Interreg
EUROPEAN UNION
Danube Transnational Programme
GRENDEL

Concept and technical solutions using LNG as fuel for river shipping on the Danube

SHIP DESIGN GROUP (SDG)

W2GAS – Waste-To-Compost and Green Energy
2nd Know-how-Event
26th of November 2020

Project co-funded by European Union Funds (ERDF, IPA)

The GRENDEL project

An EU-funded project supporting the Danube vessel operators and public counterparts towards the modernization of the inland waterway transportation system.

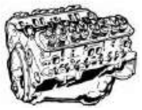
Tackles low carbon and alternative fuels, reduction of air pollutants, improvement in energy efficiency, transport & logistics management and development of regulatory frameworks and public support measures via state aid schemes.

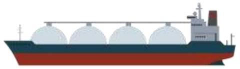
Project partners include several Romanian and Austrian private and public actors, as well as representatives of other riparian countries.

Is in line with the European Green Deal objectives.

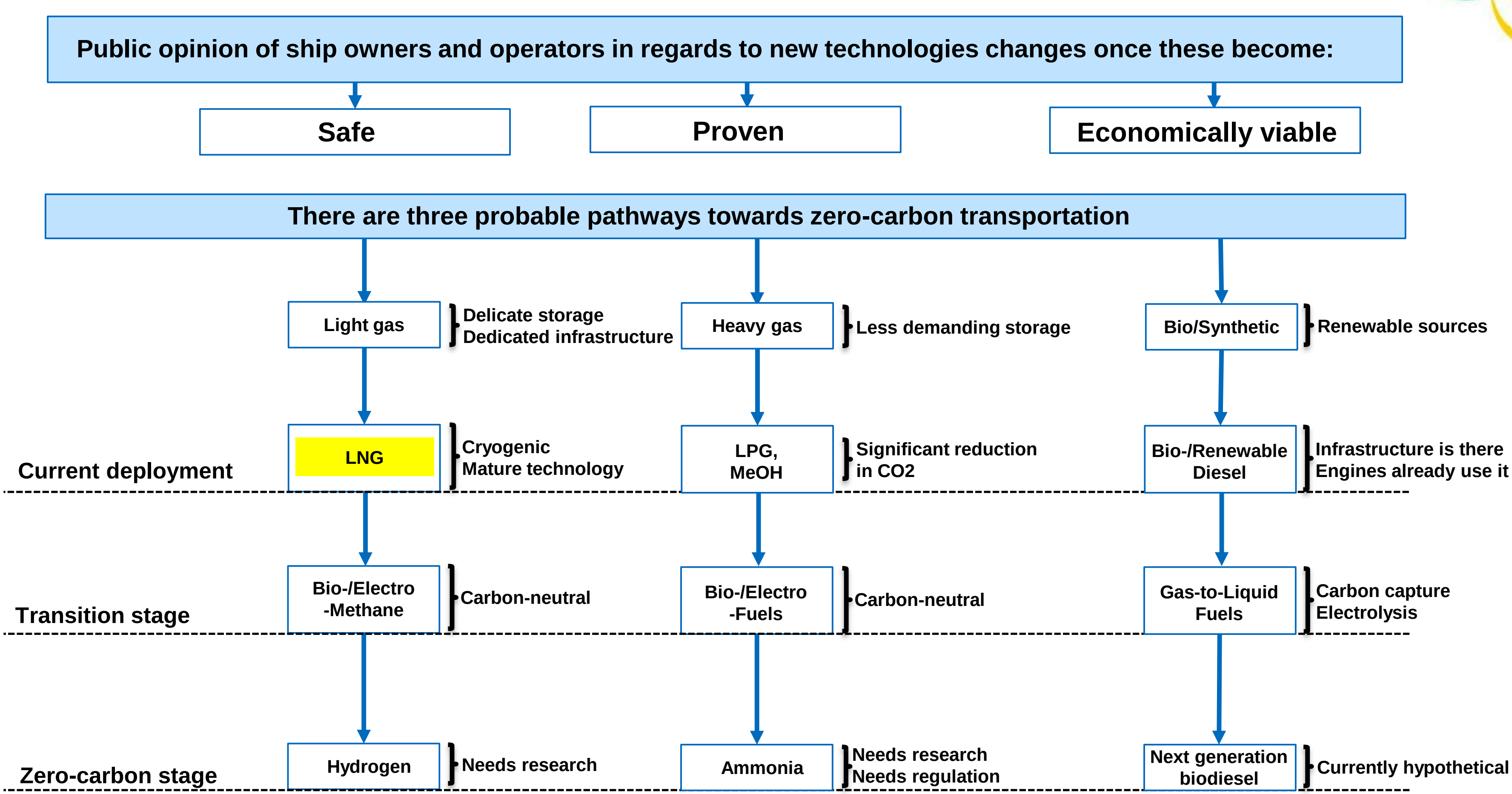
For GRENDEL, SHIP DESIGN GROUP has studied two lines of research:

- **Retrofit technologies for vessels in operation**
- **LNG for newbuilds**





Carbon neutral pathways and the transition



European regulation for the transition stage

Emission limits for non-road mobile machinery have been put forth to aid the process of transition. Inland waterway vessels have been included in the regulations.

