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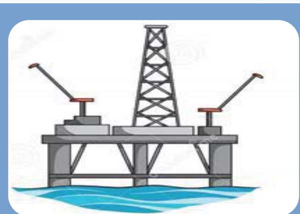
11 partners; **5 Foreign Countries:** *Croatia, Cyprus, Greece , Egypt and Tunisia*

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 (c**hallenges 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)**

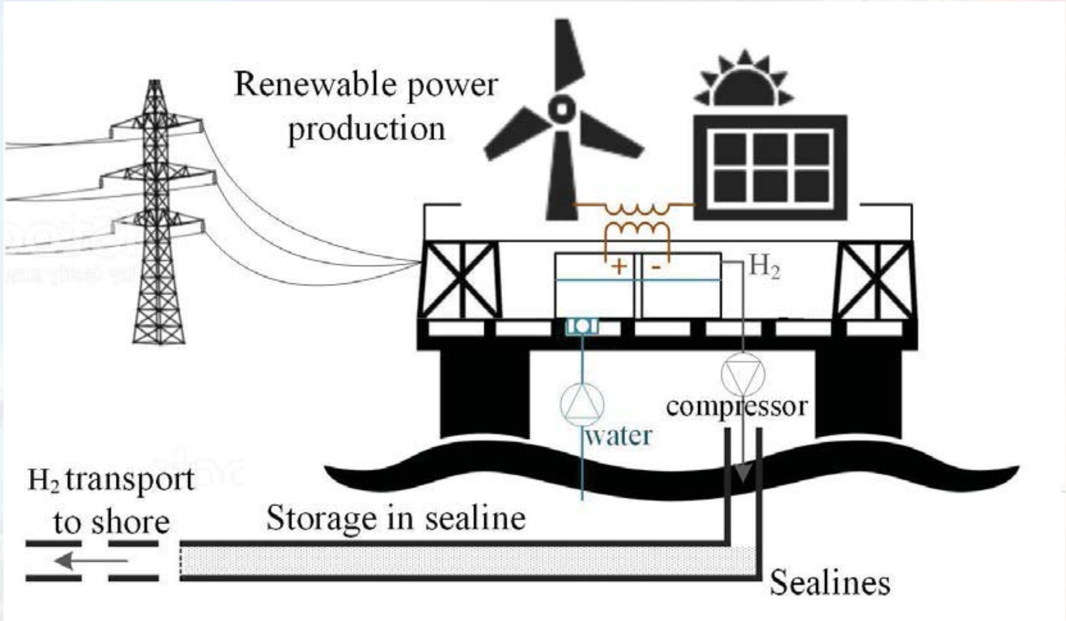
ABOUT SEALINES START-UP ACTION PROPOSAL

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)

AZALEA A	A.C8.ME	Lat. 44,171769 N Long. 12,714258 E	Bitubolare a portale	NO	SI
PC 73	PORTO CORSINI MARE	Lat. 44,385037 N Long. 12,579101 E	Monotubolare	NO	SI

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)

	Center	*Line name*	*Type*	*Fluid*	*Date*	offshore Length (m)	*Nominal diameter (")*	*Thickness (mm)*
Sealine 1	Rubicone	Azalea 1-2 - Anemone Cluster	Rigid	GAS	1978	4580	6	10.97
Sealine 2	Rubicone	Azalea 1-2 - Anemone Cluster	Rigid	GLICOLE	1978	4580	3	4.78

AVAILABLE RENEWABLE RESOURCES FOR AZALEA A PLATFORM

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

PLATFORM NAME	AZALEA A		
Emerged part dimensions [m]	19*4		
Height m a.s.l.	17		
Distance from the shoreline [km]	16		
Seabed depth [m]	19		
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

