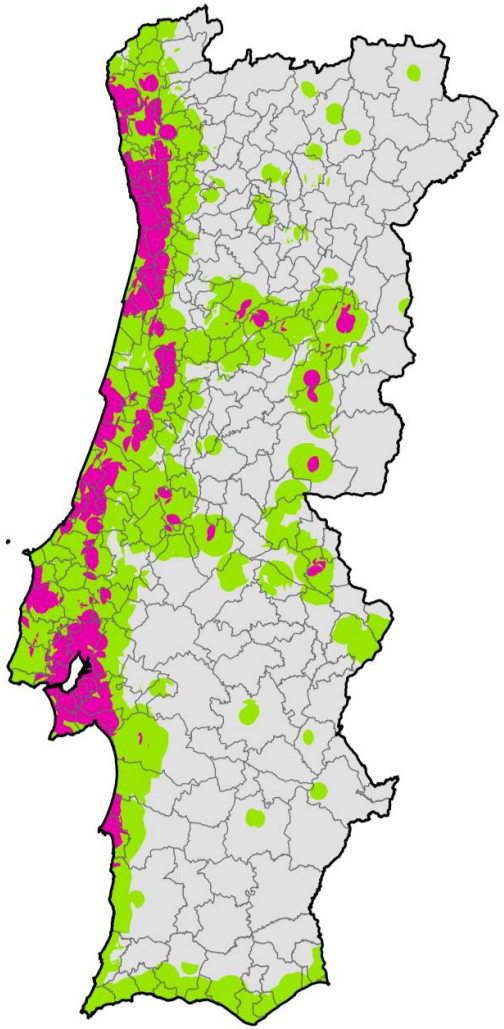
Comparison of 4 Scenarios

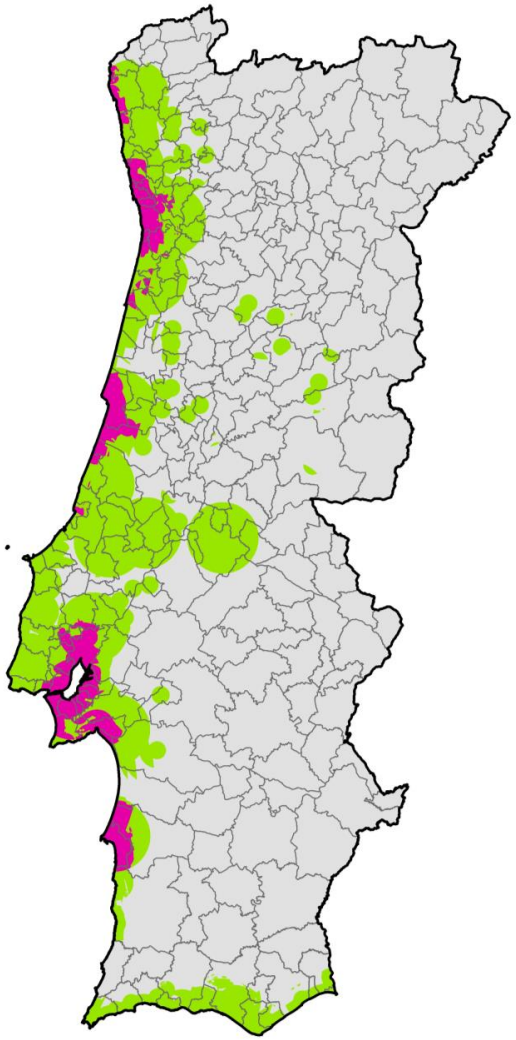
Areas affected by location exclusion criteria have not been removed here



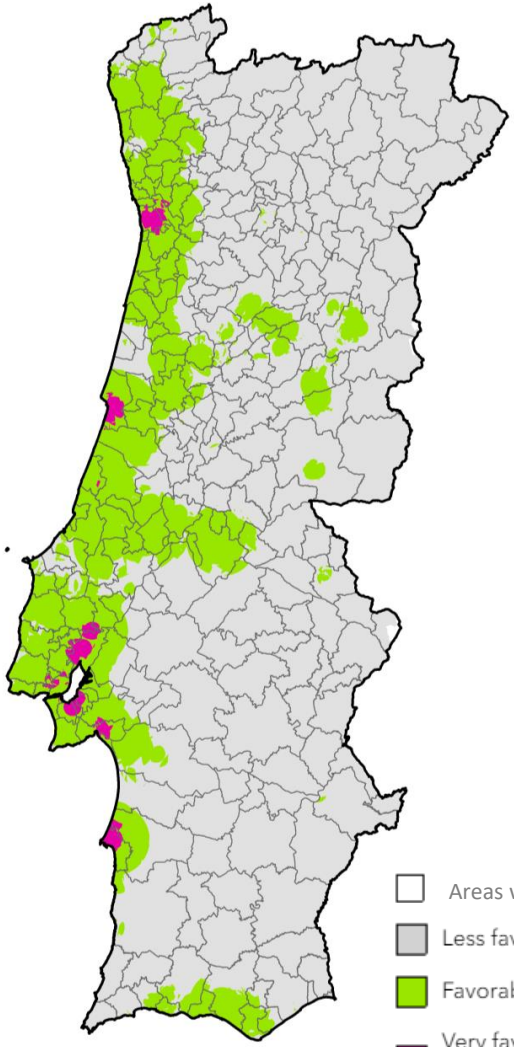
Scenario A
"Diversified"



Scenario B
"Drought +Gas and Transport Network"



Scenario C
"Drought + Gas Consumers"



Scenario D
"Prospective"

- Areas with no potential
- Less favorable areas
- Favorable areas
- Very favorable areas for implementation of H2 Green facilities

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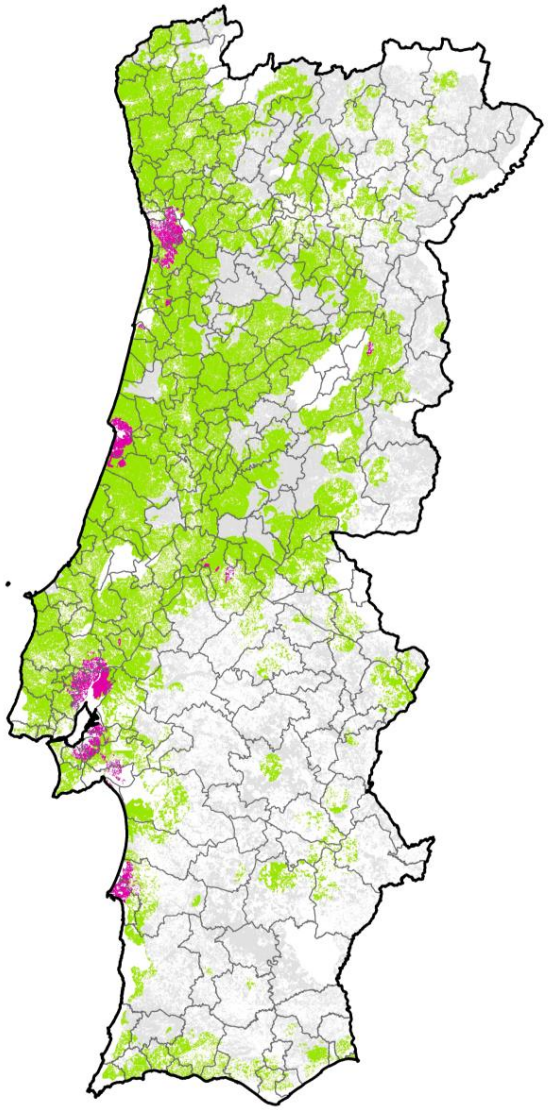
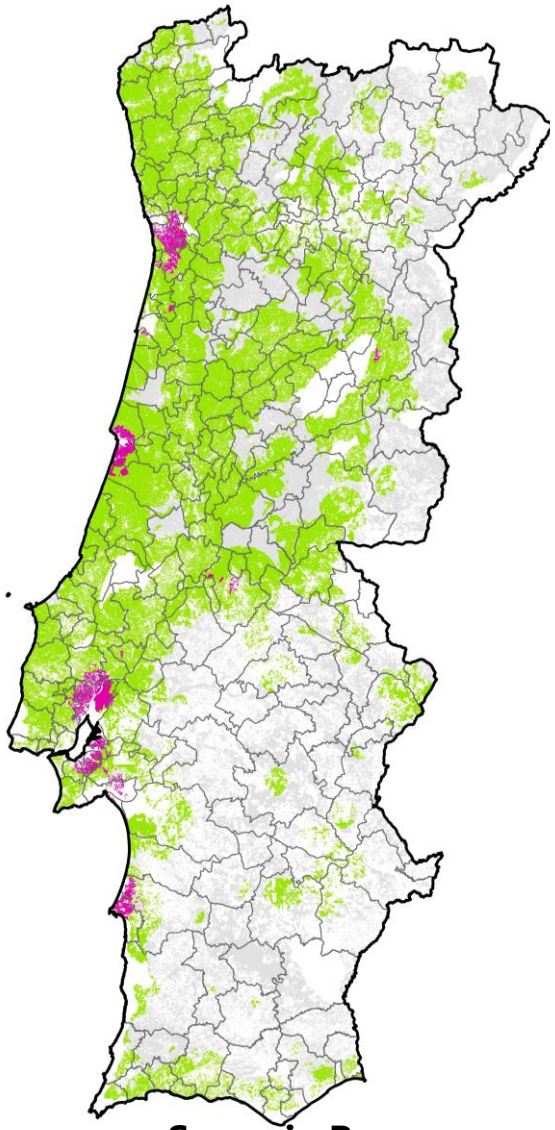
4 Scenarios: removed all areas affected by location exclusion criteria

