Comparison Ship Study

Patrol Vessel Rijkswaterstaat

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GREEN MARITIME METHANOL

C-JOB
DEDICATED NAVAL ARCHITECTS

Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

REVISION HISTORY

B	03/06/2025	UPDATE LOGO	JVD	DB	NDV
A	06/03/2025	UPDATED TABLE 2-1 and 2-2	JVD	DB	NDV
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DESCRIPTION OF MODIFICATIONS

Rev	**Description of modifications**
0	Initial issue
A	Updated table 2-1 and 2-2 with an installed power column
B	Updated report with GMM logo

TABLE OF CONTENTS

1. INTRODUCTION

Prior to starting engineering works on the new vessel design, a review is made on existing solutions in the market. This documents present the results of the comparison of the main vessel requirements compared to existing designs with similar characteristics. From this study the expected bandwidth of main particulars will be estimated and reflected upon.

The comparison study is divided into two parts. In the first part reference vessels are selected, and their main parameters are compared. In the second part, an estimate of the additional required volume and weight to power the vessel with methanol is made and compared to the tank sizes of the reference vessels.

Reference documents

[1] 000-032-001-List of Reference vessels and main particulars
[2] SND01012 - DI16 415 kW 2100 RPM MD97 - Propulsion - Data sheet V03 -ShEx

2. COMPARISON SHIP STUDY

The full list of reference ships can be found in Ref.[1].

2.1. Goal of the Comparison

The goal of this comparison ship study is to ensure that there is a feasible starting point for the concept design of a new methanol driven high speed patrol vessel. Using a list of reference vessels, a better understanding is created with regards to the main particulars, hull shapes, hull materials, and installed power of ships with similar speed requirements. Hydrofoils are excluded from this comparison study because no information about hydro foiling reference vessels is available.

2.2. Study Parameters and Limitations

The study is driven by three non-negotiable parameters given by the client. These client requirements are:

1. The vessel is to be shorter than 19,95 m.
2. The maximum speed is to be 40 km/h (22 knots).
3. The vessel is to be able to operate for a total of 12 hours at the maximum speed.

Furthermore, some technical limitations are given due to the limited availability of methanol engines. This means that the maximum engine size taken into account during this study is 415 kW. This results in two configurations, a two engine and three engine configuration. These configurations set the maximum installed power at 830 kW, and 1.245 kW respectively. These limitations will be leading during the specification of reference vessels.

Two hull shapes are taken into account during this study, monohulls, and catamarans. For these two hull shapes, both planing and foiling vessels are taken into account as a means to reduce the resistance at high speeds, minimizing the required installed power.

With the above parameters and limitations, the below comparison study of section 2.3 has been completed.

2.3. Comparison of Reference Vessels

To limit the number of reference vessels to be used during this study, the following filters are used to make a selection of reference vessels:

1. The vessel must be between 18m and 25m.
2. The vessel must have an installed power of less than 2.000 kW.

All of the reference vessels with the above limitations have been plotted in Figure 2-1, this figure shows the speed against the installed power for the different vessels, while making a distinction between the hull shape of the vessels and the "main" building material used for the hull[1] (i.e. Aluminum Alloys, Reinforced Plastics or Steel).

Figure 2-2 and Figure 2-3 (catamarans and monohulls respectively) show the plots of speed-installed power-displacement of these different vessels, where the displacement data was available. The areas of interest based on the power and speed requirements was shown in red.

[1] If no building material was known, the vessels were classed as unknown.

Using the installed power cutoff points given in the previous section, two tables have been generated with the reference vessels. Table 2-1 shows the vessels with less than 830 kW of installed power and Table 2-2 shows the vessels with less than 1.245 kW of installed power.

Many of the references shown in the below tables, do not have an associated light-ship weight, which makes it difficult to establish a relation between LSW and tank size. Displacement data is used for reference comparison instead, where it is available. Figure 2-2 and Figure 2-3 show the relation between speed, power and displacement for catamarans and monohulls respectively.

The vessels of Table 2-2 will most likely only be a reference for monohulls with 3 propellers or monohulls and catamarans with a methanol-electric setup to generate more than 415 kW of power at each propeller shaft.