Engine Category	Power ranges (kW)	Sub-category (1)	Reference Power(2)	Placing of engines on the market	Emission durability period(3)	CO g/kWh	HC g/kWh (4)	NOx g/kWh (4)	PM mass g/kWh	PN #/kWh
IWP Inland waterway propulsion engines	19<P<75	IWP-1	Maximum/ Rated power	1st of January 2019	10000 hours	5.00	Total < 4.70		0.30	-
	75<P<130	IWP-2				5.00	Total < 5.40		0.14	-
	130<P<300	IWP-3				3.50	1.00	2.00	0.10	-
	P>300	IWP-4		1st of January 2020		3.50	0.19	1.80	0.015	1 x 10^{12}
IWA Inland waterway auxiliary engines	19<P<75	IWA-1		1st of January 2019		5.00	Total < 4.70		0.30	-
	75<P<130	IWA-2				5.00	Total < 5.40		0.14	-
	130<P<300	IWA-3				3.50	1.00	2.00	0.10	-
	P>300	IWA-4		1st of January 2020		3.50	0.19	1.80	0.015	1 x 10^{12}

The LNG pusher – pathway towards zero-carbon

LNG technology

Economically feasible	Community perspective improving	Supply chains improving	Technology is mature
			

Vessel requirements

Ship type	Pusher
Ship fuel	LNG
Power	> 4000 HP
Range	> 1000 km upstream
Navigation area	Danube river, up to Passau
Length	< 42 m, due to Danube locks
Breadth	< 23 m, due to Danube locks
Draught	< 2 m, due to Danube depth
Air draught	< 7.7 m, Passau bridge

SDG input

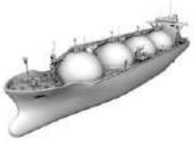
The design process

The concept vessel

"One of the most powerful and modern pushers on the Danube River"

Why is LNG challenging

Engine manufacturers have been focusing on maritime applications



The materials used need to be certified for cryogenic temperatures

LNG related systems need to have carefully controlled pressure reliefs

The LNG tanks and the processing units need careful placement

The ventilation system is critical

The gas piping and tank storage need to be protected and separated from safe spaces

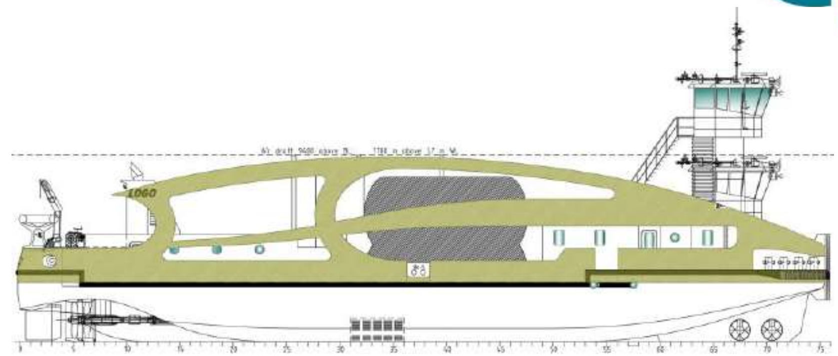
Conventional vessel systems are impacted by the LNG addition

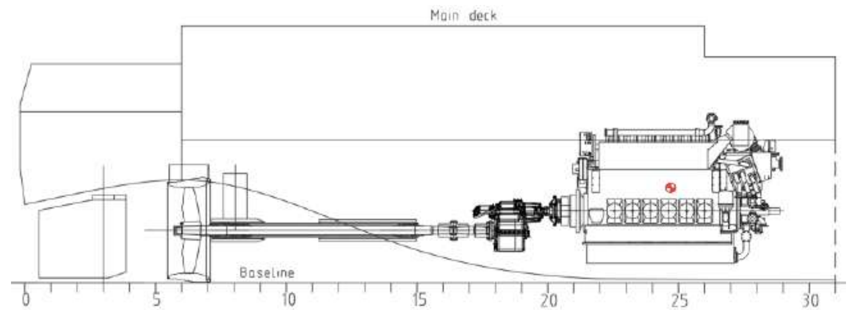
Leaks have to be controlled and accounted for during the design process

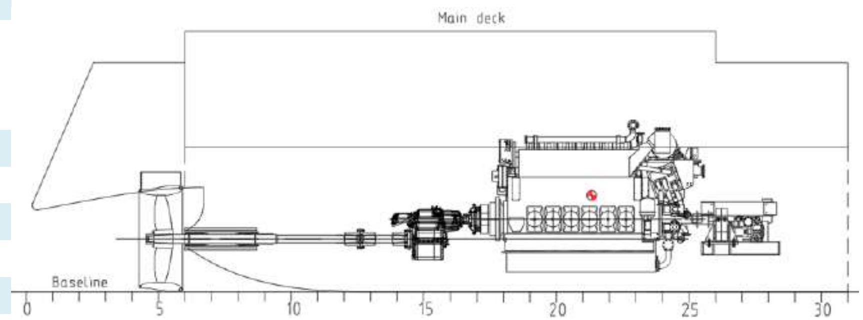
The general arrangement of the vessel is critical

Particular data

Main dimensions		
Length overall	42.00	m
Length hull	41.5	m
Breadth	13.5	m
Depth	3.0	m
Design draught	1.85	m
Scantling draught	2.0	m
Air draft above B.L.	9.40	m
Capacities		
Ballast	83	m^3
Fresh water	30	m^3
Sewage at 85% fill	26	m^3
Lubrication oil	8	m^3
LNG (total/net)	220/190	m^3
Crew	8	
Equipment		
Propulsion engines	3x1460 kW @ 900 RPM	
Gearbox	1:2.548 gearbox ratio	
Shaft generator	100 ekW	
Gas generator	100 ekW	
Side thrusters	42”, 2x250 kW	
Propellers	2 x FPP, 1 x CPP, 1.8 m	
Hydraulic unit	600 kW	
LNG Pack	2 Bilobe tanks @ 110 m3 each	







