TugeZine

all about tugs

Hybrids & Greenies...

vol. 4 **nr. 20**
October 2023

Hybrids & Greenies

On the occasion of the Europort 2023 maritime trade show this issue is dedicated to the towage industry and shipyards aiming at lowering the ecological footprint of their vessels.

Since 2015 we regularly reported on the subject. To be exact: in Lekko International 212 (2015), 218 (2016), 224 (2017), 602 (2018) and 607 (2019).

This time the conclusion may be that the search for alternative fuels has gained momentum. For deepsea shipping this is more easy than for small ships like tugs and workboats. The reason being that most alternative fuels have less energy density than the current fossil fuels. For instance: petrol has a density of 9 kWh per kg, coal 8, hydrogen 2,4 and li-ion batteries 0,1 kWh / kg. Nevertheless when operating vessels within a short distance of a recharging / bunkering station alternative fuels may be an option. Especially when these fuels can be used without major alterations to existing machinery.

In this issue you will find a variety of solutions to the problems. Svitzer announced their tugs in the U.K. were to change to bio fuel, as this lowers their footprint without major alterations to the engines.. CO2 emissions per kWh 70 grams for biomass compared to 700 grams for LNG.

Furthermore we have a new design for a pushboat which can be recycled for near 100%. The boat was groundbreaking to a level that it did not fit within existing regulations.

This issue has been slightly delayed as we wanted it to be published close to the Europort trade show. Our December issue likewise will be published earlier than usual to coincide with the Salvage & Wreck Removal Conference.

Job van Eijk (editor)

An early form of hybrid propulsion: 2 FP (family-power) pulling the barge along the small canal where sailing is impossible
photo: coll. Dutch National Towage Museum

Frontpage:
The all-electric tug SPARKY 'bunkering' energy via a shore connection. In this issue it is 'all about hybrids & greenies'
photo: courtesy Damen Shipyards

TugeZine
is published every even month in digital format only.

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TugDoc International

ISSN 2667-1441

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Hybrids & Greenies 2015-2023

This article is the latest in a series produced by the author since 2015. The earlier articles were published in Lekko International, the (print) tug and towage magazine that closed down in 2020.

by Job van Eijk

For the purpose of uniform terminology we will define a hybrid tug as **a towing vessel using two or more different and individual power (or energy) sources in the drive train**. A 'green' tug is defined is defined simply as a tug that has a significant lower environmental footprint compared to a traditional diesel-driven tug. The cleaner diesels complying with the Tier 2, 3, 4 etc norms produce a lower carbon footprint but are nevertheless only a function of engine development and therefore not in this article.

The first hybrids

Hybrid propulsion has been along for ages. Sail assisted steamers to reduce the consumption of coal, the 'seeking' tugs that used sail to widen their operational range, sailing vessels assisted by the power of rowing. And not to forget the inland waters vessels under sail that were obliged to be pulled along when in narrow channels, pulled by horses, the family of the barge master, or by road or rail vehicles along a tow path.

The first 'modern' hybrid came about because of ecological awareness. But sometimes it was just a matter of reducing operating costs.

Foss Maritime had already for a number of years been applying new techniques to reduce the environmental footprint of their shiphandling tugs. This varied from NOx-reducing fuel filters to the use of low-sulphur fuel and a number of things in between. Operating in ports such as San Francisco, Los Angeles, Long Beach - which also have dense populated areas nearby – initiated a next, more drastic, step.

Considering further options diesel-electric propulsion came to the fore. Sailing electric-only would dramatically reduce the environmental footprint but clashed with the necessity to have a big engine output available at a moment's notice. Foss decided on a lay-out which included diesel main engines, generators and batteries. Their tug-of-choice was their "Dolphin"-class, an azimuthing stern-drive shiphandling tug. This Robert Allan design was built in their own shipyard and at the time eight had been delivered. Compact tugs of 23,77 x 10,36 m they have an output of 5.080 bhp and a bollard pull of 60 tonnes. Number nine, ***Carolyn***