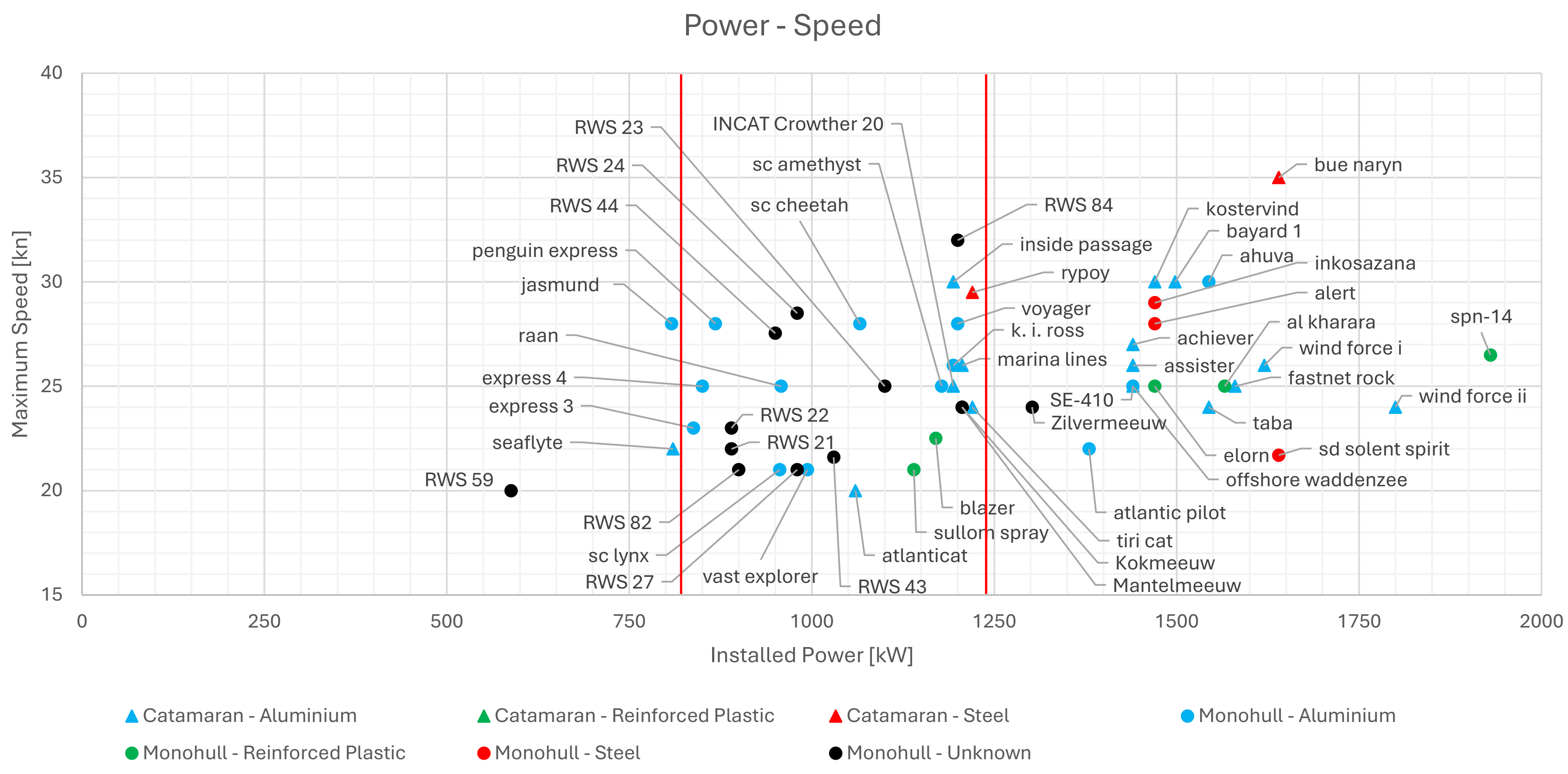

Figure 2-1: Power - Speed Comparison

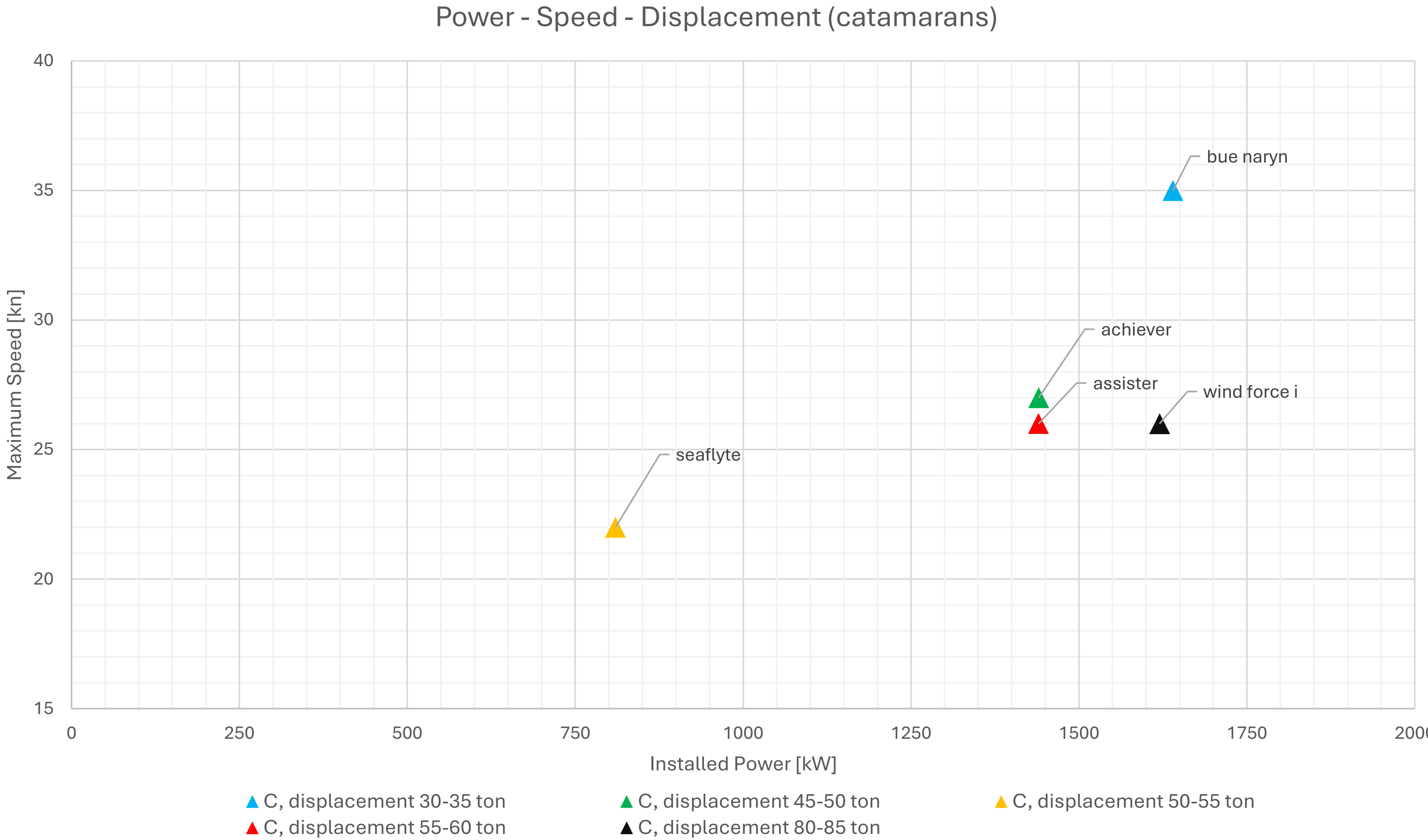

Figure 2-2 Power-Speed-Displacement comparison for catamarans