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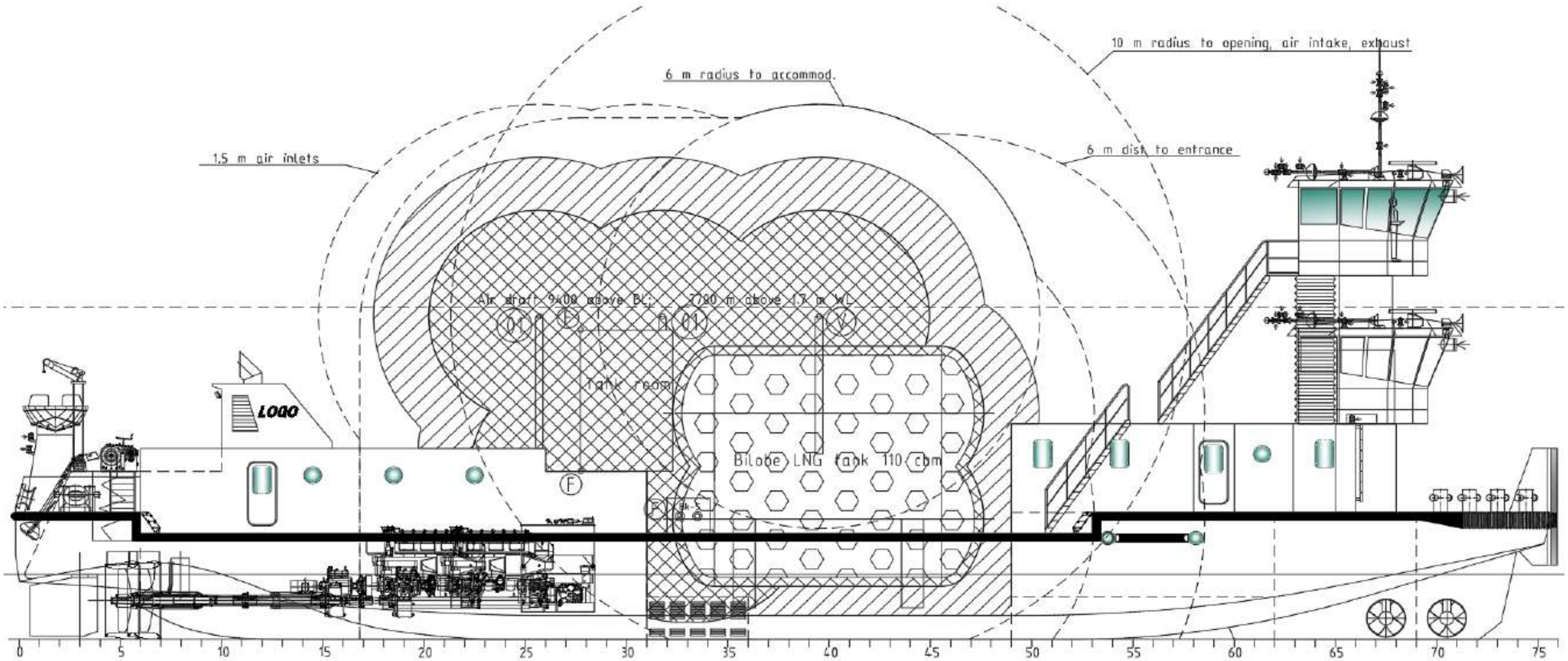
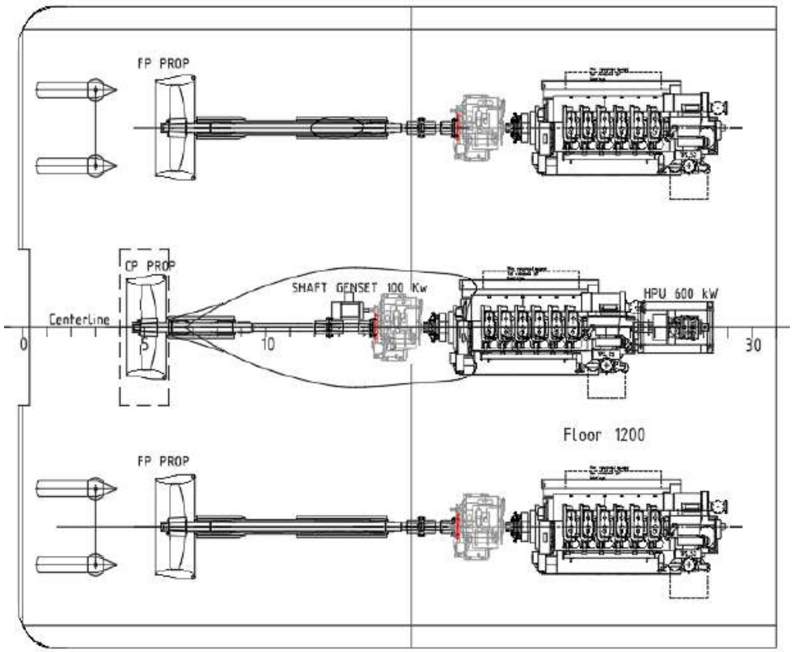
The hazardous areas plan

Critical for the design stage, the Hazardous Areas plan is done according to regulation and it dictates the layout of the vessel, the routing of piping systems and placement of equipment. The LNG concept has an engine compartment rated as ‘Gas safe’, due to employing double-walled piping and safety mechanisms.



