Circularity in the O&G sector: the SEA LINES project

4th of November, 2020

ECOMONDO “Blue Growth sana e circolare nei mari italiani: esempi di circolarità nelle catene del valore marittime”

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About Sealines Start-Up Action

BLUEMED CALL FOR START UP ACTION

Grant number: 727453

Budget: 32.000 euro

Main Outcomes: 3 international workshops and final feasibility or case study.

Legal Representative: Italian Ministry of Economic Development

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11 partners; 5 Foreign Countries: Croatia, Cyprus, Greece, Egypt and Tunisia

Italian Ministry of Economic Development –DGS UNMIG; Rosetti Marino S.p.A., Basis Engineering; National Research Institute of Astronomy and Geophysics (NRIAG); Hellenic Hydrocarbon Resource Management (HHRM); Croatian Hydrocarbons Agency (AZU); Ministry of Transport, Communications and Works Department of Public Works –Republic of Cyprus; Ministry of Labour, Welfare and Social Insurance –Department of Labour Inspection – Republic of Cyprus; Ministry of Agriculture, Rural Development and Environment –Department of Environment –Republic of Cyprus; National Institute of Oceanography and Applied Geophysics (OGS); University of L’Aquila –Department of Industrial and Information Engineering and Economics; Institute National des Sciences et Technologies de la Mer (INSTM), Laboratoire Milieu Marin (LMM); Polytechnic of Turin, Department of Applied Science And Technology (DISAT); National Research Council –Institute of Marine Sciences –Institute of Marine Engineering (CNR-ISMAR;CNR-INM)
**SEALINES targets for BLUEMED challenges**

- Promotion of an **international offshore safety network**: **crosscutting action** for **international cooperation** between scientists, stakeholders, policy and decision-makers and civil society (Challenge A)

- **Definition of a case study**: governance of maritime space and marine resources in the Mediterranean (challenges E1, E2 and D1): on sustainable management and efficient use of sealines assuring transition from traditional maritime economic to blue growth activities

- Implementation of innovative methods and technologies for monitoring: understanding pollution impacts, mitigation and remediation in the Mediterranean Sea” and “Forecasting the Mediterranean Sea dynamics and climate” (challenges A2, B1)

- **Train for blue professionals**: high education program (challenges A4)
ABOUT SEALINES START-UP ACTION PROPOSAL

RETHINKING
Offshore Infrastructures
For energy transition

research hub for
an integrated green energy system: reusing Sealines for H2 storage and transport

Main objective: innovative solutions for reusing an inactive offshore gas platform and its associated infrastructures as a scientific research hub, where an integrated energy system and innovative environmental monitoring methods are envisaged.

Methods: study of the engineering solutions on a pilot case for the combined production of solar and wind energy coupled with hydrogen production from seawater electrolysis. The study analyzes the potential for storage and transport on land of the produced hydrogen using the sealines connected to the platform.
Definition of the pilot case

Ministerial Decree 15th February 2019

«establish both the list of platforms and related infrastructure in mining decommissioning that must be removed, and the list of platforms and related infrastructure that can be reused (art. 5) .. “interested companies may submit a feasibility study for the re-use of the platforms and related infrastructures” (art. 8)

<table>
<thead>
<tr>
<th>Center</th>
<th>Line name</th>
<th>Type</th>
<th>Fluid</th>
<th>Date</th>
<th>offshore Length (m)</th>
<th>Nominal diameter (”)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sealine 1</strong></td>
<td>Rubicone</td>
<td>Azalea 1-2 - Anemone Cluster</td>
<td>Rigid</td>
<td>GAS</td>
<td>1978</td>
<td>4580</td>
<td>6</td>
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<tr>
<td></td>
<td>Rubicone</td>
<td>Azalea 1-2 - Anemone Cluster</td>
<td>Rigid</td>
<td>GLICOLE</td>
<td>1978</td>
<td>4580</td>
<td>3</td>
</tr>
</tbody>
</table>

