Interreg Baltic Sea Region

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BLUE ECONOMY

Blue Supply Chains

Technical study on vessel design for zero-emission inland navigation corridor

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Introduction

The imperative to adopt alternative fuels for inland waterways vessels is driven by a confluence of environmental, economic, and regulatory factors. As the global community becomes increasingly cognizant of the impacts of climate change, the maritime sector is under scrutiny for its environmental footprint. Inland waterways vessels, which have traditionally relied on diesel fuel, contribute to greenhouse gas emissions, air pollution, and water contamination. The transition to alternative fuels, such as methanol, ammonia, hydrogen, and electricity, offers a pathway to mitigate these adverse effects. These fuels can significantly reduce emissions of carbon dioxide, nitrogen oxides, and sulfur oxides, aligning with international efforts to combat air pollution and protect aquatic ecosystems. Moreover, the economic incentives for switching to alternative fuels are strengthened by the volatility of oil prices and the potential for cost savings in the long term. Regulatory bodies are also playing a pivotal role, enacting stringent emissions standards and providing subsidies for green technologies. This study aims to explore the multifaceted rationale behind the shift to alternative fuels in inland waterways vessels, examining the environmental benefits, economic viability, and regulatory landscape that are shaping the future of maritime transport.

Initial conditions for calculation

Choosing the main dimensions of a river pusher vessel involves several considerations to ensure optimal performance and efficiency. The total length, breadth, depth, and draft are critical dimensions that influence the vessel's capability to maneuver and its stability in shallow waters. Additionally, the design draft and air draft are essential for determining the vessel's ability to navigate under bridges and through various river conditions. Propulsion systems, such as the number and type of main engines, along with the propeller specifications, play a significant role in the vessel's thrust and towing capacity. It's also important to consider the vessel's displacement and maximum speed, which affect its performance during transport maneuvers. In summary, the main dimensions and propulsion characteristics are tailored to meet the specific requirements of river navigation, ensuring the vessel can perform its intended functions effectively.

The pusher should be made for river Neman shipping from Klaipeda to Kaunas. The vessel must be able to push the barge 2000-ton DWT with main dimensions below.

VVKD BARGE main dimensions	
Length over all	74,54 m
Length waterline	73,50 m
Breath	15,85 m
Main deck	2,30 m
Max draft	2,05 m
Deadweight	1800 t
Displacement	2100 t

The length of the road from Klaipeda – Kaunas is 300km.

The maximum speed of the convoy is 10km/h.

The average speed of the stream is 1 m/s.

Maximum draft is 1.5 m.

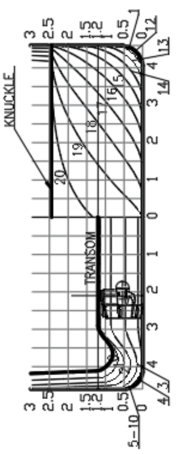
Maximum air draft is 6.2m

Pusher vessels are characterized by their robust build and a shallow draft, which allows them to navigate through less deep waters. The main dimensions of a river pusher can vary significantly based on their intended use and the waterways they navigate. Pusher in this study will have main dimensions:

VVKD PUSHER main dimensions	
Length over all	27.7 m
Breath	9.2 m
Main deck	3 m
Max draft	1.5 m

These dimensions ensure that the vessel can perform with maximum efficiency, maneuverability, and thrust, especially in shallow waters.

Hull surface was especially designed for this vessel according to best marine practice and river Neman restrictions. Hull lines you may see on the next page.

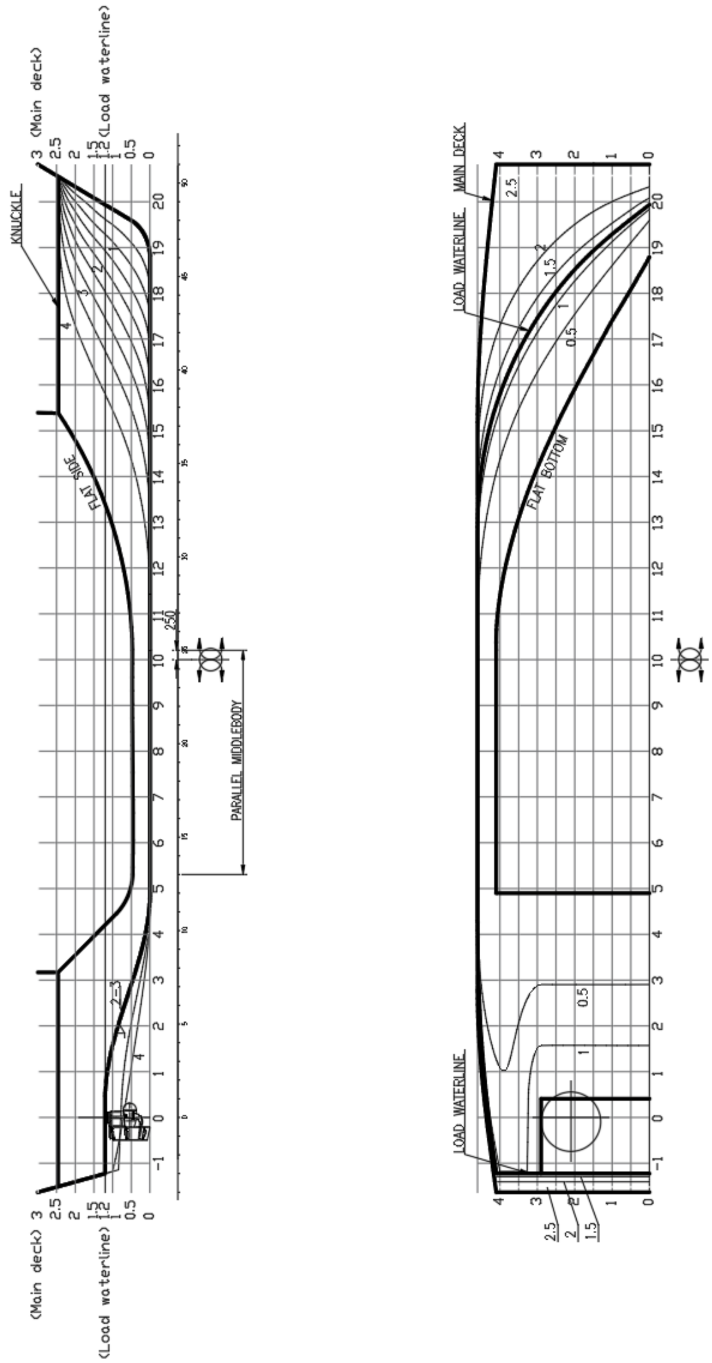


Main Dimensions:

Length over all	27,7	m
Length between p.p	24,42	m
Breadth moulded	9,2	m
Depth	3,0	m
Draught max	1,5	m

Main characteristics

Loa	=	27.70	m
Lwl	=	25.92	m
Lpp	=	24.42	m
Bmax	=	9.20	m
Bwl	=	9.20	m
Tdwl	=	1.20	m
Lwl/Bwl	=	2.82	
Lwl/Tdwl	=	21.60	
Bwl/Tdwl	=	7.67	
Disp	=	197	t
Disv	=	196	m3
S	=	253	m2
Cb	=	0.7274	
Cm	=	0.9892	
Cp	=	0.7354	
Cwp	=	0.9472	
LCB	=	−1.67	%
VCB	=	0.64	m
KMT	=	7.52	m



Elevating wheelhouses on river pushers are a critical feature for ensuring optimal visibility and safety during navigation. These structures are designed to move vertically, allowing the pilot to adjust their vantage point according to the vessel's load and the river's conditions. The system typically consists of telescopic columns that can be raised or lowered using hydraulic cylinders. This adjustability is particularly important for maintaining clear sightlines over stacked cargo, which can vary significantly in height. The design and construction of these wheelhouses must adhere to specific classification society rules, which outline the requirements for materials, structural integrity, and operational reliability. For instance, the wheelhouse columns may be integrated into the ship's structure, providing additional support and vibration isolation, which is essential for the wheelhouse's functionality and the crew's comfort. Moreover, the sustainability of river pushers can be enhanced by considering new design options that accommodate higher container stacks without compromising the line of sight from the wheelhouse. On our vessel should be a wheelhouse elevating system, the elevating height is near 3.6 meters.

Resistance calculation

Calculating the resistance of a river-pushed convoy involves understanding the complex hydrodynamics of inland waterway vessels. These vessels, often operating in shallow waters, face unique challenges compared to their seagoing counterparts. The total resistance (Rt) can be divided into viscous resistance (Rv), which dominates at low speeds, and wave-making resistance (Rw), which becomes significant at higher speeds. For accurate resistance calculation, especially in shallow waters, empirical methods such as those by CFD calculation. Computational Fluid Dynamics (CFD) is a sophisticated analysis method that utilizes numerical algorithms and computational resources to solve and analyze problems involving fluid flows. CFD allows engineers and scientists to simulate fluid behavior in different environments and under various conditions without the need for expensive and time-consuming experiments. For a comprehensive analysis, model tests are recommended, although CFD methods may suffice during the early design stages. It's also essential to consider the design of the hull and the propulsors, as these significantly affect the flow around the vessel and consequently its hydrodynamics. Understanding these principles is crucial for the efficient and safe design of river-pushed convoys, ensuring they meet the demands of modern transportation on inland waterways. The calculation was made in Siemens Star CCM+ software.

Initial conditions of calculation are the surfaces of the pusher and barge.

The calculation was made for different drafts and speeds. In calculation draft of the pusher and barge is the same. Initial conditions of the calculation you may see in the table below.

Draft 2 meters was added due to maximum draft of the barge.

Maximum speed of pusher.

Deep water	
Draft 1.2 m	**Draft 1.5 m**
Speed from shoe, knots	Speed from shoe, knots
8	8
10	10
11	11
12	12

Resistance calculation of pushed convoy up and down stream.

Upstream calculation is made for different speeds to find the best economical solution.

Upstream Klaipeda-Kaunas					
Deep water			**Shallow water**		
Draft 1.2 m	**Draft 1.5 m**	**Draft 2.05 m**	**Draft 1.2 m**	**Draft 1/5 m**	**Draft 2.05 m**
Speed from shoe, km/h	Speed from shoe km/h	Speed from shoe km/h	Speed from shoe, km/h	Speed from shoe km/h	Speed from shoe km/h
6	6	6	6	6	6
8	8	8	8	8	8
10	10	10	10	10	10

Downstream calculation is made only for one speed because there is no necessity to reduce the speed for less consumption.

Downstream Kaunas-Klaipeda					
Deep water			**Shallow water**		
Draft 1.2 m	**Draft 1.5 m**	**Draft 2.05 m**	**Draft 1.2 m**	**Draft 1.5 m**	**Draft 2.05 m**
Speed from shoe, km/h	Speed from shoe km/h	Speed from shoe km/h	Speed from shoe, km/h	Speed from shoe km/h	Speed from shoe km/h
10	10	10	10	10	10

Mesh

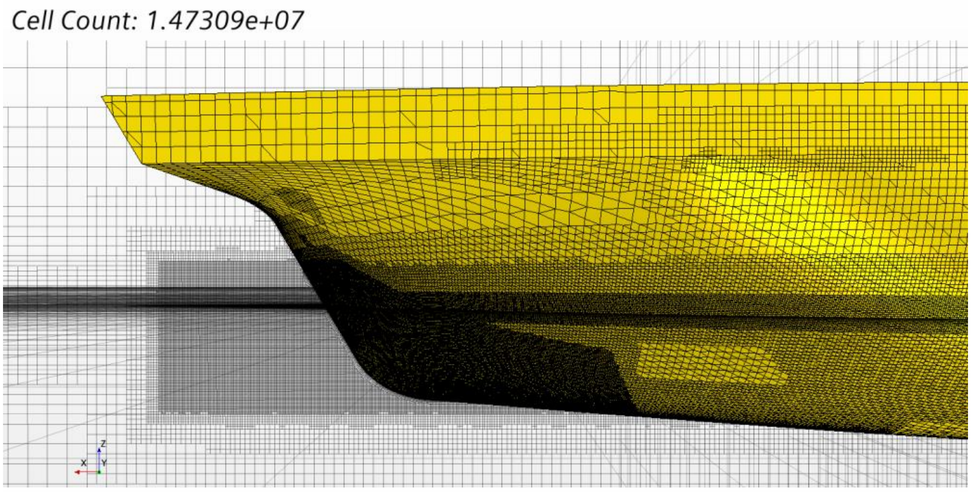
Creating a mesh for a pushed convoy in computational fluid dynamics (CFD) calculations is a complex task that requires careful consideration of various factors to ensure accurate simulation results. The mesh serves as the foundation of a CFD simulation. A high-quality mesh is crucial as it directly influences the convergence and accuracy of the simulation. It's composed of numerous cells, each representing a discrete portion of the fluid domain, and the flow parameters within these cells are approximated to solve the fluid dynamic field numerically. The mesh density is a significant factor; a finer mesh typically yields more accurate results but requires more computational resources. Therefore, a balance must be struck between mesh quality and computational efficiency. This is often achieved through a mesh sensitivity study, which involves comparing the results of simulations with varying mesh densities to determine the point at which further refinement does not significantly alter the results.

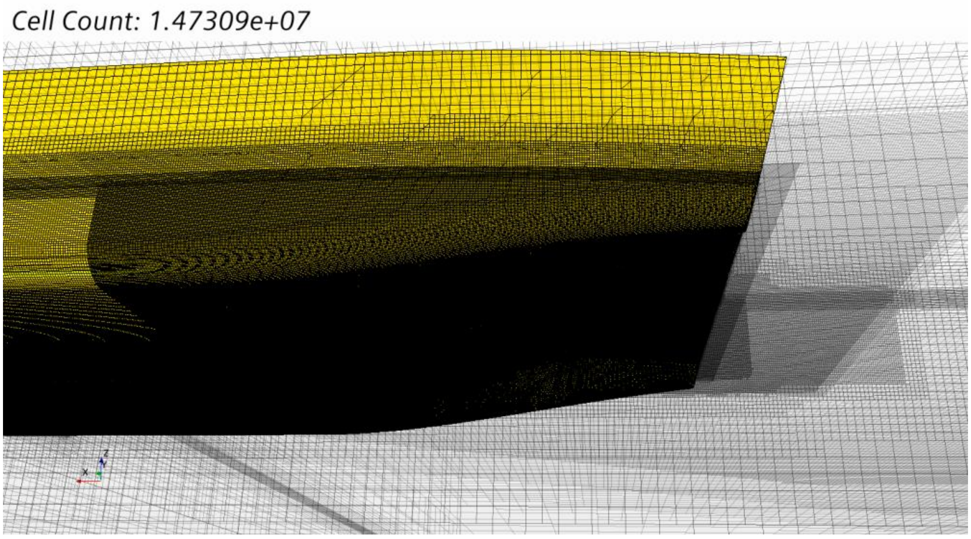
For a pushed convoy, which could involve a tugboat and a barge, the mesh must capture the intricate flow details around each vessel and the interactions between them. The proximity of the vessels in a convoy can lead to complex flow patterns, including wake interference and bow shielding effects, which must be accurately captured by the mesh.

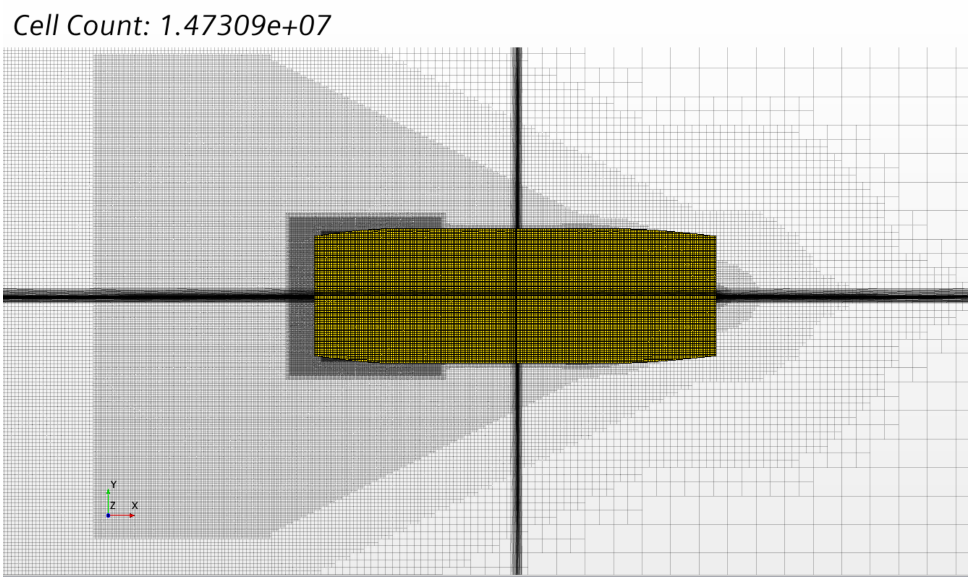
In practice, this means defining a progressively finer mesh near the surfaces of the vessels while ensuring a smooth transition in mesh density to avoid introducing errors into the solution. Advanced meshing tools and techniques, such as surface refinement and refinement boxes, are employed to control the cell size and adapt the mesh to the geometry's details.

Moreover, the global mesh parameters play a pivotal role in the overall mesh quality. Parameters like the base cell size set the starting point for the mesh, and subsequent refinements are applied relative to this size. The mesh must also be robust enough to accommodate changes in the CAD geometry, which may be necessary to achieve a high-quality mesh.

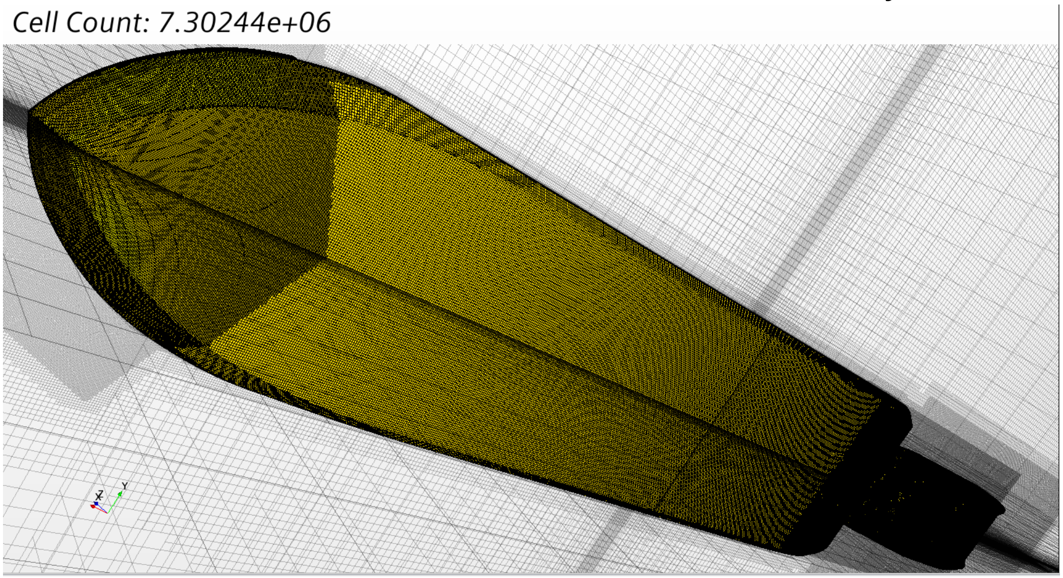
Mesh for resistance calculation of pusher.

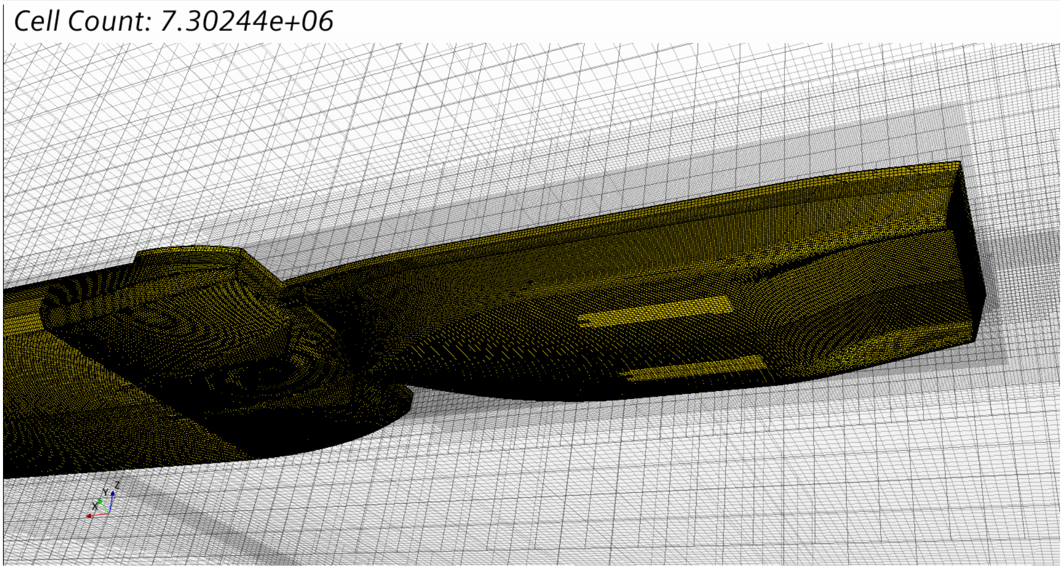


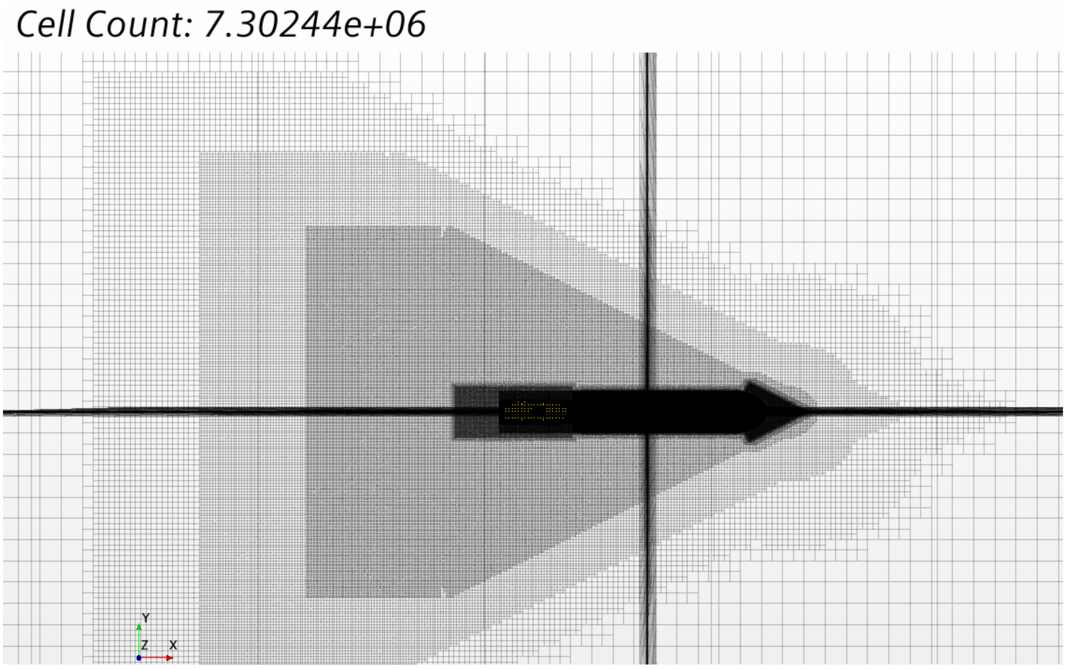




Mesh for resistance calculation of convoy



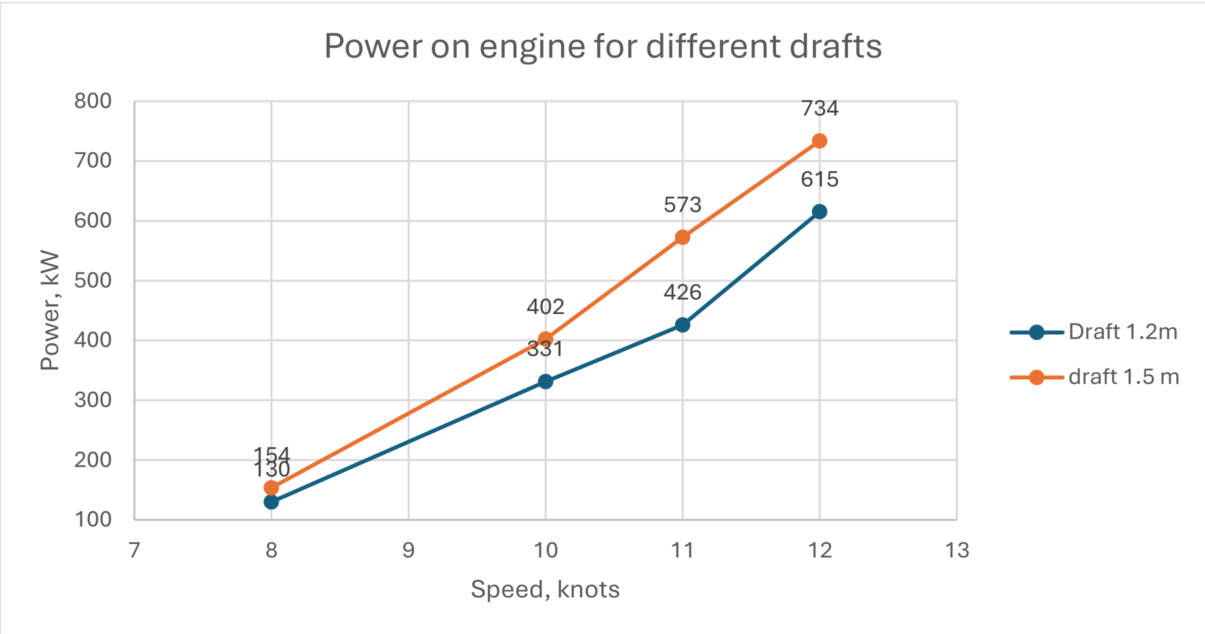




Results of calculation: resistance of pusher

Draft 1.2 m Deep water				
Speed from shoe, knots	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
8	11	68	113	130
10	28	173	288	331
11	36	222	370	426
12	52	321	535	615