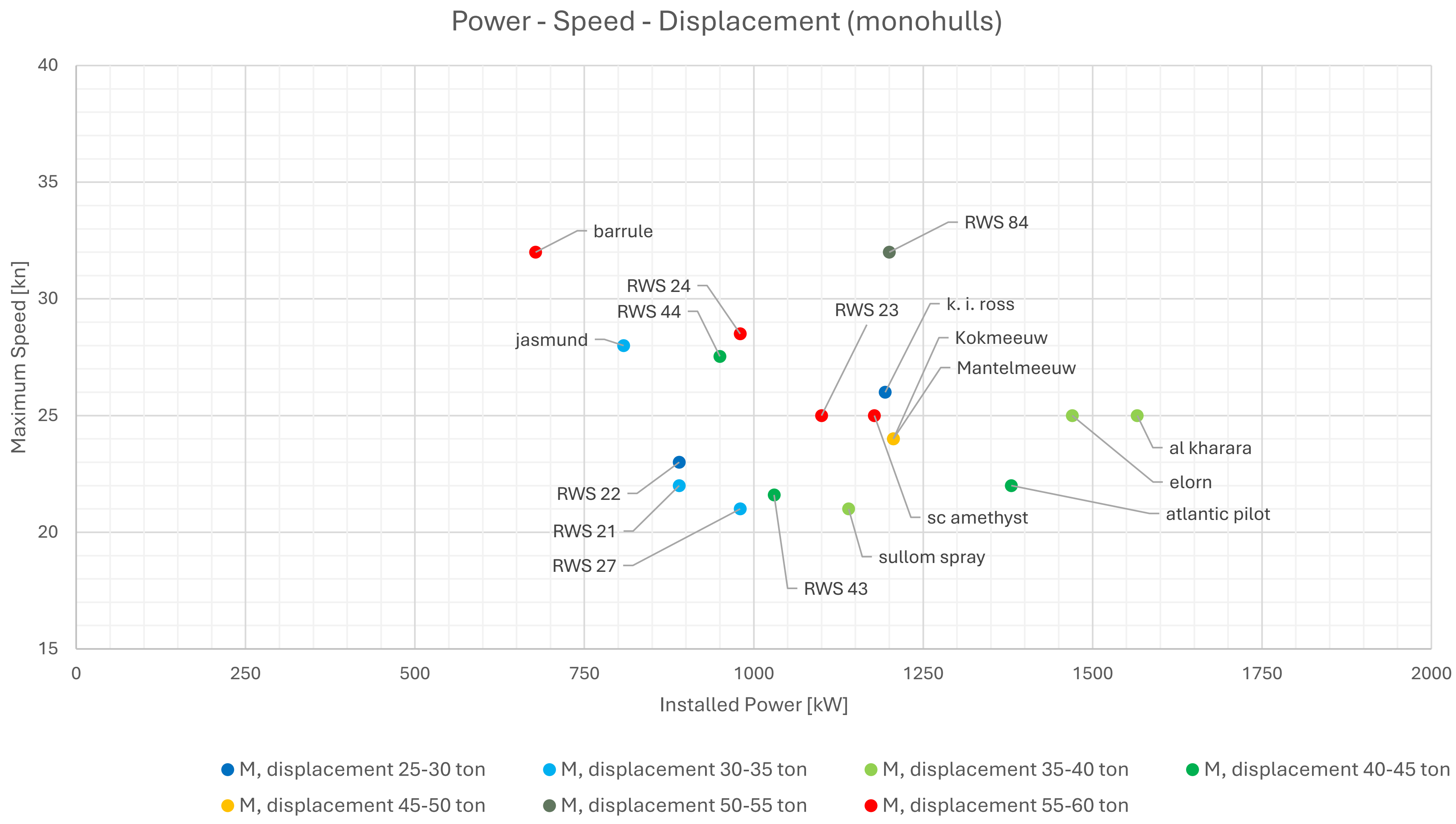

Figure 2-3 Power-Speed-Displacement comparison for monohulls

Table 2-1: Reference Vessels less than 830 kW Installed Power

Vessel Name	Hull Type	Material	Length [m]	Displacement [ton]	Installed power [kW]	Max. Speed [kn]
Jasmund	Monohull	Aluminium	19,25	34	808	28
RWS 59	Monohull	-	19,45	65	588	20
Seaflyte	Catamaran	Aluminium	21,50	54	810	22