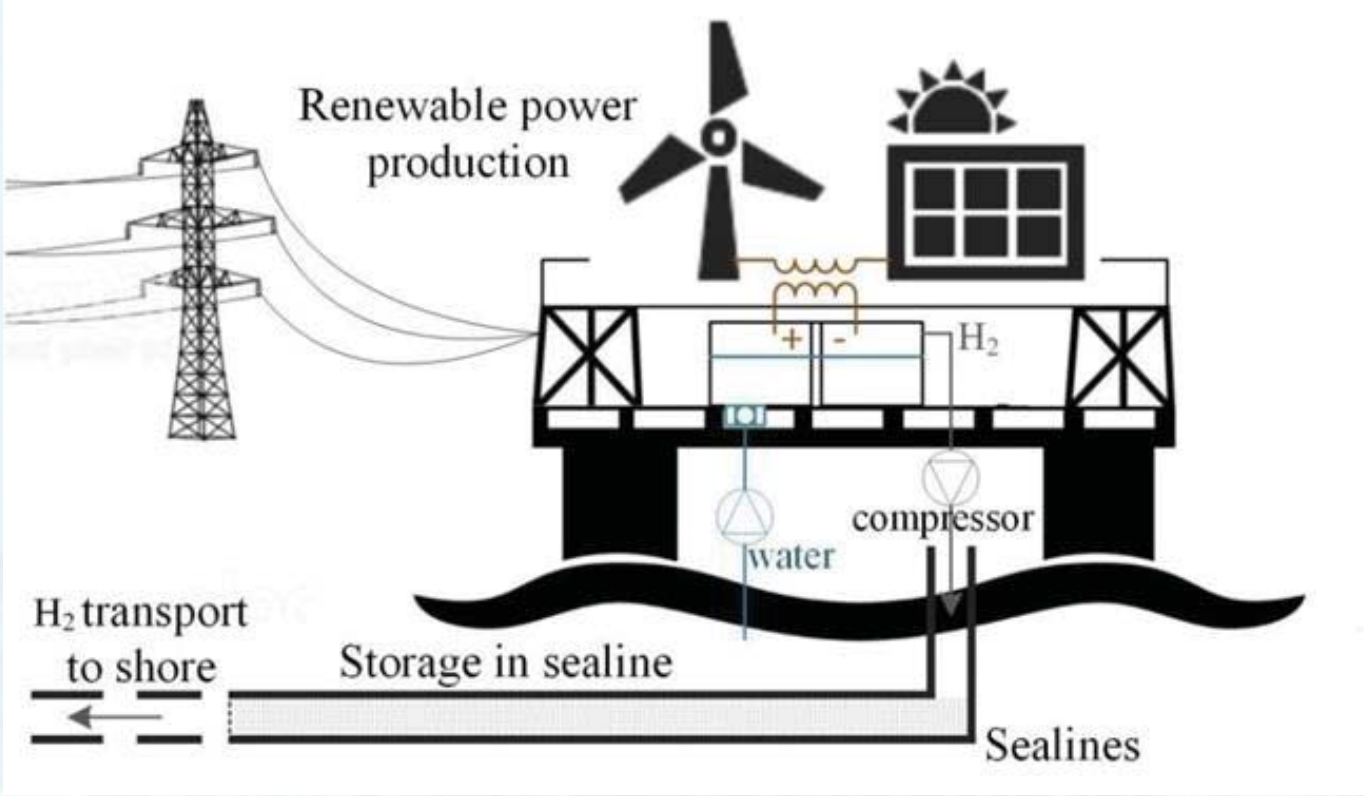
Reuse options for Adriatic infrastructures are investigated.

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 H_2 injected into the existing natural gas sealines.



Case 3: injection of the produced H_2 into the abandoned sealines and stored onshore

Case 4: injection of the produced H_2 into the abandoned sealines used as storage and transport facilities.

Basis of Design of the Case Studies

Solar Energy

Solar panel selection criteria

Available space : about 100 m^2

Module area: 1.6 m^2

Module allocations: 60 modules

Module Peak power: 330 Wp

Solar resource availability

Incident solar radiation on the plane

1680 kWh/year/m^2
(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/m^2

(60% of the design condition)

Deck maximum load: 10 ton

Wind turbine nominal power: 100kW

Wind energy availability

- average wind velocity of 4.3 m/s
- turbine nacelle height of 75 mt 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,
H_2 production at higher pressure.