(note that at this stage it has not yet been possible to exclude RAN and REN areas)

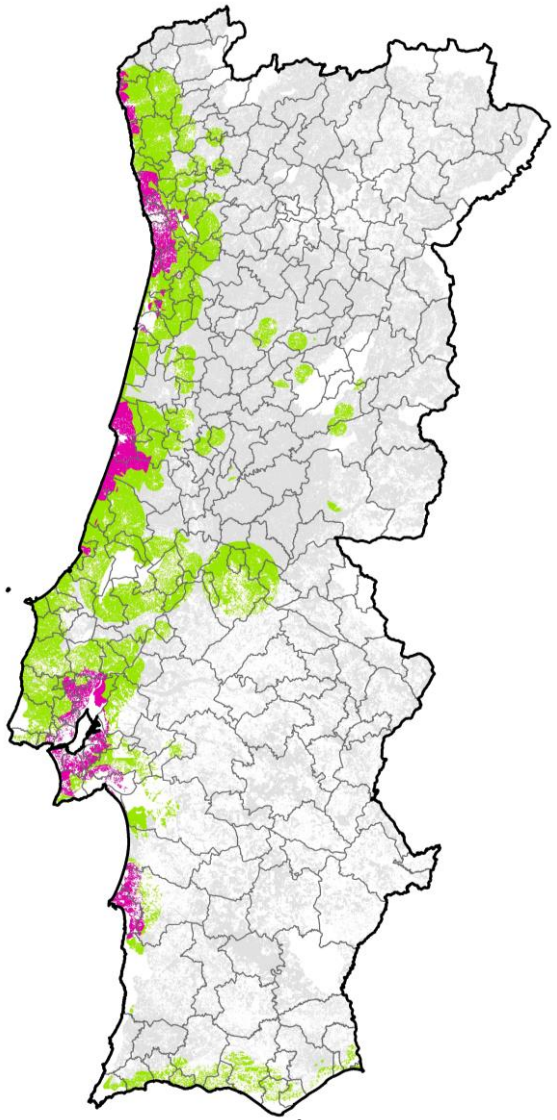


Scenario A
"Diversified"

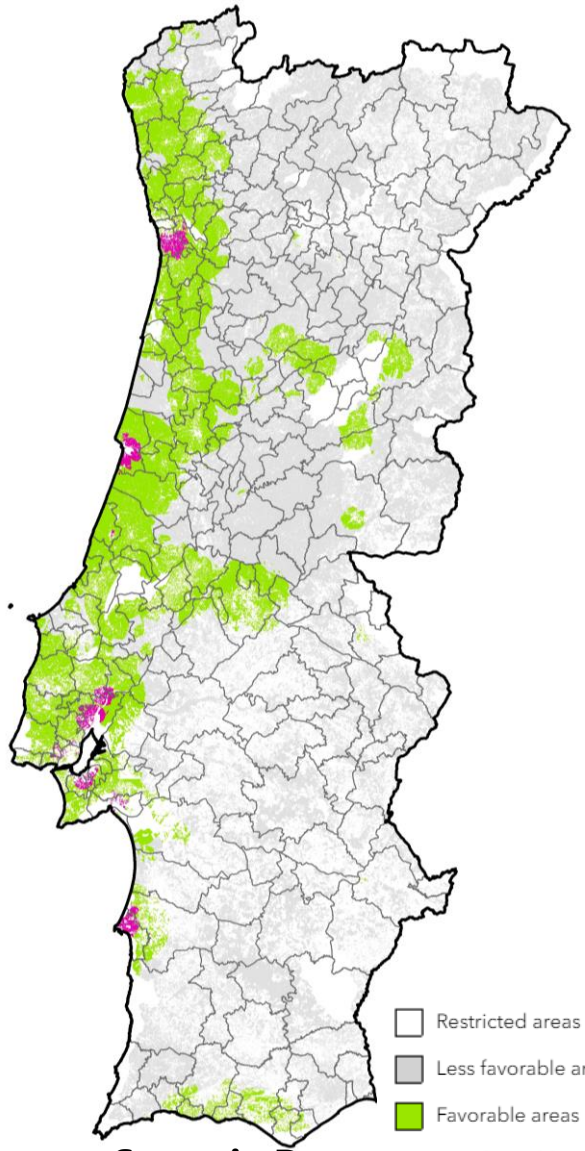


Scenario B

"Drought +Gas and Transport Network"



Scenario C
"Drought + Gas Consumers"