Draft 1.5 m Deep water				
Speed from shoe, knots	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
8	13	80	134	154
10	34	210	350	402
11	48,4	299	498	573
12	62	383	638	734



Results of calculation: resistance of convoy

Upstream Klaipeda-Kaunas				
Draft 1.2 m				
Deep water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
6	17,6	55,9	93,1	107,1
8	26,2	97,5	162,5	186,9
10	35,3	150,9	251,5	289,2

Upstream Klaipeda-Kaunas				
Draft 1.5 m				
Deep water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
6	21,1	66,9	111,5	128,2
8	30,4	113,0	188,3	216,5
10	43,2	184,5	307,5	353,7

Upstream Klaipeda-Kaunas				
Draft 2.05 m				
Deep water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
6	24,9	78,8	131,3	151,0
8	30,2	112,2	187,0	215,0
10	48,2	206,3	343,8	395,3

Upstream Klaipeda-Kaunas Draft 1.2 m Shallow water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
6	20,2	64,0	106,6	122,6
8	30,0	111,6	186,0	213,9
10	40,4	172,7	287,9	331,0

Upstream Klaipeda-Kaunas Draft 1.5 m Shallow water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
6	24,6	77,8	129,6	149,1
8	35,3	131,4	219,0	251,8
10	50,2	214,6	357,7	411,3

Upstream Klaipeda-Kaunas Draft 2.05 m Shallow water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
6	33,0	104,5	174,1	200,2
8	40,0	148,8	248,0	285,2
10	64,0	273,6	456,0	524,4

Downstream Kaunas-Klaipeda				
Draft 1.2 m				
Deep water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
10	1,3	6,6	11	13

Downstream Kaunas-Klaipeda				
Draft 1.5 m				
Deep water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
10	1,4	7,2	12	14

Downstream Kaunas-Klaipeda				
Draft 2.05 m				
Deep water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
10	1,5	7,8	13	15

Downstream Kaunas-Klaipeda				
Draft 1.2 m				
Shallow water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
10	1,3	6,6	11	13

Downstream Kaunas-Klaipeda				
Draft 1.5 m				
Shallow water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
10	1,4	7,2	12	14

Downstream Kaunas-Klaipeda				
Draft 2.05 m				
Shallow water				
Speed from shoe, km/h	Resistance, kN	Propulsion power, kW	Power_S, kW	Power_S + sea margin, kW
10	1,5	7,8	13	15

Conclusion

The maximum power for propulsion of pusher on draft 1.2 m is **615kW.**

The maximum power for propulsion of pusher on draft 1.5 m is **734 kw**

The maximum power for propulsion of convoy on draft 2 m is **524.4 kW.**

There is no difference in resistance downstream in shallow and deep water because the speed is very low and there is not a big wave resistance impact in total resistance.

I this study is represented different types of generating systems. For each type of fuel system was made the calculation of resistance, electro balance, deadweight and maximum draft. Resistance calculation was made for many cases of draft and ways. The worst-case scenario is pusher with barge going upstream (Klaipeda-Kaunas) where the power on engine should be at least **524.4kW**.

Power calculation

The river pusher propulsion system, a pivotal component in the realm of inland waterway transportation, epitomizes the synergy between power and maneuverability. This system, primarily consisting of a pusher craft and one or more barges, harnesses the thrust generated by powerful propellers to navigate through rivers and canals. The pusher, often equipped with either an open or ducted propeller, serves as the propulsor, translating the energy from the drive into effective thrust. The choice between an open or ducted propeller is influenced by the specific operational needs, with ducted propellers being favored for their low-speed thrust capabilities and protective benefits around the propeller blades.

The design intricacies of the pusher vessel are tailored to meet the challenges of river navigation. Features such as a flat nose for pushing against barges, a wide hull to accommodate side-by-side engines, and a shallow draft for operation in shallow waters, are all critical to its functionality. Moreover, the upturned stern allows for a larger propeller diameter, pairing with the engine's power to provide the necessary thrust for moving heavy barge loads.

The maneuverability of the pusher-barge system is a subject of extensive study, as it must navigate through restricted waters, sharp bends, and varying load conditions with precision and safety. The system's stability and turning ability are affected by the barge's load condition, which alters the hydrodynamic forces acting on the pusher. For instance, an increase in barge draft can deteriorate the course stability due to changes in the pressure field over the pusher bow, influenced by the wake shed from the barge.

In dynamic operations, such as backing and maneuvering, the propeller characteristics play a significant role. The propeller must be capable of handling the demands of both steady-state long hauls and transient dynamics. The engine power, exceeding the vessel's own resistance requirements, is utilized to generate additional thrust for pushing barges and barge trains. This necessitates a propeller design that can operate efficiently across a range of conditions, providing the thrust needed for both the pusher vessel and the barges it moves.

Propulsion power

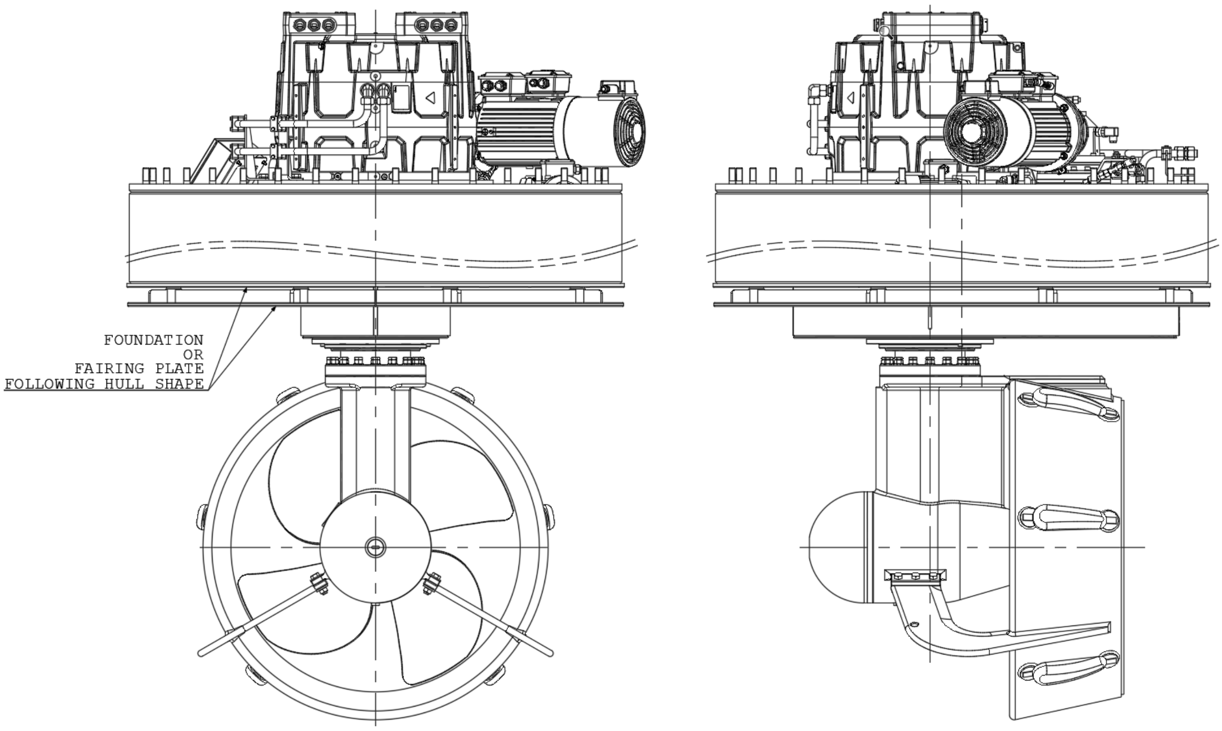
For this project of pusher the best solution to install azimuth trusters with electric engine. Azimuth thrusters will give the best maneuverability on low speeds, electric motors are the best solution for green fuel generating systems.

Maximum continuous power of the vessel will be while pushing the barge on maximum draft and speed (The maximum power for propulsion of convoy on draft 2 m is **524.4 kW),** good marine practice to add extra 25% margin for maneuverability. In this case minimum power on propulsion system should be **656 kW**.

We chose the azimuth truster from Veth supplier. Model **VL-320**. This azimuth truster has a nozzle that gives us extra trust on low speed and propeller will be more protected from damage. Main data of propulsion system you may see on the pictures below.

Power range single propeller Z-drives (VZ), L-drives (VL) and Hybrid Drives (VHD)

Type	Max power (kW)	Propeller diameter nozzled (mm)
VL-50	57	Ø450
VL-100	102	Ø575
VL-180	192	Ø700
VZ/VL-200	260	Ø900
VZ/VL-320	330	Ø1050



Total power of propulsion system will be **660kW.**

Electro balance with different types of fuel

On the table below you may see the distribution and balance of power throughout the vessel. The electro balance system would manage the power supply to the propulsion systems, navigational equipment, and any other electrical components, helping to prevent overloads and potential failures. Properly balanced electrical systems are also more energy-efficient, which can lead to cost savings and a reduced environmental impact over time.

Calculation was made for each type of green generating system.

In this calculation is represented main load cases, maximum speed of pusher (maximum load on electricity), pusher towing barge upstream with maximum draft and maximum speed 10km/h (main operational load), pusher towing barge upstream with maximum draft and maximum speed 8 km/h (spare operational load), maneuvering mode, harbor and emergency. Every load is calculated according to data from supplier. For every energy case the balance is different, because different equipment is in work. For fuel cell system must be add the extra batteries for accumulating extra power and peak shaving. The capacity calculation of extra batteries was made according to supplier data and preliminary time for turning on the fuel cell. According to electro balance calculation we chose the number of generating equipment for each case.

Load balance for battery solution

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - MAXIMUM SPEED Maximum speed 12 knots Draft 1.2m				SHALLOW WATER WITH BARGE - SERVICE MODE Service speed 10 km/h Maximum draft 2m				SHALLOW WATER WITH BARGE - ECO MODE ECO speed 8 km/h Maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M
THRUSTERS																													
1	Azimuth Thruster	330,00	680,00	2	660,00	2	100	660,00		2	79	524,04		2	43	285,12		2	30	198,00									
					660,00			**660,00**	**0,00**			**524,04**	**0,00**			**285,12**	**0,00**			**198,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
MACHINERY																													
2	Bilge Pump	4	380	1	4,00																								
3	Fire Pump	4	380	1	4,00																								
4	Hydraulic Power Unit for Wheelhouse Elevation System	4,2	380	1	4,20																								
5	FW Cooling Pump	7	380	2	14,00	1	90	6,3	6,30	1	90	6,3	6,30	1	90	6,3	6,30	1	90	6,30	6,30								
6	Working Air Compressor	2,2	380	1	2,20																								
7	ICAF System	0,5	230	1	0,50	1	100	0,5	0,50	1	100	0,5	0,50	1	100	0,5	0,50												
					28,90			**6,80**	**6,80**			**6,80**	**6,80**			**6,80**	**6,80**			**6,30**	**6,30**			**0,00**	**0,00**			**0,00**	**0,00**
FIRE FIGHTING SYSTEM																													
8	Sprinkler system	2,20	380	1	2,20																					1	85	1,87	
9	CO2 FiFi System																												
					2,20			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**1,87**	**0,00**
DECK MACHINERY																													
10	Bow Anchor-Mooring Winch	15,00		1	15,00													1	80	12,00									
11	Aft Anchor Winch	15,00		2	30,00													1	80	12,00									
					45,00			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**24,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
AIRCON & REFRIGERATION SYSTEM																													
12	Pump Room Supply Fan	1,3	380	2	2,60																								
13	Fan of Mess Room / Galley (Supply+Exhaust)	0,3	380	2	0,60	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90		0,27				
14	Wheelhouse Air Condition System	8,5	230	1	8,50	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65								
15	WH Supply Fan	0,07	230	1	0,07																								
16	WH Windows Supply Fan	0,07	230	1	0,07	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06								
17	Supply fan for WH Elevation Room	0,16	230	1	0,16																								
18	Supply Fan of Electrical & Hydraulic eq.	0,07	230	1	0,07																								
19	Accomodation Fans (set of 6pcs)	0,51	230	1	0,51	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46								
20	Ceiling Heating Batteries for Accommodation	0,5	230	10	5,00																								
21	Heating batteries for Technical Room	1	230	4	4,00																								
22	Heating batteries for DG & Pump Room	1,5	230	3	4,50																	3	90	4,05					
					26,08			**8,44**	**8,44**			**8,44**	**8,44**			**8,44**	**8,44**			**8,44**	**8,44**			**4,05**	**0,27**			**0,00**	**0,00**
GALLEY/PAUNTRY/LAUNDRY & ACCOM. EQUIPMENT																													
23	Galley stove w/oven (4x2.6 + 1x6kW)	16	380	1	16,40																	1	25	4,1	4,10				
24	Other galley Equipment	11	230	1	11,43																								
25	Fresh water hydrophore unit (cold water)	1	230	1	0,85																	1	50	0,425	0,43				
26	Hot water Circulation Pump	1	380	1	1,00																								
27	Fresh Water Heater (hot water)	4	380	1	4,00																	1	25	1	1,00				
28	Sololift	1	230	1	0,65																								
29	Sewage Transfer Pump	4	380	1	3,50																	1	25	0,875	0,88				
					37,83			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**6,40**	**6,40**			**0,00**	**0,00**
220V D. B. & PANEL																													
30	Navigation, Communication Equipment DB	6,00	230V / 24VDC	1	6,00																					1	85	5,10	
31	Lighting Internal	1,20	230	1	1,20																	1	60	0,72	2,40				
32	Lighting External	1,20	230	1	1,20																								
33	Lighting Emergency	0,50	230	1	0,50																					1	100	0,50	
34	Search Lights	1,00	230	2	2,00																					1	85	0,85	
35	Navigation Lights	0,06	230V/24VDC	16	0,96	8	100	0,48		8	100	0,48		8	100	0,48		8	100	0,48						1	40	0,02	
36	24V DC Distribution Board Battery Charger	2,50		1	2,50																								
37	UPS	2,50		1	2,50																								
					16,86			**0,48**	**0,00**			**0,48**	**0,00**			**0,48**	**0,00**			**0,48**	**0,00**			**0,72**	**2,40**			**6,47**	**0,00**
	TOTAL				**816,87**			**675,72**	**15,24**			**539,76**	**15,24**			**300,84**	**15,24**			**237,22**	**14,74**			**11,17**	**9,07**			**8,34**	**0,00**

Load balance for methanol solution

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m				SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m				SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)	
								CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M
	THRUSTERS																												
1	Azimuth Thruster	330,00	680,00	2	660,00	2	100	660,00		2	79	524,04		2	43	285,12		2	30	198,00									
					660,00			**660,00**	**0,00**			**524,04**	**0,00**			**285,12**	**0,00**			**198,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
	MACHINERY																												
2	Bilge Pump	4	380	1	4,00																								
3	Fire Pump	4	380	1	4,00																								
4	Hydraulic Power Unit for Wheelhouse Elevation System	4,2	380	1	4,20																								
5	FO Transfer Pump	0,6	380	1	0,60																								
6	FW Cooling Pump	7	380	2	14,00	2	90	12,6	12,60	2	90	12,6	12,60	1	90	6,3	6,30	1	90	6,30	6,30								
7	Working Air Compressor	2,2	380	1	2,20	1	90	1,98	1,98	1	90	1,98	1,98	1	90	1,98	1,98	1	90	1,98	1,98								
8	Nox Cleaning Unit	5	380	1	5,00																								
9	ICAF System	0,5	230	1	0,50	1	100	0,5	0,50	1	100	0,5	0,50	1	100	0,5	0,50												
10	Nitrogen unit	2	230	2	4,00	1	100	2	2,00	1	100	2	2,00	1	100	2	2,00	1	100	2,00	2,00	1	100	2	2,00				
					38,50			**17,08**	**17,08**			**17,08**	**17,08**			**10,78**	**10,78**			**10,28**	**10,28**			**2,00**	**2,00**			**0,00**	**0,00**
	FIRE FIGHTING SYSTEM																												
11	Sprinkler system	2,20	380	1	2,20																					1	85	1,87	
12	CO2 FiFi System																												
					2,20			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**1,87**	**0,00**
	DECK MACHINERY																												
13	Bow Anchor-Mooring Winch	15,00		1	15,00													1	80	12,00									
14	Aft Anchor Winch	15,00		2	30,00													1	80	12,00									
					45,00			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**24,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
	AIRCON & REFRIGERATION SYSTEM																												
15	Pump Room Supply Fan	1,3	380	1	1,30									1	80	1,04	1,04	1	80	1,04	1,04								
16	Fan of Mess Room / Galley (Supply+Exhaust)	0,3	380	2	0,60	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90		0,27				
17	Wheelhouse Air Condition System	8,5	230	1	8,50	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65								
18	WH Supply Fan	0,07	230	1	0,07																								
19	WH Windows Supply Fan	0,07	230	1	0,07	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06								
20	Supply fan for WH Elevation Room	0,16	230	1	0,16																								
21	Supply Fan of Electrical & Hydraulic eq.	0,07	230	1	0,07																								
22	Accomodation Fans (set of 6pcs)	0,51	230	1	0,51	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46								
23	Ceiling Heating Batteries for Accommodation	0,5	230	10	5,00																								
24	Heating batteries for Technical Room	1	230	4	4,00																								
25	Heating batteries for DG & Pump Room	1,5	230	3	4,50																	3	90	4,05	4,05				
26	Airlock fans	0,5	230	3	1,50	3	90	1,35	1,35	3	90	1,35	1,35	3	90	1,35	1,35	3	90	1,35	1,35	3	90	1,35	1,35				
27	Methanol preparation room fans	1,3	380	2	2,60	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34				
28	Battery charging system	15	380	2	30,00	1	50	7,5	7,50	1	50	7,5	7,50	1	50	7,5	7,5												
					58,88			**19,63**	**19,63**			**19,63**	**19,63**			**20,67**	**20,67**			**13,17**	**13,17**			**7,74**	**8,01**			**0,00**	**0,00**
	GALLEY/PAUNTRY/LAUNDRY & ACCOM. EQUIPMENT																												
29	Galley stove w/oven (4x2.6 + 1x6kW)	16	380	1	16,40																	1	25	4,1	4,10				
30	Other galley Equipment	11	230	1	11,43																								
31	Fresh water hydrophore unit (cold water)	1	230	1	0,85																	1	50	0,425	0,43				
32	Hot water Circulation Pump	1	380	1	1,00																								
33	Fresh Water Heater (hot water)	4	380	1	4,00																	1	25	1	1,00				
34	Sololift	1	230	1	0,65																								
35	Sewage Transfer Pump	4	380	1	3,50																	1	25	0,875	0,88				

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m				SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m				SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)	
								CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M
					37,83			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**6,40**	**6,40**			**0,00**	**0,00**
	220V D. B. & PANEL																												
36	Navigation, Communication Equipment DB	6,00	230V / 24VDC	1	6,00																					1	85	5,10	
37	Lighting Internal	1,20	230	1	1,20																	1	60	0,72	2,40				
38	Lighting External	1,20	230	1	1,20	1	60	0,72	0,72	1	60	0,72	0,72	1	60		0,72	1	60		0,72								
39	Lighting Emergency	0,50	230	1	0,50																					1	100	0,50	
40	Search Lights	1,00	230	2	2,00																					1	85	0,85	
41	Navigation Lights	0,06	230V / 24VDC	16	0,96	8	100	0,48	0,48	8	100	0,48		8	100	0,48		8	100	0,48						1	40	0,02	
42	24V DC Distribution Board Battery Charger	2,50		1	2,50																								
43	UPS	2,50		1	2,50																								
					16,86			**1,20**	**1,20**			**1,20**	**0,72**			**0,48**	**0,72**			**0,48**	**0,72**			**0,72**	**2,40**			**6,47**	**0,00**
	TOTAL				**859,27**			**697,91**	**37,91**			**561,95**	**37,43**			**317,05**	**32,17**			**245,93**	**24,17**			**16,86**	**18,81**			**8,34**	**0,00**