Productivity

Productivity 4.5 ÷7.5 kWh/Nm^3 H_2

Water consumption: 1 lt/Nm^3 H_2

Hydrogen Production

Available electric power of: **132,800 kWh/year,**

H_2 Generation: 27,700 Nm^3/year H_2
about 2,200 kg/year

CASE 1
Renewable electric power generation export to the nearby platform in operation

Photovoltaic:
Modules and rqd. Area: 60 x 330Wp/100 m^2
Electric power yeld: 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€***

CASE 2
H_2 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€

H_2 Conversion:
Electrolyzer
Installed Power: 100 kWp Electrolyzer Yeld: 6.7 kWh/Nm^3 H_2

H_2 Production: ***25,000 Nm^3/year***

Investment Costs:
Electrolyzer: 0.3 M€
Auxyliaries: 0.1 M€
TOTAL Equip. INVESTMENT COSTS: ***0.8 M€***

The produced H_2 is sold at the same price of the natural gas

CASE 3
H_2 inland transportation and onshore Storage

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

Total Electric Power Production: 130 MWh/year

H_2 Production: 25,000 Nm^3/year

H_2 Storage : N˚1 module, 12 bottles x 1.6 m^3 each
Storage capacity/ Pressure: 19.2 m^3/200 bar

Investment Costs
Power Gen. and H_2 Conversion: 0.4 M€
Storage and auxiliaries Investment Costs: 0.9 M€
TOTAL **1.3 M€**

CASE 4
Existing pipelines as H_2 inland transportation and Storage

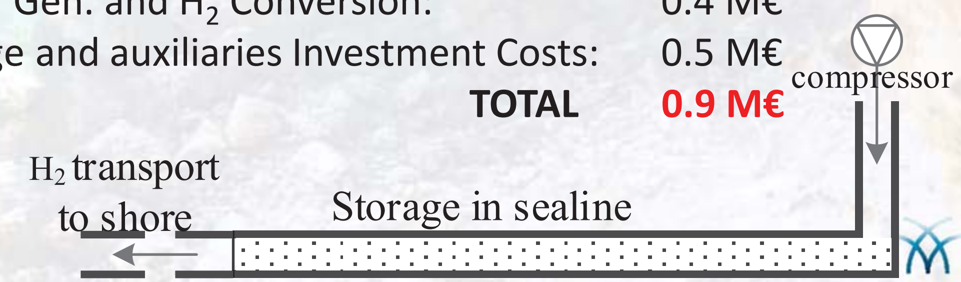
Hybrid Power Generation by Photovoltaic and Wind Turbine as per Business Case 2 and 3

Total Electric Power Production: 130 MWh/year

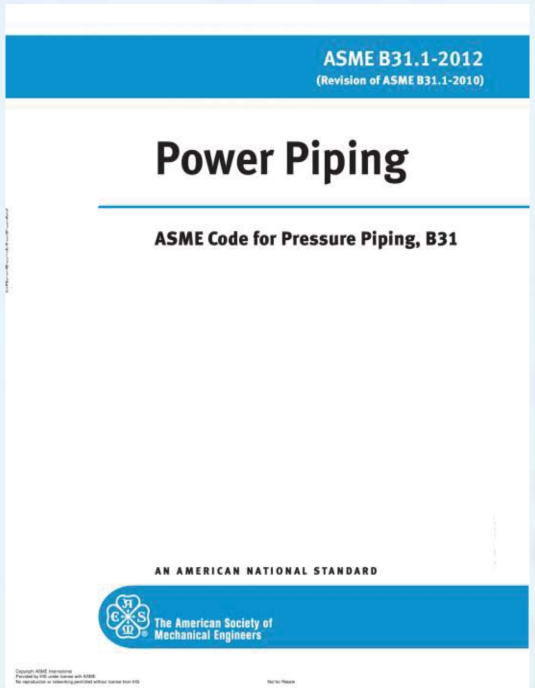
H_2 Production: 25,000 Nm^3/year

H_2 Storage: by existing sealines: 4850 m,
DN 150 and 80 mm
length: 4850 m
Total storage capacity: **100 m^3**