The 600 hp paddle tug EPPLETON HALL is seen fitted with sails at the start of her voyage from Dover to San Francisco to become a museum ship. In the early years of towage many such paddle tugs and early stem tugs were fitted with sails. Thus equipped tugs from the Thames area went down the Channel and even as far as the Western Approaches. This was a typical hybrid application as the tugs saved the coal for towing while station keeping awaiting a contract. This particular tug, however, spent her life working in the North of England between Newcastle and Sunderland. She was built in 1914 for account of Lambton & Hepton Collieries Ltd. Fitted with two side-lever a.k.a. grasshopper engines the 32,00 x 10,05 m tug later served with the France, Fenwick fleet from 1945 onwards. She was sold in 1967 to Seaham Harbour & Dock Co. Probably the oldest working steam-powered paddle tug she was sold for scrap in 1969, but rescued for service as a museum ship in the USA photo: coll. Job van Eijk

Dorothy, was completed as a hybrid tug and became operational in 2009.

The resultant savings were at the time estimated as 20-30% in fuel costs and an estimated 44% lower NOx and PM emission compared to conventional "Dolphin"-class tugs. On the flip side were the increased newbuilding costs. Foss at the time estimated an additional USD 2,5 million on top. According to Foss the savings on fuel and maintenance would not be enough to recover capital lay-out. The ports of Los Angeles and Long Beach, however, subsidised part of the extra costs. In addition these ports started fitting shore power installations which by 2018 became available throughout the port.

In 2012 she was joined by a retro-fit sister, ***Campbell Foss*** – built in 2005. With lessons learned, the new hybrid was fitted with lithium polymer batteries. There were 10 Corvus lithium polymer batteries fitted, compared with 126 lead-acid batteries on *Carolyn Dorothy*. These also used half the space compared to the earlier vessel. In addition, they were lighter, could provide full output for a longer time and the charge-time was 50% faster. Two 500 kW Teco-Westinghouse shaft generators / motors were fitted that could either drive the tug or charge the batteries or provide the necessary auxiliary power. Two auxiliary generators were available to charge the batteries if required. When the tug was in idle mode it was powered by the 125 kW generator alone. Transit speed on one generator was 7 knots.

The extra costs for the refit were almost equal to the extra cost for the newbuilding *Carolyn Dorothy*, at about 2 million USD. The ports of Long Beach and Los Angeles subsidised each hybrid with USD 1 million. Compared to a conventional Dolphin-class tug the hybrids generated 73% less particulate matter, 51% less NOx and 27% less CO2. Savings on fuel costs were approximately 20%.

CAROLYN DOROTHY, the world's first dedicated hybrid tug *photo: courtesy Robert Allan Ltd*

RT ADRIAAN was the first European hybrid tug *photo: Ruud Zegwaard*

Kotug

The first European hybrid became Rotterdam-based Kotug's ***RT Adriaan***. This, a two year old Rotor Tug type shiphandling tug, was converted to hybrid propulsion and re-entered service in January, 2012. Again Aspin-Kemp and XeroPoint Energy were involved in this rebuilt. In the rebuild a battery bank with 12 Corvus Energy lithium batteries - totalling 78 kW – was fitted while three Teco-Westinghouse 480 V ac / 60 Hz / 500 kW shaft generators / motors were fitted in the drive train between the main engine clutch and the thruster.

In late 2015 two next-generation hybrid Rotor Tugs were delivered by Damen Shipyards. The design is a cooperation between Robert Allan, Rotortug BV and Damen Shipyards. The ART 80-32 ***RT Evolution*** and ***RT Emotion*** again feature Aspin Kemp XeroPoint power management. Bollard pull is 80 tbp. Kotug initially employed the tugs in the Port of Rotterdam. Apart from the hybrid propulsion a whole lot of other environmental and cost-reducing measures were implemented in the tugs.

