Gruppo CLAS 40 1975 2015

POSEIDON-MED

Feasibility study for LNG use in the port of Trieste

Activities 7.1 and 7.2

October 2015

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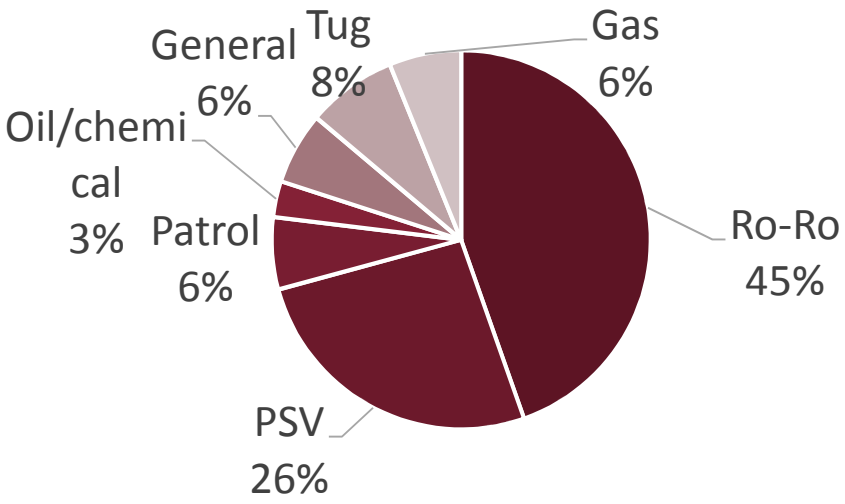
CONTENTS OF THE STUDY

1- ANALYSIS OF THE LNG DEMAND

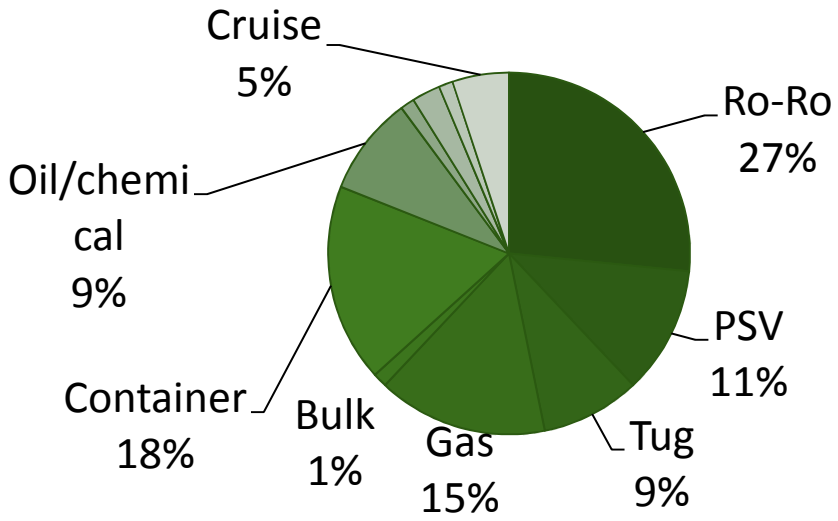
ANALYSIS OF THE LNG DEMAND

Current demand and fleet consistency at global level

The fleet of LNG-powered ships mainly includes Ro-Ro and Ro-Pax and units used in the services of supply to offshore platforms (Platform supply vessel). In June 2015 there were 65 LNG-powered ships. The number will double in a very short period, surpassing 120 units in 2017.
About 81% of the fleet currently in use is in Norway.



LNG fleet (June 2015)



Orders 2015-2020 (July 2015)

Maritime transport of rolling stocks has progressively grown in the port of Trieste in last years, with an average annual variation of 3.6% between 2005 and 2014.

Main sources: DNV-GL, Italian Ministry of Economic Development, Assoporti, Wärtsilä