Investment Costs
Power Gen. and H_2 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 B31.1-2012
(Revision of ASME B31.1-2010)

Power Piping

ASME Code for Pressure Piping, B31

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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.

$$\sigma_{eq,fluid+sea} = \sigma_{eq,fluid} + \sigma_{eq,sea}$$

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

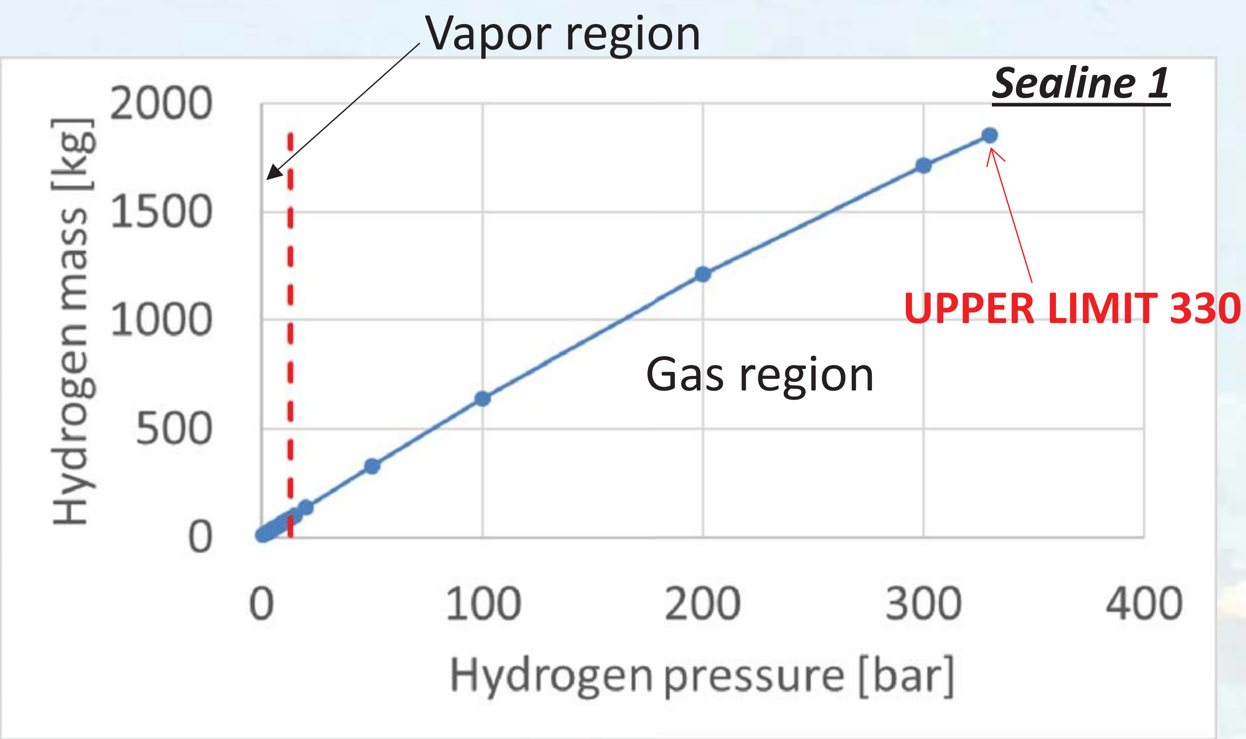
$$\sigma_{eq,fluid+sea} \leq \frac{\sigma_{yield,API5LX52}}{SF}$$