Table 2-2: Reference Vessels less than 1245 kW Installed Power

Vessel Name	Hull type	Material	Length [m]	Displacement [ton]	Installed power [kW]	Max. Speed [kn]
Atlanticat	Catamaran	Aluminium	19,66	-	1060	20
Blazer	Monohull	Reinforced Plastic	20,80	-	1170	22
Express 3	Monohull	Aluminium	20,83	-	838	23
Express 4	Monohull	Aluminium	20,80	-	850	25
INCAT Crowther 20	Catamaran	Aluminium	20,60	-	1044	25
Inside Passage	Catamaran	Aluminium	20,90	-	1194	30
K.I. Ross	Monohull	Aluminium	21,15	25	1194	26
Kokmeeuw	Monohull	-	19,80	37	1206	24
Mantelmeeuw	Monohull	-	19,80	49	1206	24
Marina Lines	Catamaran	Aluminium	21,69	-	1206	26
Penguin Express	Monohull	Aluminium	18,05	-	868	28
Raan	Monohull	Aluminium	20,30	-	958	25
RWS 21	Monohull	-	18,80	30	890	22
RWS 22	Monohull	-	18,80	29	890	23
RWS 23	Monohull	-	21,75	56	1100	25
RWS 24	Monohull	-	18,80	56	980	29
RWS 27	Monohull	-	18,80	30	980	21
RWS 43	Monohull	-	19,90	40	1030	22
RWS 44	Monohull	-	19,90	40	950	28
RWS 82	Monohull	-	18,80	-	900	21
RWS 84	Monohull	-	21,41	54	1200	32
Rypoy	Catamaran	Steel	20,50	-	1220	30
SC Amethyst	Monohull	Aluminium	20,25	57	1178	25
SC Cheetah	Monohull	Aluminium	18,50	-	1066	28
SC Lynx	Monohull	Aluminium	18,50	-	956	24
Sullom Spray	Monohull	Reinforced Plastic	19,80	39	1140	21
Tiri Cat	Catamaran	Aluminium	22,00	-	1220	24
Vast Explorer	Monohull	Aluminium	20,00	-	994	21
Voyager	Monohull	Aluminium	18,56	-	1200	28

2.4. Conclusion

From the reference vessels, it seems feasible to create a high-speed patrol vessel that can reach speeds of up to 22 knots with two or three ScandiNAOS engines. Table 2-1 shows the possibility of running the vessel with two ScandiNAOS engines, while Table 2-2 shows the possibilities with three engines.

Since most reference vessels will be plaining at their maximum speed, it is expected that the weight of the vessel will be critical, especially because of the added weight of the methanol fuel. Therefore, it is recommended to continuously update and evaluate the weight of the concept design during the design process.

3. METHANOL TANK SIZE COMPARISON

A first indication of the required methanol tank size can be made using;

- Client requirements as shown in section 2.2,
- ScandiNAOS DI16 Datasheets, see Ref.[2].
- The specification of methanol MD97

This tank size will be compared with the tank sizes of the reference vessels to get an indication of the average fuel tank size versus the required size of a methanol fuel tank. The first section shows the calculation to determine the required methanol tank size. In the second section the tank sizes of the reference vessels are compared. Finally, a conclusion is made with regards to the tank size of the methanol driven high speed patrol vessel.

3.1. Methanol tank size calculation

Table 3-1 shows the specifications of the ScandiNAOS DI16 engines operating at 100% MCR. These specifications will be used to determine the methanol tank requirements according to the vessel specifications given in Table 3-2.

Table 3-1: ScandiNAOS DI16 415 kW engines specifications

Parameter	Symbol	Value	Unit
Engine Type	-	ScandiNAOS DI16	
Fuel Type	-	MD97	
Fuel Density	ρ_{MeOH}	790	[kg/m^3]
Engine Weight	m_E	1660	[kg]
Engine Power	P_E	415	[kW]
Engine Speed	ω	2100	[rpm]
Specific Fuel Consumption	SFC	470	[g/kWh]

Table 3-2: Vessel specifications that influence the required tank size

Parameter	Symbol	Value	Unit
Operating time	T	12	[Hours]
Filling Limit[1]	F_{FL}	92	[%]
No. of Engines	N_E	2 or 3	[-]
Stiffener Reduction Factor[2]	F_{SRF}	97	[%]

Notes:

1. The filling limit of methanol is based on several factors. The maximum filling limit of methanol tanks according to class is set at 98%. To ensure thermal expansion of methanol is possible within this limit over a range of 40°C, the limit has to be adjusted to 93,5%. Finally, a 1,5% reduction has been introduced as a tolerance before reaching the filling limit.