*The two tugs were since sold to **Boluda** as part of the sale of Kotug-Smit to Boluda.*

TSUBASA - the first Japanese hybrid tug, operated by Wing Maritime (Nippon Yusen Kaisha) *photo: Nobu Tadaki*

BORGOY, the first LNG-only tug *photo: Sanmar Shipyards*

EDDY 1 seen here on 18-09-2014 was built by Holland Shipyards. The tug has the drives in-line forward and aft. Tested around the globe she got a charter with Iskes Towage as ATLAS. Currently operated in Norway as FFS ATHOS *photo: Hans Hoffmann*

Tokyo Kisen

In the same year Tokyo Kisen put ***Ginga*** to work in the ports of Yokohama and Kawasaki. *Ginga* is a hybrid without a battery bank, Dimensions are 38 x 10 m. The tug is fitted with hybrid diesel-electric propulsion. *Ginga* was completed by Kanagawa Zosen in September, 2013.

In the 'boost' mode the output of the e-motors is added to that of the main engines, totalling an equivalent of 4.400 bhp with which 57 tbp is generated.

Holland Shipyards

In 2014, the innovative double-ended ***Eddy-1*** was constructed 'on spec' by Holland Shipyards, The Netherlands, jointly with Eddy Tug, as a prototype. Here, the propulsion is hybrid diesel-electric, with the electric motors driving the Schottel azimuthing thrusters alone, in combination with the main engines or by main engines alone. The power from the electric motor on the thruster can be added to that of the main engine. To this end, **Schottel** developed a special azimuthing thruster.

Damen-built

Iskes' ***Bernardus*** was built by Damen Shipyards. The tug is a standard Damen ASD 2810 tug re-designed for hybrid propulsion. *Bernardus* had additional battery-stored electric power. Furthermore electric shaft motor / generators were fitted between main engine and thruster which can also be powered from the generator. A point of interest in this case was that Iskes also operated an identical non-hybrid sister. Both tugs were fitted with extensive on-line data-logging systems allowing for reliable comparisons to be made.

Svitzer Australia

By the end of 2014 Svitzer Australasia was taking delivery of four hybrids for operations on the Gorgon project. ***Svitzer Euro***, ***Svitzer Perentie***, ***Svitzer Boodie*** and ***Svitzer Dugong*** to be operated at Barrow Island LNG, NW Australia. The 75-tbp diesel-electric hybrids were built by ASL Singapore. The ECO tugs combine a diesel engine with a giant, 5,5-tonne battery bank. With the diesel engine shut down, the battery bank can provide 525 kW of power, enough to propel the tugs up to speeds of 6 knots for 1,5 hours before recharging is needed.

Bouwman Marine

Also in The Netherlands the Kooiman Shipyard in 2015 carried out an extensive reconstruction with an unfinished hull that resulted in the hybrid tug ***Sil-Jeske B*** for account of **capt. Wout Bouwman**. Unlike other tugs this was not a shiphandler but was operated in the dredging and engineering support business. This work may require a tug to be around idling for considerable time - which is where the hybrid propulsion came into its own. This year the tug was sold for further trading. Now named *Isa* the new owner – **capt. Willem-Harm Mastenbroek** - is very happy with his significantly reduced fuel bills.

All-electric

The first such tug is the1928-built ***Tender 4.*** This small diesel-driven tug has been re-fitted with an all-electric drive train. She re-entered service in June, 2014 on the Utica section of the Erie Canal. The tug operates as a tender supporting dredging and maintenance works of the New York State Canal Corporation. Elco Motor Yachts of Athens, NY, rebuilt the tug. Now, two Elco EP-10000 electric motors and a battery bank are fitted. The tug's battery pack is recharged every day when at the end of a working day she is plugged-into the shore power.

Alternative fuels

Apart from technical solutions the use of

continue at page 206

Overview of Hybrids & Greenies – vessel names / owners are current, former history in the footnotes. Note that 'cleaner' diesel engines (IMO Tier II etc., EU stage V etc) are omitted as th lower emissions are a matter of engine-technology only. Likewise conventional diesel-electric propulsion is omitted as that is considered a single drive train, not hybrid.