Maximum allowable pressure	$p_{fluid,max} = 330\ bar$	*For 6 in. inner diameter pipe*
	$p_{fluid,max} = 290\ bar$	*For 3 in. inner diameter pipe*

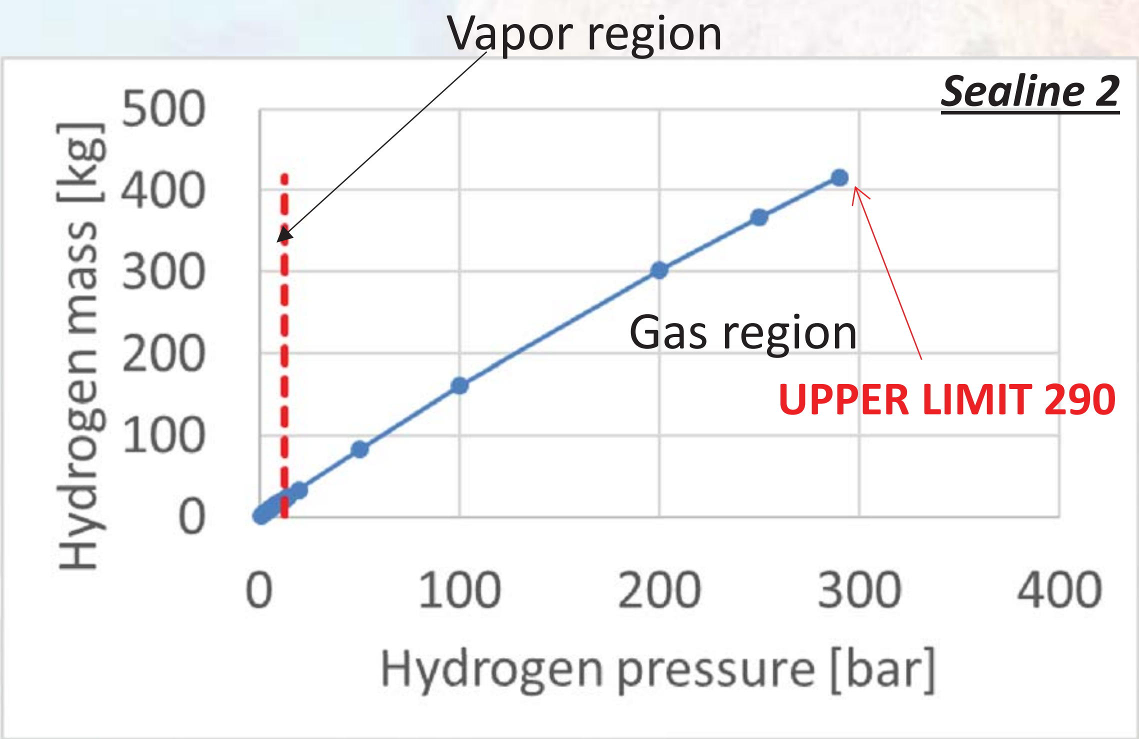
Footnote

AZALEA A – SCENARIOS OF HYDROGEN STORAGE in SEALINES

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



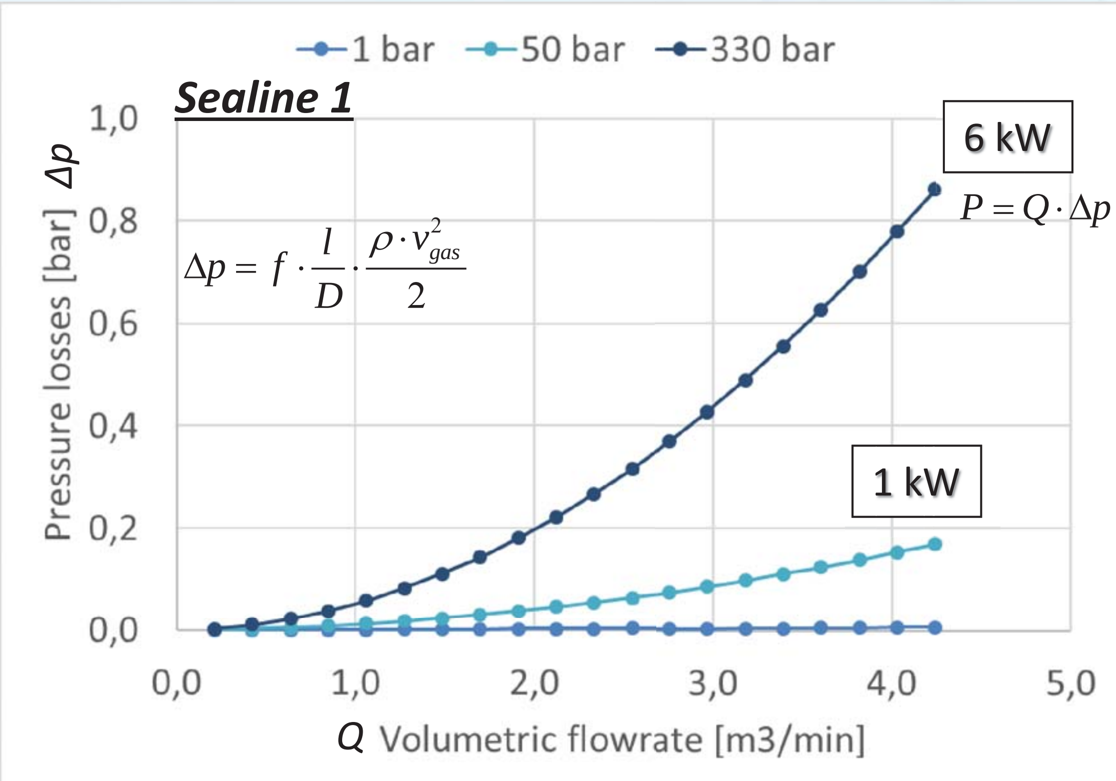
6 in. Inner diameter, 10.97 mm wall thickness, 4850 m length