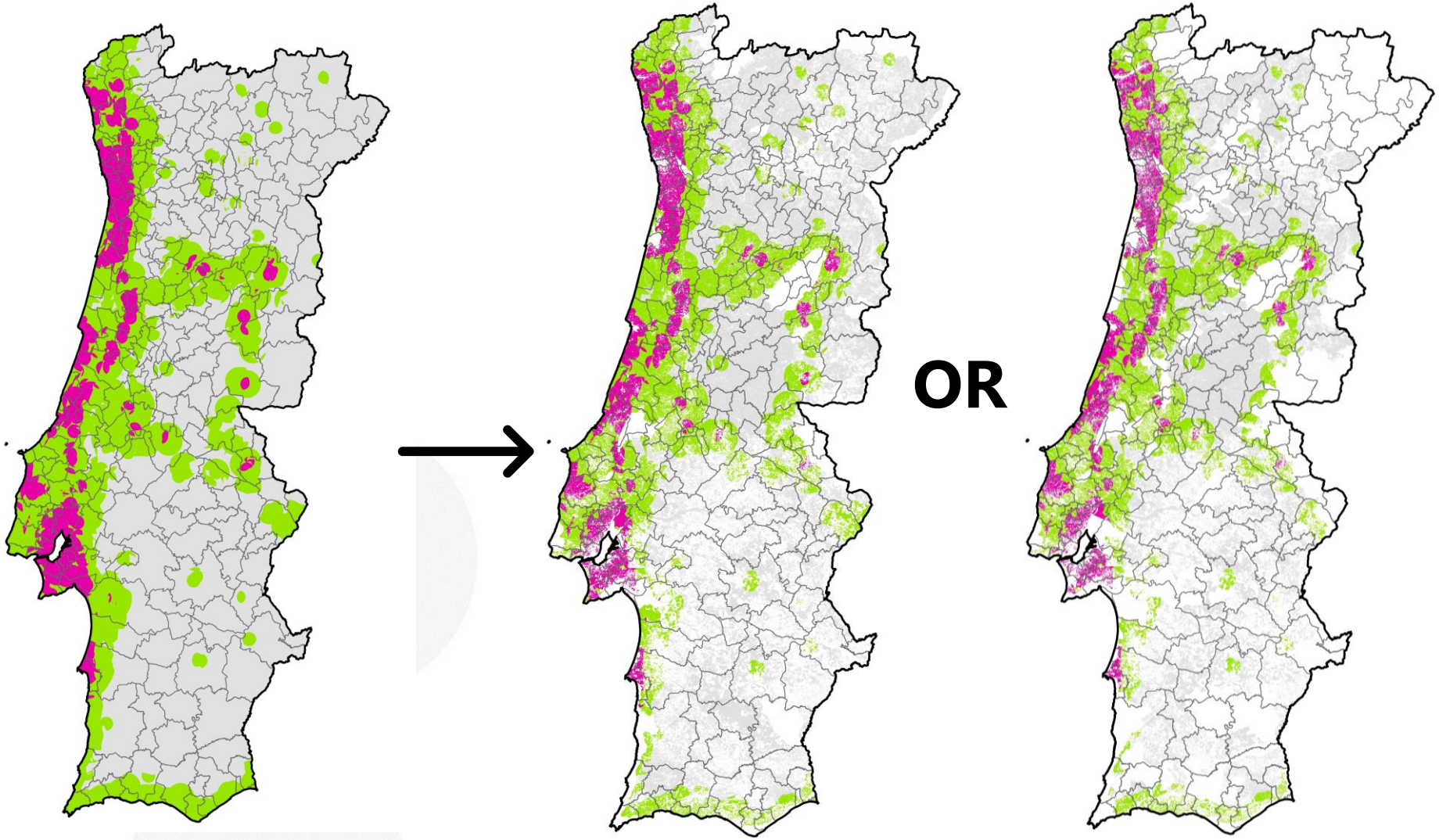
Scenario D

"Prospective"

- Restricted areas
- Less favorable areas
- Favorable areas
- Very favorable areas for implementation of H2 Green facilities

Scenario B “Drought + Gas and Transport Network”

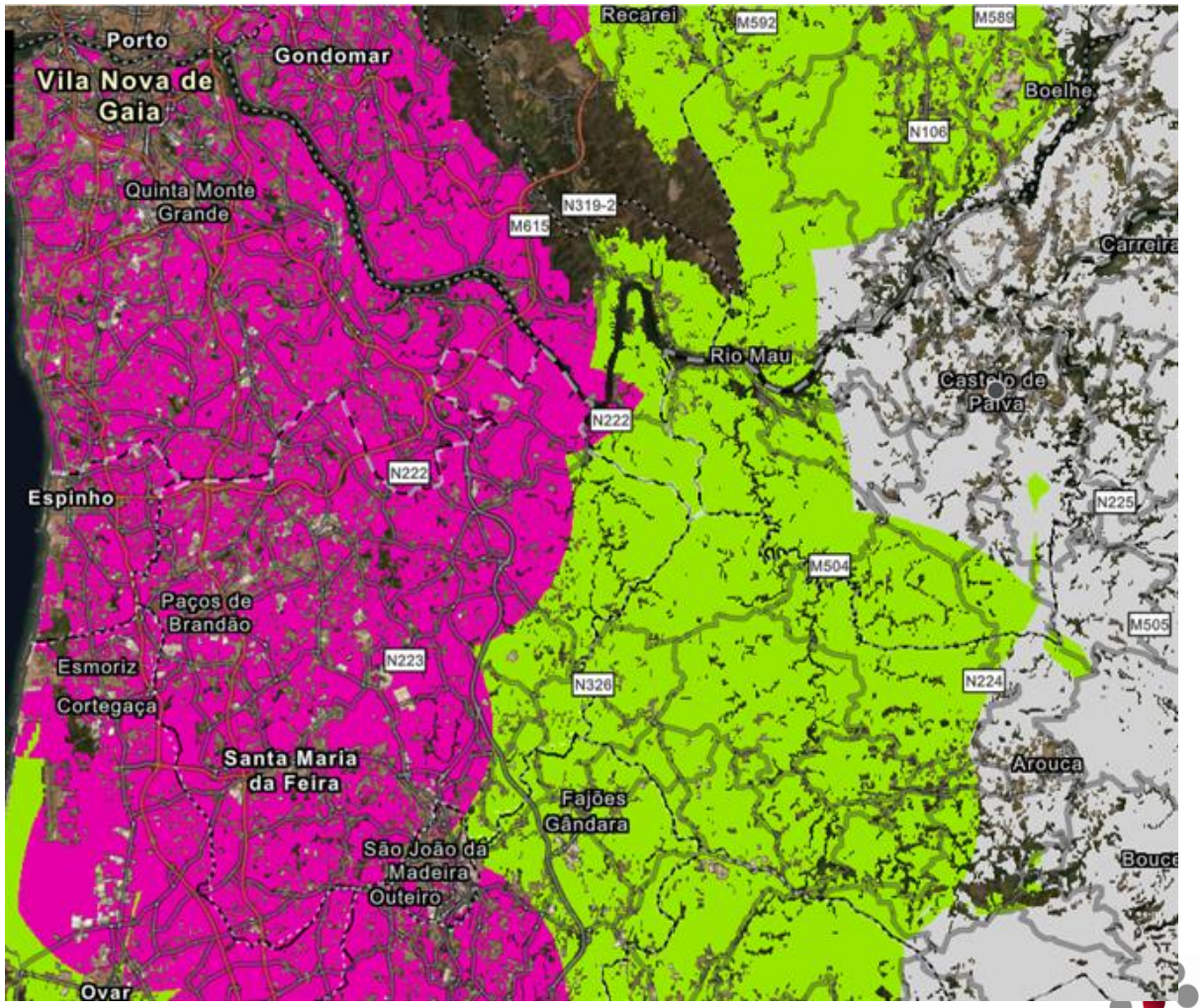
Impact of removing areas considering project location exclusion conditions



Zoom in two areas in the country – we do not have RAN and REN!

Sines Scenario B

North Coast / Center Scenario B



Limitations

This presentation shows a version of the Green H_2 Sustainable Atlas that benefited from much appreciated feedback from a group of public and private stakeholders.

The currently considered criteria for exclusion of some areas where location of H_2 projects is not possible do not include:

- all the public utility restrictions in Portuguese law (e.g. power grids, defense facilities, etc.)
- areas of RAN and REN, gardens/urban parks or any other land cover classes other than those mentioned (e.g., forest Monsanto Park in Lisbon)
- Municipal plans and regulation classifying current and future land use (ex. PDM – municipal master plans)
- SEVESO major accident hazard zones
- protected areas under the Water Framework Directive
- flood risk zones and/or geologically unstable areas (erosion, terrain movements), etc.

The information used and the resolution of some layers (indicators) limits the analysis (e.g., COS sparse vegetation contained in urban areas)

This Atlas does not replace a detailed analysis of projects to be implemented under the applicable law. The used geographic information has inherent limitations with respect to date, scale, resolution and sources. Moreover, the feasibility assessment for a concrete project requires detailed information beyond the variables contained in this Atlas and considers other factors and legal compliance aspects*, which cannot be considered at this scale.

* National Natural Gas Transport Network Regulation , Safety Regulation regarding design, construction, operation and maintenance of liquid and liquefied hydrocarbon transport pipelines, Safety Regulation for Plants for Explosive Products Manufacturing and Storage, ...

What is the purpose of the Green H_2 Atlas ?

The added value of this approach is to contribute to supporting decision making at various scales by looking at the territory of mainland Portugal as a whole.

The H_2 economy is developing very rapidly, and it is necessary to support this development with transparent and integrated information, empowering and considering all stakeholders involved (public and private).

The approach is flexible, allowing the design of scenarios depending on the business model and land use restrictions considered. Additional scenarios can be designed and co-developed with stakeholders.