Load balance for ammonia solution

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m				SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m				SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)		NO. IN USE	UF %	LOAD (KW)	
								CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M			CONT.	INT'M
	THRUSTERS																												
1	Azimuth Thruster	330,00	680,00	2	660,00	2	100	660,00		2	79	524,04		2	43	285,12		2	30	198,00									
					660,00			**660,00**	**0,00**			**524,04**	**0,00**			**285,12**	**0,00**			**198,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
	MACHINERY																												
2	Bilge Pump	4	380	1	4,00	1	80	3,2	3,20	1	80	3,2	3,20	1	80	3,2	3,20					1	80		3,20				
3	Fire Pump	4	380	1	4,00																	1	80		3,20				
4	Hydraulic Power Unit for Wheelhouse Elevation System	4,2	380	1	4,20	1	80	3,36	3,36	1	80	3,36	3,36	1	80	3,36	3,36												
5	FO Transfer Pump	0,6	380	1	0,60	1	90	0,54	0,54	1	90	0,54	0,54	1	90	0,54	0,54	1	90		0,54								
6	FW Cooling Pump	7	380	2	14,00	2	90	12,6	12,60	2	90	12,6	12,60	1	90	6,3	6,30	1	90	6,30	6,30								
7	Working Air Compressor	2,2	380	1	2,20	1	90	1,98	1,98	1	90	1,98	1,98	1	90	1,98	1,98	1	90	1,98	1,98								
8	Nox Cleaning Unit	5	380	1	5,00																								
9	ICAF System	0,5	230	1	0,50	1	100	0,5	0,50	1	100	0,5	0,50	1	100	0,5	0,50					1	100		0,50				
10	Nitrogen unit	2	230	2	4,00	1	100	2	2,00	1	100	2	2,00	1	100	2	2,00	1	100	2,00	2,00	1	100	2	2,00				
					38,50			**24,18**	**24,18**			**24,18**	**24,18**			**17,88**	**17,88**			**10,28**	**10,82**			**2,00**	**8,90**			**0,00**	**0,00**
	FIRE FIGHTING SYSTEM																												
11	Sprinkler system	2,20	380	3	6,60																					3	85	5,61	
12	CO2 FiFi System																												
					6,60			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**5,61**	**0,00**
	DECK MACHINERY																												
13	Bow Anchor-Mooring Winch	15,00		1	15,00													1	80	12,00	12,00								
14	Aft Anchor Winch	15,00		2	30,00													1	80	12,00	12,00								
					45,00			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**24,00**	**24,00**			**0,00**	**0,00**			**0,00**	**0,00**
	AIRCON & REFRIGERATION SYSTEM																												
15	Pump Room Supply Fan	1,3	380	1	1,30	1	80	1,04	1,04	1	80	1,04	1,04	1	80	1,04	1,04	1	80	1,04	1,04								
16	Fan of Mess Room / Galley (Supply+Exhaust)	0,3	380	2	0,60	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90		0,27				
17	Wheelhouse Air Condition System	8,5	230	1	8,50	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65								
18	WH Supply Fan	0,07	230	1	0,07													1	90	0,063	0,06								
19	WH Windows Supply Fan	0,07	230	1	0,07	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06								
20	Supply fan for WH Elevation Room	0,16	230	1	0,16													1	90	0,144	0,14								
21	Supply Fan of Electrical & Hydraulic eq.	0,07	230	1	0,07													1	90	0,063	0,06								
22	Accomodation Fans (set of 6pcs)	0,51	230	1	0,51	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46								
23	Ceiling Heating Batteries for Accommodation	0,5	230	10	5,00													1	90	0,45	0,45								
24	Heating batteries for Technical Room	1	230	4	4,00													1	90	0,9	0,90								
25	Heating batteries for DG & Pump Room	1,5	230	3	4,50													1	90	1,35	1,35	3	90	4,05	4,05				
26	Airlock fans	0,5	230	2	1,00	2	90	0,9	0,90	2	90	0,9	0,90	2	90	0,9	0,9	2	90	0,9	0,90	2	90	0,9	0,90				
27	Methanol preparation room fans	1,3	380	2	2,60	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34				
28	Battery charging system	15	380	2	30,00	1	50	7,5	7,50	1	50	7,5	7,50	1	50	7,5	7,5												
					58,38			**20,22**	**20,22**			**20,22**	**20,22**			**20,22**	**20,22**			**15,69**	**15,69**			**7,29**	**7,56**			**0,00**	**0,00**
	GALLEY/PAUNTRY/LAUNDRY & ACCOM. EQUIPMENT																												
29	Galley stove w/oven (4x2.6 + 1x6kW)	16	380	1	16,40																	1	25	4,1	4,10				
30	Other galley Equipment	11	230	1	11,43																								
31	Fresh water hydrophore unit (cold water)	1	230	1	0,85																	1	50	0,425	0,43				
32	Hot water Circulation Pump	1	380	1	1,00																								
33	Fresh Water Heater (hot water)	4	380	1	4,00																	1	25	1	1,00				
34	Sololift	1	230	1	0,65																								
35	Sewage Transfer Pump	4	380	1	3,50																	1	25	0,875	0,88				

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m				SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m				SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M
					37,83			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**6,40**	**6,40**			**0,00**	**0,00**
	220V D. B. & PANEL																												
36	Navigation, Communication Equipment DB	6,00	230V / 24VDC	1	6,00																					1	85	5,10	
37	Lighting Internal	1,20	230	1	1,20																	1	60	0,72	2,40				
38	Lighting External	1,20	230	1	1,20	1	60	0,72	0,72	1	60	0,72	0,72	1	60	0,72	0,72												
39	Lighting Emergency	0,50	230	1	0,50																					1	100	0,50	
40	Search Lights	1,00	230	2	2,00																					1	85	0,85	
41	Navigation Lights	0,06	230V / 24VDC	16	0,96	8	100	0,48	0,48	8	100	0,48	0,48	8	100	0,48	0,48	8	100	0,48	2,40					1	40	0,02	
42	24V DC Distribution Board Battery Charger	2,50		1	2,50																								
43	UPS	2,50		1	2,50																								
					16,86			**1,20**	**1,20**			**1,20**	**1,20**			**1,20**	**1,20**			**0,48**	**2,40**			**0,72**	**2,40**			**6,47**	**0,00**
	TOTAL				**863,17**			**705,60**	**45,60**			**569,64**	**45,60**			**324,42**	**39,30**			**248,45**	**52,91**			**16,41**	**25,26**			**12,08**	**0,00**

Load balance for hydrogen solution

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m				SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m				SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M
	THRUSTERS																												
1	Azimuth Thruster	330,00	680,00	2	660,00	2	100	660,00		2	79	524,04		2	43	285,12		2	30	198,00									
					660,00			**660,00**	**0,00**			**524,04**	**0,00**			**285,12**	**0,00**			**198,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
	MACHINERY																												
2	Bilge Pump	4	380	1	4,00																								
3	Fire Pump	4	380	1	4,00																								
4	Hydraulic Power Unit for Wheelhouse Elevation System	4,2	380	1	4,20																								
5	FO Transfer Pump	0,6	380	1	0,60																								
6	FW Cooling Pump	7	380	2	14,00	2	90	12,6	12,60	2	90	12,6	12,60	1	90	6,3	6,30	1	90	6,30	6,30								
7	Working Air Compressor	2,2	380	1	2,20	1	90	1,98	1,98	1	90	1,98	1,98	1	90	1,98	1,98	1	90	1,98	1,98								
8	Nox Cleaning Unit	5	380	1	5,00																								
9	ICAF System	0,5	230	1	0,50	1	100	0,5	0,50	1	100	0,5	0,50	1	100	0,5	0,50												
10	Nitrogen unit	2	230	2	4,00	1	100	2	2,00	1	100	2	2,00	1	100	2	2,00	1	100	2,00	2,00	1	100	2	2,00				
					38,50			**17,08**	**17,08**			**17,08**	**17,08**			**10,78**	**10,78**			**10,28**	**10,28**			**2,00**	**2,00**			**0,00**	**0,00**
	FIRE FIGHTING SYSTEM																												
11	Sprinkler system	2,20	380	3	6,60																					3	85	5,61	
12	CO2 FiFi System																												
					6,60			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**5,61**	**0,00**
	DECK MACHINERY																												
13	Bow Anchor-Mooring Winch	15,00		1	15,00													1	80	12,00									
14	Aft Anchor Winch	15,00		2	30,00													1	80	12,00									
					45,00			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**24,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**
	AIRCON & REFRIGERATION SYSTEM																												
15	Pump Room Supply Fan	1,3	380	1	1,30	1	80	1,04	1,04	1	80	1,04	1,04	1	80	1,04	1,04	1	80	1,04	1,04								
16	Fan of Mess Room / Galley (Supply+Exhaust)	0,3	380	2	0,60	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27	1	90	0,27	0,27								
17	Wheelhouse Air Condition System	8,5	230	1	8,50	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65	1	90	7,65	7,65								
18	WH Supply Fan	0,07	230	1	0,07																								
19	WH Windows Supply Fan	0,07	230	1	0,07	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06	1	90	0,063	0,06								
20	Supply fan for WH Elevation Room	0,16	230	1	0,16																								
21	Supply Fan of Electrical & Hydraulic eq.	0,07	230	1	0,07																								
22	Accomodation Fans (set of 6pcs)	0,51	230	1	0,51	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46	1	90	0,459	0,46								
23	Ceiling Heating Batteries for Accommodation	0,5	230	10	5,00																								
24	Heating batteries for Technical Room	1	230	4	4,00																								
25	Heating batteries for DG & Pump Room	1,5	230	3	4,50																	3	90	4,05	4,05				
26	Airlock fans	0,5	230	2	1,00	2	90	0,9	0,90	2	90	0,9	0,90	2	90	0,9	0,9	2	90	0,9	0,90	2	90	0,9	0,90				
27	Methanol preparation room fans	1,3	380	2	2,60	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34	2	90	2,34	2,34				
28	Battery charging system	15	380	2	30,00	1	50	7,5	7,50	1	50	7,5	7,50	1	50	7,5	7,5												
					58,38			**20,22**	**20,22**			**20,22**	**20,22**			**20,22**	**20,22**			**12,72**	**12,72**			**7,29**	**7,29**			**0,00**	**0,00**
	GALLEY/PAUNTRY/LAUNDRY & ACCOM. EQUIPMENT																												
29	Galley stove w/oven (4x2.6 + 1x6kW)	16	380	1	16,40																	1	25	4,1	4,10				
30	Other galley Equipment	11	230	1	11,43																								
31	Fresh water hydrophore unit (cold water)	1	230	1	0,85																	1	50	0,425	0,43				
32	Hot water Circulation Pump	1	380	1	1,00																								
33	Fresh Water Heater (hot water)	4	380	1	4,00																	1	25	1	1,00				
34	Sololift	1	230	1	0,65																								

SR. NO.	ITEM / APPARATUS	INSTALLED POWER (MOTOR POWER), KW	VOLTAGE	NO. OF SETS	TOTAL POWER (KW)	SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m				SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m				SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m				MANEUVERING				HARBOUR				EMERGENCY			
						NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M	NO. IN USE	UF %	LOAD (KW) CONT.	LOAD (KW) INT'M
35	Sewage Transfer Pump	4	380	1	3,50																	1	25	0,875	0,88				
					37,83			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**0,00**	**0,00**			**6,40**	**6,40**			**0,00**	**0,00**
	220V D. B. & PANEL																												
36	Navigation, Communication Equipment DB	6,00	230V / 24VDC	1	6,00																					1	85	5,10	
37	Lighting Internal	1,20	230	1	1,20																	1	60	0,72	2,40				
38	Lighting External	1,20	230	1	1,20	1	60	0,72	0,72	1	60	0,72	0,72	1	60		0,72	1	60		0,72								
39	Lighting Emergency	0,50	230	1	0,50																					1	100	0,50	
40	Search Lights	1,00	230	2	2,00																					1	85	0,85	
41	Navigation Lights	0,06	230V / 24VDC	16	0,96	8	100	0,48	0,48	8	100	0,48	0,48	8	100	0,48	0,48	8	100	0,48						1	40	0,02	
42	24V DC Distribution Board Battery Charger	2,50		1	2,50																								
43	UPS	2,50		1	2,50																								
					16,86			**1,20**	**1,20**			**1,20**	**1,20**			**0,48**	**1,20**			**0,48**	**0,72**			**0,72**	**2,40**			**6,47**	**0,00**
	TOTAL				**863,17**			**698,50**	**38,50**			**562,54**	**38,50**			**316,60**	**32,20**			**245,48**	**23,72**			**16,41**	**18,09**			**12,08**	**0,00**

Table with total data for every type of generating system

Type of fuel	**SEA GOING WITH BARGE - DESIGN SPEED Service speed 12 knots Draft 1.2m**	**SEA GOING WITH BARGE - DESIGN SPEED Service speed 10 km/h maximum draft 2m**	**SEA GOING - ECO MODE ECO speed 8 km/h maximum draft 2m**	**MANEUVERING**	**HARBOUR**	**EMERGENCY**
	LOAD (KW)	**LOAD (KW)**	**LOAD (KW)**	**LOAD (KW)**	**LOAD (KW)**	**LOAD (KW)**
Batteries	675.72	539.76	300.84	237.22	11.17	8.34
Methanol	697.91	561.95	317.05	245.93	16.86	8.34
Ammonia	705.60	569.64	324.42	248.45	16.41	12.08
Hydrogen	698.50	562.54	316.60	245.48	16.41	12.08

Battery system

For battery solution we use battery packs from Zenocen because this supplier has the highest power capacity per unit. Main data of one container is in the table below.

BESS Container important parameters	ZEN Response
Dimensions (container size)	6227 x 2438 x 1473mm (include power cabinet)
Weight, t	~33 t
Ingres Protection (IP rate)	IP67 for the steel structure and cabinet. Battery modules are subsea
Door(s) arrangement	Top Lid secured with nut/washer
Cable connections (interface with ship, Power, Control)	Connector to decided
Other connection(s) (Piping, Duct, etc.)	DN25 Flange PN16
Thermal Runaway Prevention	freshwater immersion, with a max temp of 42°C
Installed Energy, kWh	Nominal capacity: 4.2MWh
Maximum Continuous Power, kW	1260kW (0.3C)
Max. Voltage, VDC	985.5V
Min. Voltage, VDC	675V
Nominal Voltage, VDC	869.4V
C-Rate	0.3C
Conditions for BESS container(s) storage	storage temperature without cooling or heating hookup: 0-65°C

One container capacity is **4.2MWh**. The working capacity is 90%, that is **3.78MWh**.

The calculation of the power capacity is made for cases with pushing the barge up and down stream. For calculation upstream is using the data from CFD calculation and electro balance. For downstream calculation is used data from electro balance calculation for maneuvering mode.

Draft 1.2 m

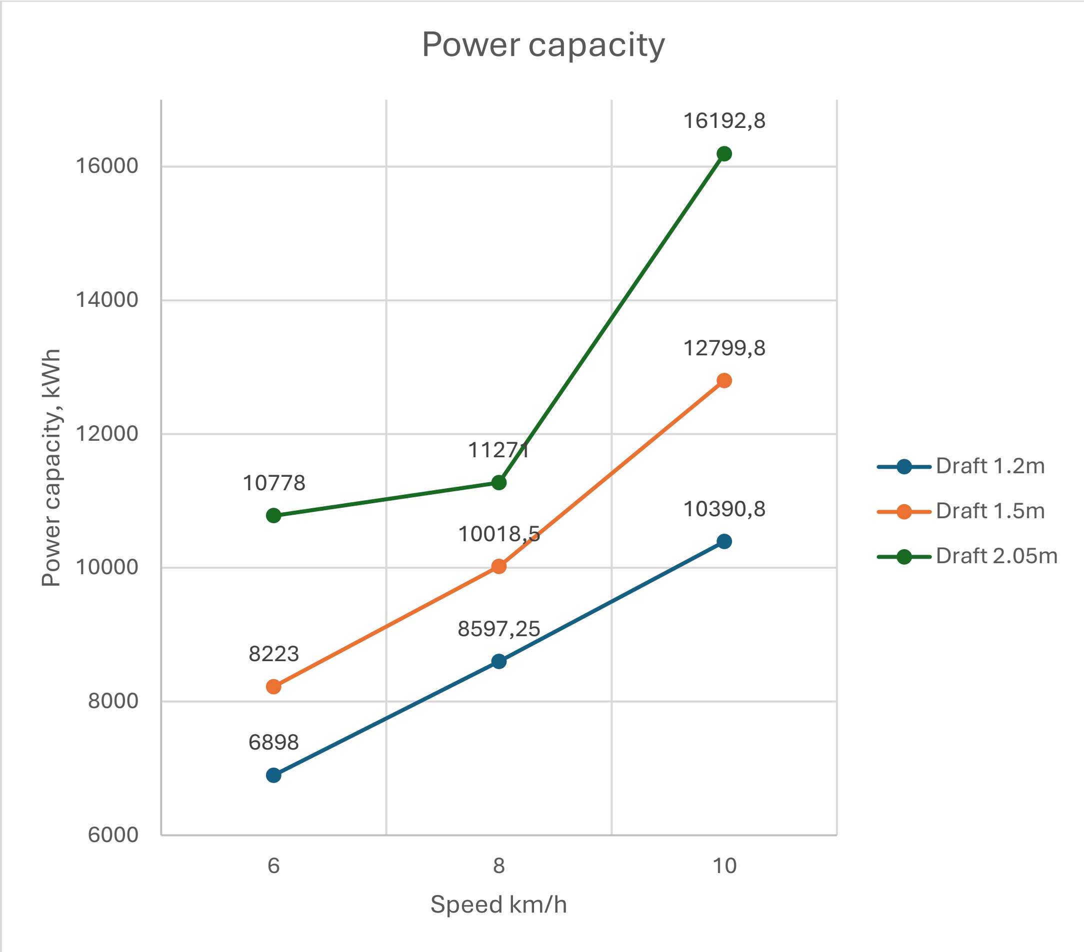
Way	Speed from shoe, km/h	Power_S + sea margin, kW	Time in the route, hours	Power capacity, kWh	One ESS capacity, kWh	Number of ESS
Upstream	6	122,6	50	6898	3780	2
Upstream	8	213,9	37,5	8597,3	3780	3
Upstream	10	331	30	10390,8	3780	3
Downstream	10	237,22	30	7577,4	3780	2

Draft 1.5 m

Way	Speed from shoe, km/h	Power_S + sea margin, kW	Time in the route, hours	Power capacity, kWh	One ESS capacity, kWh	Number of ESS
Upstream	6	149,1	50	8223	3780	3
Upstream	8	251,8	37,5	10018,5	3780	3
Upstream	10	411,3	30	12799,8	3780	4
Downstream	10	237,22	30	7577,4	3780	2

Draft 2.05 m

Way	Speed from shoe, km/h	Power_S + sea margin, kW	Time in the route, hours	Power capacity, kWh	One ESS capacity, kWh	Number of ESS
Upstream	6	200,2	50	10778	3780	3
Upstream	8	285,2	37,5	11271	3780	3
Upstream	10	524,4	30	16192,8	3780	5
Downstream	10	237,22	30	7577,4	3780	2



Power capacity
Power capacity, kWh
16000
14000
12000
10000
8000
6000
6
8
10
Speed km/h
16192,8
12799,8
11271
10778
10018,5
10390,8
8597,25
8223
6898
Draft 1.2m
Draft 1.5m
Draft 2.05m

Methanol system

The integration of methanol fuel cell systems in marine vessels, such as river pushers, represents a significant advancement in the pursuit of sustainable and eco-friendly waterway transportation. Methanol, as a clean-burning fuel, offers a promising alternative to traditional fossil fuels, with the potential to significantly reduce emissions of pollutants and greenhouse gases. A methanol fuel cell system operates by converting methanol into electricity through a chemical process, which then powers the vessel's electric motors. This technology not only contributes to cleaner air and water but also enhances the energy efficiency of the vessel. The development of such systems aligns with global efforts to decarbonize the maritime industry and transition towards greener energy sources, marking a pivotal step in achieving environmental conservation goals while maintaining the robustness required for commercial and industrial river transport operations. The adoption of methanol fuel cells in river pushers could set a precedent for other types of vessels, leading to widespread changes in industry and a cleaner future for our waterways.

For this project was chosen the containerized fuel cell packs.

Calculation of number of fuel cells you may see in the table below.

For calculation upstream is using the data from CFD calculation and electro balance. For downstream calculation is used data from electro balance calculation for maneuvering mode.

Maximum electric load in different cases.

Draft 1.2 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	245,83	200	2	61
Upstream	10	368,91	200	3	61
Downstream	10	245,93	200	2	61
Max speed	22.2	697.91	200	4	87
Draft 1.5 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	283,73	200	2	71
Upstream	10	449,21	200	3	75
Downstream	10	245,93	200	2	61
Max speed	22.2		200	4	
Draft 2,05 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	317,05	200	2	79
Upstream	10	561,95	200	3	94
Downstream	10	245,93	200	2	61

Ammonia system

Ammonia fuel cells represent a promising technology for powering river pushers, offering a cleaner alternative to traditional fossil fuels. These systems utilize ammonia as an indirect hydrogen storage medium, which can be converted into electricity through a fuel cell. The concept of 'green ammonia,' produced from renewable energy sources, is gaining traction as a sustainable fuel option. While technology is advancing, challenges such as material selection, NOx formation, CO2 tolerance, power density, and long-term stability are being addressed to enhance the viability of ammonia fuel cells for marine applications. Moreover, recent initiatives have seen the integration of ammonia cracker technology with fuel cell systems, aiming to demonstrate power conversion with significant output, marking a step forward in the practical application of this technology.

For this project was chosen the containerized fuel cell packs. Main data on the picture below.

AMOGY AMOGY-23.10-SPECS-001-Rev1-Powerpack

Item	Amogy 200 kW Powerpack	
Performance Characteristics	**Values**	**Units**
Gross power output	200	kW
Output voltage (V)	Customizable (e.g., 690 VAC, 400 VDC)	
Cold start time	2	hours
NH_3 Fuel Efficiency	2.1	kWhe/kg
Reactants & Cooling		
Fuel specification	Anhydrous NH_3	
Grade	Industrial (<0.5 wt% H_2O)	
Maximum heat rejection/cooling duty[a]	360	kW
Physical Characteristics (Per 200 kW Train)		
Reactor (l x w x h)	1.2 x 1.2 x 2.2	m
Adsorber (l x w x h)	1.2 x 0.8 x 2.2	m
Fuel Cell (l x w x h)	1.2 x 0.75 x 2.2	m
Weight per train[b]	4000	kg

Calculation of number of fuel cells you may see in the table below.

For calculation upstream is using the data from CFD calculation and electro balance. For downstream calculation is used data from electro balance calculation for maneuvering mode.

Maximum electric load in different cases.

Draft 1.2 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	253,2	200	2	63
Upstream	10	376,6	200	3	63
Downstream	10	248,45	200	2	62
Max speed	22	698	200	4	87
Draft 1.5 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	291,1	200	2	73
Upstream	10	456,9	200	3	76
Downstream	10	248,45	200	2	62
Max speed	22	698	200	4	87
Draft 2,05 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	324,5	200	2	81
Upstream	10	570	200	3	95
Downstream	10	248,45	200	2	62

Hydrogen system

The integration of hydrogen fuel cell systems in river pushers is a significant advancement in the maritime industry, aiming to reduce carbon emissions and enhance sustainability. applications.

For this project was chosen the integrated fuel cell packs. Main data on the picture below.