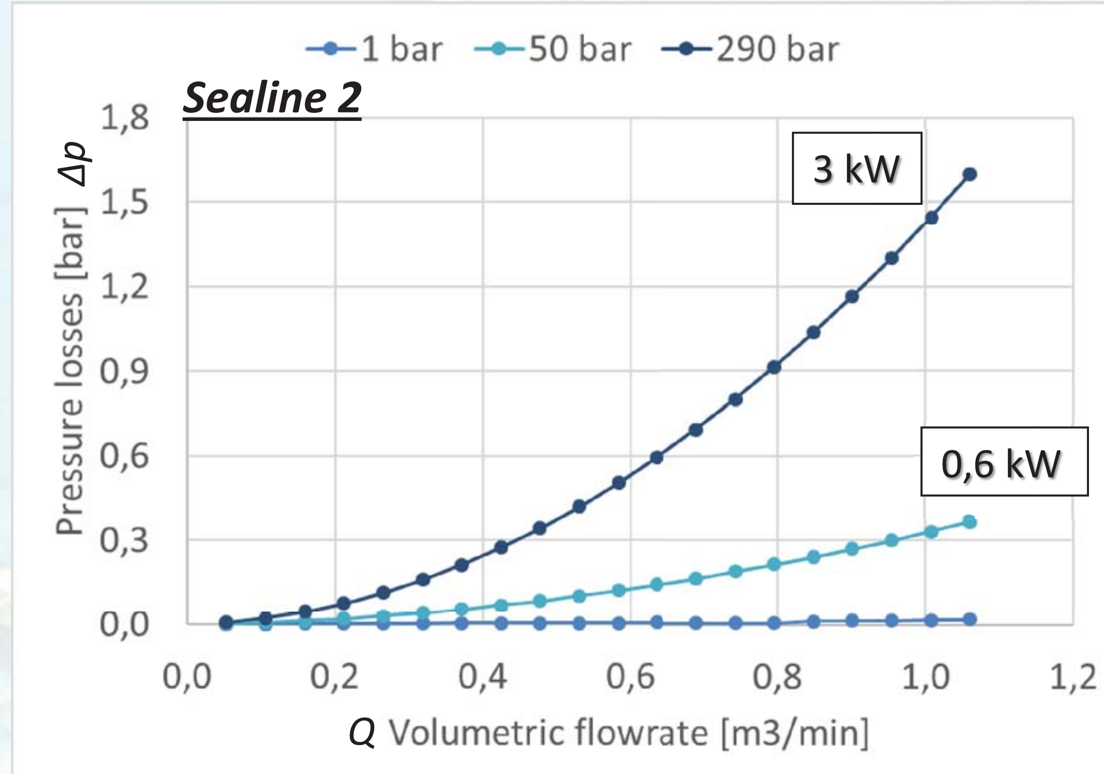


3 in. Inner diameter, 4.78 mm wall thickness 4850 m length

AZALEA A – SCENARIOS OF HYDROGEN TRANSPORT in SEALINES