Name	operator	flag	type	built	retro-fit
Steel Rebel	Rebel Marine	USA	hybrid		retrofit
Norfolk Rebel	Rebel Marine	USA	hybrid		newbuild

* Hybrids avant-la-lettre. Consideration was saving on fuel costs only. While Steel Rebel's wind assist came more or less by coincidence, Norfolk Rebel was purposely designed for wind-assist. Only post WW2 tugs fitted with sails. Hybrid diesel / sail. **See story with photo back page this issue.**

Carolyn Dorothy	Foss	USA	hybrid	2009	newbuild
*Bering Wind**	Cook Inlet T&B	USA	hybrid	2005	2012

* *Bering Wind* ex *Campbell Foss* transferred from Foss to subsidiary Cook Inlet Tug & Barge in 2018. Her towing gear consists of a Markey DEPGF 42 winch on her bow. The tug's power system can accept regenerated power from the winch. The DEPGF 42 hybrid winch is configured to generate power back into the batteries when the winch is rendering, the motor acts as a generator.

KV Barentshav	Coastguard	Norway	diesel / LNG	2009	newbuild
KV Bergen	Coastguard	Norway	diesel / LNG	2010	newbuild
KV Sortland	Coastguard	Norway	diesel / LNG	2010	newbuild

* Oceangoing with towing capability. The propulsion system integrates a Bergen B32 diesel engine, electric propulsion motor and gas powered generator sets. The conventional CP propeller is driven by a main engine or combined electric motor / shaft generator driven by gas-fuelled generators. The hybrid configuration allows the two systems to drive the propeller at the same time. Emission reduction CO_2 – 25%, NOx -90% and fuel costs -25% over conventional drive trains.

Svitzer Gaia	Svitzer	Denmark	eco-diesel-electric	2011	newbuild
Svitzer Geo	Svitzer	Denmark	eco-diesel-electric	2012	newbuild

* Propulsion is by electrical Schottel Combi Drive SCD 1515 azimuthing thrusters. Other features are double-glazed windows and extra insulation reducing heath loss, exhaust silencers reducing noise, LED lighting, silicone underwater anti-fouling paint, SCR genset exhausts reducing NOx and a particulate filter on the centre gen set to reduce particulate matter exhaust. Svitzer indicated the costs of this tug compared to a 'normal' comparable diesel tug were 50% higher.

VB Kracht	Boluda	Netherlands	hybrid	2010	2012

* Delivered in 2010 by Niigata Shipbuilding, Japan, as *RT Adriaan*, the third of a series of 4, the others being *RT Rob*, *RT Peter*, and *RT Eduard*. RotorTug type, designed by KTS BV (Kooren Shipbuilding & Trading). Dimensions: 32,00 (oa) x 12,00 m. Max draught 5,95 m. Main engines 3x Caterpillar 3512 C-HD, total output 7.200 bhp. 3x Schottel SRP 1215-FP azimuthing thrusters. 2x Caterpillar C9 250 kW gen stets, 1 x Caterpillar C4.4 36 kW harbour gen set. Bollard pull 84 tonnes max. Operating at Rotterdam. 11-11-2011 arrived at Padmos Shipyard, Stellendam, for reconstruction with a hybrid propulsion system. Electric motor / generators installed in the drivelines. Aspin Kemp Xeropoint hybrid power management switchboard fitted and a Li-ion battery bank with 12 units totalling 78 kWh / 532 V capacity added. March 2012 operational. First European hybrid shiphandling tug; third in the world. 31-7-2019 Kotug-Smit purchased by Boluda, including *RT Adriaan*. 2020 renamed *VB Kracht*. Emission reductions achieved: PM -44%m unburned hydrocarbons -48 %, NOx -32%, CO2 -35%. Still operating at Rotterdam.

Tsubasa	Wing Maritime	Japan	hybrid	2013	newbuild
Sakigake	Wing Maritime	Japan	LNG-dual-fuel	2015	newbuild

* Wing Maritime is a NYK (Nippon Yusen Kaisha) subsidiary. Built by Keihin Dock. Niigata engines.