FCM 400 PRODUCT DATASHEET

GENERAL INFORMATION	
Type of Fuel Cell	Proton Exchange Membrane
Type of Fuel	Hydrogen
Hydrogen Grade	ISO14687:2019 Grade D
Fuel Cell Stack Supplier	TECO2030 ASA
VOLTAGE | CURRENT | POWER	
Equivalent installed power on system level [1]	400 kW
Rated Power (at BOL)	366 kW
Efficiency at Rated Power (at BOL)	48%
Maximum Efficiency	55%
Auxiliary Power Consumption at Rated Power (BOP external supply)	41 kW
Design Lifetime	35.000 hours
Stack Voltage: Idle, Rated power (at BOL)	1089 VDC, 888 VDC
Maximum Voltage Output	1452 VDC
Stack Current: Rated, Idle	412.5 A, 22 A
Voltage Input for Auxiliary Power Supply (BOP external supply)	750 VDC
Module Dynamic Behavior	54 kW/s
FUEL CONSUMPTION	
At Rated power (at BOL)	20.5 kg/hour, incl. H_2 purge losses
At Idle	1.1 kg/hour, incl. H_2 purge losses
HYDROGEN SUPPLY	
Pressure, Max., Min. at FCM 400 boundary	6 bar(a), 4 bar(a) (gaseous H_2)
Temp., Max., Min. at FCM 400 boundary	70°C, 3°C
ISOLATION RESISTANCE	
Lower alarm limit	0.5MΩ
COOLANT WASTE HEAT | HIGH TEMPERATURE LOOP	
Coolant Waste Heat (at Rated Power, at BOL)	340 kWth
Max. Coolant Outlet Temperature	59°C
Max. Coolant Flow	600 l/min
Volume Coolant	49 l
COOLANT WASTE HEAT | LOW TEMPERATURE LOOP	
Coolant Waste Heat (at Rated Power, at BOL)	5 kWth
Max. Coolant Outlet Temperature	70 °C
Max Coolant Flow	20 l/min
COMMUNICATION	
Protocol	EtherCAT / Modbus TCP
DIMENSIONS	
FCM400 structural cabinet dimensions and weight (L x D x H)	1374 x 987 x 2288 mm
FCM400 weight (operational)	1550 kg
CERTIFICATION	
Approval in Principle (DNV)	Granted September 30th 2021
Type Approval (DNV)	Ongoing
Temperature Class | Ambient room temperature (DNV-CG-0339) [2]	< T2 | +0 to +45 °C
IP protection of Fuel Cell Stack [3]	≥ IP 54

Calculation of number of fuel cells you may see in the table below.

For calculation upstream is using the data from CFD calculation and electro balance. For downstream calculation is used data from electro balance calculation for maneuvering mode.

Maximum electric load in different cases.

Draft 1.2 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	245,38	200	2	61
Upstream	10	369,5	200	3	62
Downstream	10	245,48	200	2	61
Max speed	22	698	200	4	87
Draft 1.5 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	283,28	200	2	71
Upstream	10	449,8	200	3	75
Downstream	10	245,48	200	2	61
Max speed	22	698	200	4	87
Draft 2,05 m					
Way	Speed from shoe, km/h	Max power kW	Fuel cell power, kW	Number of fuel cells	UF,%
Upstream	8	316,68	200	2	79
Upstream	10	562,9	200	3	94
Downstream	10	245,48	200	2	61

Deadweight calculation

Deadweight is the maximum weight that a ship or vessel can safely carry, which includes cargo, fuel, fresh water, stores, and crew. In the context of river pusher tugs, it is crucial as these vessels are designed to navigate inland waterways, often pushing a convoy of barges.

As our river pusher doesn't have cargo on board the deadweight will include:

- Fuel
- Fresh water
- Grey water tanks
- Stores and crew

As the difference between pushers is just in the generating system, the difference in deadweight will be in the mass of fuel, other parts of the deadweight will be the same. This calculation you may find below.

Fresh water

Calculation of fresh water is made according to Lithuanian sanitary rules for III category vessels.

According to the rules potable water should be 20 liters per person for 24 hours, technical water 30 liters per person for 24 hours.

As our pusher has 4 people on board and maximum time on trip is 50 hours, maximum freshwater tank should be 420 liters. Good marine practice to make this volume twice, so the mass of FW tank will be **1 ton**.

Grey water

Calculation of grey water is made according to Lithuanian sanitary rules for III category vessels.

According to the rules grey water should be 100 liters per person for 24 hours.

As our pusher has 4 people on board and maximum time on trip is 50 hours, maximum greywater tank should be 835 liters. Good marine practice to make this volume twice, so the mass of GWT tank will be **2 tons**.

Stores

Certain mass of stores could be calculated only on the basic design stage preliminary mass of stores is **1 ton** for spare parts, ropes, etc.

Crew

Mass of 1 person with baggage 100 kg as we have 4 people on board crew mass **0.4 ton.**

Provision

Calculation of provision stores is made according to Lithuanian sanitary rules for lll category vessels.

According to the total food mass should be 2.5 kg per person for 24 hours.

As our pusher has 4 people on board and maximum time on trip is 50 hours, maximum food mass should be 21kg. Good marine practice to make this mass twice, so the mass of food will be **0.04 tons**.

Total table

DWT part	Weight, t
Fresh water	1
Grey water	2
Stores	1
Crew	0.4
Provision	0.04
Total	4.44

Fuel calculation is made according to data from supplier and power that we need on the vessel. For every energy case deadweight parts: fresh water, grey water, stores, provision, crew - are the same, that's why changes between energy cases will be only in number of fuel. The maximum weight of deadweight part is with batteries, in worst case it is **170 ton**. Batterie packs are very heavy, and their number and weight highly increase with speed and draft. On the other hand, batteries are the simplest decision for vessels compartment. Because on the vessel will be just main equipment without extras: special firefighting systems, ventilation, etc.

Methanol and ammonia generating systems have nearly the same deadweight of fuel and it is not so big in worst case less than **8 ton**, but lightweight of the vessel is much higher than in battery system. It comes from the amount of extra equipment for safety.

The hydrogen system is the lightest system of all. Mass of H2 is less than **1 ton**, but the mass of hydrogen tanks and extra equipment is high. As vessel should carry near 65 H2 tanks on the main deck, it is spent a lot of space on the open deck.

For each type of generating system the fuel calculation you may find below.

Battery

Battery packs

For battery case there are no fuel on the vessel just containerized batteries.

The weight of each battery pack is 33t. With different speed and draft cases, the number of batteries will be variable.

Total weight of each battery pack.

Draft 1.2 m				
Way	Speed from shoe, km/h	Number of ESS	Weight ESS, t	Total DWT, t
Upstream	6	2	66	70,44
Upstream	8	3	99	103,44
Upstream	10	3	99	103,44
Downstream	10	2	66	70,44
Draft 1.5 m				
Way	Speed from shoe, km/h	Number of ESS	Weight ESS, t	Total DWT, t
Upstream	6	3	99	103,44
Upstream	8	3	99	103,44
Upstream	10	4	132	136,44
Downstream	10	2	66	70,44
Draft 2.05 m				
Way	Speed from shoe, km/h	Number of ESS	Weight ESS, t	Total DWT, t
Upstream	6	3	99	103,44
Upstream	8	3	99	103,44
Upstream	10	5	165	169,44
Downstream	10	2	66	70,44

Methanol

Calculation of deadweight for methanol generating system is on the table below.

Draft 1.2 m								
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, t/kWh	Fuel weight, t	Total DWT, t
Upstream	8	37,5	200	2	61	0,087	6,53	10,97
Upstream	10	30	200	3	61	0,087	7,83	12,27
Downstream	10	30	200	2	61	0,087	5,22	9,66
Draft 1.5 m								
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, t/kWh	Fuel weight, t	Total DWT, t
Upstream	8	37,5	200	2	71	0,087	6,53	10,97
Upstream	10	30	200	3	75	0,087	7,83	12,27
Downstream	10	30	200	2	61	0,087	5,22	9,66
Draft 2,05 m								
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, t/kWh	Fuel weight, t	Total DWT, t
Upstream	8	37,5	200	2	79	0,087	6,53	10,97
Upstream	10	30	200	3	94	0,087	7,83	12,27
Downstream	10	30	200	2	61	0,087	5,22	9,66

Ammonia

Calculation of deadweight for ammonia generating system is on the table below.

Draft 1.2 m								
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, t/kWh	Fuel weight, t	Total DWT, t
Upstream	8	37,5	200	2	63	0,0002	3,525	7,97
Upstream	10	30	200	3	63	0,0002	4,23	8,67
Downstream	10	30	200	2	62	0,0002	2,82	7,26
Draft 1.5 m								
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, t/kWh	Fuel weight, t	Total DWT, t
Upstream	8	37,5	200	2	73	0,0002	3,525	7,97
Upstream	10	30	200	3	76	0,0002	4,23	8,67
Downstream	10	30	200	2	62	0,0002	2,82	7,26
Draft 2,05 m								
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, t/kWh	Fuel weight, t	Total DWT, t
Upstream	8	37,5	200	2	81	0,0002	3,525	7,97
Upstream	10	30	200	3	95	0,0002	4,23	8,67
Downstream	10	30	200	2	62	0,0002	2,82	7,26

Hydrogen

Calculation of deadweight for hydrogen generating system is on the table below. In calculation added the information about hydrogen fuel tanks. H2 capacity of each tank is 14.6 kg of compressed hydrogen. Mass of each tank is 191kg.

Draft 1.2 m										
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, kg/kWh	Fuel weight, kg	Number of H2 tanks	Mass of H2 tanks, t	TOTAL DWT, t
Upstream	8	37,5	200	2	61	10,25	768,75	53	10,1	15,33
Upstream	10	30	200	3	62	10,25	922,5	64	12,2	17,59
Downstream	10	30	200	2	61	10,25	615	43	8,2	13,27
Draft 1.5 m										
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, kg/kWh	Fuel weight, kg	Number of H2 tanks	Mass of H2 tanks, ton	TOTAL DWT, t
Upstream	8	37,5	200	2	71	10,25	768,75	53	10,1	15,33
Upstream	10	30	200	3	75	10,25	922,5	64	12,2	17,59
Downstream	10	30	200	2	61	10,25	615	43	8,2	13,27
Draft 2,05 m										
Way	Speed from shoe, km/h	Time. Hours	Fuel cell power, kW	Number of fuel cells	UF,%	Consumption, kg/kWh	Fuel weight, kg	Number of H2 tanks	Mass of H2 tanks, ton	TOTAL DWT, t
Upstream	8	37,5	200	2	79	10,25	768,75	53	10,1	15,33
Upstream	10	30	200	3	94	10,25	922,5	64	12,2	17,59
Downstream	10	30	200	2	61	10,25	615	43	8,2	13,27

General arrangement with different types of fuel

The general arrangement of a river pusher vessel is a critical aspect of its design, particularly when considering the integration of alternative fuels such as hydrogen, methanol, ammonia, or batteries. These energy sources represent a shift towards more sustainable and environmentally friendly maritime operations. For instance, hydrogen fuel, with its high energy content and zero-emission profile, is becoming increasingly viable for river pushers.

Methanol, another alternative fuel, is gaining attention due to its lower emissions compared to traditional fossil fuels. The future of that utilizes methanol to significantly reduce CO2 emissions. This initiative highlights the potential for methanol to play a pivotal role in decarbonizing the supply chain within inland waterway shipping.

Ammonia fuel is also being explored for its potential in maritime applications. While it presents challenges in terms of storage and handling, its high hydrogen content and carbon-free combustion make it an attractive option for reducing greenhouse gas emissions. Research into the compatibility of pusher-barge systems with ammonia fuel is ongoing, aiming to assess its feasibility and performance in various maritime conditions.

Lastly, battery-powered river pushers offer a silent and emission-free alternative, aligning with the increasing demand for sustainable transportation methods. The integration of batteries into the general arrangement of river pushers requires careful consideration of weight distribution, energy storage capacity, and charging infrastructure to ensure operational efficiency and reliability.

The general arrangement of river pushers is evolving with the adoption of alternative fuels, reflecting a commitment to innovation and sustainability in the maritime industry. Each fuel option presents unique advantages and challenges, necessitating a tailored approach to vessel design and operation to optimize performance and environmental benefits. As the industry moves forward, these developments signify a transformative period for river transportation, with the potential to significantly impact global efforts to reduce maritime emissions and promote cleaner energy sources.

The general arrangement of river pusher main fetchers involves a detailed plan that outlines the specifications and naval terminology necessary for the construction and operation of these vessels. Typically, these arrangements are meticulously designed to ensure the efficient movement of barges or other river artifacts. The pusher, acting as the propulsion unit, is paired with a barge, which serves as the functional unit, to transport bulk cargo such as coal, limestone, or dredged materials. This system is lauded for its cost-effectiveness and efficiency, particularly in reducing unloading times and fuel consumption compared to self-propelled cargo vessels. The adaptability of the pusher-barge system allows for specialized operations, enhancing the economic viability of waterway transportation.

General arrangements are made for each type of generating system. Each project has a monohull hull, accommodation in the fore part of the vessel, technical rooms in the aft, elevating wheelhouse system on the main deck. Under the main deck all projects has crew cabins in the fore, mechanical rooms in the middle and azimuth thruster room in the aft part. Subdivision of the vessel is achieved by five main bulkheads, double bottom and continuous main deck.

For every case, fore part of the vessel is the same. Accommodation will be made for 4 persons with big galley/day room on the main deck. The change room with laundry is made on the main deck near the entrance. All crew cabins are made under main deck to make free space on the main deck. There are two single and one double cabin. One toilet and shower for all crew members.

Pump room is made in the middle part of the vessel. There will be sea chests, pumps and tanks for auxiliary systems. Entrance will be through the crew cabins and technical space in the aft.

The technical room in the middle is reserved for special equipment, fuel tanks and systems.

Special features of battery type general arrangement.

Batteries are installed on the main deck in the middle of the vessel. Under main deck technical room and switchboard room.

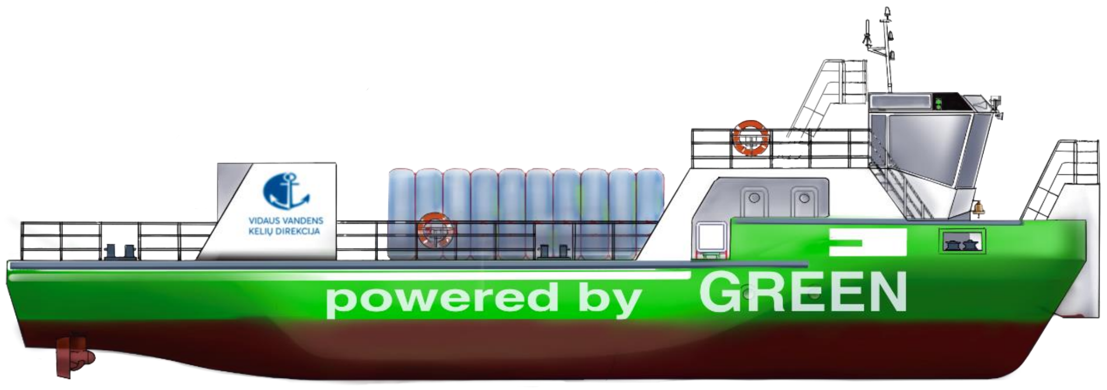
Special features of hydrogen type general arrangement.

All the hydrogen tanks are installed in the main deck to avoid explosions. The fuel preparation room and tech room are arranged in aft part on the main deck. In this place is special ventilation and emergency reset. Fuel cells, switchboard room and accumulator room are under the main deck. Nitrogen and CO2 rooms are made under main deck with special entrance from main deck.

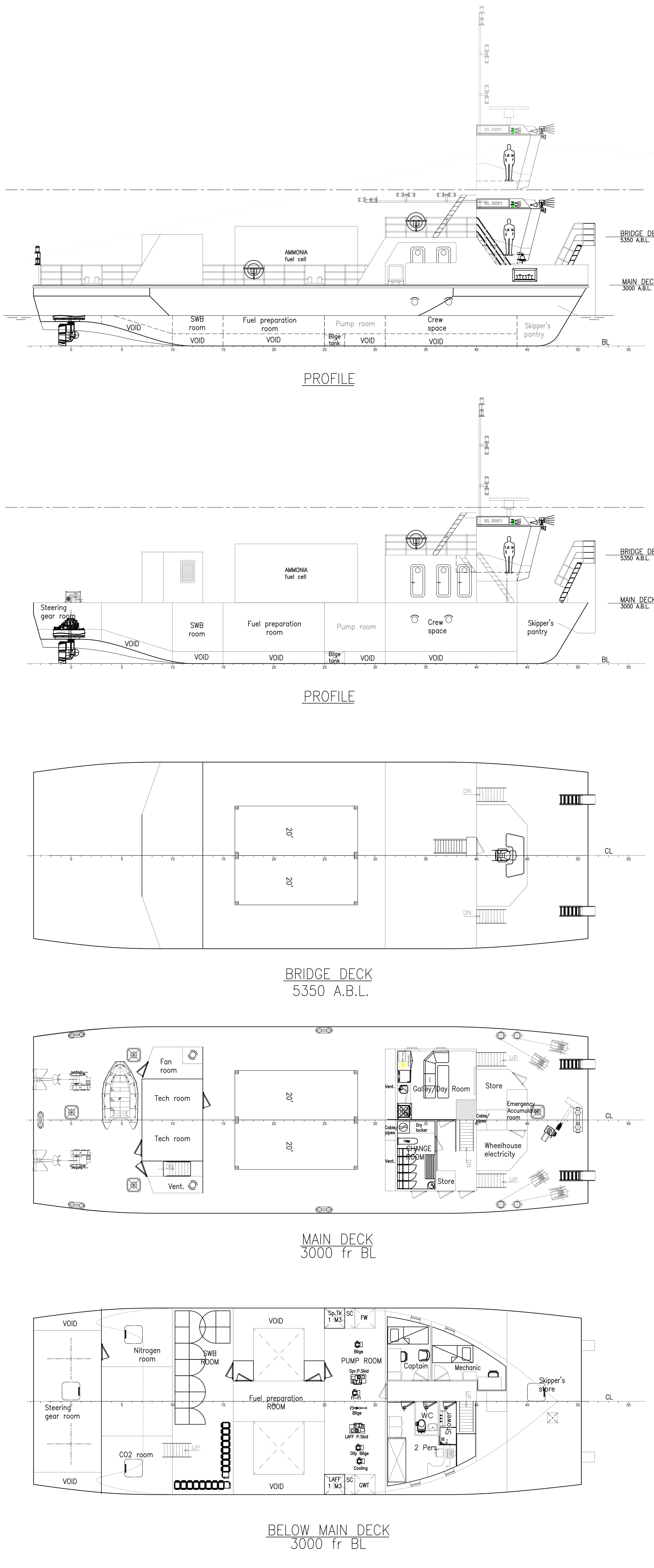
Special features of methanol and ammonia type general arrangement.

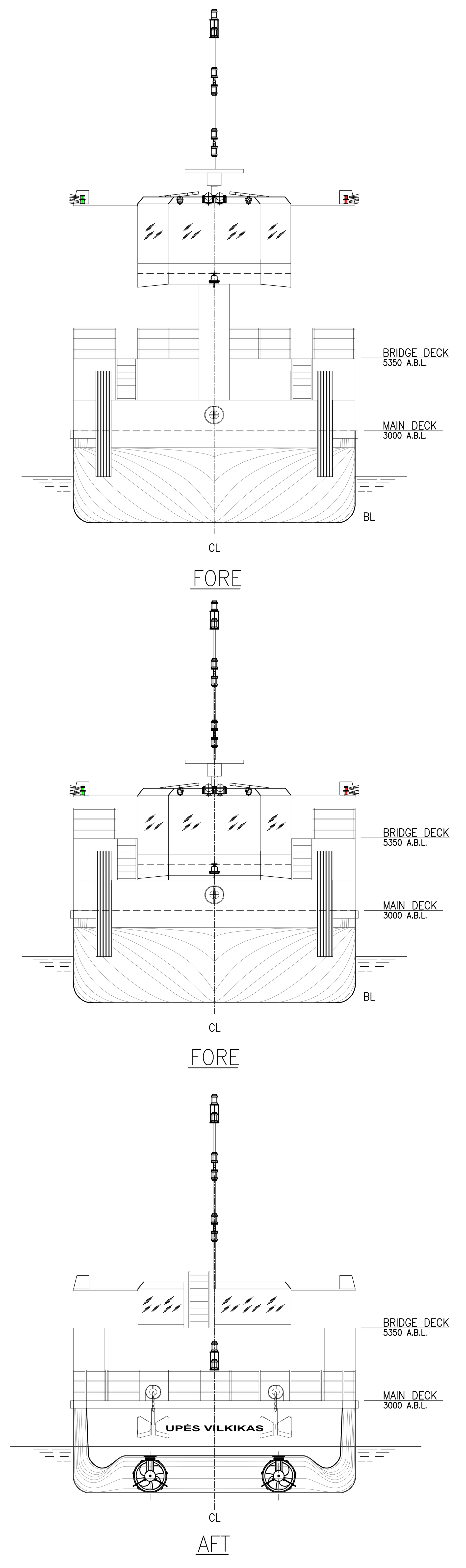
Fuel tanks are arranged under main deck with fuel preparation room. All tanks and spaces are made according to IGF Code and have cofferdams and airlocks. Nitrogen and CO2 rooms are made under main deck with special entrance from main deck. On the main deck are installed containerized generating systems.

Preliminary views of the pusher you may see below



All general arrangements you may see below.





MAIN CHARACTERISTICS

TYPE OF VESSEL....................PUSHER
$L_{DESIGN.}$ 26.00m
BREADTH....................9.20m
MAXIMUM DRAFT....................1.50m
DRAFT....................1.20m
MAIN DECK HEIGHT....................3.00m
DISPLACEMENT 199,3t
UPSTREAM SPEED....................10,0 km/h
WEIGHT OF PUSHED BARGE TO....................2000t
CREW....................4 p.