Pressure drops evaluation along pipelines and correspondent hydraulic power needed



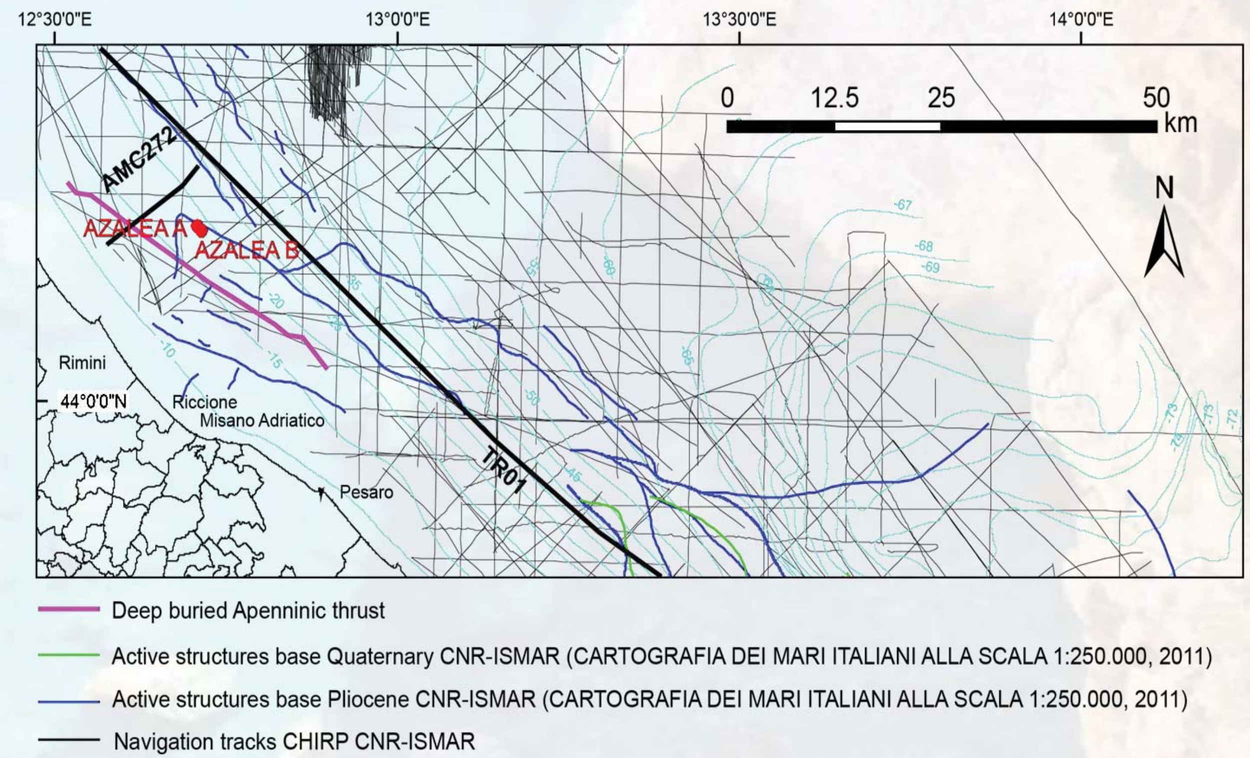


6 in. Inner diameter, 10.97 mm wall thickness, 4850 m length.