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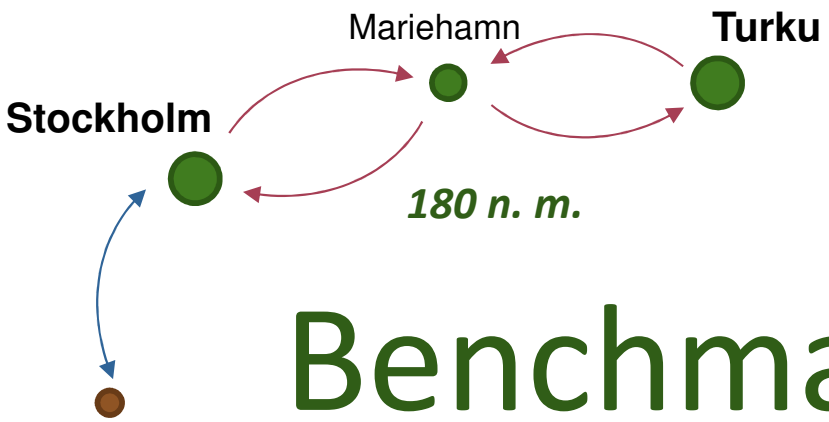
ANALYSIS OF THE LNG DEMAND

Best practice-maritime transport

An interesting case of benchmarking is the Viking Line ferry service with its Viking Grace vessel, first world Ro – pax vessel fueled with LNG. It began its service in 2013 and currently has been operating on the route between Turku, Aland Island (ports of Mariehamn and Långnäs) and Stockholm (180 nautical miles).
Viking Grace consumes between 45 and 60 metric tons of LNG every 24 hours and the supply takes place in Stock-holm port daily, with Seagas ship, which has 77 LNG ton storage capacity, equivalent to 187 cubic meters. In 2014 the total consumption of LNG Viking Grace ferry was 15,951 tons, an average supply of 43 tonnes per day (126 cubic meters). As per time-table set out, Viking Grace makes a complete service turnaround within 24 hours, with only three hours of stop.



Stockholm	Mariehamn	Turku	Långnäs	Stockolm
07:45	14:10			
	14:25	19:50		
		20:55	01:05	
			01:20	06:30
	24 hour roundtrip			**07:45**

Benchmark!

Suitable to be implemented in other contexts and routes, e.g. between Trieste and the ports of Greece and Turkey

Main sources: Viking Line, Port Authority of Stockholm, Wärtsilä

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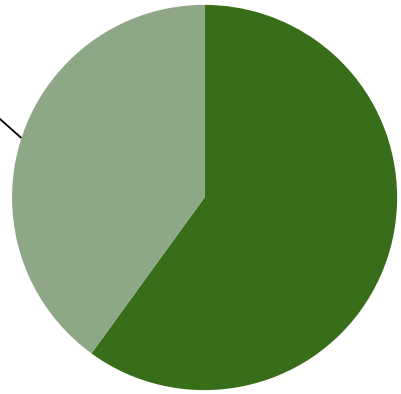
ANALYSIS OF THE LNG DEMAND

Potential demand for the port of Trieste-maritime side

The 2011 Port Master Plan estimated a growth of Ro - Ro freight up to 10.5 million tons in 2020 (with 6% average annual growth in the period 1998 to 2020). A proportion of traffic carried by Ro - pax of 1.3 million tons in 2020 has to be added. The Master Plan of Trieste Port points out that traffic Ro - Ro and Ro - pax represents approximately 40% of the annual ships in the port.

Sea distances fromTrieste in nautical miles			
Durres	425	Ambarli	1.137
Patras	604	Istanbul	1.152
Igoumenitsa	480	Izmir	1.000
Ancona	128	Mersin	1.320

Traffic composition in the port of Trieste



Durres
Patras
Igoumenitsa
Ancona
Istanbul/ Pendik
Ambarli
Cesme/ Izmir
Mersin

Ro-Ro traffic

is very suitable for the introduction of LNG as a propulsion system, due to the certainty of the demand, to the possibility of regular bunkering, to the not very high length of the trips normally covered by the vessels

5,600-11,203 Tons

Potential demand of LNG per year in 2020, 5%-10% of the entire fleet, assuming a need of 50 tons of LNG per ship moored