Performances



With an average flow speed of 4 km/h, the convoy speed relative to the land is at least:

- **8 km/h upstream**
- **14 km/h downstream**

Presumed range of the vessel:

- **Upstream: 1200 km**
- **Downstream: 3150 km**

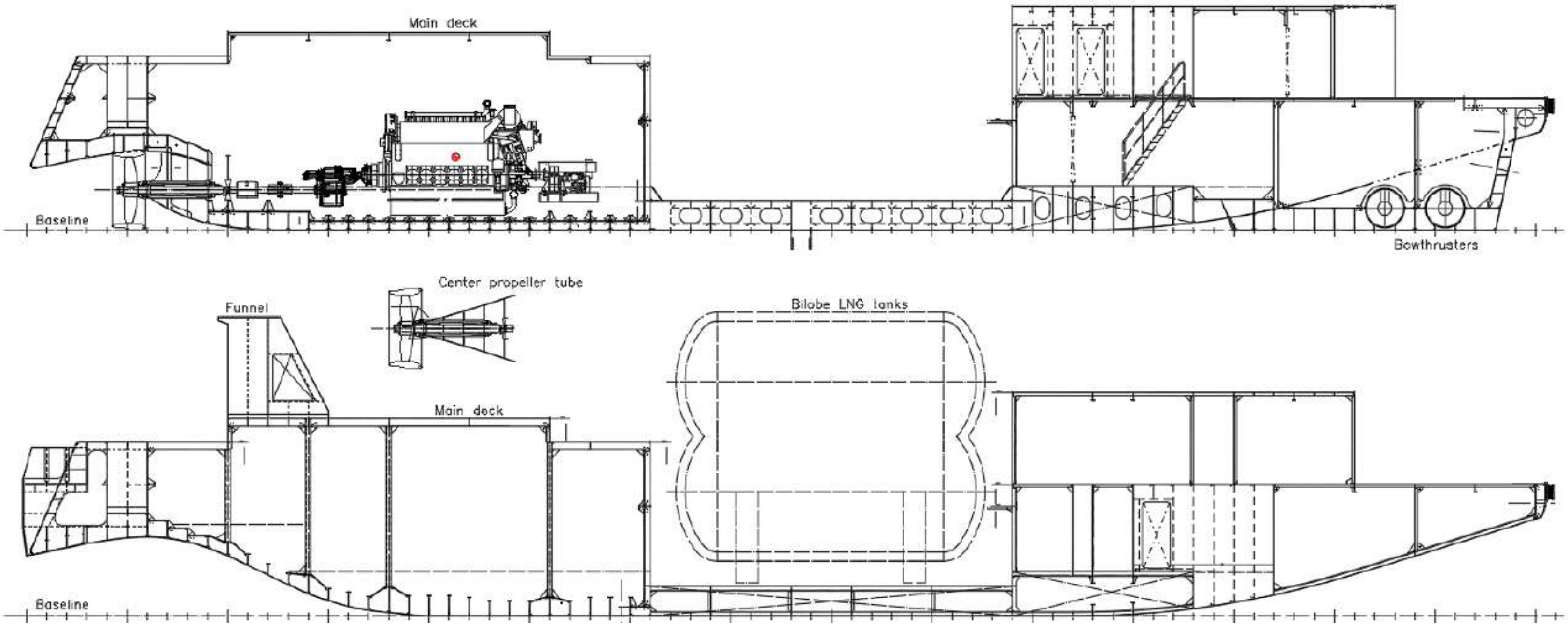
One year of operation results in approximately 3150 m^3 of LNG consumption.

Scenario	kW	HP	Thrust [kN]	Speed [km/h]
Maximum thrust	4050	5500	408	13
Using side thrusters and shaft generator	3400	4600	355	12
Side engines only	2700	3650	270	11

The hull basic design

The hull technical concept involves the assessment of relevant strength criteria and resulting structure scantlings.

- **Steel hull, grade A or equivalent**
- **Vessel specific solutions**
- **Designed for efficiency**