REV	DESCRIPTION	DATE	AUTHOR
A	First issue	2024.06.25	VKU

CUSTOMER	VIDAUS VANDENS KELIŲDIREKCIJA	WBE220 Ammonia Stūmikas	
DRAWN	VKU	2024.06.25	SCALE 1:100
CHECKED		GENERAL ARRANGEMENT	FORMAT A1
APPROVED			
		WBE220-101-01	SHEET 1/1 — REVISION A

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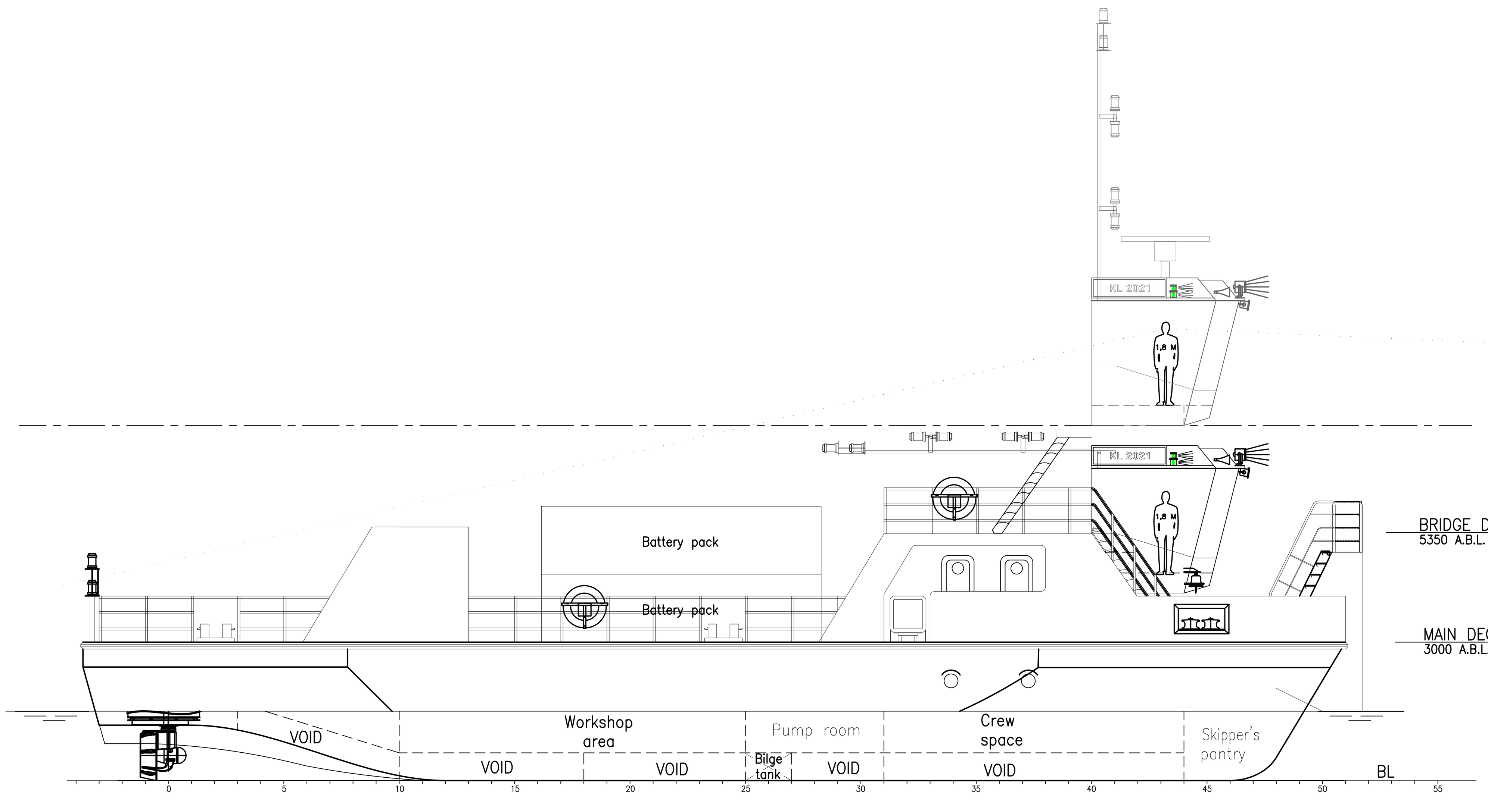

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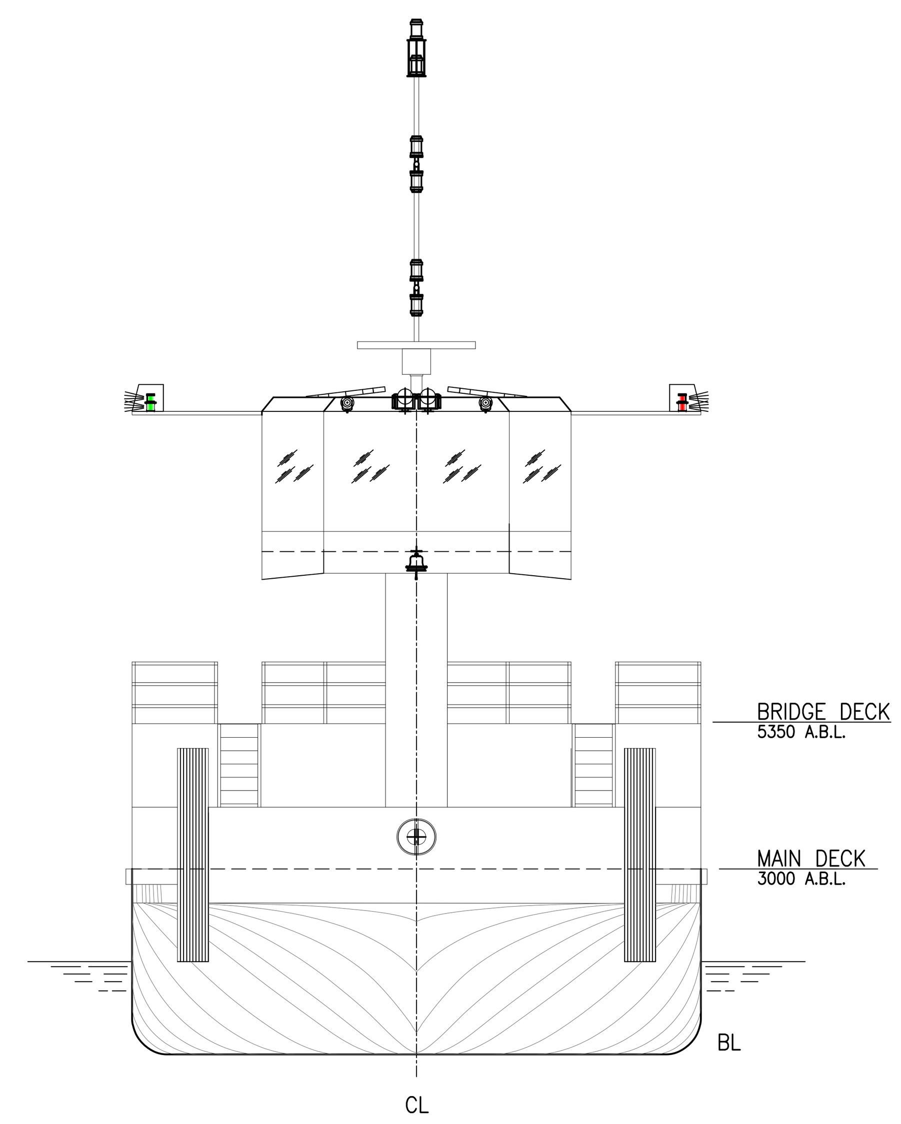

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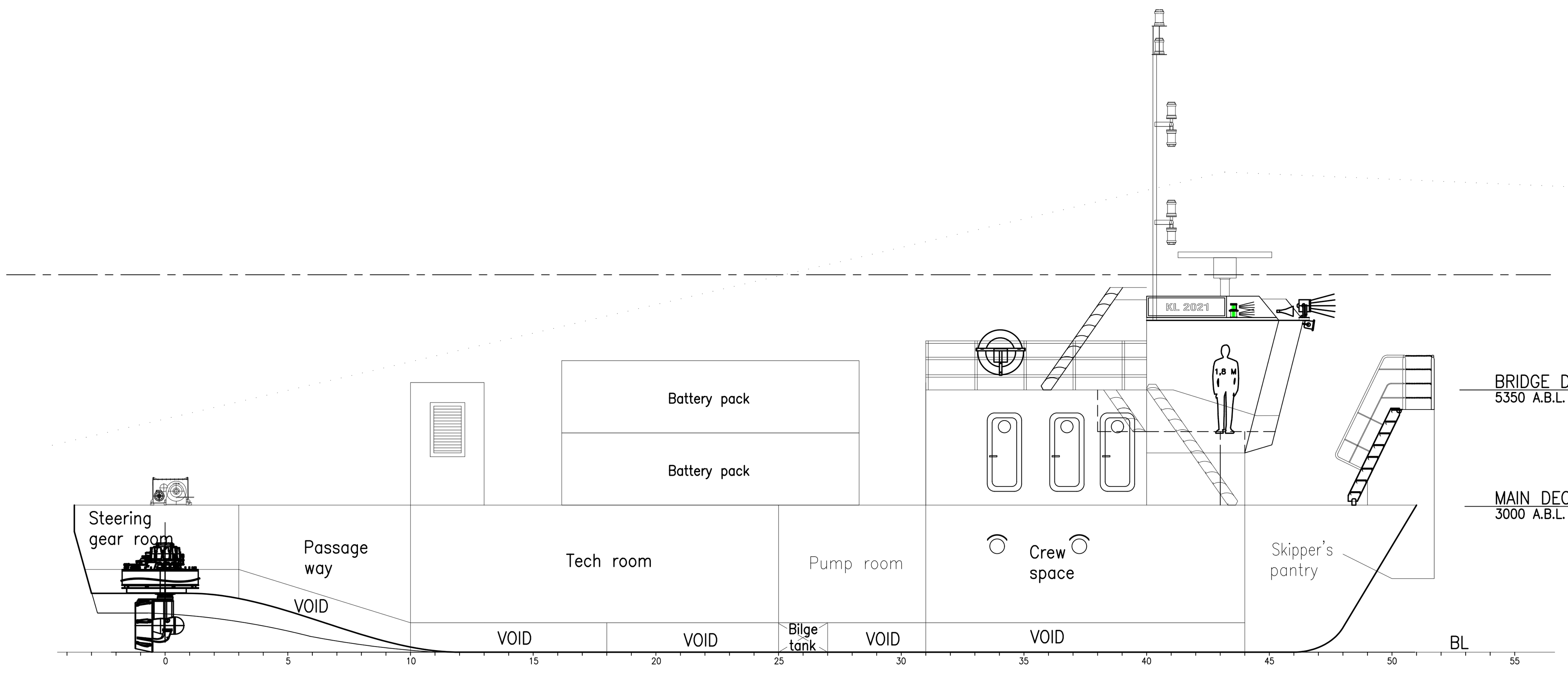

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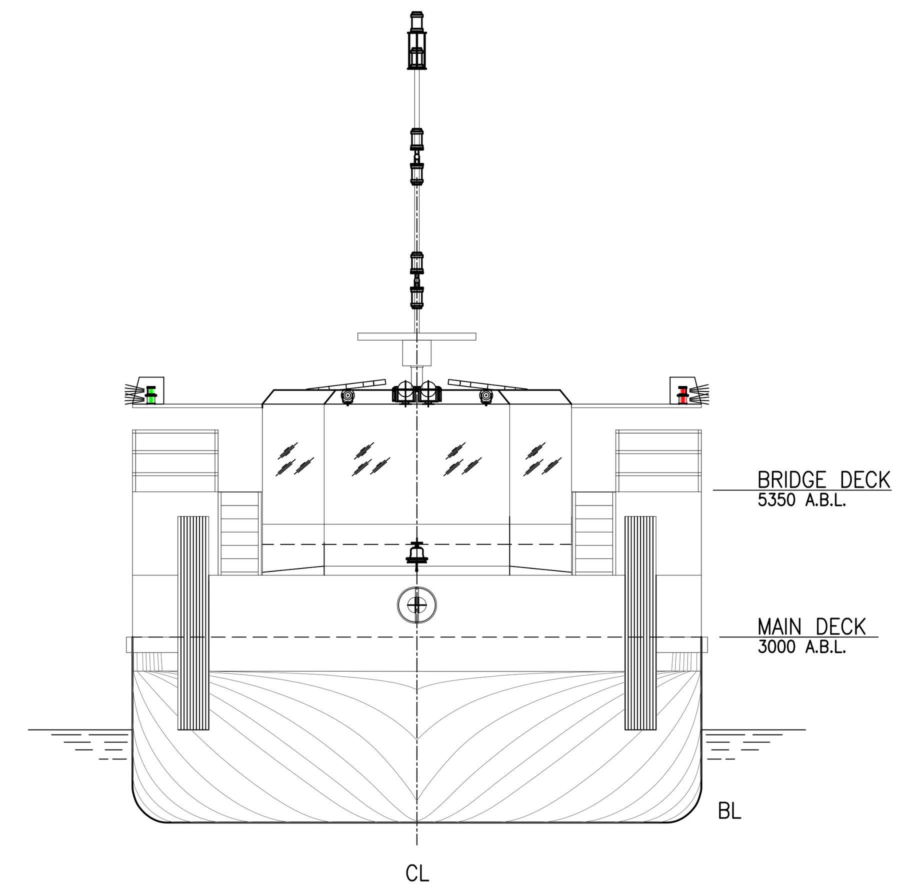

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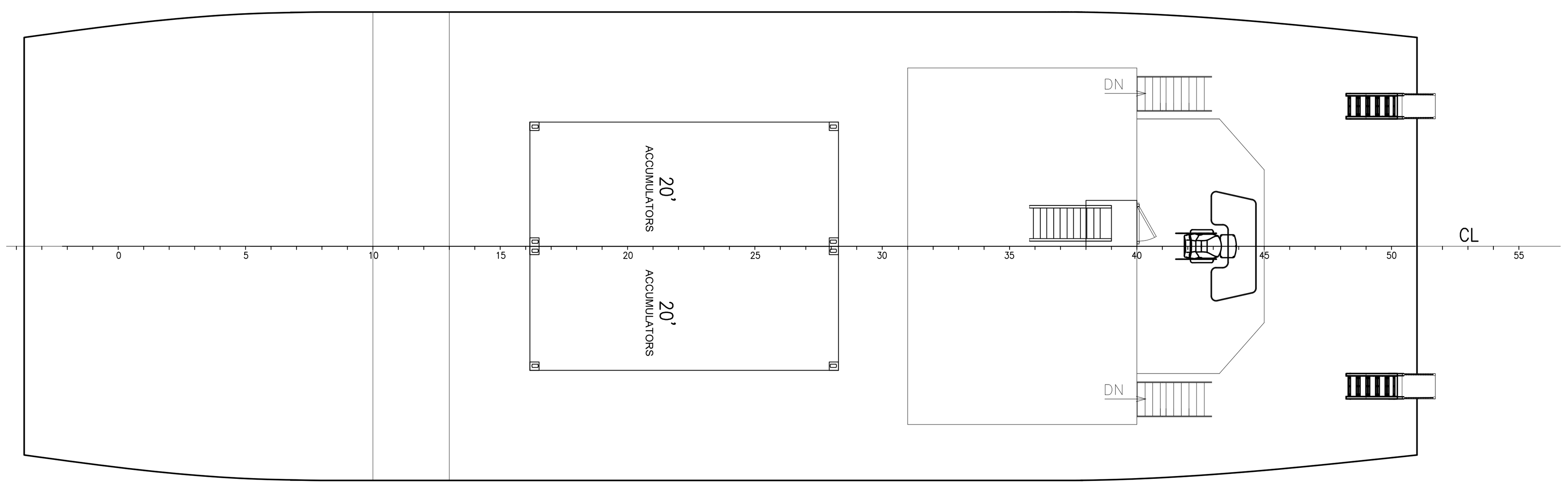
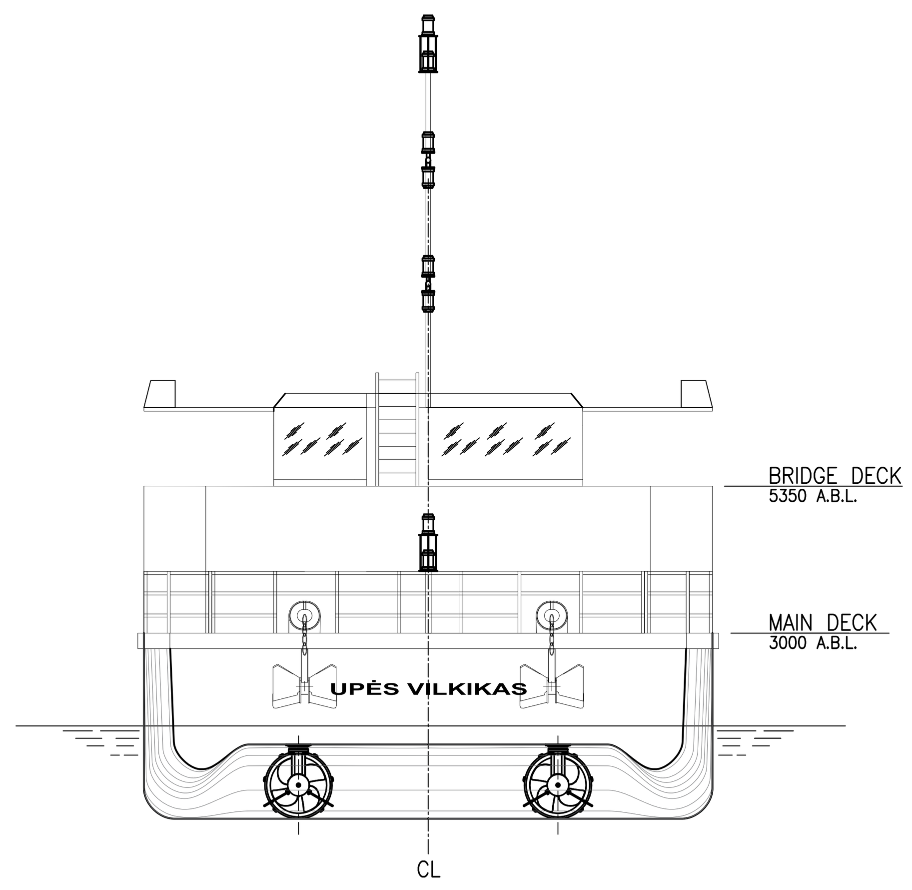
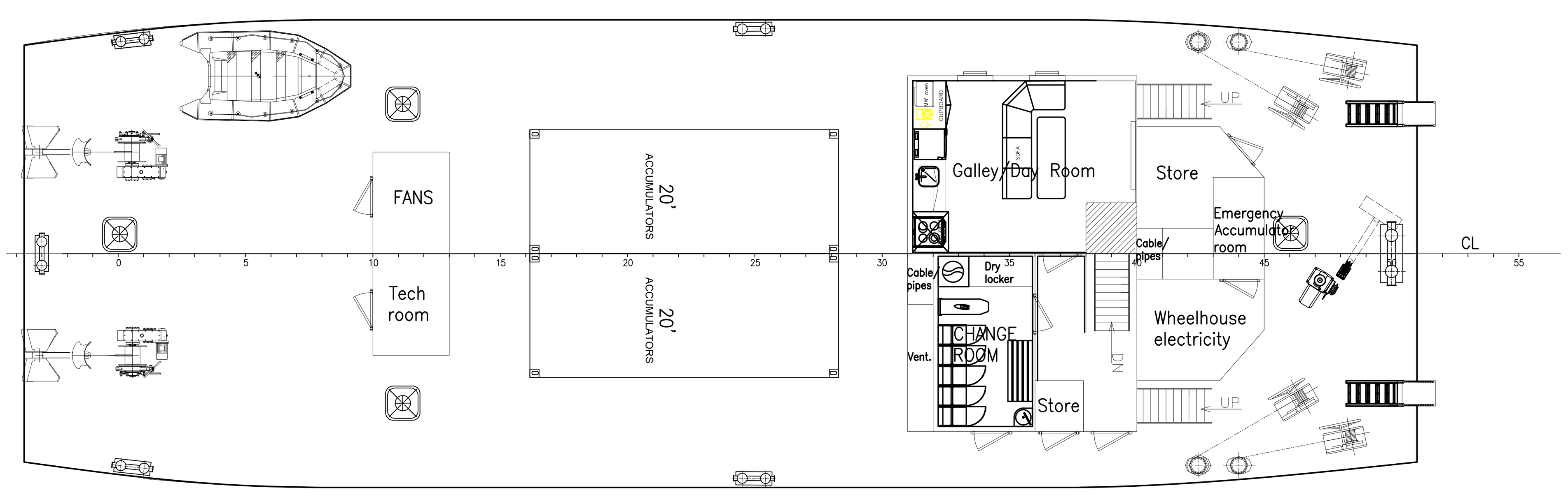


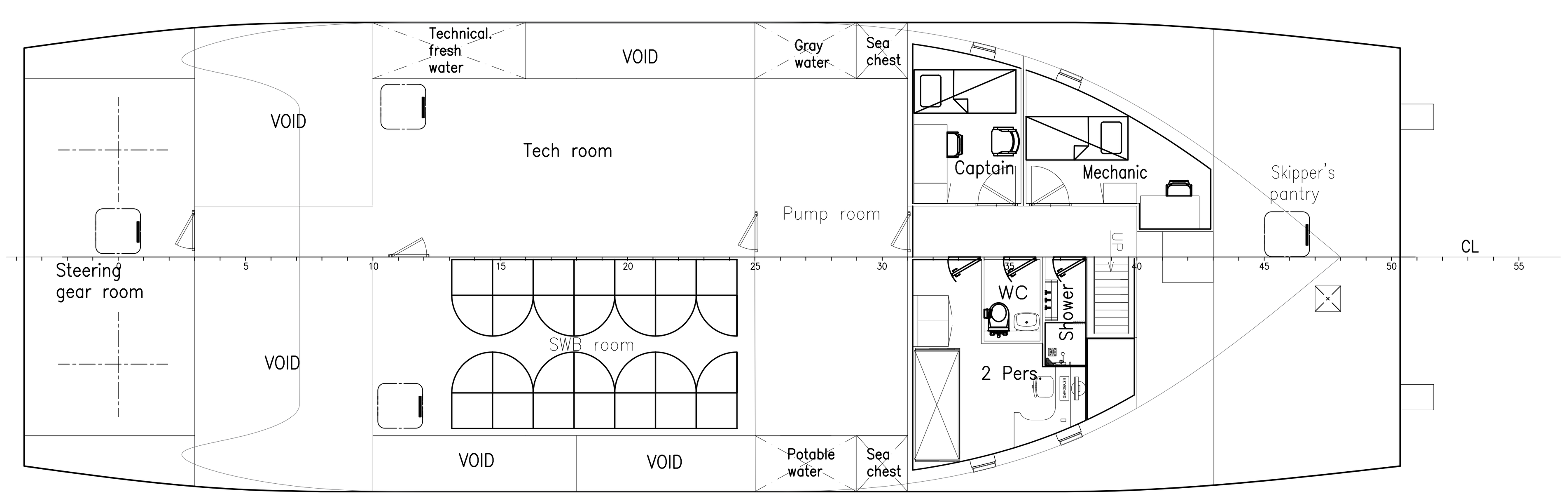
BRIDGE DECK
5350 A.B.L.



AFT



MAIN DECK
3000 fr BL



BELOW MAIN DECK
3000 fr BL

MAIN CHARACTERISTICS

TYPE OF VESSEL........................PUSHER

$L_{DESIGN.}$ 26.00m

BREADTH........................9.20m

MAXIMUM DRAFT........................1.50m

DRAFT........................1.20m

MAIN DECK HEIGHT........................3.00m

DISPLACEMENT 199.3t

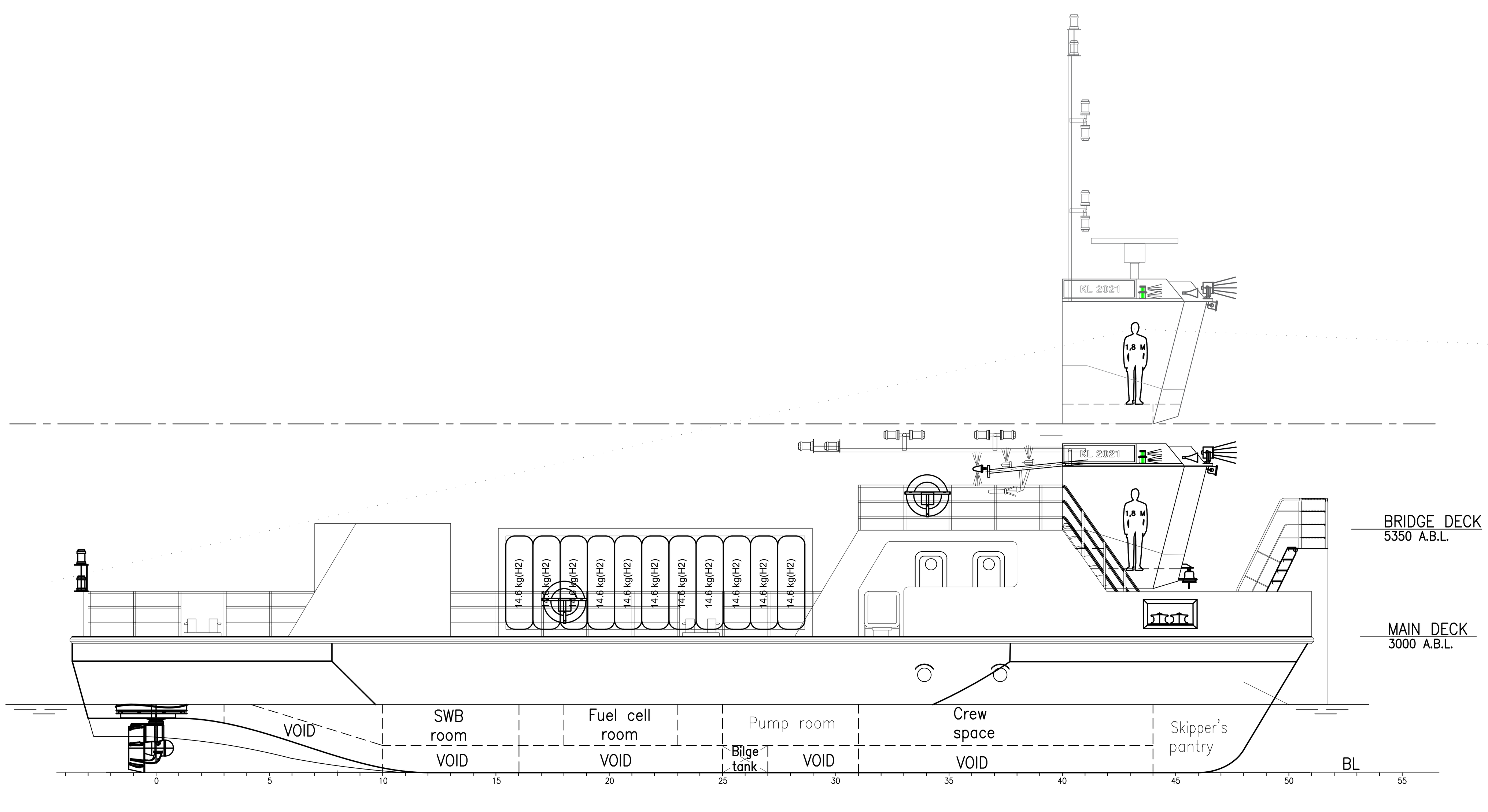
UPSTREAM SPEED........................10,0 km/h

WEIGHT OF PUSHED BARGE TO........................2000t

CREW........................4 p.