2. The stiffener reduction factor, F, is taken as 97% based on experience with structural tanks of new builds.

With the information of Table 3-1 and Table 3-2, the fuel consumption per engine at 415 kW can be determined using:

$$Fuel\ Consumption = \dot{m} = P_E * \frac{SFC}{1000}$$

From the fuel consumption, the tank volume can be calculated using the below formula.

$$Tank\ Volume = V = \frac{\dot{m} \times T}{\rho_{MeOH}} \times \left(\frac{1}{F_{FL} \times F_{SRF}}\right)$$

The tank volumes are show in Table 3-3 for both the two and three engine configurations. Since we need to evaluate the tank size with other vessels, both the fuel volume and tank volume are shown. The tank volume is based on the total size required on board for the methanol tank, while the fuel volume is the actual volume of the fuel.

Table 3-3: Required Tank Volume per Engine Layout

Parameter	Symbol	2x Engines	3x Engines	Unit
Installed Power	P_E	830	1245	[kW]
Fuel Consumption	$\dot{m}$	390	585	[kg/hr]
Required Methanol Fuel for 12 hours	m_{req}	4681	7022	[kg]
	V_{req}	5,93	8,88	[m^3]
Tank Volume	V_{tank}	6,64	9,96	[m^3]
		6640	9960	[l]

As compared to the regular diesel and assuming the same efficiency of the engines, the required weight of methanol is 2,15 higher than the required diesel weight.

3.2. Reference ship tank sizes

This section shows the reference vessels of chapter 2 which have their tank size available in Table 3-4. The length and installed power will be compared to the tank size of these vessels to be able to determine if a methanol tank dimensions are feasible for the size of vessel considered. Furthermore, a comparison has been made on the operating time of the reference vessels based on their installed power and tank size to evaluate the operating time of the methanol driven high speed patrol boat.

Table 3-4: Tank Size per Installed Power

Name	Monohull or Catamaran	Length [m]	Installed Power [kW]	Tank Size [l]	Operating Time[1] [hr]
INCAT CROWTHER 20	Catamaran	20,60	1194	6000	22,6
RWS 21	Monohull	18,80	890	2487	12,6
RWS 22	Monohull	18,80	890	2400	12,2
RWS 24	Monohull	18,80	980	4000	18,4
RWS 27	Monohull	18,80	980	2487	11,5
RWS 82	Monohull	18,80	810	2500	12,5
RWS 59	Monohull	19,45	588	3600	27,6
RWS 43	Monohull	19,90	1030	3100	13,6
RWS 44	Monohull	19,90	950	3100	14,7
RWS 84	Monohull	21,41	1200	2500	9,4
RWS 23	Monohull	21,75	1100	3000	12,3

Notes:

1. The operating time is estimated based on an SFC of 200 g/kWh and a fuel density of 900 kg/m^3.

Figure 3-1 is using the data from the section 3.1 to plot the fuel weight carrier at fully loaded condition for selected vessels as well as methanol 2 and 3 engine concepts. As can be seen, the methanol-powered vessels have a significantly larger fuel weight on board especially for lower installed powers. For higher installed power, methanol fuel weight is only slightly higher than in case of reference vessels. This can be explained by the lower bunkering frequency of these vessels. In case of methanol-powered vessel, the bunkering frequency will be higher. Approximately 2,15 times more methanol fuel is needed as compared to regular diesel for the same operational time and power. This is a critical point with regards to DWT and thus also the displacement of the vessel.

Figure 3-2 shows the relation between the ships displacement and the fuel tank size for several monohulls, for which the displacement and tank size data is available. The tank size is dependent on displacement, thus a larger displacement allows for a larger tank size.