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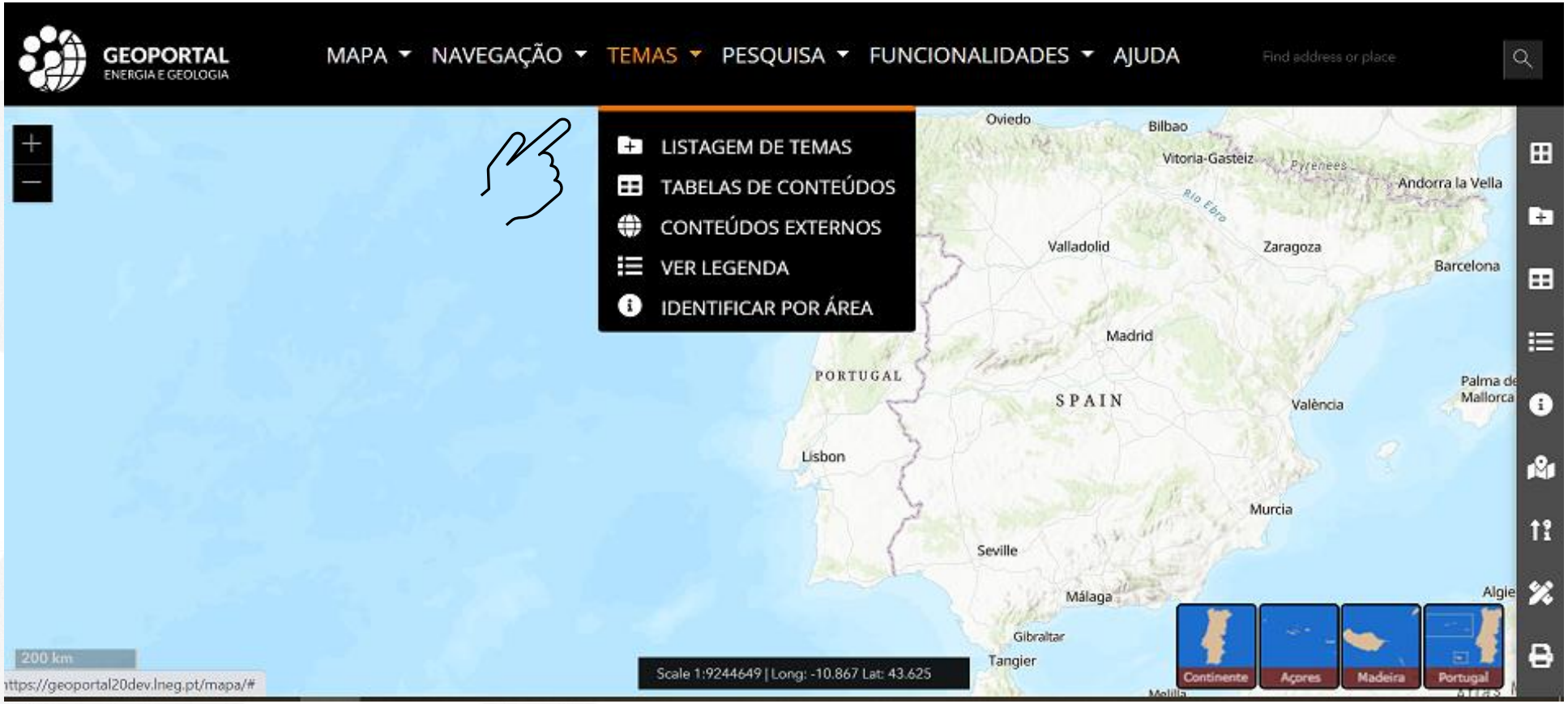
Next steps

- **consider seasonality in wind and solar resources** (complementarity)
- **smaller wastewater plants to be used as water source**
- **RAN and REN (and perhaps other exclusion areas?)**
- **financial aspects / costs**
- **potential underground H_2 storage**
- **water availability supply curve depending on the number of projects to be implemented**
- **future locations of potential consumers**
- **climate change impact**

To give the user **the possibility to draw the final map in real time**
To explore this approach in **other energy vectors** (e.g. biomethane?)

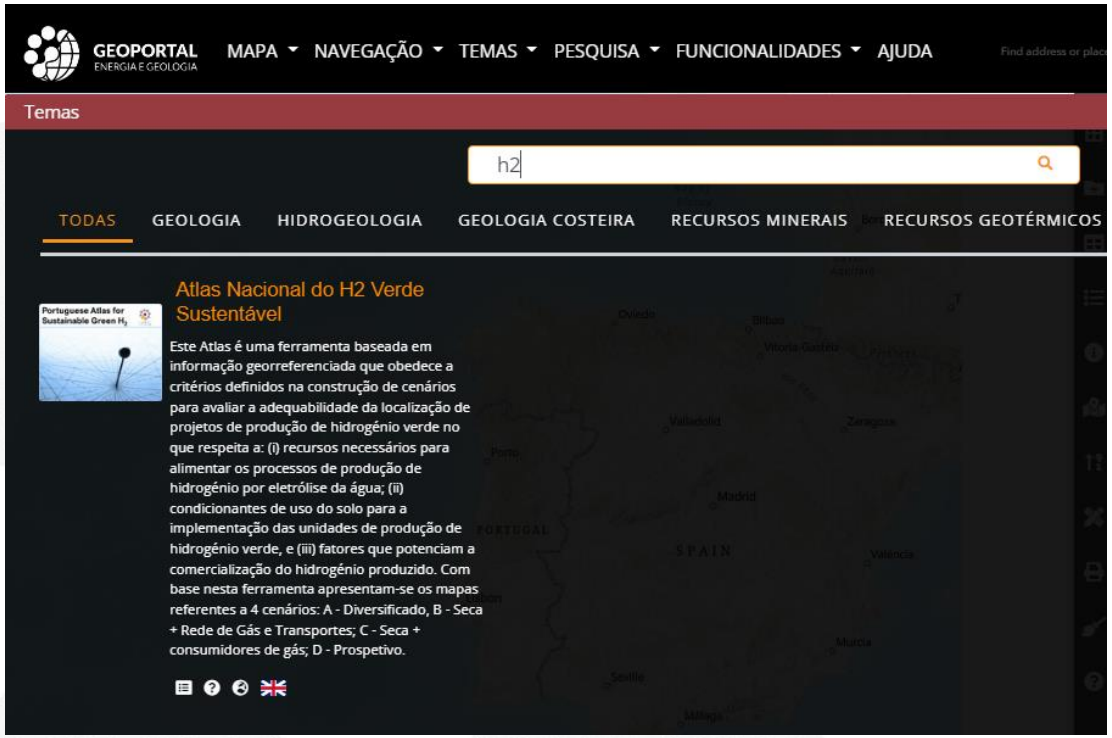
The Atlas at LNEG's GeoPortal
Access via link to the MAP VIEWER