Centerline and side propeller sections

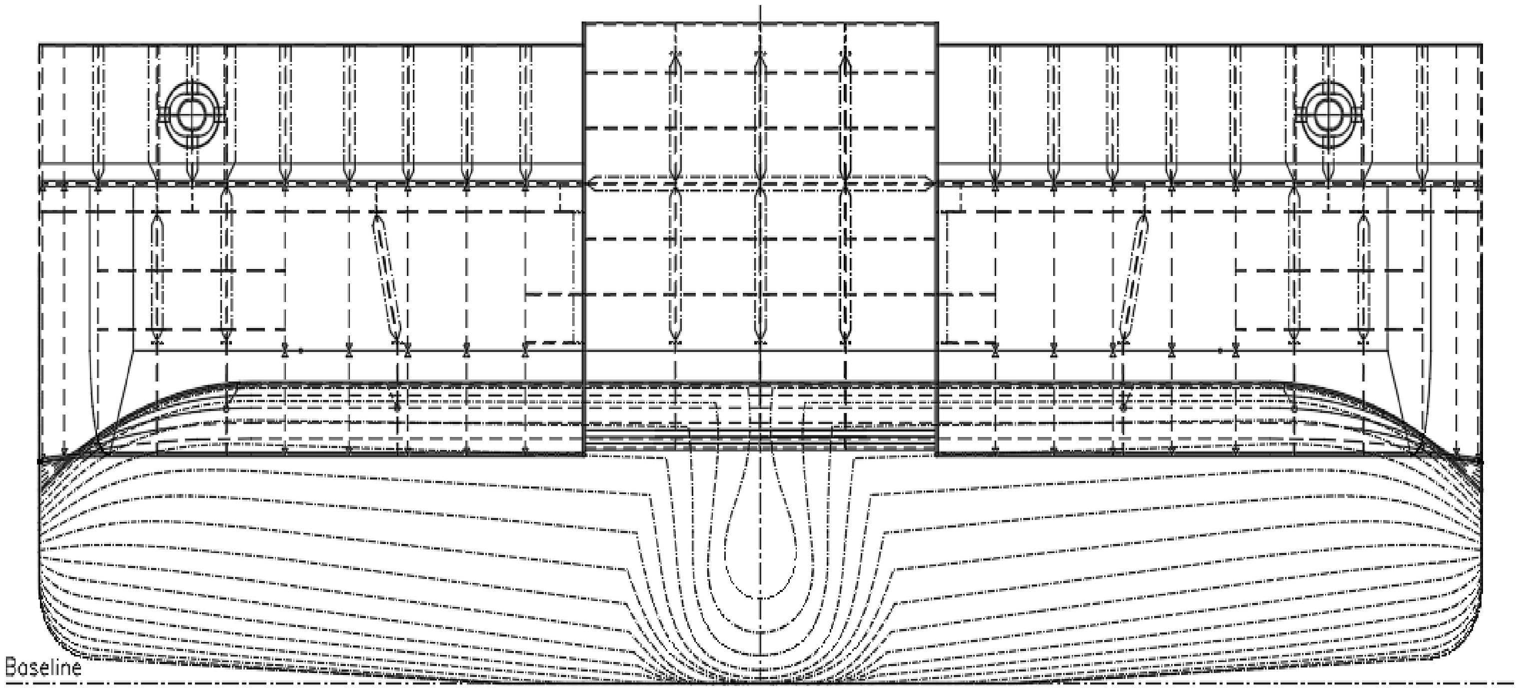
The hull basic design

The hull technical concept involves the assessment of relevant strength criteria and resulting structure scantlings.

Steel hull, grade A or equivalent

Vessel specific solutions

Designed for efficiency



Aft structure

The hull basic design

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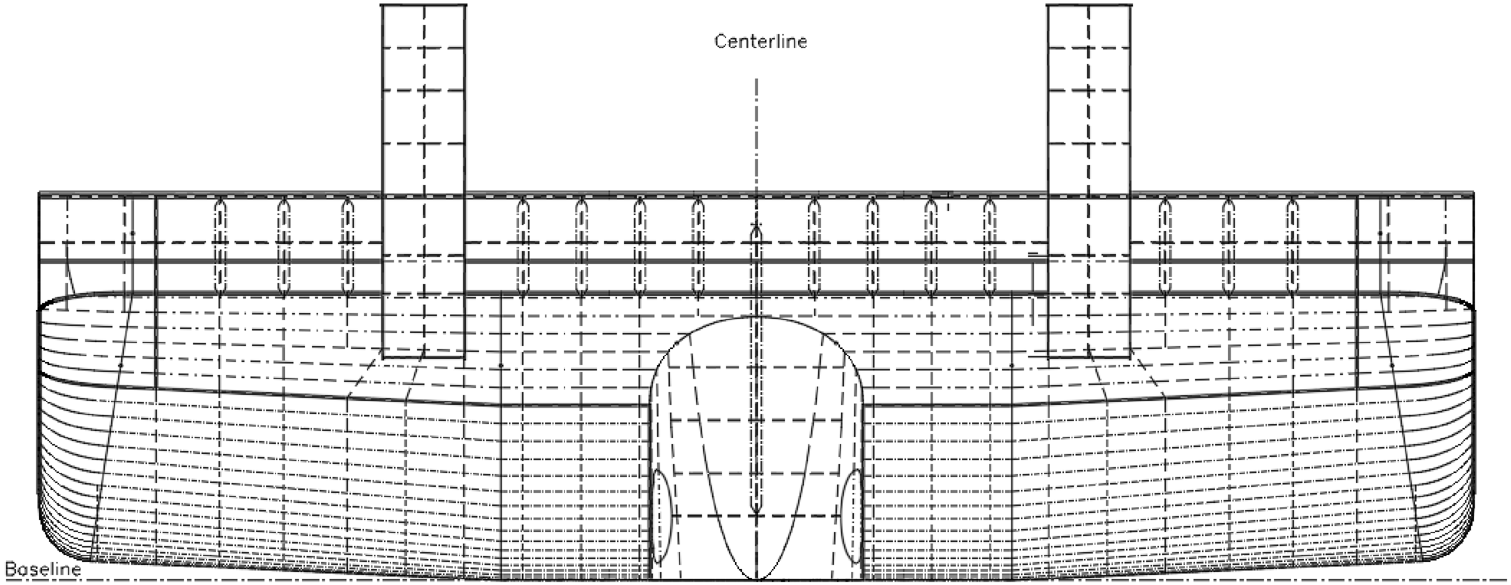