Technical Features
- Exploitation licences A.C8.ME
- bitubular (19*4 meters) platform installed in 1984 by ENI S.p.A.;
- gas extraction platform;
- 16 km from the coastline;
- height above sea level is 17 meters;
- seabed is 19 meters deep
- connected to the Rubicone central (Forlì-Cesena, Italy);
- platform is within the 12-mile limit
- pipe material: API 5LX52 (yield strength= 359 MPa)
# AVAILABLE RENEWABLE RESOURCES FOR AZALEA A PLATFORM

Summary table about the potential renewable resources around Azalea A platform (RSE, 2017)

<table>
<thead>
<tr>
<th>PLATFORM NAME</th>
<th>AZALEA A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerged part dimensions [m]</td>
<td>19*4</td>
</tr>
<tr>
<td>Height m a.s.l.</td>
<td>17</td>
</tr>
<tr>
<td>Distance from the shoreline [km]</td>
<td>16</td>
</tr>
<tr>
<td>Seabed depth [m]</td>
<td>19</td>
</tr>
</tbody>
</table>

## WIND RESOURCE

| Annual mean wind speed at 25 m a.s.l. [m/s] | 3.8 | Specific annual energy production at 25 m a.s.l. [MWh/MW] | 632 |
| Annual mean wind speed at 50 m a.s.l. [m/s] | 4.1 | Specific annual energy production at 50 m a.s.l. [MWh/MW] | 891 |
| Annual mean wind speed at 75 m a.s.l. [m/s] | 4.3 | Specific annual energy production at 75 m a.s.l. [MWh/MW] | 992 |
| Annual mean wind speed at 100 m a.s.l. [m/s] | 4.4 | Specific annual energy production at 100 m a.s.l. [MWh/MW] | 1083 |

## SOLAR RESOURCE

| Optimal tilt angle of PV plant [°] | 34 |
| Incident solar radiation on the horizontal plane [kWh/m²] | 1463 |
| Incident solar radiation on the plane with optimal tilt angle [kWh/m²] | 1681 |

## MARINE RESOURCE

| Annual mean power available from waves [kW/m/year] | 2.8 |
| Marine current power flow [W/m²] | 2.3 |
Executive Summary

Reuse options for Adriatic infrastructures are investigated.

Installation of wind turbines, solar panels and energy conversion by electrolysis for hydrogen production and storage (Energy HUB).

The investigated alternative solutions are the following:
**Case 1:** hybrid electric power generation exported to the nearby platform in operation

**Case 2:** Produced H₂ injected into the existing natural gas sealines.

**Case 3:** injection of the produced H₂ into the abandoned sealines and stored onshore

**Case 4:** injection of the produced H₂ into the abandoned sealines used as storage and transport facilities.
### Solar Energy

**Solar panel selection criteria**
- Available space: about 100 m²
- Module area: 1.6 m²
- Module allocations: 60 modules
- Module Peak power: 330 Wp

**Solar resource availability**
- Incident solar radiation on the plane: 1680 kWh/year/m² (with optimal tilt angle)

**Solar energy production**
- 168,000 kWh/year

**Electric power production**
- 33,600 kWh/year

### Wind Energy

**Turbine rated power selection**
- Deck available loading capacity: 300 kg/m² (60% of the design condition)
- Deck maximum load: 10 ton
- Wind turbine nominal power: 100 kW

**Wind energy availability**
- Average wind velocity of 4.3 m/s
- Turbine nacelle height of 75 m a.s.l
- Annual energy production: 992 MWh/MW

**Wind energy production**
- Electric power production: 99,200 kWh/year.

### Hydrogen Generation

**Technology Selection**
- Selected technology: Proton Exchange Membranes
- **Pros:**
  - Wide range of load,
  - Fast response to transient conditions,
  - H₂ production at higher pressure.