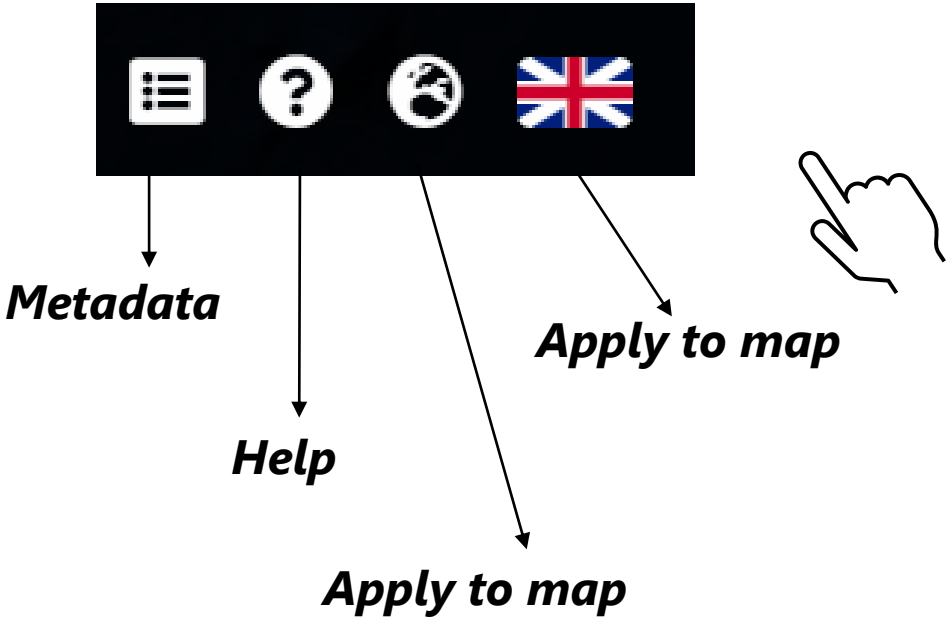
https://geoportal.lneg.pt/mapa/#

Contact: geoportal@lneg.pt

TEMAS → LISTAGEM DE TEMAS → *type H2 in the search bar*



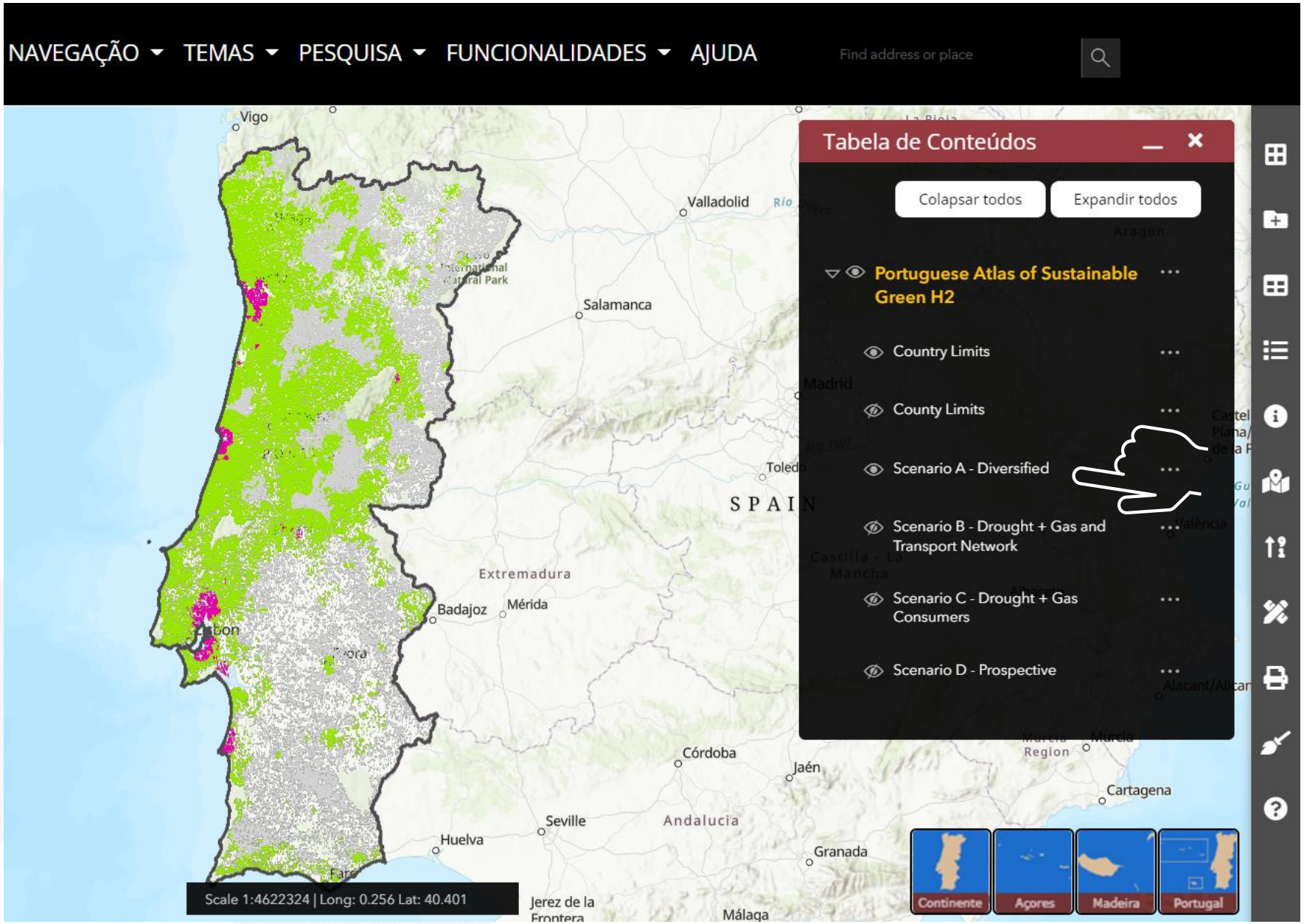
Access the information



Direct access to the Atlas

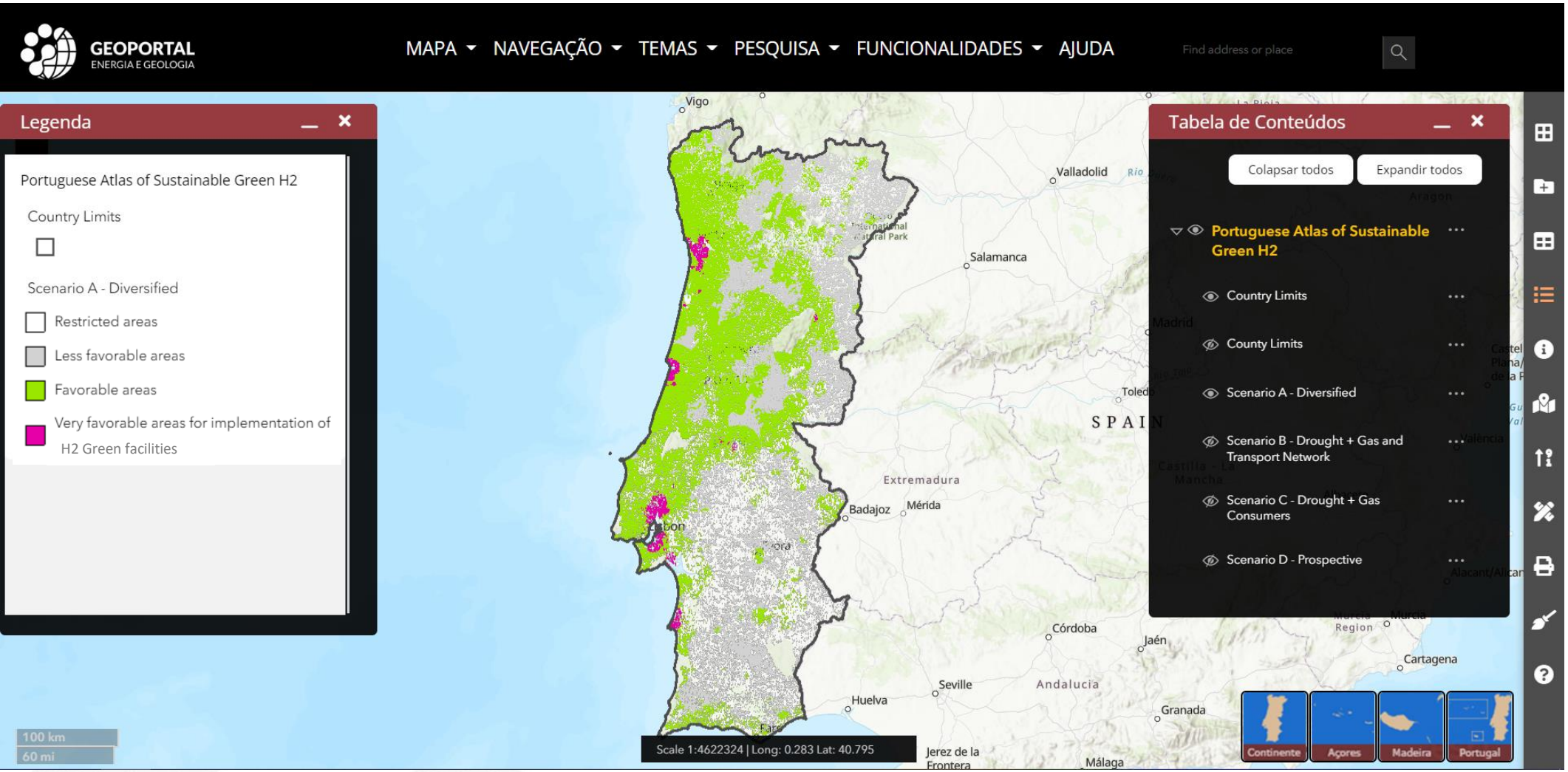
PT - https://geoportal.lneg.pt/mapa/?mapa=AtlasH2Verde