3 in. Inner diameter, 4,78 mm wall thickness 4850 m length

Environmental and geological framework

- *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*

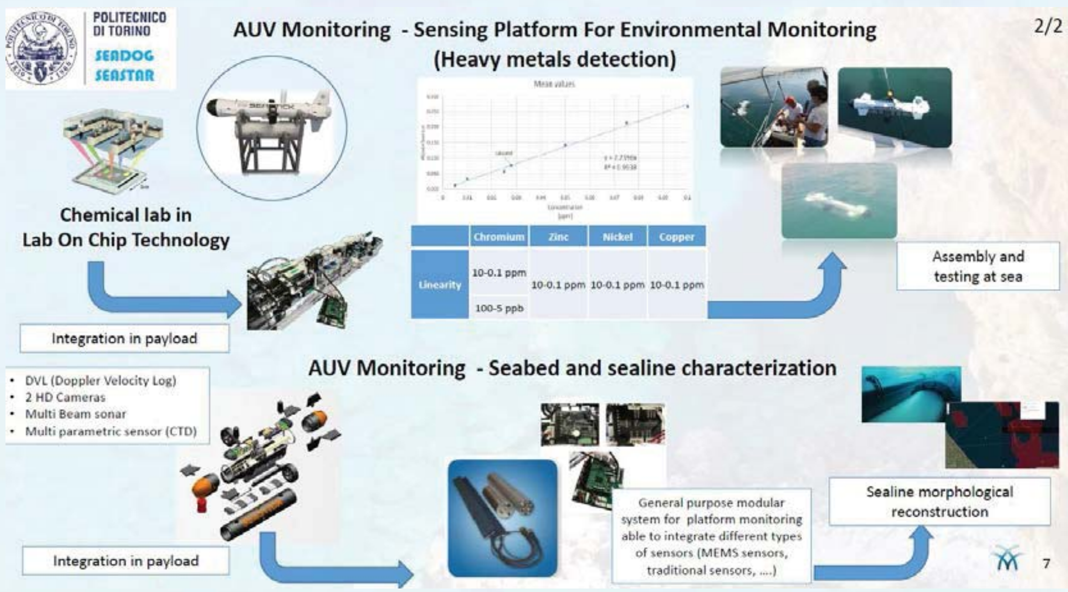


How a SEALINE is monitored before and after deployment?

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

UPH2O 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

Remotely operated vehicle (ROV) e-URoPe (e-Underwater Robotic Pet) equipped w**ith 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**
- **Feasibility study: http://www.bluemed-initiative.eu/wp content/uploads/2020/06/SEALINES-FEASIBILITY-STUDY-1.pdf**
- **Sealines @Ecomondo 2019**
- **Sealines @Ecomondo 2020**
- **Sealines on Twitter @sealinesA**
- **News on linkedin: MISE account**
- **WEBINAR IN JUNE 2020**
- Guidebook **https://unmig.mise.gov.it/images/sealines-bluemed-ecomondo2020.pdf**
- **Scientific Paper in press on** *Environmental Engineering Management Journal , Vol. 10*

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 conditio****n 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:
http://www.bluemed-initiative.eu/wp-content/uploads/2020/06/SEALINES-FEASIBILITY-STUDY-1.pdf

More info on BlueMed Start-up Actions
at http://www.bluemed-initiative.eu/the-startup-actions/
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