**Productivity**
- Productivity: 4.5 ± 7.5 kWh/Nm³ H₂
- Water consumption: 1 lt/Nm³ H₂

**Hydrogen Production**
- Available electric power of: 132,800 kWh/year
- H₂ Generation:
  - 27,700 Nm³/year H₂
  - About 2,200 kg/year
**CASE 1**

*Renewable electric power generation export to the nearby platform in operation*

**Photovoltaic:**
- Modules and reqd. Area: 60 x 330Wp/100 m²
- Electric power yield: 1,680 kWh/year/kWp
- Total installed peak power: 20 kWp
- Electric Power Production: 33,600 kWh/year
- Investment Costs: 0.1 M€

**Wind Turbine:**
- Installed Power: 100 kWp
- Running hours: 2,500 h/year
- Electric Power Production: 99,200 kWh/year

**Investment Costs:**
- Turbine: 0.2 M€
- BOP el.: 0.1 M€

**TOTAL Electric Power Production:** 130,000 kWh/year

**TOTAL Equip. INVESTMENT COSTS:** 0.4 M€

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**CASE 2**

*H₂ injection into the existing natural gas sealines*

**Hybrid Power Generation - Photovoltaic and Wind Turbine**

- Total Electric Power Production: 0.13 MWh/anno
- Power Gen. Investment Costs: 0.4 M€

**H₂ Conversion:**
- Electrolyzer
  - Installed Power: 100 kWp
  - Electrolyzer Yield: 6.7 kWh/Nm³ H₂

**H₂ Production:** 25,000 Nm³/year

**Investment Costs:**
- Electrolyzer: 0.3 M€
- Auxiliaries: 0.1 M€

**TOTAL Equip. INVESTMENT COSTS:** 0.8 M€

The produced H₂ is sold at the same price of the natural gas.
**CASE 3**

*H₂ inland transportation and onshore Storage*

Hybrid Power Generation by Photovoltaic and Wind Turbine as per Case 2

Total Electric Power Production: 130 MWh/year

H₂ Production: 25,000 Nm³/year

H₂ Storage: N°1 module, 12 bottles x 1.6 m³ each

Storage capacity/ Pressure: 19.2 m³/200 bar

*Investment Costs*

- Power Gen. and H₂ Conversion: 0.4 M€
- Storage and auxiliaries Investment Costs: 0.9 M€
- **TOTAL** 1.3 M€

**CASE 4**

*Existing pipelines as H₂ inland transportation and Storage*

Hybrid Power Generation by Photovoltaic and Wind Turbine as per Business Case 2 and 3

Total Electric Power Production: 130 MWh/year

H₂ Production: 25,000 Nm³/year

H₂ Storage: by existing sealines: 4850 m, DN 150 and 80 mm length: 4850 m

Total storage capacity: **100 m³**

*Investment Costs*

- Power Gen. and H₂ Conversion: 0.4 M€
- Storage and auxiliaries Investment Costs: 0.5 M€
- **TOTAL** 0.9 M€
AZALEA A - POTENTIAL FOR HYDROGEN STORAGE AND TRANSPORT

ASME Boiler & Pressure Vessel Code, section B31.1 sets:
- conditions for the design of piping systems;
- allowable stresses, quality factors, etc.;
- criteria for pressure design of piping components.

Equilibrium of pressure forces on the pipe wall:
- Internal pressure of gas (Hydrogen);
- External hydrostatic pressure from sea water.

Assumptions: fluid temperature inside the pipe equal to sea temperature (15°C)

\[ \sigma_{eq,\text{fluid+sea}} = \sigma_{eq,\text{fluid}} + \sigma_{eq,\text{sea}} \]

Maximum allowable pressure

\[ p_{\text{fluid,max}} = 330 \text{ bar} \quad \text{For 6 in. inner diameter pipe} \]
\[ p_{\text{fluid,max}} = 290 \text{ bar} \quad \text{For 3 in. inner diameter pipe} \]
AZALEA A – SCENARIOS OF HYDROGEN STORAGE in SEALINES

different scenarios for hydrogen storage: mass storable vs. storage pressure

Sealine 1

6 in. Inner diameter, 10.97 mm wall thickness, 4850 m length

Sealine 2

3 in. Inner diameter, 4.78 mm wall thickness, 4850 m length

Vapor region
Gas region

UPPER LIMIT 330

UPPER LIMIT 290
AZALEA A – SCENARIOS OF HYDROGEN TRANSPORT in SEALINES

Pressure drops evaluation along pipelines and correspondent hydraulic power needed

\[ \Delta p = f \cdot \frac{l}{D} \cdot \frac{\rho \cdot v^2}{2} \]

\[ P = Q \cdot \Delta p \]