A	First issue	2024.06.25	VKU
REV	DESCRIPTION	DATE	AUTHOR

CUSTOMER	VIDAUS VANDENS KELIŲDIREKCIJA			WBE220 Battery Stūmikas		
DRAWN	VKU		2024.06.25	GENERAL ARRANGEMENT		SCALE 1:100
CHECKED						FORMAT A1
APPROVED						
WWW.WSY.LT WESTERN BALTIC ENGINEERING		Phone: +370 46 483617 Fax: +370 46 483627 WBE@WSY.LT		WBE220-101-01	SHEET 1/1	REVISION A



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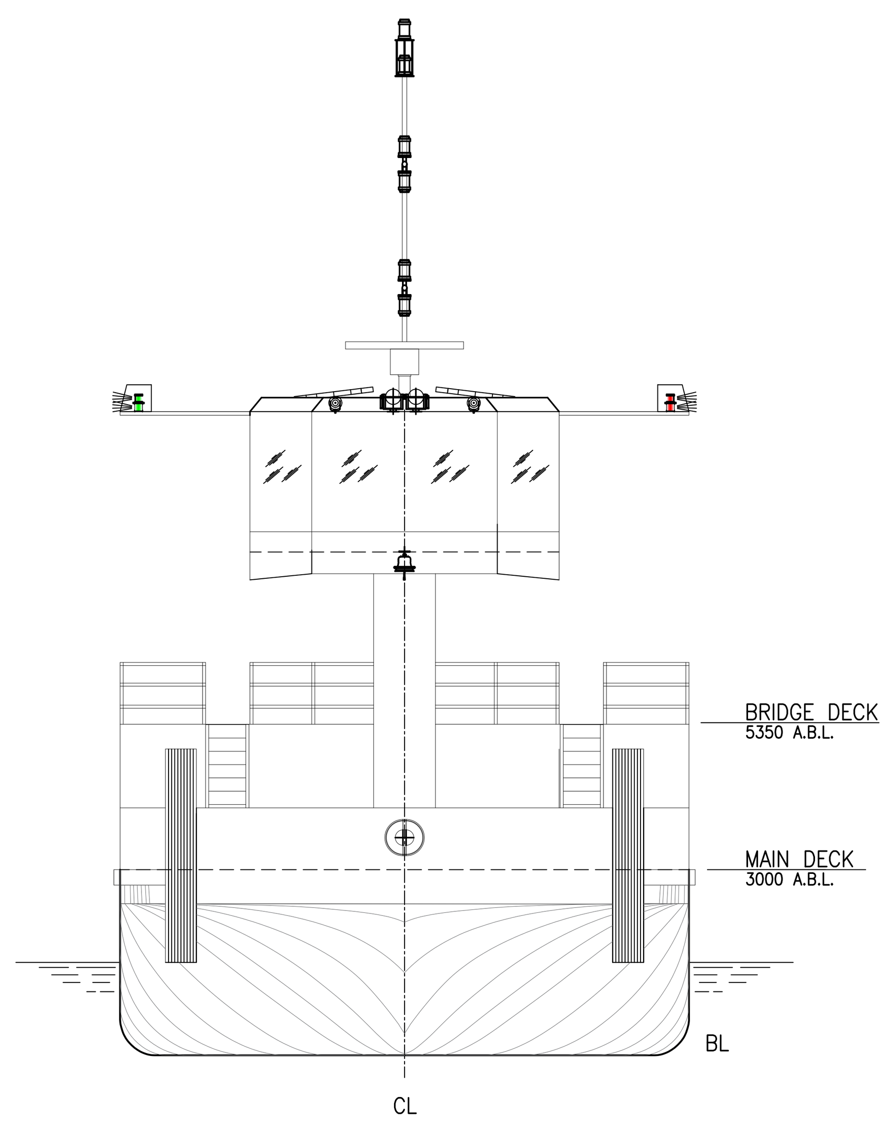

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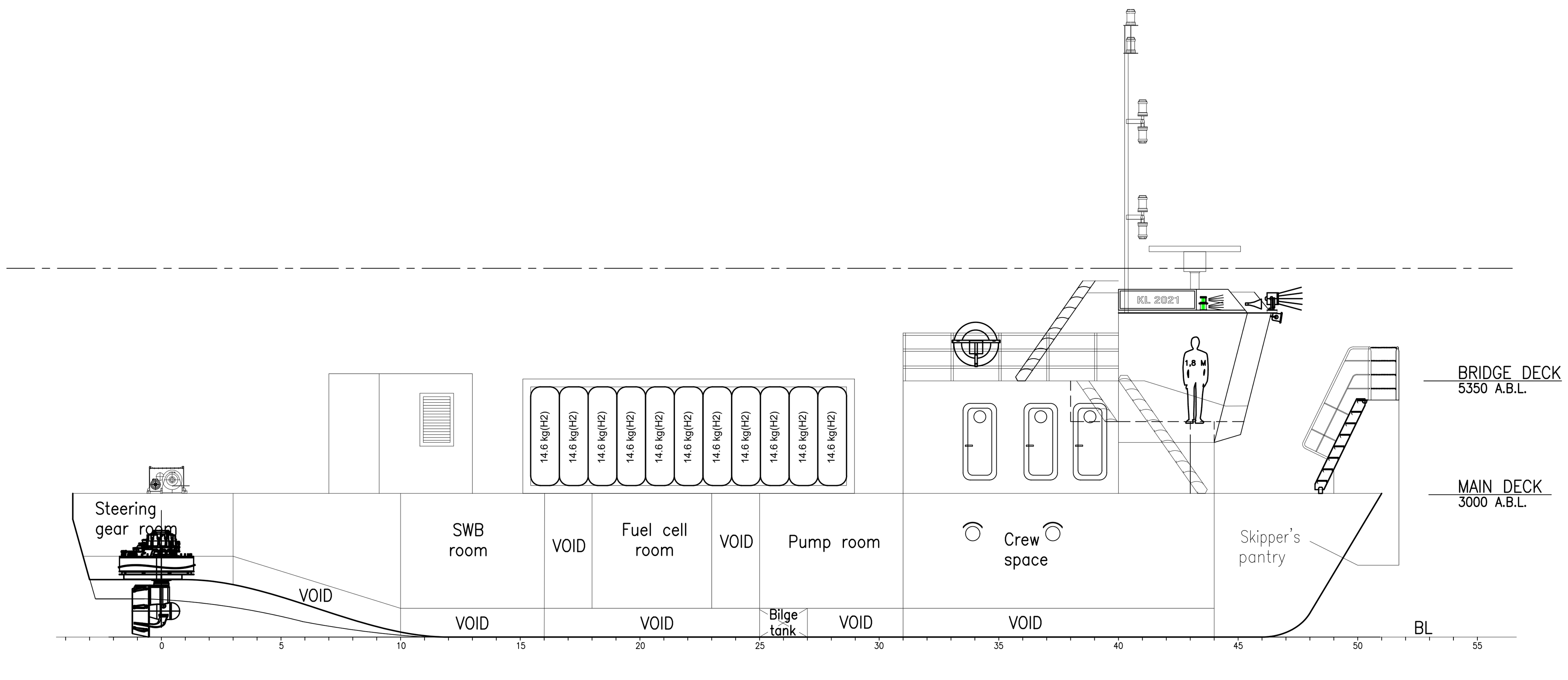

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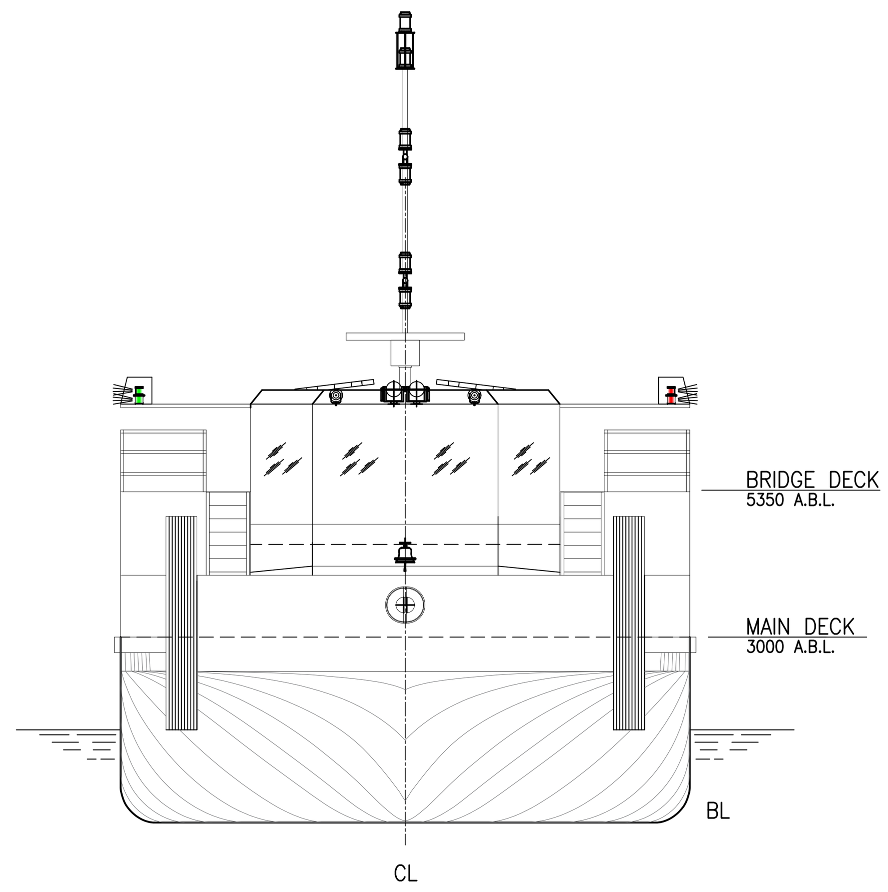

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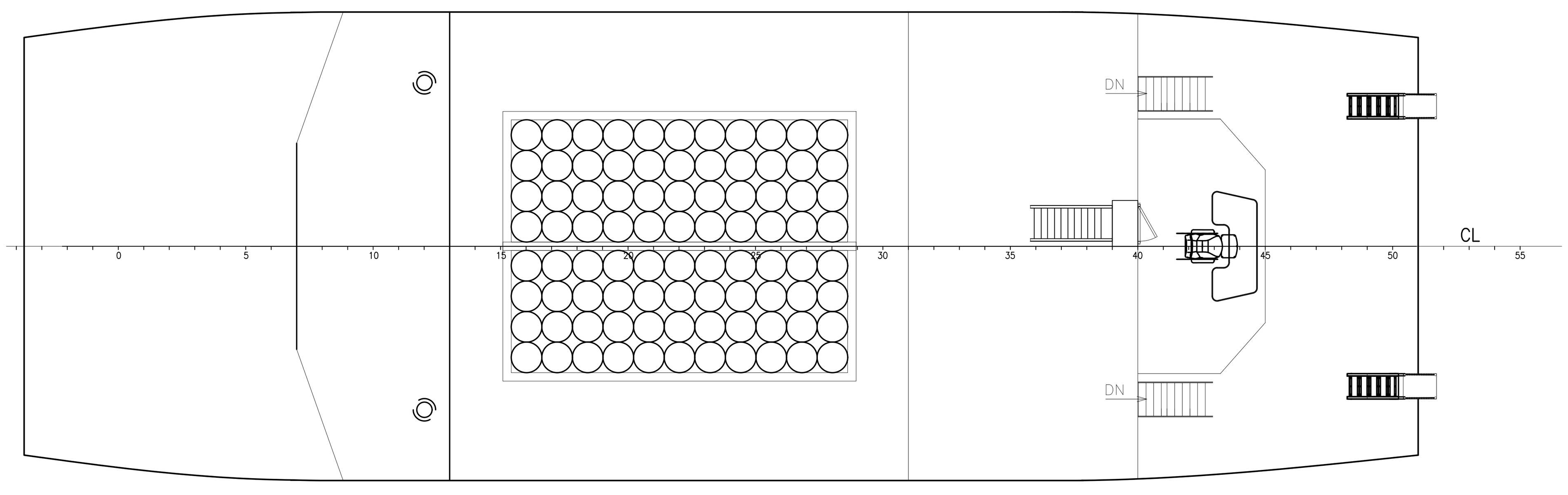
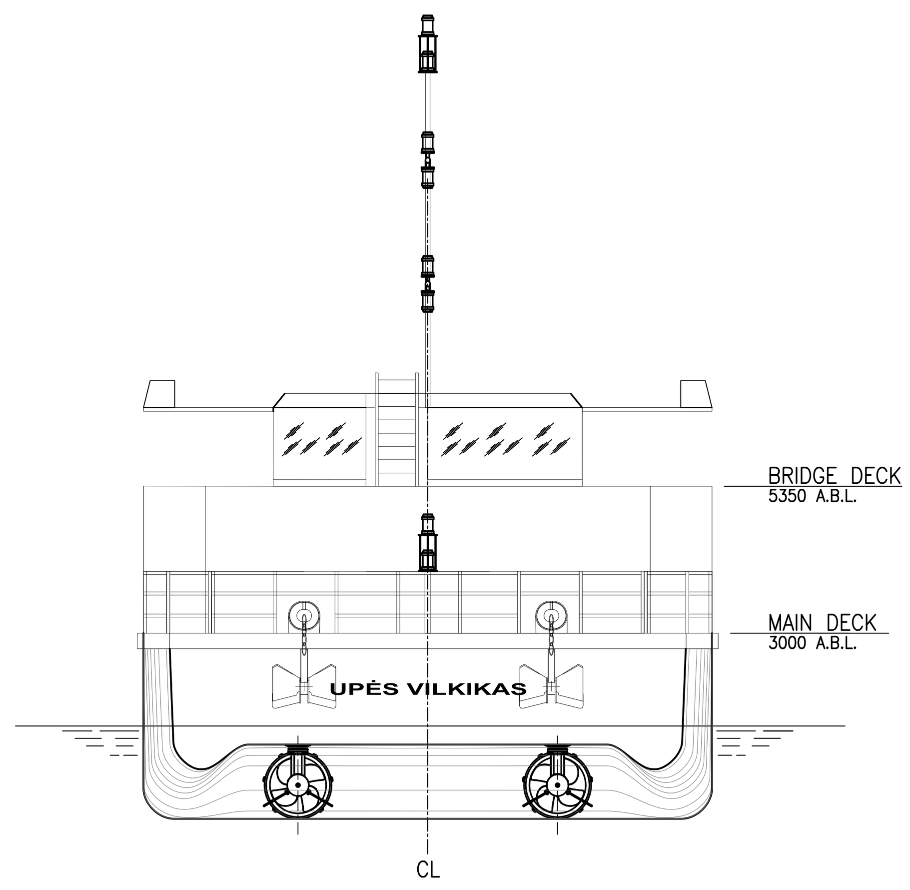


BRIDGE DECK
5350 A.B.L.



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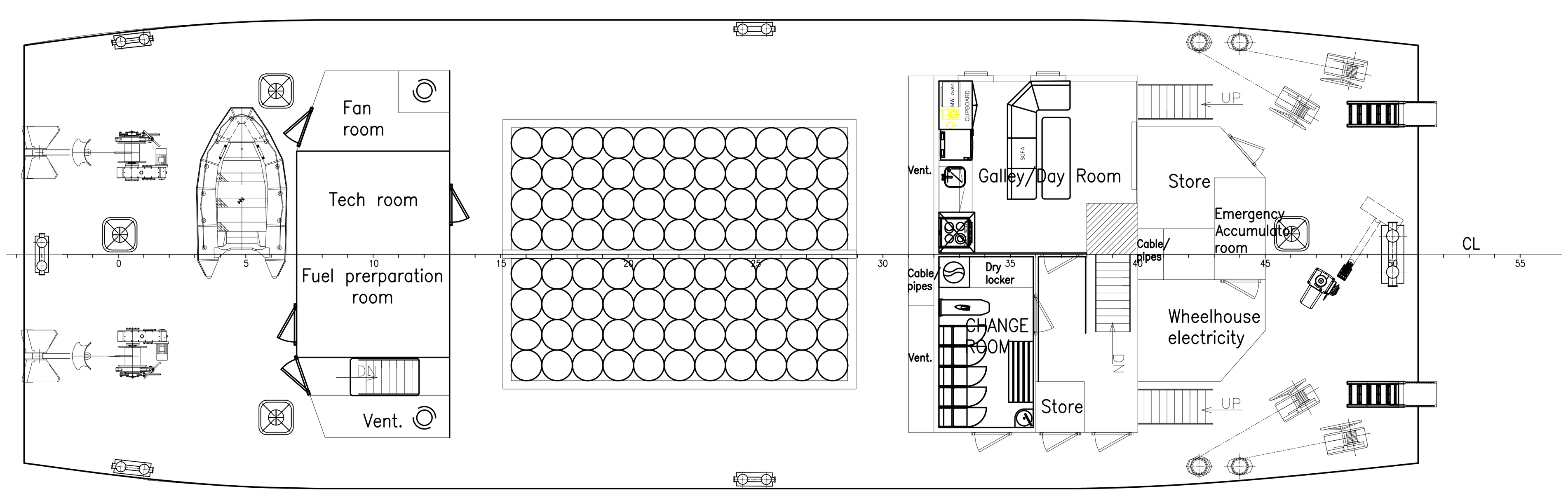


MAIN DECK
3000 fr BL

MAIN CHARACTERISTICS

TYPE OF VESSEL..........PUSHER

Ldesign. 26.00m

BREADTH..........9.20m

MAXIMUM DRAFT..........1.50m

DRAFT..........1.20m

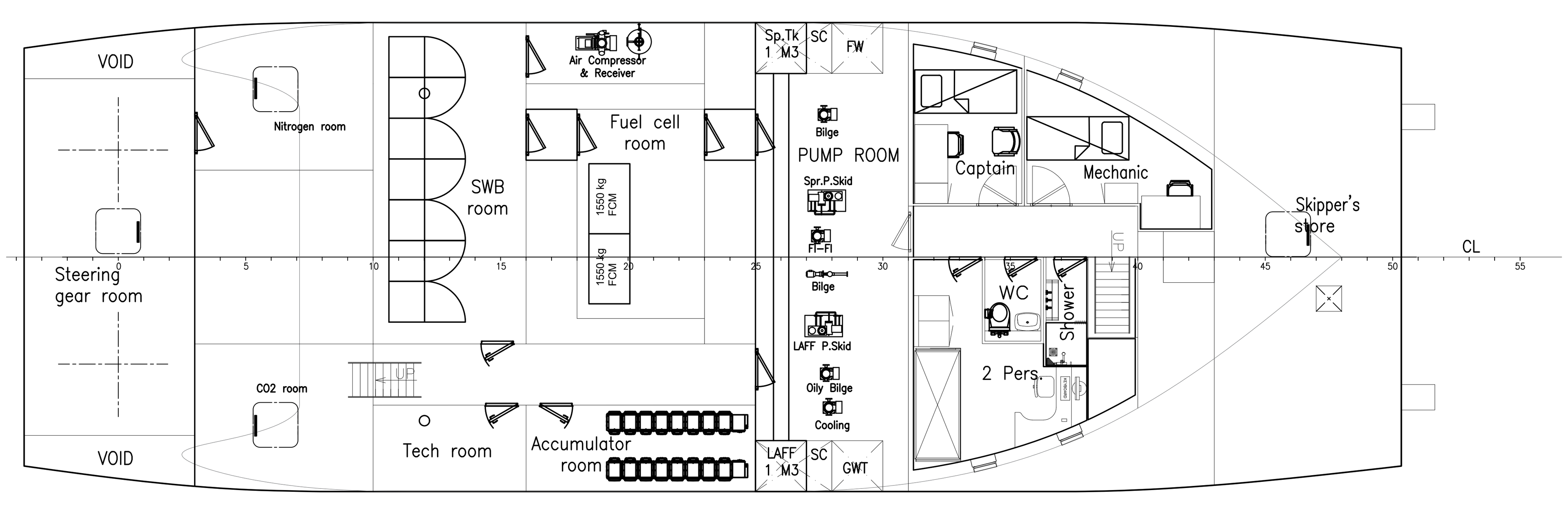
MAIN DECK HEIGHT..........3.00m

DISPLACEMENT 199,3t

UPSTREAM SPEED..........10,0 km/h

WEIGHT OF PUSHED BARGE TO..........2000t

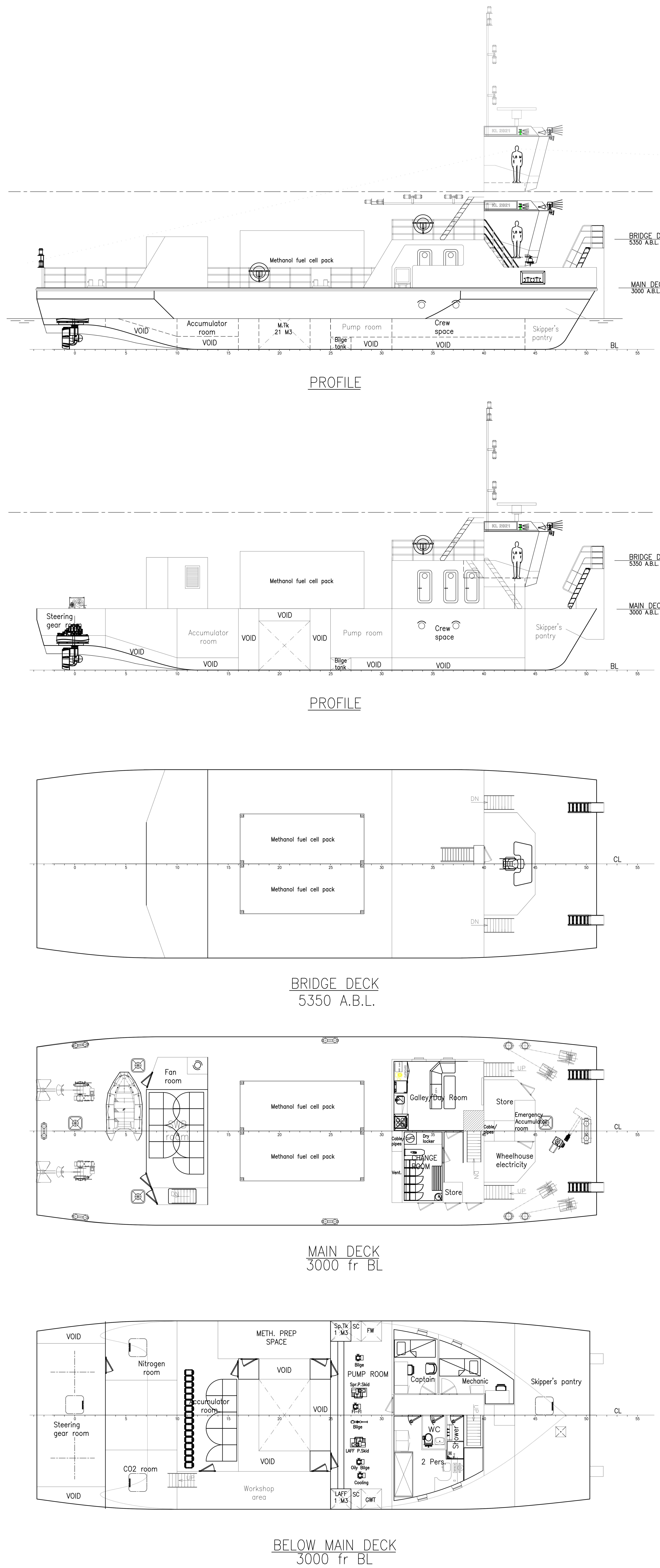
CREW..........4 p.