Fore structure

The hull basic design

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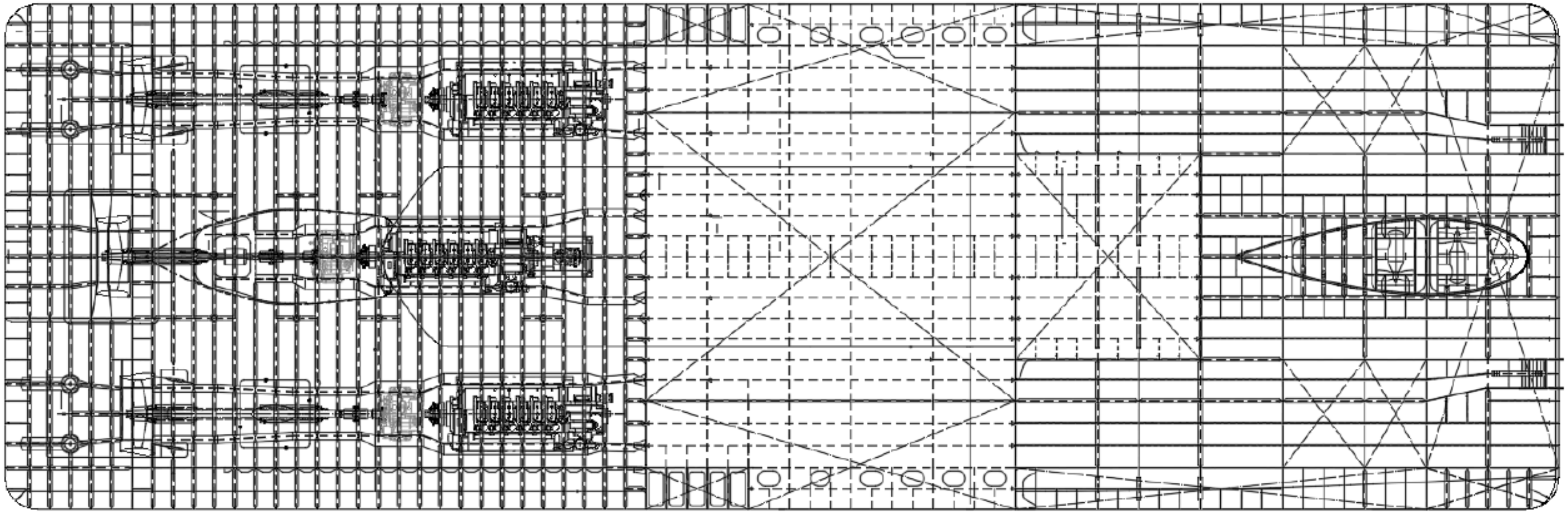

Bottom structure

The hull basic design

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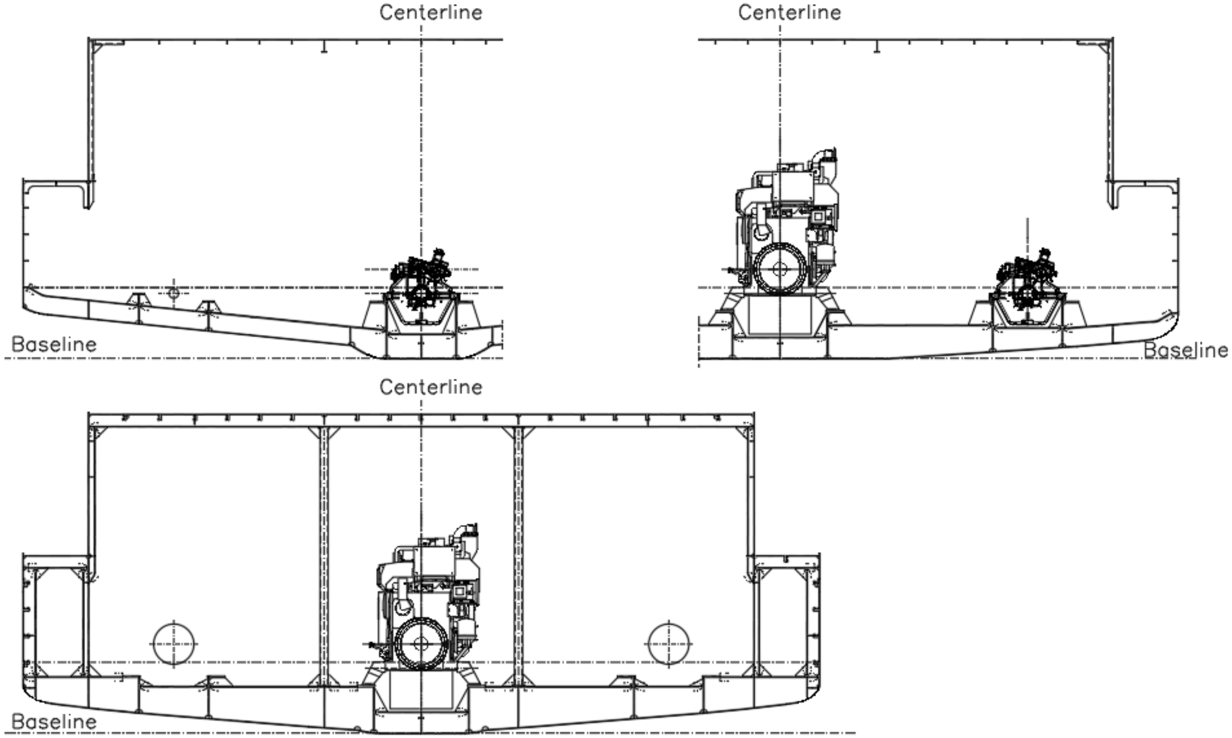


Relevant sections in way of engines

The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

The tank sounding system → **Sounding pipes connect spaces and need careful consideration.**