EN - https://geoportal.lneg.pt/mapa/?mapa=GreenH2Atlas



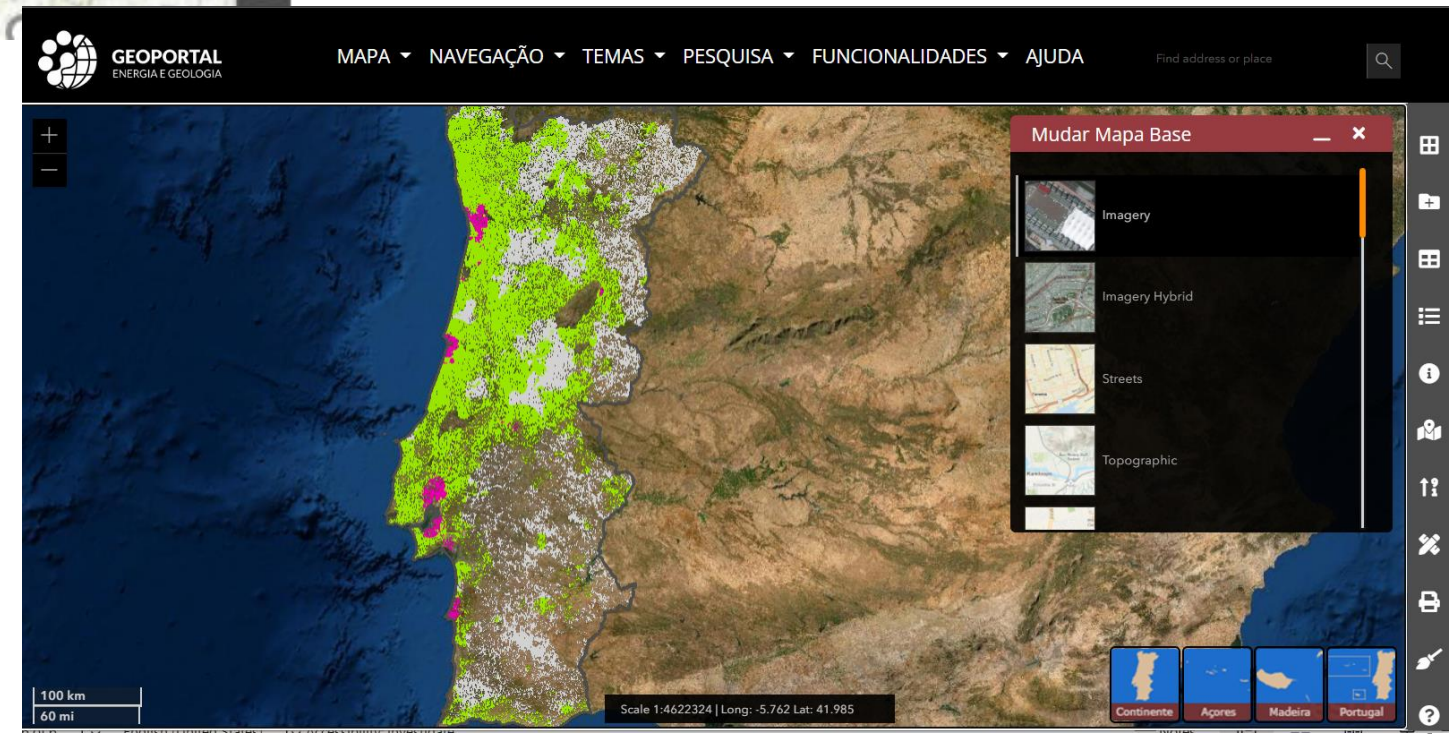
By default the Scenario A is selected

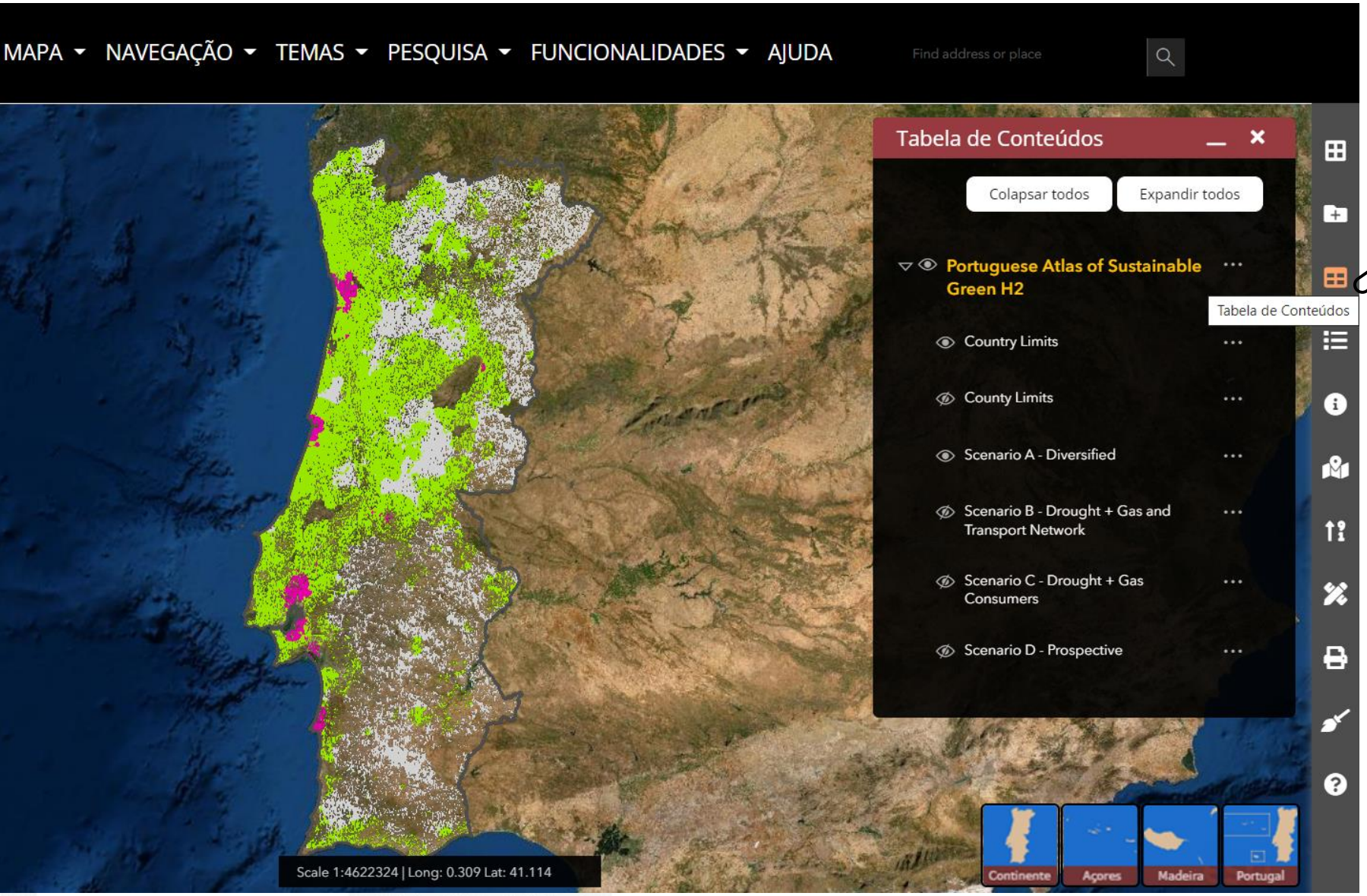
To hide layers and view others



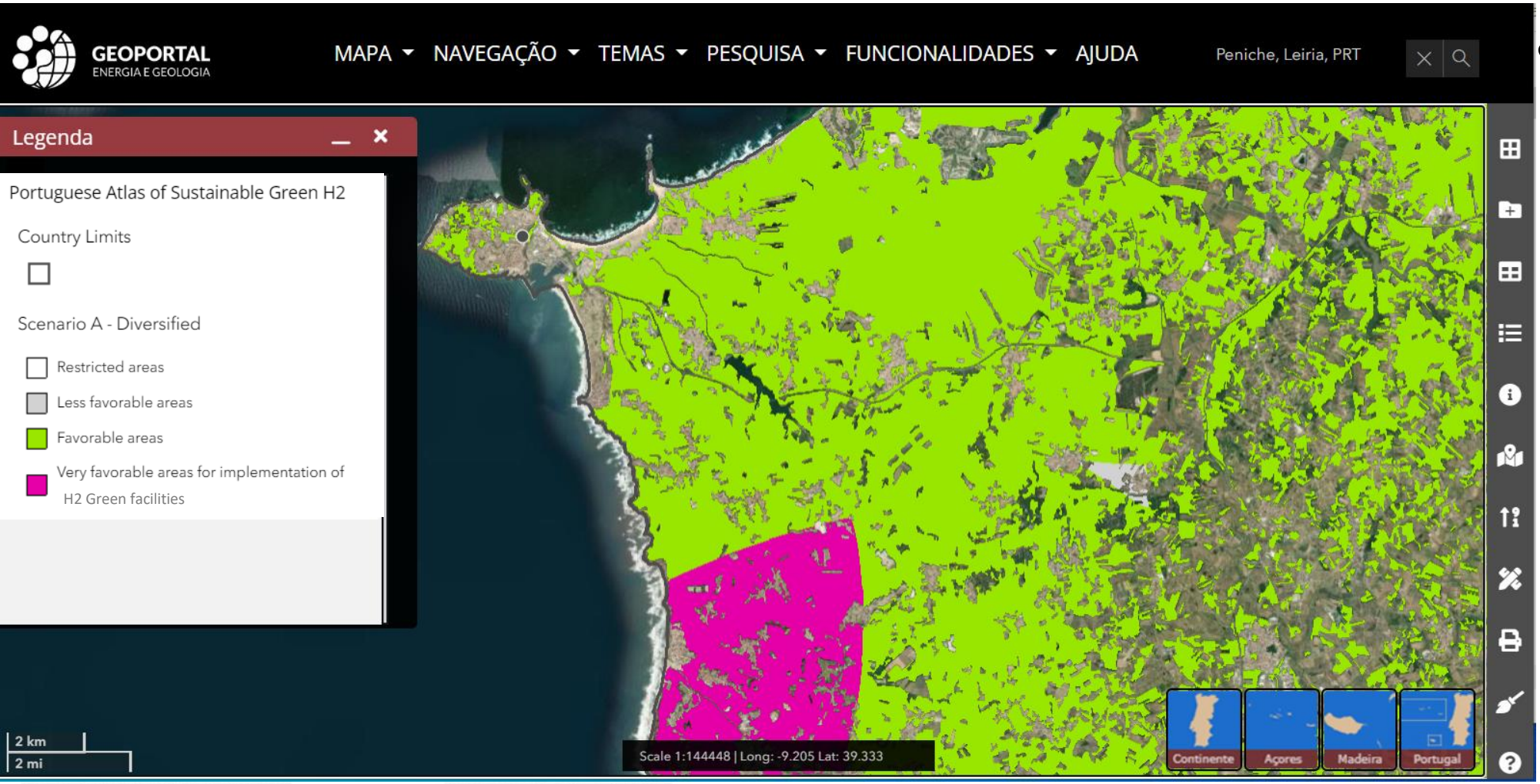
To view the caption

To change the basemap

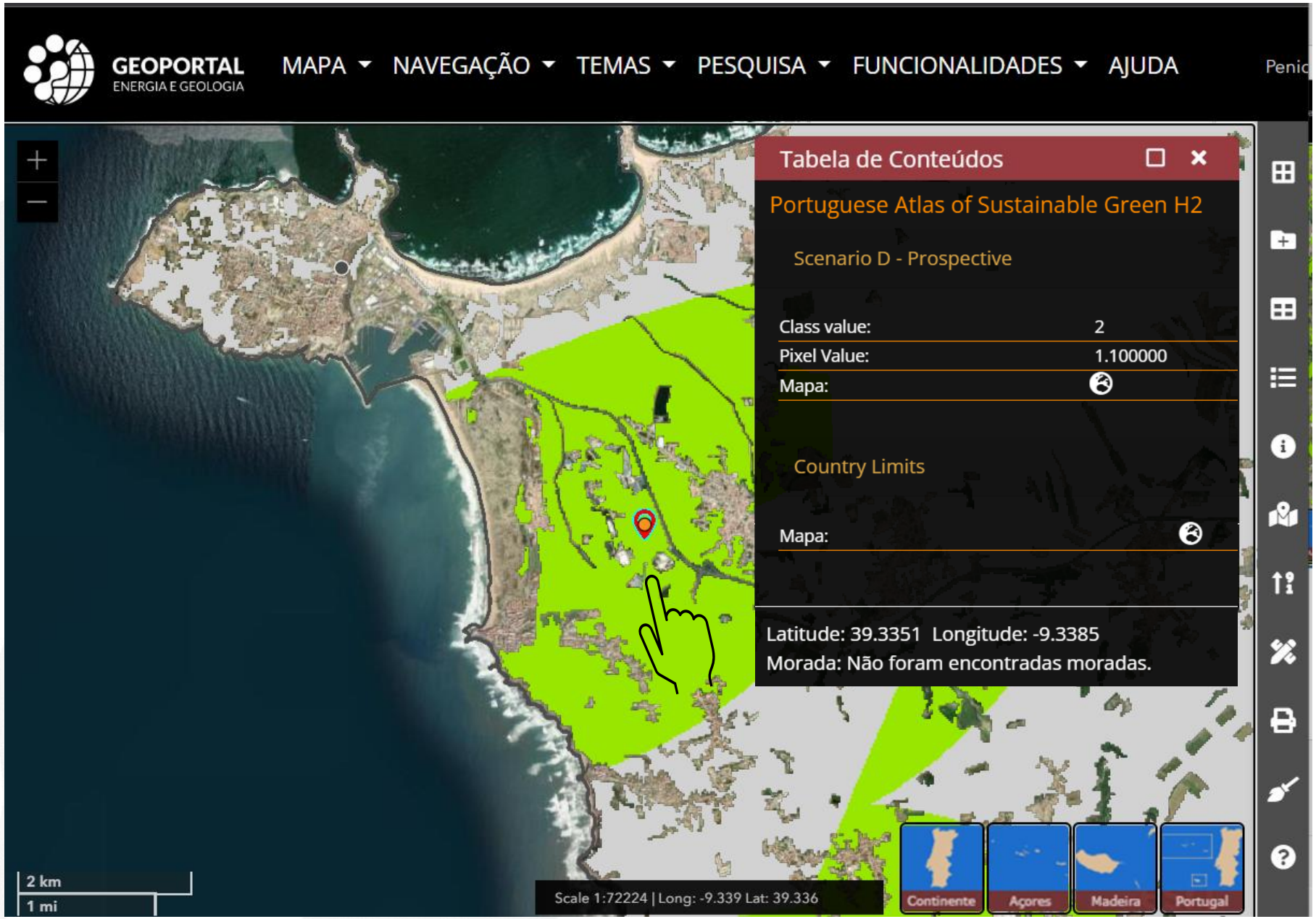