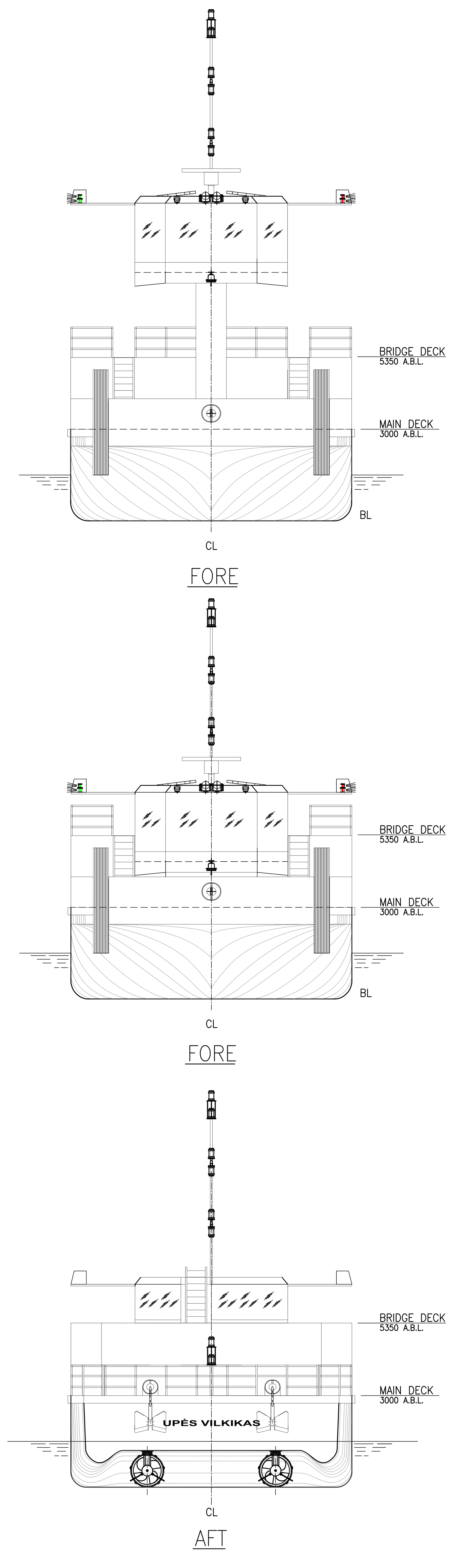


BELOW MAIN DECK
3000 fr BL

REV	DESCRIPTION	DATE	AUTHOR
A	First issue	2024.06.25	VKU

CUSTOMER	VIDAUS VANDENS KELIŲDIREKCIJA	WBE220 Hydrogen Stūmikas	
DRAWN	VKU 2024.06.25	GENERAL ARRANGEMENT	SCALE 1:100
CHECKED			FORMAT A1
APPROVED			
WWW.WSY.LT Phone: +370 46 483617 Fax: +370 46 483627 WBE@WSY.LT WESTERN BALTIC ENGINEERING		WBE220-101-01	SHEET 1/1 · REVISION A





MAIN CHARACTERISTICS

TYPE OF VESSEL.......PUSHER

$L_{DESIGN.}$ 26.00m

BREADTH.......9.20m

MAXIMUM DRAFT.......1.50m

DRAFT.......1.20m

MAIN DECK HEIGHT.......3.00m

DISPLACEMENT 199,3t

UPSTREAM SPEED.......10,0 km/h

WEIGHT OF PUSHED BARGE TO.......2000t

CREW.......4 p.

REV	DESCRIPTION	DATE	AUTHOR
A	First issue	2024.06.25	VKU

CUSTOMER	VIDAUS VANDENS KELIŲDIREKCIJA		
DRAWN	VKU		2024.06.25
CHECKED			
APPROVED			

WBE220 Methanol
Stūmikas

GENERAL ARRANGEMENT

SCALE 1:100
FORMAT A1

WBE220-101-01

SHEET 1/1
REVISION A

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Lightweight and maximum draft calculation

Lightweight is the mass of a ship when it is not loaded with any cargo, fuel, passengers, water, or stores. It is essentially the weight of the ship's structure, including its hull, machinery, equipment, and furnishings, but without any of the variable loads that it carries when in operation. This measurement is crucial for various calculations related to a ship's stability, capacity, and performance. Understanding the lightweight is also important for shipyards during construction and for ship operators when calculating the vessel's deadweight, which is the weight of the cargo, fuel, and other consumables a ship can carry. The lightweight, combined with the deadweight, equals the ship's displacement, which is the total weight of the water displaced by the ship's hull when it is fully loaded. Knowing the lightweight helps in assessing a ship's efficiency and operational costs, as it directly impacts fuel consumption and handling characteristics. It's a key factor in the maritime industry, affecting everything from regulatory compliance to the economics of shipping operations.

Calculating the weight of a river pusher vessel involves several factors, including the dimensions of the vessel and the materials used in its construction and type of generating system. For each type of general arrangement was calculated the specific lightweight. Weight estimation was made according to a near prototype. Mass of equipment was calculation from suppliers’ data. These calculations are preliminary and must be updated on the basic design stage.

In this part the calculations are made in table form. For each type of generating system calculates the lightweight and total displacement for each case. According to this data is calculating possible draft for each case.

According to draft calculation we may see that in case battery packs, the draft is higher than initial conditions. In draft 1.2m are two cases with much bigger draft. It means that it is impossible to push the barge with such speed and draft.

The minimum draft of the vessel is hydrogen case near **1.1m** of draft.

Ammonia and methanol cases are near **1.2m** of draft.

The worst case is with batteries near **1.6 m** draft.

We have such results because the mass of batteries increases very high with increasing draft and speed.

Below you may see hydrostatic tables for draft calculation

Hydrostatic data

Stability model

The coordinates system is right handed:

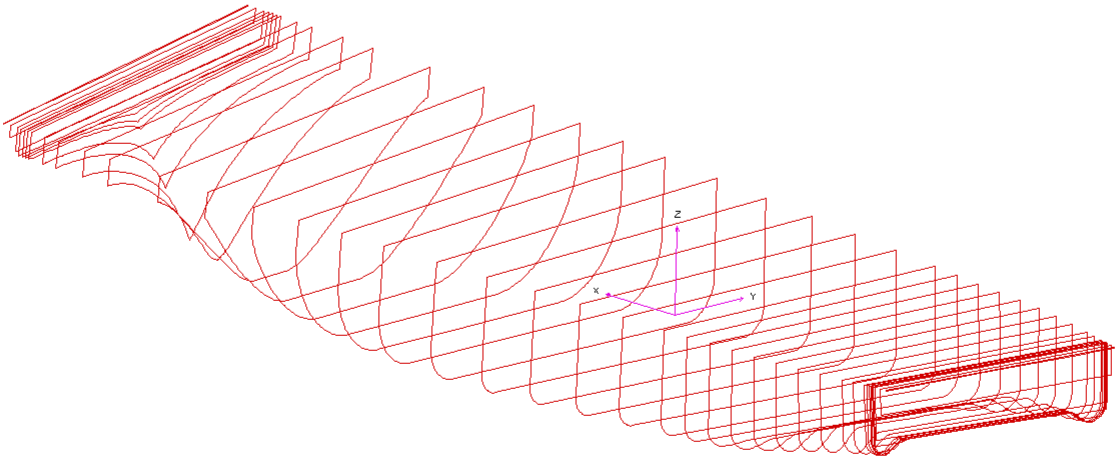
x- from #0, positive fwd;

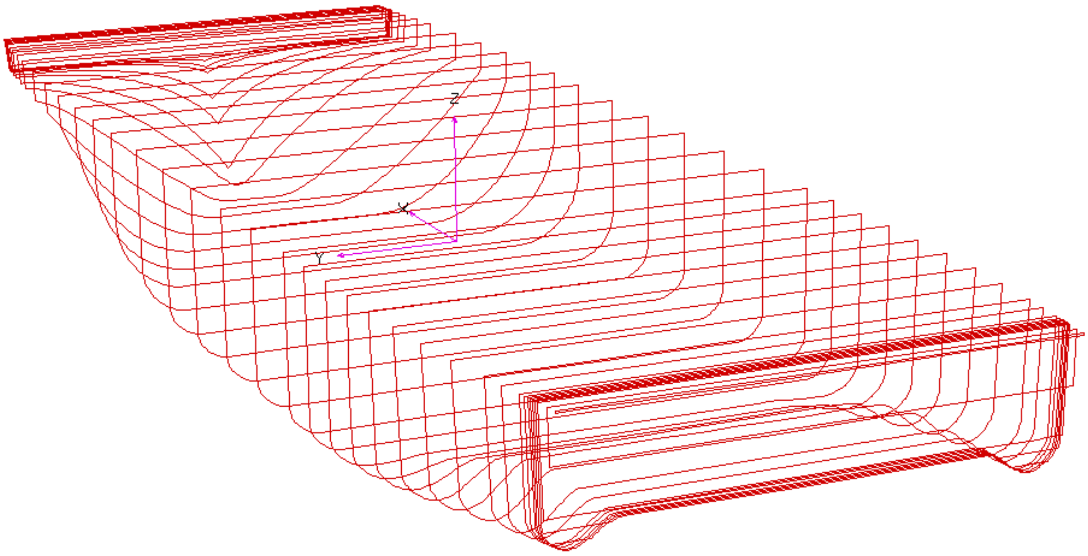
y-from CL, positive towards portside;

z-from BL, positive towards.

The ships stability model used for hydrostatic calculations (STABHULL) consist of the following components:

- Hull body below Main Deck.





T	DISP	LCB	KMT	CB	WLA	MCT	TCP
m	t	m	m		m2	tm/cm	t/cm
0,000	1,1	12,016	498,183	0,0000	114,5	0,9	1,1
0,010	2,3	12,041	256,141	0,5028	116,6	0,9	1,2
0,020	3,5	12,050	174,614	0,5091	118,2	0,9	1,2
0,030	4,7	12,055	133,567	0,5138	119,7	0,9	1,2
0,040	5,9	12,048	110,726	0,5179	125,1	1,1	1,3
0,050	7,1	12,004	93,031	0,5224	126,5	1,1	1,3
0,060	8,4	11,975	80,608	0,5292	127,7	1,1	1,3
0,070	9,7	11,960	71,260	0,5346	128,7	1,1	1,3
0,080	11,0	11,952	63,992	0,5389	129,5	1,1	1,3
0,090	12,3	11,950	58,154	0,5424	130,2	1,1	1,3
0,100	13,6	11,952	53,403	0,5454	130,8	1,2	1,3
0,110	14,9	11,948	49,374	0,5480	131,5	1,2	1,3
0,120	16,2	11,943	45,949	0,5509	132,3	1,2	1,3
0,130	17,5	11,939	43,017	0,5537	133,0	1,2	1,3
0,140	18,8	11,936	40,461	0,5564	133,7	1,2	1,3
0,150	20,2	11,933	38,231	0,5590	134,4	1,2	1,3
0,160	21,5	11,930	36,257	0,5614	135,0	1,2	1,4
0,170	22,9	11,929	34,536	0,5637	135,7	1,2	1,4
0,180	24,3	11,929	32,990	0,5659	136,4	1,3	1,4
0,190	25,6	11,928	31,588	0,5680	137,1	1,3	1,4
0,200	27,0	11,927	30,308	0,5701	137,8	1,3	1,4
0,210	28,4	11,926	29,149	0,5721	138,5	1,3	1,4
0,220	29,8	11,925	28,090	0,5741	139,2	1,3	1,4
0,230	31,2	11,924	27,138	0,5760	140,0	1,3	1,4
0,240	32,6	11,920	26,829	0,5779	147,7	1,5	1,5
0,250	34,1	11,902	25,878	0,5800	148,3	1,5	1,5
0,260	35,6	11,885	24,997	0,5830	148,8	1,5	1,5
0,270	37,1	11,870	24,184	0,5859	149,3	1,6	1,5
0,280	38,6	11,855	23,428	0,5887	149,8	1,6	1,5
0,290	40,1	11,842	22,720	0,5914	150,3	1,6	1,5
0,300	41,6	11,830	22,099	0,5940	150,9	1,6	1,5
0,310	43,1	11,819	21,507	0,5964	151,4	1,6	1,5
0,320	44,6	11,810	20,943	0,5988	151,9	1,6	1,5
0,330	46,1	11,800	20,407	0,6011	152,4	1,6	1,5
0,340	47,6	11,792	19,902	0,6032	152,9	1,6	1,5
0,350	49,2	11,784	19,427	0,6054	153,4	1,7	1,5
0,360	50,7	11,777	18,973	0,6074	153,9	1,7	1,5
0,370	52,2	11,770	18,534	0,6094	154,3	1,7	1,5
0,380	53,8	11,762	18,118	0,6114	154,7	1,7	1,5
0,390	55,3	11,756	17,722	0,6133	155,2	1,7	1,6
0,400	56,9	11,749	17,344	0,6152	155,6	1,7	1,6
0,410	58,5	11,743	16,985	0,6170	156,0	1,7	1,6
0,420	60,0	11,738	16,642	0,6188	156,4	1,7	1,6

T	DISP	LCB	KMT	CB	WLA	MCT	TCP
m	t	m	m		m2	tm/cm	t/cm
0,430	61,6	11,732	16,314	0,6206	156,8	1,7	1,6
0,440	63,2	11,727	16,020	0,6223	157,3	1,8	1,6
0,450	64,7	11,722	15,724	0,6240	157,7	1,8	1,6
0,460	66,3	11,717	15,440	0,6256	158,1	1,8	1,6
0,470	67,9	11,712	15,165	0,6272	158,6	1,8	1,6
0,480	69,5	11,708	14,899	0,6288	159,0	1,8	1,6
0,490	71,1	11,703	14,646	0,6304	159,4	1,8	1,6
0,500	72,7	11,699	14,413	0,6319	159,8	1,8	1,6
0,510	74,3	11,694	14,325	0,6334	163,9	2,0	1,6
0,520	75,9	11,686	14,089	0,6350	164,3	2,0	1,6
0,530	77,6	11,678	13,860	0,6367	164,6	2,0	1,6
0,540	79,2	11,671	13,637	0,6385	165,0	2,0	1,6
0,550	80,9	11,664	13,422	0,6402	165,3	2,0	1,7
0,560	82,5	11,657	13,219	0,6418	165,7	2,0	1,7
0,570	84,2	11,650	13,023	0,6435	166,1	2,0	1,7
0,580	85,8	11,643	12,833	0,6451	166,4	2,0	1,7
0,590	87,5	11,637	12,649	0,6466	166,8	2,1	1,7
0,600	89,2	11,631	12,471	0,6482	167,1	2,1	1,7
0,610	90,8	11,625	12,299	0,6497	167,5	2,1	1,7
0,620	92,5	11,619	12,140	0,6512	167,9	2,1	1,7
0,630	94,2	11,613	11,985	0,6527	168,3	2,1	1,7
0,640	95,9	11,608	11,834	0,6542	168,7	2,1	1,7
0,650	97,6	11,603	11,685	0,6556	169,0	2,1	1,7
0,660	99,3	11,597	11,540	0,6571	169,4	2,2	1,7
0,670	101,0	11,592	11,404	0,6585	169,8	2,2	1,7
0,680	102,7	11,587	11,271	0,6599	170,2	2,2	1,7
0,690	104,4	11,582	11,141	0,6612	170,5	2,2	1,7
0,700	106,1	11,577	11,015	0,6626	170,9	2,2	1,7
0,710	107,8	11,573	10,892	0,6640	171,3	2,2	1,7
0,720	109,5	11,568	10,779	0,6653	171,7	2,3	1,7
0,730	111,2	11,563	10,668	0,6666	172,1	2,3	1,7
0,740	112,9	11,559	10,558	0,6679	172,5	2,3	1,7
0,750	114,7	11,554	10,450	0,6692	172,9	2,3	1,7
0,760	116,4	11,549	10,347	0,6705	173,3	2,3	1,7
0,770	118,1	11,545	10,248	0,6718	173,8	2,3	1,7
0,780	119,9	11,540	10,152	0,6731	174,2	2,4	1,7
0,790	121,6	11,535	10,059	0,6743	174,6	2,4	1,7
0,800	123,4	11,531	9,968	0,6756	175,1	2,4	1,8
0,810	125,2	11,523	10,034	0,6768	182,6	2,7	1,8
0,820	127,0	11,513	9,930	0,6783	182,9	2,7	1,8
0,830	128,8	11,503	9,828	0,6799	183,2	2,7	1,8
0,840	130,7	11,494	9,728	0,6815	183,5	2,7	1,8
0,850	132,5	11,485	9,630	0,6831	183,8	2,7	1,8

T	DISP	LCB	KMT	CB	WLA	MCT	TCP
m	t	m	m		m2	tm/cm	t/cm
0,860	134,3	11,476	9,534	0,6846	184,1	2,7	1,8
0,870	136,2	11,467	9,441	0,6861	184,4	2,7	1,8
0,880	138,0	11,459	9,349	0,6876	184,7	2,8	1,8
0,890	139,9	11,450	9,260	0,6891	185,0	2,8	1,8
0,900	141,7	11,442	9,172	0,6906	185,3	2,8	1,9
0,910	143,6	11,434	9,086	0,6920	185,6	2,8	1,9
0,920	145,4	11,427	9,003	0,6935	185,8	2,8	1,9
0,930	147,3	11,419	8,921	0,6949	186,1	2,8	1,9
0,940	149,2	11,412	8,841	0,6963	186,4	2,8	1,9
0,950	151,0	11,405	8,762	0,6976	186,6	2,8	1,9
0,960	152,9	11,398	8,685	0,6990	186,9	2,8	1,9
0,970	154,8	11,391	8,610	0,7004	187,2	2,9	1,9
0,980	156,6	11,384	8,537	0,7017	187,4	2,9	1,9
0,990	158,5	11,378	8,465	0,7030	187,7	2,9	1,9
1,000	160,4	11,372	8,395	0,7043	188,0	2,9	1,9
1,010	162,3	11,365	8,326	0,7056	188,2	2,9	1,9
1,020	164,2	11,359	8,259	0,7069	188,5	2,9	1,9
1,030	166,0	11,353	8,193	0,7081	188,8	2,9	1,9
1,040	167,9	11,348	8,129	0,7094	189,0	2,9	1,9
1,050	169,8	11,342	8,068	0,7106	190,0	3,0	1,9
1,060	171,7	11,335	8,048	0,7118	192,2	3,1	1,9
1,070	173,7	11,328	7,985	0,7131	192,5	3,1	1,9
1,080	175,6	11,322	7,923	0,7144	192,7	3,1	1,9
1,090	177,5	11,315	7,863	0,7157	193,0	3,1	1,9
1,100	179,4	11,308	7,803	0,7170	193,2	3,1	1,9
1,110	181,4	11,302	7,746	0,7183	193,5	3,1	1,9
1,120	183,3	11,296	7,690	0,7195	193,8	3,1	1,9
1,130	185,3	11,289	7,635	0,7208	194,0	3,2	1,9
1,140	187,2	11,283	7,613	0,7220	196,9	3,3	2,0
1,150	189,2	11,275	7,580	0,7233	198,1	3,3	2,0
1,160	191,2	11,267	7,526	0,7246	198,4	3,3	2,0
1,170	193,2	11,260	7,474	0,7259	198,6	3,3	2,0
1,180	195,1	11,252	7,424	0,7273	198,9	3,4	2,0
1,190	197,1	11,244	7,580	0,7286	213,3	4,1	2,1
1,200	199,3	11,228	7,519	0,7299	213,5	4,1	2,1
1,210	201,4	11,213	7,460	0,7317	213,7	4,1	2,1
1,220	203,6	11,198	7,402	0,7335	213,8	4,1	2,1
1,230	205,7	11,183	7,345	0,7352	214,0	4,1	2,1
1,240	207,8	11,169	7,289	0,7370	214,2	4,1	2,1
1,250	210,0	11,155	7,234	0,7387	214,3	4,1	2,1
1,260	212,1	11,141	7,180	0,7404	214,4	4,1	2,1
1,270	214,3	11,128	7,128	0,7420	214,6	4,2	2,1
1,280	216,4	11,115	7,076	0,7437	214,8	4,2	2,1