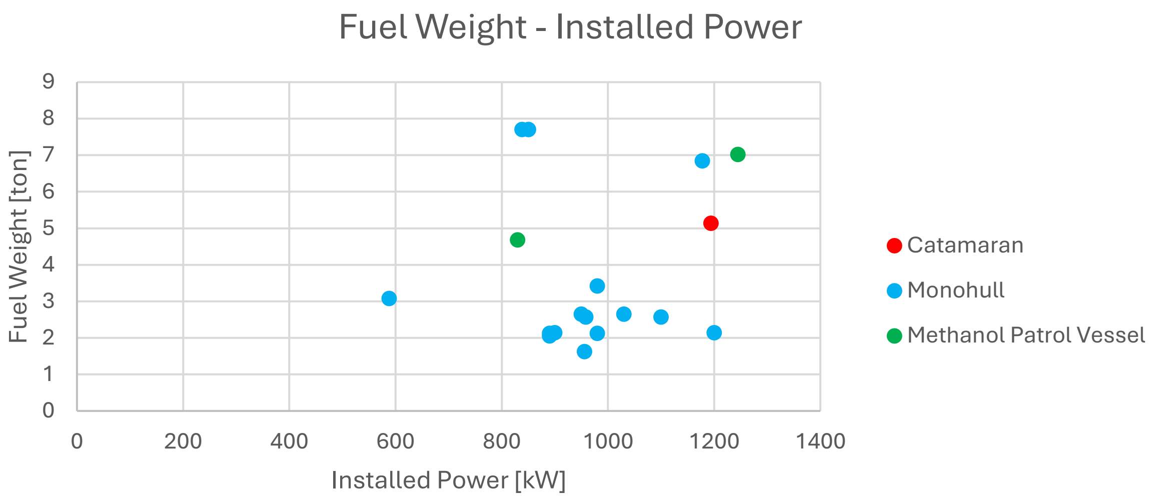

Figure 3-1 Fuel weight - Installed power

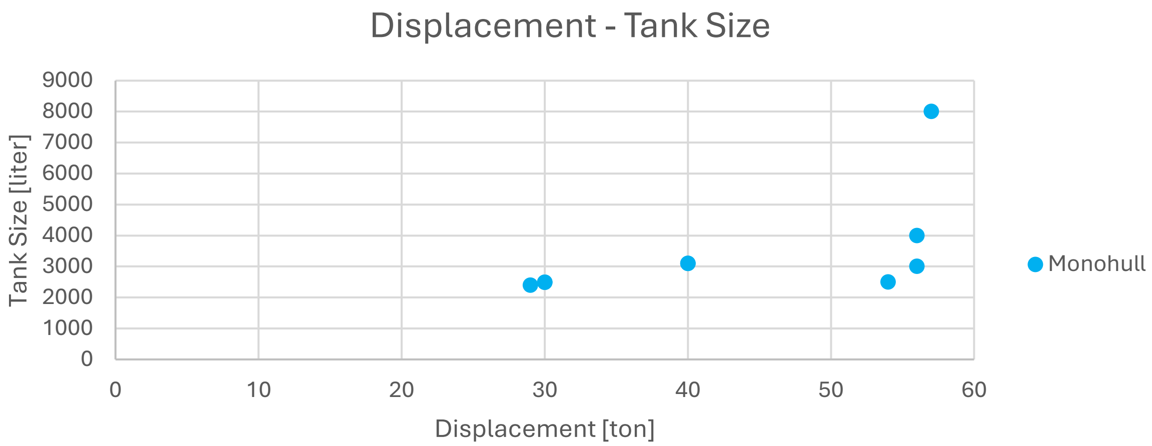

Figure 3-2 Displacement - Tank size

3.3. Conclusion

The weight and size of the methanol fuel tank is larger than those on vessels driven by conventional fuels. The increased tank size may cause difficulties reserving the space required for the methanol storage for monohulls. Additionally, the increased fuel weight directly increases the required DWT and the displacement of the patrol vessel.

The weight of the vessel is of particular importance for planing and hydro-foiling vessels. For those vessel types more weight leads to more resistance or a higher take-off speed, which leads to a higher power requirement and more fuel consumption, which increases the overall weight of the vessel. This could potentially lead to a negative design spiral.

Furthermore, the operating time of the methanol driven high speed patrol boat will be relatively short compared to the reference vessels. This means that more bunkering actions will be required, which should be considered when looking at the bunkering location and procedure in later design stages.