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ANALYSIS OF THE LNG DEMAND

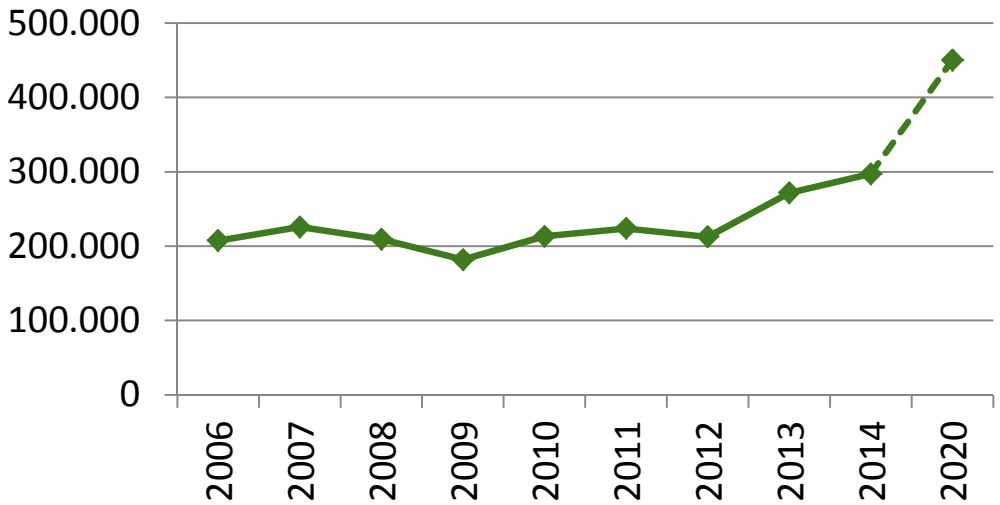
Potential demand for the port of Trieste-land side

The offer of LNG -powered road vehicles is still very limited and refers to some models of trucks and buses produced by Iveco, Scania and Mercedes. Several studies have proved **the economic profitability** of the LNG technology if compared with traditional road vehicles.
The European Agency for the Cooperation of Energy Regulators (ACER) has estimated that LNG technology applied in freight transport sector could reach a share of between 5% and 10% of the fleet in Europe over the next 10 years. . In the case of Trieste that would mean 22,500 or 45,000 vehicles a year in 2020.

Iveco Stralis Hi Road LNG

LNG tank 185 kg
Max. output, kW (hp) 243 (330)

Trucks on Ro –Ro in the port of Trieste



4,275-8,550 Tons

Potential demand of LNG per year in 2020, 5%-10% of the entire fleet, considering heavy vehicles with a storage capacity of 190 kg per vehicle

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ANALYSIS OF THE LNG DEMAND

Current demand and fleet consistency at global level

According to analysis, the potential demand for LNG in the port of Trieste varies from a minimum of 15 tons to a maximum of 31 tons per day if referred to Ro- Ro and Ro- pax vessels. In a “conservative scenario” this means an LNG -powered ship moored in the port every 3 days. In the “non conservative scenario” it is envisaged a mooring every 36 hours. For the road transport, the highest potential demand for LNG reaches 8,550 tons per year. In conclusion aggregating the information presented above, it is possible to estimate a potential demand for LNG in the port of Trieste from a minimum of 27 tons to a maximum of 54 tons per day by 2020.

Potential LNG demand estimation for Ro-Ro services	
TOTAL ARRIVING AND DEPARTING SHIPS (2014)	3.949
RO-RO SHIPS (40%)	1579
ANNUAL GROWTH RATE RO-RO TRAFFIC 2014-2020	6%
PENETRATION RATE AT 2020 (CONSERVATIVE)	5%
PENETRATION RATE AT 2020 (HIGH SCENARIO)	10%
LNG NEEDS PER SHIP (ton)	50

Potential LNG demand estimation in Road truck transport sector	
YEARLY TRUCKS AT 2020	450.000
PENETRATION RATE AT 2020 (CONSERVATIVE)	5%
PENETRATION RATE AT 2020 (HIGH SCENARIO)	10%
CAPACITY PER VEHICLE (Kg)	190

9,877

Tons per year

Conservative scenario

19,753

Tons per year

High scenario

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2- ANALYSIS OF THE LNG SUPPLY CHAIN

ANALYSIS OF THE LNG SUPPLY CHAIN

Study of the supply chain as a whole

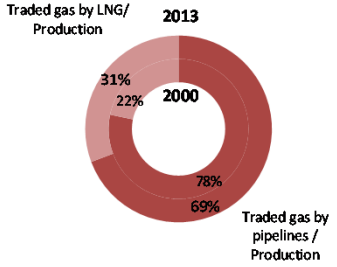
Extraction and production

Natural gas is extracted in areas with large reserves. First three countries with natural gas reserves have more than 50% of world reserve. Russia is among these three, with 24.4% of reserve. Approximately 78% of reserves are controlled by state owned companies (so-called National oil companies). Once extracted, gas is treated in order to separate methane from other gaseous hydrocarbons (propane, butane and ethane). It can also be cleaned from harmful substances such as sulfur and sulfur dioxide. Gas is then traded through pipelines of liquefied.