The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

- **The tank sounding system**
- **The tank vent and HVAC systems** → **Can connect safe spaces with hazardous areas and the other way around.**

The piping basic design

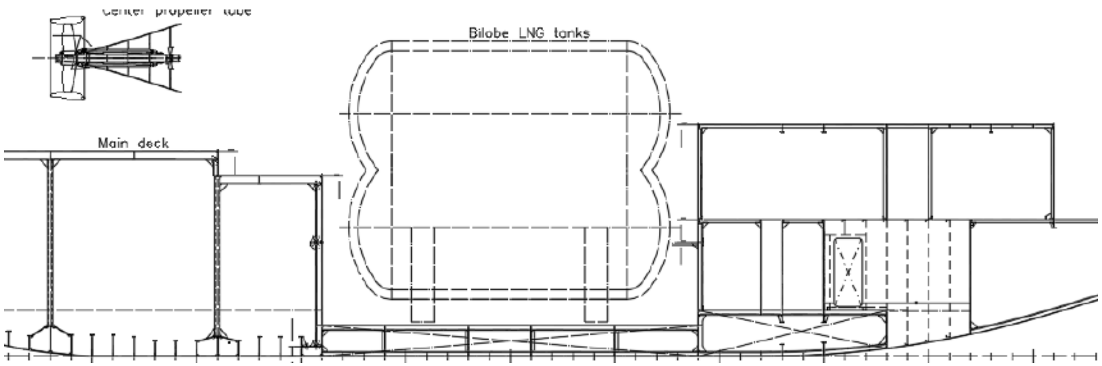
Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

The tank sounding system

The ventilation system

The bilge system

Leakages underneath the LNG tanks need to be collected. The material used must be cryogenic. The piping used for LNG discharge must be separated from the rest of the system.



The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

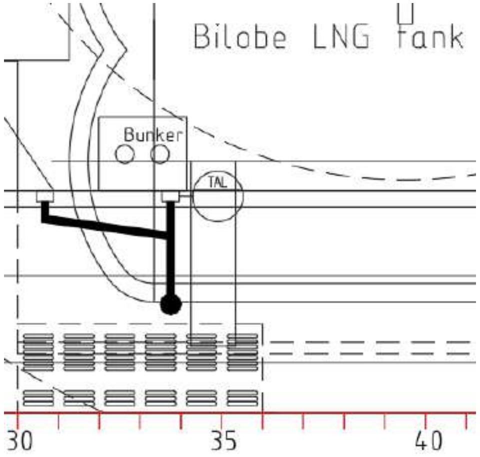
The tank sounding system

The ventilation system

The bilge system

The external drainage system

The bunker station drainage needs to lead overboard and beneath the waterline. Draining it on the hull plate exposes the steel to cryogenic temperatures.



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The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

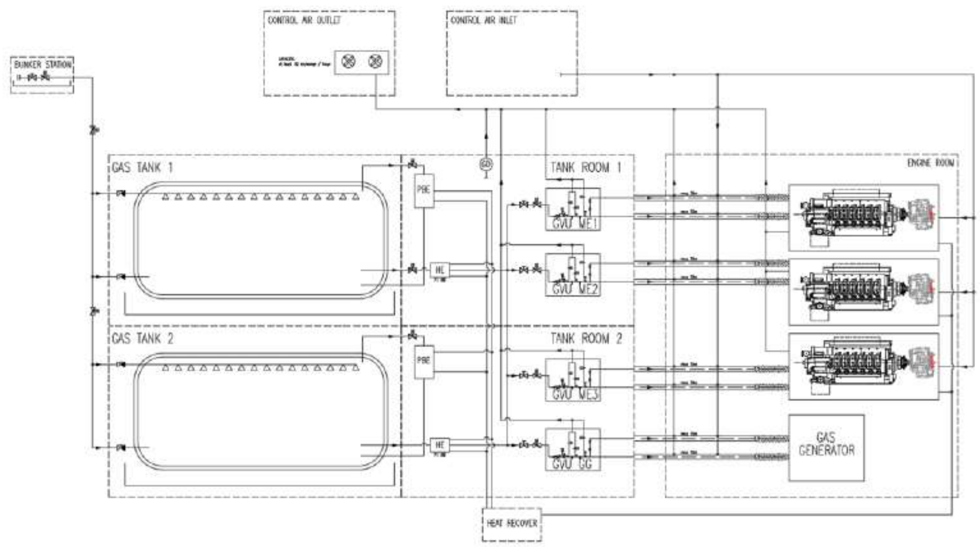
- **The tank sounding system**
- **The ventilation system**
- **The bilge system**
- **The external drainage system**
- **The water spray system**

The system uses fresh water to cool the area around the LNG tanks in case of leakages, which prevents rapid evaporation of the gas.