T	DISP	LCB	KMT	CB	WLA	MCT	TCP
m	t	m	m		m2	tm/cm	t/cm
1,290	218,6	11,102	7,025	0,7453	214,9	4,2	2,1
1,300	220,7	11,090	6,976	0,7469	215,1	4,2	2,2
1,310	222,9	11,078	6,927	0,7485	215,2	4,2	2,2
1,320	225,0	11,066	6,880	0,7501	215,4	4,2	2,2
1,330	227,2	11,054	6,833	0,7517	215,5	4,2	2,2
1,340	229,3	11,043	6,791	0,7532	215,8	4,2	2,2
1,350	231,5	11,032	6,747	0,7547	216,0	4,2	2,2
1,360	233,7	11,021	6,703	0,7562	216,1	4,2	2,2
1,370	235,8	11,010	6,660	0,7577	216,3	4,2	2,2
1,380	238,0	11,000	6,618	0,7592	216,4	4,2	2,2
1,390	240,1	10,990	6,577	0,7606	216,6	4,3	2,2
1,400	242,3	10,980	6,536	0,7621	216,8	4,3	2,2
1,410	244,5	10,970	6,497	0,7635	216,9	4,3	2,2
1,420	246,7	10,961	6,458	0,7649	217,1	4,3	2,2
1,430	248,8	10,952	6,419	0,7663	217,2	4,3	2,2
1,440	251,0	10,943	6,382	0,7677	217,4	4,3	2,2
1,450	253,2	10,934	6,345	0,7690	217,5	4,3	2,2
1,460	255,4	10,925	6,309	0,7704	217,7	4,3	2,2
1,470	257,5	10,917	6,274	0,7717	217,9	4,3	2,2
1,480	259,7	10,908	6,239	0,7731	218,0	4,3	2,2
1,490	261,9	10,900	6,205	0,7744	218,2	4,3	2,2
1,500	264,1	10,892	6,171	0,7757	218,4	4,3	2,2
1,510	266,3	10,885	6,139	0,7770	218,5	4,4	2,2
1,520	268,5	10,877	6,106	0,7782	218,7	4,4	2,2
1,530	270,6	10,870	6,075	0,7795	218,8	4,4	2,2
1,540	272,8	10,862	6,044	0,7808	219,0	4,4	2,2
1,550	275,0	10,855	6,013	0,7820	219,2	4,4	2,2
1,560	277,2	10,848	5,983	0,7832	219,3	4,4	2,2
1,570	279,4	10,842	5,954	0,7845	219,5	4,4	2,2
1,580	281,6	10,835	5,925	0,7857	219,7	4,4	2,2
1,590	283,8	10,828	5,896	0,7869	219,8	4,4	2,2
1,600	286,0	10,822	5,869	0,7881	220,0	4,4	2,2
1,610	288,2	10,816	5,841	0,7892	220,2	4,4	2,2
1,620	290,4	10,810	5,814	0,7904	220,3	4,5	2,2
1,630	292,6	10,804	5,788	0,7916	220,5	4,5	2,2
1,640	294,8	10,798	5,762	0,7927	220,7	4,5	2,2
1,650	297,0	10,792	5,736	0,7938	220,9	4,5	2,2
1,660	299,3	10,786	5,711	0,7950	221,0	4,5	2,2
1,670	301,5	10,781	5,687	0,7961	221,2	4,5	2,2
1,680	303,7	10,776	5,662	0,7972	221,4	4,5	2,2
1,690	305,9	10,770	5,639	0,7983	221,5	4,5	2,2
1,700	308,1	10,765	5,615	0,7994	221,7	4,5	2,2
1,710	310,3	10,760	5,592	0,8005	221,9	4,5	2,2

T	DISP	LCB	KMT	CB	WLA	MCT	TCP
m	t	m	m		m2	tm/cm	t/cm
1,720	312,6	10,755	5,569	0,8016	222,1	4,6	2,2
1,730	314,8	10,750	5,547	0,8026	222,3	4,6	2,2
1,740	317,0	10,746	5,525	0,8037	222,4	4,6	2,2
1,750	319,2	10,741	5,504	0,8048	222,6	4,6	2,2
1,760	321,5	10,737	5,483	0,8058	222,8	4,6	2,2
1,770	323,7	10,732	5,462	0,8068	223,0	4,6	2,2
1,780	325,9	10,728	5,442	0,8079	223,1	4,6	2,2
1,790	328,2	10,724	5,422	0,8089	223,3	4,6	2,2
1,800	330,4	10,720	5,402	0,8099	223,5	4,6	2,2
1,810	332,6	10,716	5,382	0,8109	223,7	4,6	2,2
1,820	334,9	10,712	5,363	0,8119	223,9	4,7	2,2
1,830	337,1	10,708	5,345	0,8129	224,1	4,7	2,2
1,840	339,4	10,704	5,326	0,8139	224,3	4,7	2,2
1,850	341,6	10,701	5,308	0,8149	224,4	4,7	2,2
1,860	343,8	10,697	5,290	0,8159	224,6	4,7	2,2
1,870	346,1	10,694	5,273	0,8169	224,8	4,7	2,2
1,880	348,3	10,691	5,255	0,8178	225,0	4,7	2,3
1,890	350,6	10,687	5,239	0,8188	225,2	4,7	2,3
1,900	352,9	10,684	5,222	0,8198	225,4	4,7	2,3
1,910	355,1	10,681	5,206	0,8207	225,6	4,8	2,3
1,920	357,4	10,678	5,190	0,8217	225,8	4,8	2,3
1,930	359,6	10,675	5,174	0,8226	226,0	4,8	2,3
1,940	361,9	10,672	5,158	0,8235	226,2	4,8	2,3
1,950	364,2	10,670	5,143	0,8245	226,4	4,8	2,3
1,960	366,4	10,667	5,128	0,8254	226,6	4,8	2,3
1,970	368,7	10,664	5,113	0,8263	226,8	4,8	2,3
1,980	371,0	10,662	5,099	0,8272	227,0	4,8	2,3
1,990	373,2	10,659	5,085	0,8281	227,2	4,8	2,3
2,000	375,5	10,657	5,071	0,8290	227,4	4,9	2,3

Lightweight and draft calculation for battery type.

Lightweight calculation

Name of mass	Weight, t	X, m	Y, m	Z, m	MX, tm	MY, tm	MZ, tm
Hull	100,5	11,34	0,00	1,70	1139,06	0,00	170,79
Deckhouse	5	21,30	0,00	6,00	106,50	0,00	30,00
Electricity	10	4,00	0,00	2,50	40,00	0,00	25,00
Machinery installation	7,2	4,00	0,00	2,50	28,70	0,00	17,94
Piping	3,6	8,00	0,00	1,50	28,70	0,00	5,38
Outfitting	3,6	0,50	0,00	4,50	1,79	0,00	16,15
supplies	3,6	4,00	0,00	2,50	14,35	0,00	8,97
Sea margin	2	10,50	0,00	4,00	21,00	0,00	8,00
Lightweight	135,404	10,19	0,00	2,08	1380,11	0,00	282,23

Draft calculation

Draft 1.2 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	6	50	70,44	205,844	1,23
Upstream	8	37,5	103,44	238,844	1,385
Upstream	10	30	103,44	238,844	1,385
Downstream	10	30	70,44	205,844	1,23
Draft 1.5 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	6	50	103,44	238,844	1,385
Upstream	8	37,5	103,44	238,844	1,385
Upstream	10	30	136,44	271,844	1,53
Downstream	10	30	70,44	205,844	1,23
Draft 2.05 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	6	50	103,44	238,844	1,385
Upstream	8	37,5	103,44	238,844	1,385
Upstream	10	30	169,44	304,844	1,68
Downstream	10	30	70,44	205,844	1,23

Lightweight and draft calculation for hydrogen type.

Lightweight calculation

Name of mass	Weight, t	X, m	Y, m	Z, m	MX, tm	MY, tm	MZ, tm
Hull	100,5	11,34	0,00	1,70	1139,06	0,00	170,79
Deckhouse	5	21,30	0,00	6,00	106,50	0,00	30,00
Fuel cell system	10	4	0	2,5	40,00	0,00	25,00
Electricity	10	4,00	0,00	2,50	40,00	0,00	25,00
Machinery installation	7,2	4,00	0,00	2,50	28,70	0,00	17,94
Piping	3,6	8,00	0,00	1,50	28,70	0,00	5,38
Outfitting	3,6	0,50	0,00	4,50	1,79	0,00	16,15
Supplies	3,6	4,00	0,00	2,50	14,35	0,00	8,97
Accumulators	15,4	12,00	0,00	1,50	184,32	0,00	23,04
Sea margin	2	10,50	0,00	4,00	21,00	0,00	8,00
Lightweight	160,8	9,98	0,00	2,05	1604,43	0,00	330,27

Draft calculation

Draft 1.2 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	15,33	176,1	1,08
Upstream	10	30	17,59	178,4	1,09
Downstream	10	30	13,27	174,0	1,075
Draft 1.5 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	15,33	176,1	1,08
Upstream	10	30	17,59	178,4	1,09
Downstream	10	30	13,27	174,0	1,075
Draft 2.05 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	15,33	176,1	1,08
Upstream	10	30	17,59	178,4	1,09
Downstream	10	30	13,27	174,0	1,075

Lightweight and draft calculation for methanol type.

Lightweight calculation

Name of mass	Weight, t	X, m	Y, m	Z, m	MX, tm	MY, tm	MZ, tm
Hull	100,5	11,34	0,00	1,70	1139,06	0,00	170,79
Deckhouse	5	21,30	0,00	6,00	106,50	0,00	30,00
Fuel cell system	35	12	0	4,5	420,00	0,00	157,50
Electricity	10	4,00	0,00	2,50	40,00	0,00	25,00
Machinery installation	7,2	4,00	0,00	2,50	28,70	0,00	17,94
Piping	3,6	8,00	0,00	1,50	28,70	0,00	5,38
Outfitting	3,6	0,50	0,00	4,50	1,79	0,00	16,15
Supplies	3,6	4,00	0,00	2,50	14,35	0,00	8,97
Accumulators	15,4	12,00	0,00	1,50	184,32	0,00	23,04
Sea margin	2	10,50	0,00	4,00	21,00	0,00	8,00
Lightweight	185,8	10,68	0,00	2,49	1984,43	0,00	462,77

Draft calculation

Draft 1.2 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	10,97	196,7	1,185
Upstream	10	30	12,27	198,0	1,195
Downstream	10	30	9,66	195,4	1,18
Draft 1.5 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	10,97	196,7	1,185
Upstream	10	30	12,27	198,0	1,195
Downstream	10	30	9,66	195,4	1,18
Draft 2.05 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	10,97	196,7	1,185
Upstream	10	30	12,27	198,0	1,195
Downstream	10	30	9,66	195,4	1,18

Lightweight and draft calculation for ammonia type.

Lightweight calculation

Name of mass	Weight, t	X, m	Y, m	Z, m	MX, tm	MY, tm	MZ, tm
Hull	100,5	11,34	0,00	1,70	1139,06	0,00	170,79
Deckhouse	5	21,30	0,00	6,00	106,50	0,00	30,00
Fuel cell system	40	12	0	4,5	480,00	0,00	180,00
Electricity	10	4,00	0,00	2,50	40,00	0,00	25,00
Machinery installation	7,2	4,00	0,00	2,50	28,70	0,00	17,94
Piping	3,6	8,00	0,00	1,50	28,70	0,00	5,38
Outfitting	3,6	0,50	0,00	4,50	1,79	0,00	16,15
Supplies	3,6	4,00	0,00	2,50	14,35	0,00	8,97
Accumulators	15,4	12,00	0,00	1,50	184,32	0,00	23,04
Sea margin	2	10,50	0,00	4,00	21,00	0,00	8,00
Lightweight	190,8	10,72	0,00	2,54	2044,43	0,00	485,27

Draft calculation

Draft 1.2 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	7,97	198,7	1,195
Upstream	10	30	8,67	199,4	1,2
Downstream	10	30	7,26	198,0	1,195
Draft 1.5 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	7,97	198,7	1,195
Upstream	10	30	8,67	199,4	1,2
Downstream	10	30	7,26	198,0	1,195
Draft 2.05 m					
Way	Speed from shoe, km/h	Time. Hours	Total DWT, t	Displacement, t	Draft, m
Upstream	8	37,5	7,97	198,7	1,195
Upstream	10	30	8,67	199,4	1,2
Downstream	10	30	7,26	198,0	1,195

Economic justification

Way	Speed from shoe, km/h	Time, Hours	Max power, kW	Power, kWh	Number of trips per year	Energy per year kWh	Cost of equipment CAPEX, Euro	CAPEX per year, Euro	OPEX, Euro	Fuel price, Euro/kg	Cost fuel per year, Euro	Price per year, Euro	TOTAL
Hydrogen													
Draft 1.2 m													
Upstream	8	37,5	245,38	9201,75	25	230043,75	3476231	347623,1	34762,31	9	172968,75	555354,16	2,414124096
Upstream	10	30	369,5	11085	38	421230	3725128	372512,8	37251,28	9	315495	725259,08	1,721765021
Downstream	10	30	245,48	7364,4	38	279847,2	3249961	324996,1	32499,61	9	210330	567825,71	2,029056249
Draft 1.5 m													
Upstream	8	37,5	283,28	10623	25	265575	3476231	347623,1	34762,31	9	172968,75	555354,16	2,091138699
Upstream	10	30	449,8	13494	38	512772	3725128	372512,8	37251,28	9	315495	725259,08	1,414389007
Downstream	10	30	245,48	7364,4	38	279847,2	3249961	324996,1	32499,61	9	210330	567825,71	2,029056249
Draft 2,05 m													
Upstream	8	37,5	316,68	11875,5	25	296887,5	3476231	347623,1	34762,31	9	172968,75	555354,16	1,870587883
Upstream	10	30	562,9	16887	38	641706	3725128	372512,8	37251,28	9	315495	725259,08	1,130204611
Downstream	10	30	245,48	7364,4	38	279847,2	3249961	324996,1	32499,61	9	210330	567825,71	2,029056249
Ammonia													
Draft 1.2 m													
Upstream	8	37,5	253,2	9495	25	237375	3375000	337500	33750	0,25	22031,25	393281,25	1,656793049
Upstream	10	30	376,6	11298	38	429324	4500000	450000	45000	0,25	40185	535185	1,246576013
Downstream	10	30	248,45	7453,5	38	283233	2250000	225000	22500	0,25	26790	274290	0,968425289
Draft 1.5 m													
Upstream	8	37,5	291,1	10916,25	25	272906,25	3375000	337500	33750	0,25	22031,25	393281,25	1,441085538
Upstream	10	30	456,9	13707	38	520866	4500000	450000	45000	0,25	40185	535185	1,027490756
Downstream	10	30	248,45	7453,5	38	283233	2250000	225000	22500	0,25	26790	274290	0,968425289
Draft 2,05 m													
Upstream	8	37,5	324,5	12168,75	25	304218,75	3375000	337500	33750	0,25	22031,25	393281,25	1,292758089
Upstream	10	30	570	17100	38	649800	4500000	450000	45000	0,25	40185	535185	0,823614958
Downstream	10	30	248,45	7453,5	38	283233	2250000	225000	22500	0,25	26790	274290	0,968425289

Way	Speed from shoe, km/h	Time, Hours	Max power, kW	Power, kWh	Number of trips per year	Energy per year kWh	Cost of equipment CAPEX, Euro	CAPEX per year, Euro	OPEX, Euro	Fuel price, Euro/kg	Cost fuel per year, Euro	Price per year, Euro	TOTAL
Methanol													
Draft 1.2													
Upstream	8	37,5	245,83	9218,625	25	230465,625	1800000	180000	18000	0,5	81562,5	279562,5	1,213033397
Upstream	10	30	368,91	11067,3	38	420557,4	2400000	240000	24000	0,5	148770	412770	0,981483146
Downstream	10	30	245,93	7377,9	38	280360,2	1800000	180000	18000	0,5	99180	297180	1,059993537
Draft 1.5 m													
Upstream	8	37,5	283,73	10639,875	25	265996,875	1800000	180000	18000	0,5	81562,5	279562,5	1,050999189
Upstream	10	30	449,21	13476,3	38	512099,4	2400000	240000	24000	0,5	148770	412770	0,806034922
Downstream	10	30	245,93	7377,9	38	280360,2	1800000	180000	18000	0,5	99180	297180	1,059993537
Draft 2,05 m													
Upstream	8	37,5	317,05	11889,375	25	297234,375	1800000	180000	18000	0,5	81562,5	279562,5	0,940545655
Upstream	10	30	561,95	16858,5	38	640623	2400000	240000	24000	0,5	148770	412770	0,644325914
Downstream	10	30	245,93	7377,9	38	280360,2	1800000	180000	18000	0,5	99180	297180	1,059993537

Battery

Draft 1.2 m

Way	Speed from shoe, km/h	Time, Hours	Max power, kW	Power, kWh	Number of trips per year	Energy per year kWh	Cost of equipment CAPEX, Euro	CAPEX per year, Euro	OPEX, Euro	Fuel price, kwh	Cost fuel per year, Euro	Price per year, Euro	TOTAL
Upstream	6	50	122,6	6130	21	128730	2520000	252000	25200	0,3	38619	315819	2,453344209
Upstream	8	37,5	213,9	8021,25	25	200531,25	3780000	378000	37800	0,3	60159,375	475959,375	2,373492286
Upstream	10	30	331	9930	38	377340	3780000	378000	37800	0,3	113202	529002	1,401923994
Downstream	10	30	237,22	7116,6	38	270430,8	2520000	252000	25200	0,3	81129,24	358329,24	1,325031172
Draft 1.5 m													
Upstream	6	50	149,1	7455	21	156555	3780000	378000	37800	0,3	46966,5	462766,5	2,955935614
Upstream	8	37,5	251,8	9442,5	25	236062,5	3780000	378000	37800	0,3	70818,75	486618,75	2,061397935
Upstream	10	30	411,3	12339	38	468882	5040000	504000	50400	0,3	140664,6	695064,6	1,48238704
Downstream	10	30	237,22	7116,6	38	270430,8	2520000	252000	25200	0,3	81129,24	358329,24	1,325031172
Draft 2,05 m													
Upstream	6	50	200,2	10010	21	210210	3780000	378000	37800	0,3	63063	478863	2,278021978
Upstream	8	37,5	285,2	10695	25	267375	3780000	378000	37800	0,3	80212,5	496012,5	1,855119215
Upstream	10	30	524,4	15732	38	597816	6300000	630000	63000	0,3	179344,8	872344,8	1,459219559
Downstream	10	30	237,22	7116,6	38	270430,8	2520000	252000	25200	0,3	81129,24	358329,24	1,325031172

Conclusion

I this study is represented different types of generating systems. For each type of fuel system was made the calculation of resistance, electro balance, deadweight and maximum draft. Resistance calculation was made for many cases of draft and ways. The worst-case scenario is pusher with barge going upstream (Klaipeda-Kaunas) where the power on engine should be at least **524.4kW**. Propulsion system was chosen according to supplier data and minimum power that we need. As 524.4kW is the minimum power that needs to pusher, we should add extra power for maneuverability. Good marine practice to add 25%. In this case the minimum power of engine must be at least **656kW**. The maximum power of azimuth truster according to suppliers' data will be **2x330kW**.

Next step of study is electrical balance for every case. In this calculation is represented main load cases, maximum speed of pusher (maximum load on electricity), pusher towing barge upstream with maximum draft and maximum speed 10km/h (main operational load), pusher towing barge upstream with maximum draft and maximum speed 8 km/h (spare operational load), maneuvering mode, harbor and emergency. Every load is calculated according to data from supplier. For every energy case the balance is different, because different equipment is in work. For fuel cell system must be add the extra batteries for accumulating extra power and peak shaving. The capacity calculation of extra batteries was made according to supplier data and preliminary time for turning on the fuel cell. According to electro balance calculation we chose the number of generating equipment for each case.

Fuel calculation is made according to data from supplier and power that we need on the vessel. For every energy case deadweight parts: fresh water, grey water, stores, provision, crew - are the same, that's why changes between energy cases will be only in number of fuel. The maximum weight of deadweight part is with batteries, in worst case it is **170 ton**. Batterie packs are very heavy, and their number and weight highly increase with speed and draft. On the other hand, batteries are the simplest decision for vessels compartment. Because on the vessel will be just main equipment without extras: special firefighting systems, ventilation, etc.

Methanol and ammonia generating systems have nearly the same deadweight of fuel and it is not so big in worst case less than **8 ton**, but lightweight of the vessel is much higher than in battery system. It comes from the amount of extra equipment for safety.

The hydrogen system is the lightest system of all. Mass of H2 is less than **1 ton**, but the mass of hydrogen tanks and extra equipment is high. As vessel should carry near 65 H2 tanks on the main deck, it is spent a lot of space on the open deck.

General arrangements are made for each type of generating system. Each project has a monohull hull, accommodation in the fore part of the vessel, technical rooms in the aft, elevating wheelhouse system on the main deck. Under the main deck all projects has crew cabins in the fore, mechanical rooms in the middle and azimuth thruster room in the aft part. Subdivision of the vessel is achieved by five main bulkheads, double bottom and continuous main deck.

For every case, fore part of the vessel is the same. Accommodation will be made for 4 persons with big galley/day room on the main deck. The change room with laundry is made on the main deck near the entrance. All crew cabins are made under main deck to make free space on the main deck. There are two single and one double cabin. One toilet and shower for all crew members.

Pump room is made in the middle part of the vessel. There will be sea chests, pumps and tanks for auxiliary systems. Entrance will be through the crew cabins and technical space in the aft.

The technical room in the middle is reserved for special equipment, fuel tanks and systems.

Special features of battery type general arrangement.

Batteries are installed on the main deck in the middle of the vessel. Under main deck technical room and switchboard room.

Special features of hydrogen type general arrangement.

All the hydrogen tanks are installed in the main deck to avoid explosion. Fuel preparation room and tech room are arranged in aft part on the main deck. In this place are special ventilation and emergency reset. Fuel cells, switchboard room and accumulator room are under the main deck. Nitrogen and CO2 rooms are made under main deck with special entrance from main deck.

Special features of methanol and ammonia type general arrangement.

Fuel tanks are arranged under main deck with fuel preparation room. All tanks and spaces are made according to IGF Code and have cofferdams and airlocks. Nitrogen and CO2 rooms are made under main deck with special entrance from main deck. On the main deck are installed containerized generating systems.

According to draft calculation we may see that in case battery packs, the draft is higher than initial conditions. In draft 1.2m are two cases with much bigger draft. It means that it is impossible to push the barge with such speed and draft.

The minimum draft of the vessel is with hydrogen case near **1.1m** of draft.

Ammonia and methanol cases are near **1.2m** of draft.

The worst case is with batteries **1.6 m** draft.

We have such results because the mass of batteries increases very high with increasing draft and speed.

The selection of a power generating system for pusher vessels is a critical decision that hinges on various factors, including environmental impact, efficiency, and operational requirements. Batteries, for instance, offer the advantage of being a clean energy source with zero emissions during operation. They are particularly suitable for short-distance voyages or as a supplementary power source due to their limited range stemming from weight and volume constraints. However, advancements in battery technology may enhance their viability in the future.

Ammonia and methanol, produced from green electricity, are considered promising candidates for clean shipping fuels. Ammonia, with its high energy density per weight, could be a potent fuel, but its low energy density per volume means it requires more space, which may not be ideal for larger vessels undertaking long voyages. Additionally, current regulations prohibit the use of toxic substances like ammonia as fuel, necessitating a change in legislation before it can be widely adopted.

Methanol, on the other hand, is a liquid hydrocarbon that can be used in dual-fuel engines, allowing for flexibility in fuel choice. It burns cleaner than traditional fossil fuels, reducing emissions of harmful pollutants. However, as a hydrocarbon, methanol combustion still produces carbon dioxide, and thus, to be truly green, it must be produced from non-fossil fuel sources, such as biomass or synthesized from green hydrogen and carbon dioxide.

Hydrogen, with its high energy density per weight, presents an attractive option for clean fuel. Nevertheless, its low energy density per volume poses significant storage challenges, particularly for long-distance shipping. Hydrogen could find its niche in the market for shorter routes or where space is not a constraint.

In conclusion, each power generating system has its unique set of advantages and disadvantages. Batteries are clean but currently limited in range; ammonia has potential but faces regulatory and space challenges; methanol is versatile but needs green production methods to be sustainable; and hydrogen offers clean energy but with storage hurdles. The choice ultimately depends on the specific needs and constraints of the vessel and the route it will navigate. As technology and regulations evolve, the feasibility and attractiveness of these options may change, guiding the future of maritime energy solutions.