Liquefaction allows the transportation of gas when this is not possible by pipelines. The share of gas traded through LNG has gradually increased in re-cent years.

Gas reserves: main Countries (billion of cubic meters, December 2014)	
Russia	49.541
Iran	33.948
Qatar	24.936
World (Total)	202.758

Gas trade and transport

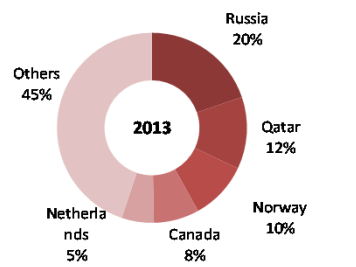


Liquefaction

Natural gas is liquefied through a series of processes of cooling and condensation. Gas is stored and can be transported in conditions of appropriate temperature, approximately -160°C. Its volume is reduced by 600 times with the process of liquefying. In 2014 the capacity of world liquefaction amounted to 298 million tons per year, 383.9 billion cubic meters. 63% of liquefaction plants are concentrated in Middle East and Africa, with Qatar leading country for potential (77 million tons /year). Within 2020 new liquefaction plants will be effective, especially in Australia and United States, due to the development of unconventional gas fields (the so-called "shale gas") that between turn United States from an importer to potential natural gas exporter.

Liquefaction capacity: main Countries (billion of cubic meters, December 2014)	
Qatar	104,8
Indonesia	43,2
Australia	35,0
World (Total)	383,9

Main export Countries (2013)

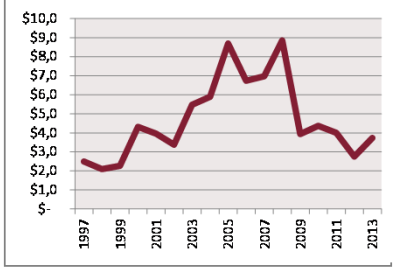


Sea transport

LNG is transported by ships equipped with tanks for the storage of liquid and its cooling. An LNG ship carries an average of 130,000 cubic meters of liquefied natural gas corresponding to 78 million cubic meters of gaseous state. In 2014 there were 395 ships in operation and orders for other 148 units. About 27% of the total movement is on spot basis. Vessels used in this sector have gradually been growing, up to class Q - Max. In 2014, 245 million tons of LNG was transported by ship, with an increase of 2% over 2013. Trade concentrated among 30 importing and 16 exporting countries. Commercial dynamics are also determined by the price of oil, from which also the LNG supply contracts are released.

Technical characteristics of ships class Q-Max	
Length	345 m
Widht	55 m
Draft	-12,5 m
Loading Capacity	266.000 m^3

Gas price ($ per MMBtu)*

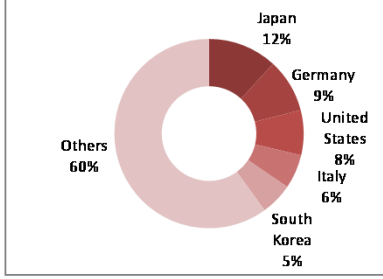


Regasification

Current worldwide regasification capacity is equal to approximately 1,000 billion cubic meters. More than 50% is concentrated in Asia. In United States due to the development of shale gas and to gradual transformation of the Country to net exporter and producer, projects of conversion for many of regasification plants to liquefaction terminals are foreseen. The geography of trade of LNG reflects the potential in terms of regasification plants. Worldwide regasification capacity is more than double than liquefaction, 904 billion cubic meters. In Europe, operational plants are effective for 199.7 billion cubic meters, and main countries are Spain (62 billion) and UK (52 billion). Natural gas, once back to gaseous phase, it is put in market network, to satisfy final consumption (energy production, household consumption, transport, industry).

Regasification: main Countries (billion of cubic meters, December 2014)	
Japan	259,2
United States	174,5
South Korea	100,4
World (Total)	904,4

Main import Countries (2013)



Part of the study was devoted to the description of the supply chain of the LNG as a whole, pointing out its main characteristics, from the production to the rigasification. Alongside the pipeline there are three large regasification plants for LNG imports in Italy: Panigallia, Rovigo, Livorno.

Main sources: Sources: Gruppo CLAS analysis on ENI, Clarkson Research, BRS group, Eia US Energy Information Admin.