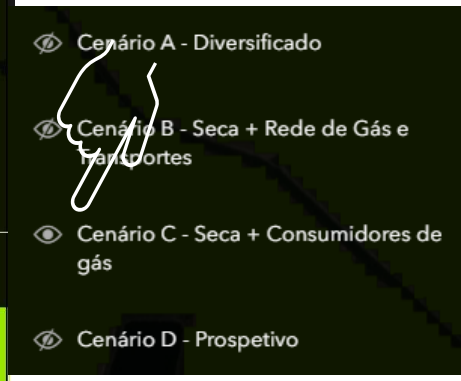
To view the table of contents

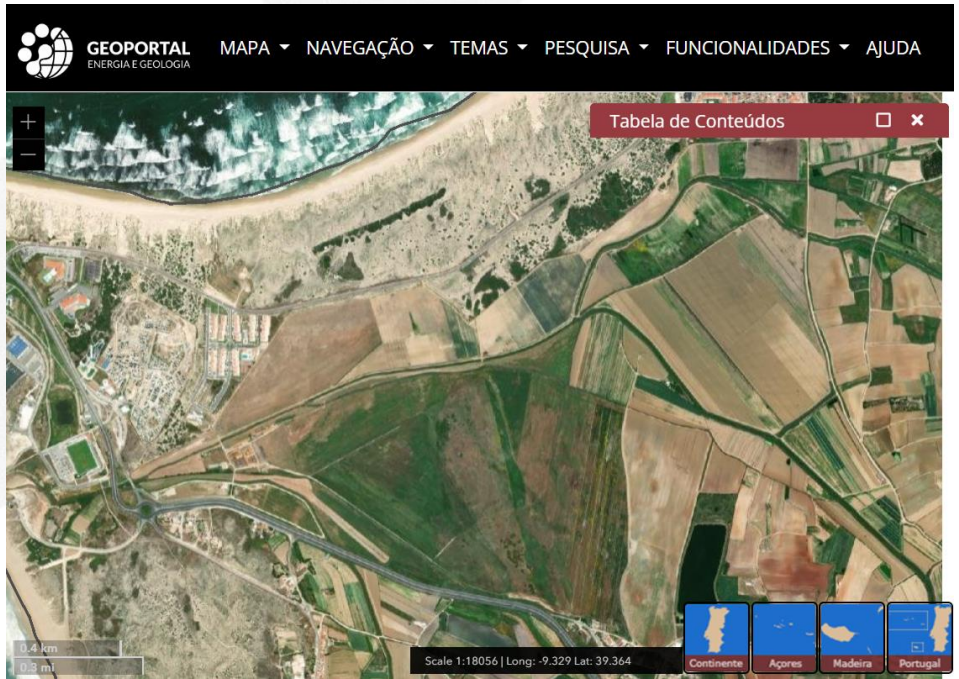


Type to go to a location



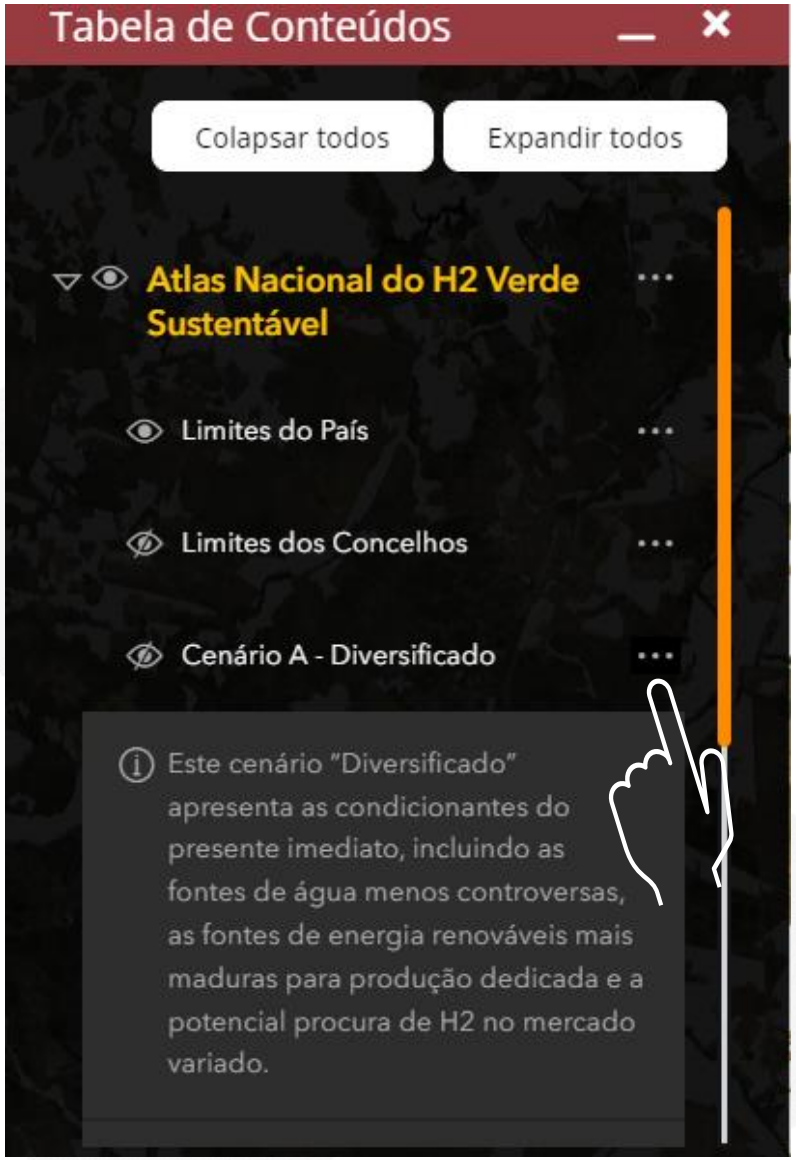
Click over the map to get information and zoom in



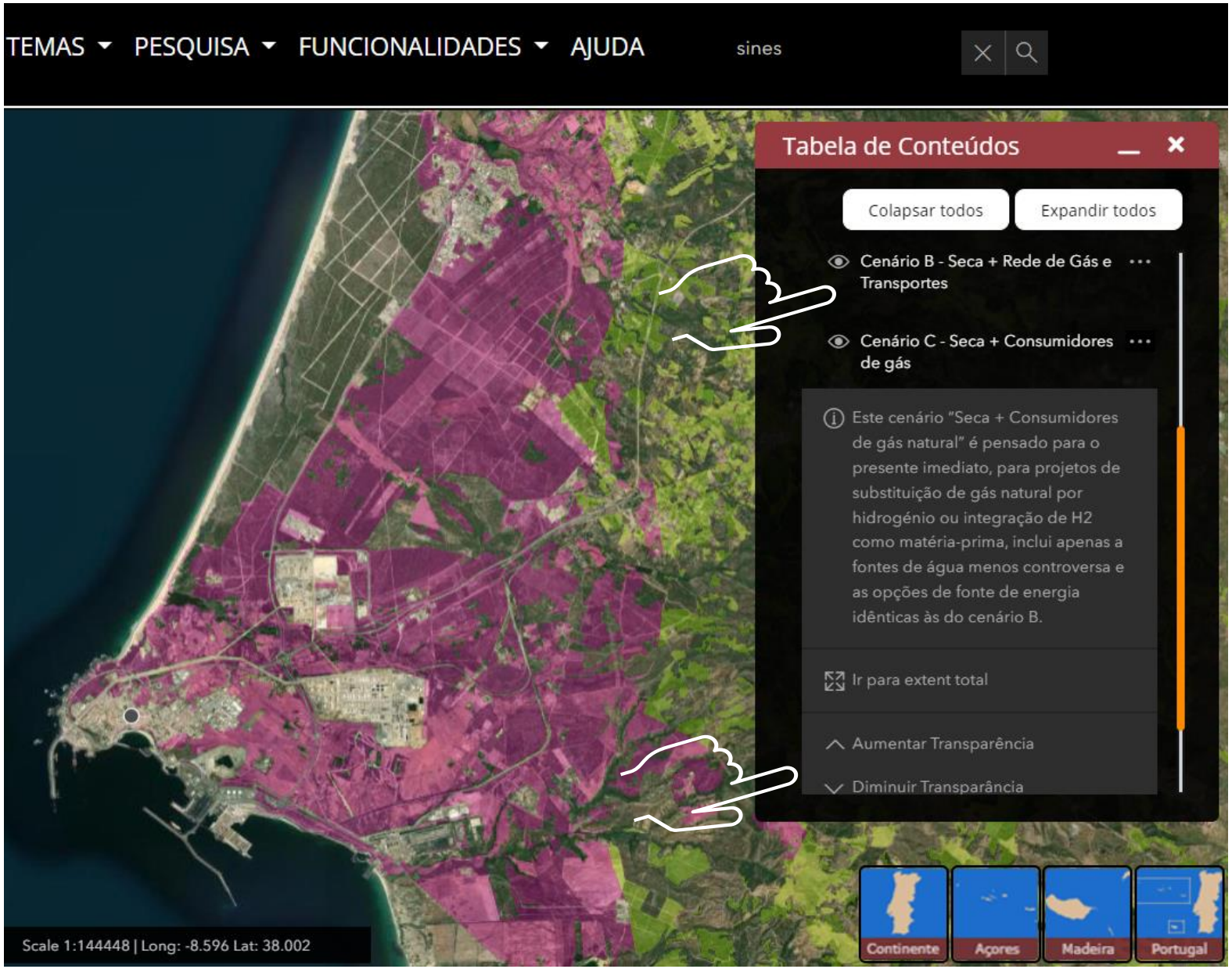


Compare Scenarios by turning on or off in the table of contents or

view the region of interest with the basemap (e.g. satellite image)



Get information on each of the Scenarios



Compare two Scenarios by increasing class transparency

Main Information Sources Used

Cartografia de Uso e Ocupação do Solo (COS)

Fan et al 2013, Global Patterns of Groundwater Table Depth, Science

Thank you!

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