**Sealine 1**

- Inner diameter: 6 in.
- Wall thickness: 10.97 mm
- Length: 4850 m

- Power required: 6 kW
- Pressure drops at 1 bar, 50 bar, and 330 bar

**Sealine 2**

- Inner diameter: 3 in.
- Wall thickness: 4.78 mm
- Length: 4850 m

- Power required: 3 kW
- Pressure drops at 1 bar, 50 bar, and 290 bar

6 in. Inner diameter, 10.97 mm wall thickness, 4850 m length.

3 in. Inner diameter, 4.78 mm wall thickness, 4850 m length.
The northern Adriatic is an area of intense maritime activities and overlapping uses of the sea (Barbanti et al., 2015). The northern Adriatic represents a hot spot of Mediterranean biodiversity (Giannoulaki et al., 2013).

Large maritime shipping produces a number of negative effects on the marine environment (ballast waters, pollution and oil spill, collision, noise and habitat degradation) that require to be monitored.

Historical seismicity and Tsunamis

Monitoring the marine environment and geo-hazard near the platform Azalea A plays an important role during both the decommissioning and reuse phases.

Environmental and geological framework

How a SEALINE is monitored before and after deployment?

Traditional monitoring survey: sampling of sediment for: grain size, T, pH, Eh, heavy metals concentrations (Al, As, Cd, Cr, Hg, Ni, Pb, Cu, Zn), TOC, N, P; heavy (C<12) and light (C<12) hydrocarbons, PHAs, pesticides, PCBs; microbiology tests; abundance and biodiversity of the macrozoobenthos (ecological health, AMBI index).
Innovative Monitoring of Hydrocarbons Seepage and Leakage

**UPH20 chemical sensor** installed on board an autonomous **underwater vehicle (AUV)**.

This sensor uses **Lab-On a-Chip microfluidic technologies** for fluid and flow management in situ analysis of the water samples.

**Remote operated vehicle (ROV) e-URoPe (e-Underwater Robotic Pet)** equipped with geophysical and geochemical sensors, which would enable high resolution and space and time repeatability of the underwater measurements.

**Acoustic reconstruction** of both the underwater environment and maintenance status of the decommissioned infrastructure, including the sealines, using multibeam sonar technology.
Communication and Dissemination

- 3 international stakeholder meetings
- Sealines @Ecomondo 2019
- Sealines @Ecomondo 2020
- Sealines on Twitter @sealinesA
- News on linkedin: MISE account
- WEBINAR IN JUNE 2020
Conclusions

1. Existing offshore infrastructures may provide added value in exploiting renewable energy generation (132,800 kWh/year by renewable may produce 27,700 Nm3/year of H2 in safe conditions);

2. Innovative approach to test a possible reuse of an oil and gas platform as a research hub to integrate and test a renewable energies offshore system (also ancillaries facilities as the sealines)

3. Existing sealines for transport and storage of pure H2 produced by renewable energy is technically and economically feasible (for Sealines type 1 the upper limit of 330 bar correspond to to a 23 kg/m3 H2 density and 1852 kg H2 stored).

4. H2 transportation and storage using the existing sealines results the most convenient scenario (about 0.9 Meuro);

5. Application of innovative technological solutions for monitoring environment and geohazard represent a new opportunity to guarantee safety condition and to prevent environmental impacts.

6. Indirect benefits: companies reputation supporting energy transition policies;

7. The proposal represents a positive example of “Blue Economy”;
Thanks for your attention!

Feasibility study is available at:

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