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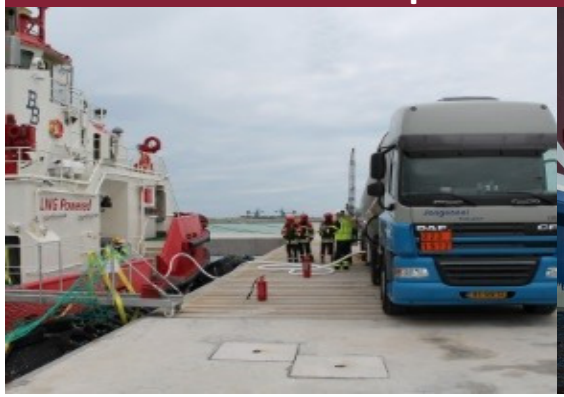
ANALYSIS OF THE LNG SUPPLY CHAIN

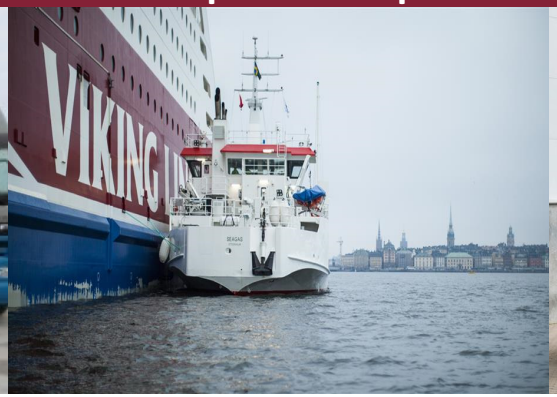
Possible bunkering systems

In general, several aspects have to be considered for the placement of an LNG terminal within a port such as the *depth* of the waters and their dredging, the characteristics of the *land surface* and the relative stability of the areas were storage tanks are located, the *possible connections* for the supply of the gas (pipelines, trucks, barges), the need for *vaporizing equipment*.
In any case **the amount of potential annual demand** is the most critical parameter for the measurement and the installation of an LNG supply station inside the port area.

Truck – To – Ship



Ship– To – Ship



Mobile tank/ISO Container

Shore To Ship

4 alternatives

Are considered as possible solutions for the realization of a bunkering station in the port of Trieste

Main sources: Italian Ministry of Economic Development

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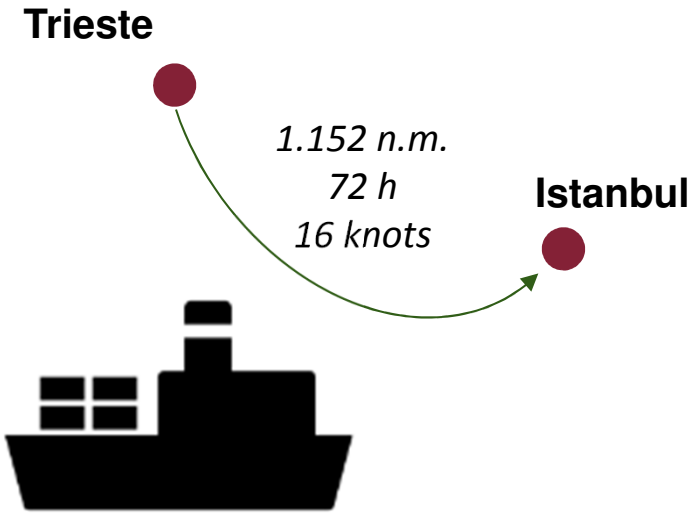
3- LNG SOLUTIONS FOR THE PORT OF TRIESTE

LNG SOLUTIONS FOR THE PORT OF TRIESTE

The LNG supply chain at the port of Trieste

As stated above, the Ro-Ro industry is the main market for the LNG in the maritime transport. The construction of a new LNG vessel or the conversion of a ship currently operating between Trieste and the ports of Turkey could be a concrete hypothesis in a medium/long term (2020-2025). The same solution adopted by Viking Lines and by the Port of Stockholm represents the reference benchmark.



Storage capacity: 160 Tons LNG
Consumption: 2 tons / hour

2 bunkering operations per roundtrip

One in the port of departure and one in the port of arrival. This amounts to 144 tons of LNG consumed per route, 288 tons for the entire roundtrip (Istanbul-Trieste-Istanbul). The port of Trieste should ensure the availability of at least 144 tons every 3 days.