The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

- **The tank sounding system**
- **The ventilation system**
- **The bilge system**
- **The external drainage system**
- **The water spray system**
- **The fuel gas system**

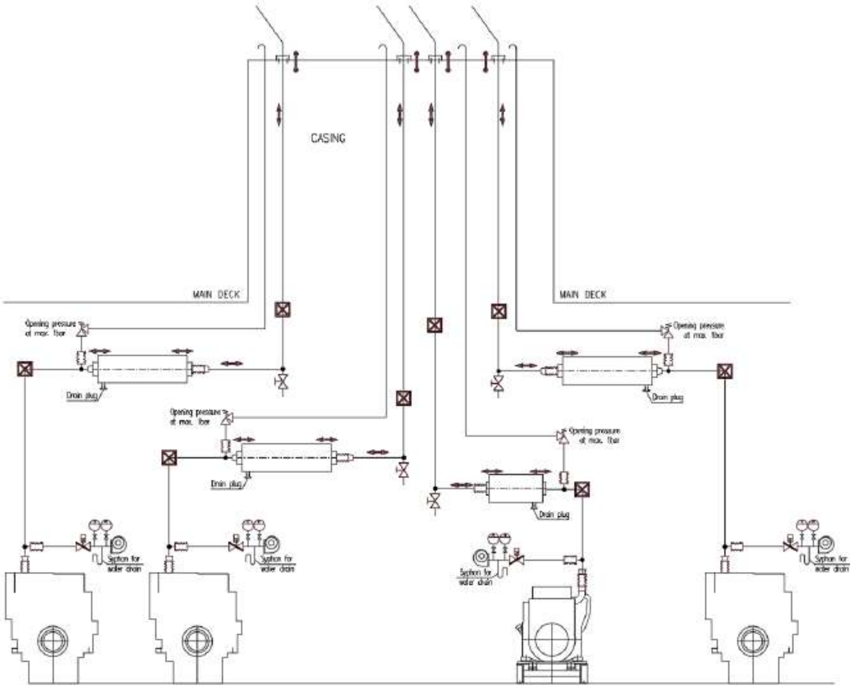


A critical system, piping is double walled, the gap between the pipes is constantly ventilated. A three way valve allows discharge to the atmosphere in case of emergency.

The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

- **The tank sounding system**
- **The ventilation system**
- **The bilge system**
- **The external drainage system**
- **The water spray system**
- **The fuel gas system**
- **The exhaust gas system**

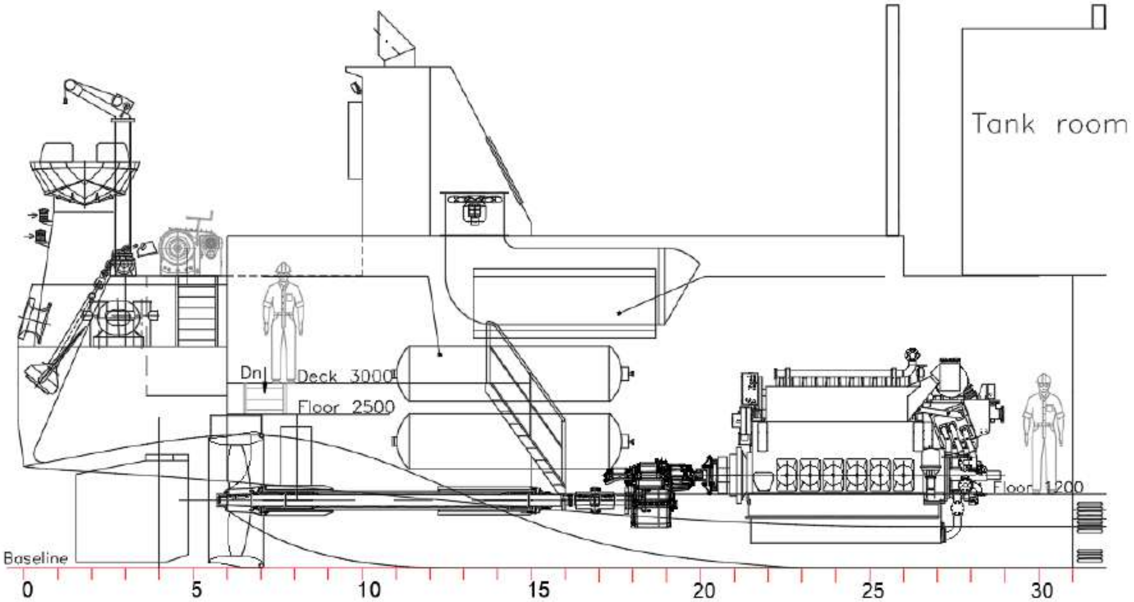


Pipes need to be ventilated to prevent accumulation of gas from methane slips. The system should be able to withstand over-pressure from LNG explosions. The pipelines create a hazardous area around the funnel.

The piping basic design

Special care is needed when designing systems that can interfere with the LNG system or auxiliary ones.

- **The tank sounding system**
- **The ventilation system**
- **The bilge system**
- **The external drainage system**
- **The water spray system**
- **The fuel gas system**
- **The exhaust gas system**
- **The compressed air system**



The air bottles of the starting system are large due to the nature of the fuel, the large capacity of the engine cylinders and the minimum startups required by Regulations.

Is Stage V achievable?

By new-builds

Yes

- LNG technology
- BIO/Synthetic LNG

25% reduction of CO_2, 90% reduction of NO_x, 100% reduction of PM

The NRMM regulations are in line with the Green Deal. Investments via the Green Deal will accelerate the push towards carbon neutrality.

Western Europe already registers new builds with LNG propulsion. However, the Danube River is more challenging because of navigation conditions, higher ranges required and a still-developing LNG infrastructure.

Collaboration between ship designers, vessel operators, public authorities and equipment manufacturers can lead to a seamless adoption of LNG technology.

The LNG concept, towards zero-carbon

SHIP DESIGN GROUP

A modern concept, flexible both in operation and in design variations. A step ahead Stage V regulations and a future-proof vessel, ready to accommodate implementations of hydrogen as fuel. The design process was delicate, but has brought to limelight particularities of the technology.

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