Downstream

- 5 trucks with a capacity of 30 ton each
- 2 barges with a delivering capacity of at least 70 ton
- A LNG bunker station with a capacity of at least 150 tons
- 5 tankers with a capacity of 30 ton each

Upstream

- Barges from Rovigo
- Tanker/barges from other North Adriatic ports
- Directly through tank ships

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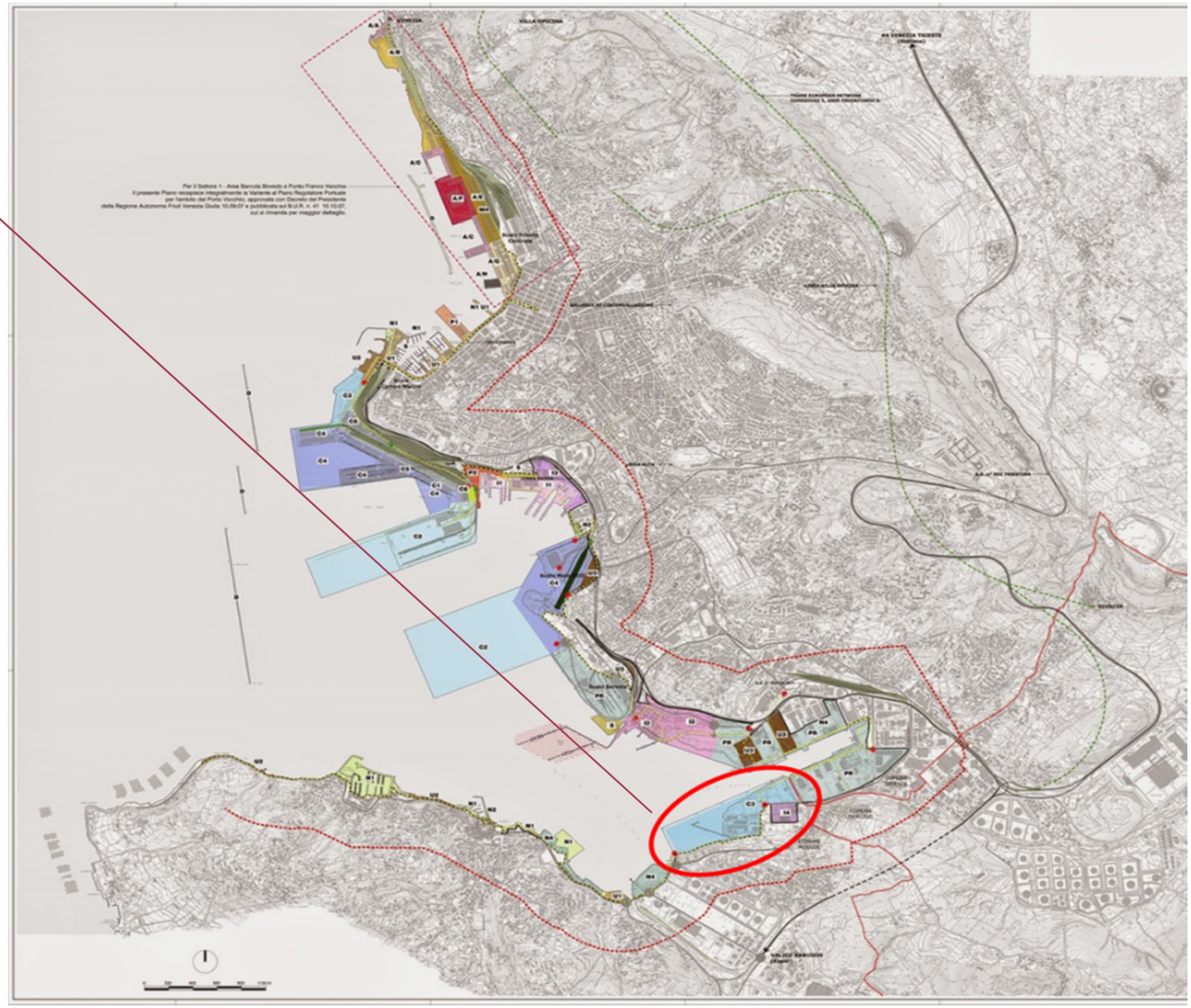
LNG SOLUTIONS FOR THE PORT OF TRIESTE

The LNG supply chain at the port of Trieste

A preliminary analysis, shows that an LNG bunkering station could be located close to the new Ro-Ro terminal.
This could be placed near the road gates of the port, in order to allow its use from private cars, public transport buses, or even LNG trucks needing a refuel.
In the long run this bunkering station could exploit the existing silos located in the backyard area as a storage facilities.



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THANK YOU VERY MUCH

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