Hai Yang Shi You 521	CNOOC	China	LNG-dual-fuel	2013	newbuild
Hai Yang Shi You 522	CNOOC	China	LNG-dual-fuel	2013	newbuild

* Fitted with Wärtsilä 6L34DF main engines**.** Built by Guangzhou Huangpu. Rolls-Royce gas-fueled Bergen engines meet IMO Tier II and Tier III regulations as well as US Environmental Protection Agency rules on NOx, with a 25 percent reduction in CO2 emissions, a 80-90 percent reduction in NOx emissions and a virtual elimination of SOx emissions and particulates.

Bokn	B&B	Norway	LNG-only	2013	newbuild
Borgoy	B&B	Norway	LNG-only	2013	newbuild

* Built by Sanmar Denizcilik. Operating at the Karsto gas terminal in Norway. Main engines are a pair of Rolls-Royce Bergen C26:33L6PG lean-burn gas engines that have a combined output of 3,410 kW at 1,000 rpm and are directly coupled to Rolls-Royce US-35 azimuth thrusters, each fitted with a 3m dia CP propeller in a nozzle. The vertically-mounted cryogenic fuel tank has a capacity of 80m³, containing enough fuel to last up to five or six days and can be bunkered in around 45 mins. The rest of the fuel system is split and duplicated into two separate gas supply lines and power trains. Each is monitored by the Rolls-Royce Acon safety, alarm and control system with gas detection in all areas. Unlike conventional diesels which require fuel pumps, filters and injectors, gas is fed to the engines by pressure in the LNG storage tank.

Ginga	Tokyo KK	Japan	hybrid	2013	newbuild

* Built by Kanagawa Zosen. The 267 GT tug measures 38,00 x 10,00 m. Depth is 4,47 m with a draft of 3,30 m. The tug is fitted with a hydraulic double-drum towing winch with 70-tones braking power. The drums are fitted with Dyneema towing lines with a break strength of 150 tonnes.

VB Evolution	Boluda	Netherlands	hybrid	2014	newbuild
RT Emotion	Boluda	Netherlands	hybrid	2014	newbuild

* Ex *RT Evolution*, resp. *RT Emotion*. ART 8-32 design RotorTugs built to the order of Kotug. 80 tbp. Operated within Kotug-Smit and were sold jointly with that JV in 2019 to Boluda. Originally operating at Rotterdam but currently from Bremerhaven.

KV BARENTSTHAV is one of three sisters in the Norwegia combined

SAKIGAKE was Japan's first LNG dual-fuel tug, seen here at

RT EMOTION being tested after delivery to Kotug, currently

n Coastguard where diesel-electric and LNG-electric are
photo: Jonas Selim / Norwegian Armed Forces - Fosvaret

Yokohama 19-06-2017
photo: Maasmond Maritime / Piet Sinke

owned by Boluda and operating at Bremerhaven
photo: courtesy Kotug

Name	operator	flag	type	built	retro-fit
FS Athos	FFS Marine	Norway	hybrid (boost)	2014	newbuild

* Ex *Atlas* ex *Eddy-1*. Dimensions: 30,3 (oa) x 13,46 (oa) x 6,65 m. Draught max 4,75 m. Main engines 2x Mitsubishi S-16-R2-T2MPTAW Tier III each 1.600 kW. 2x Scania gen sets each 750 kW. 65 tbp. Thrusters in line forward and aft. In 2018 transferred from Holland Shipyards to Iskes Tugs renamed *Atlas*. After delivery the tug – operated by Holland Shipyard - served with a variety of European tug operators for assessment of the design. Next, the tug was transferred to the Caribbean. She crossed the Atlantic on a single generator, also in electric mode. In early 2018, the tug returned from long-term charter in Venezuela (Maracaibo) to The Netherlands. 2020 to Norway as *FFS Athos*.

Tender 4	NY State	USA	all-electric	1928	2014

* Operating on the Erie Canal. Propulsion by 2 Elco electric motors energized from a battery bank. This is a day-boat only which recharges every day from shore power.

Turva	Border Guard	Finland	LNG dual drive	2014	newbuild

* This vessel combines a number of rules including ETV capability. Propulsion actually consists of two separate drive trains. A diesel-driven central propeller is flanked by LNG-dual-fuel gen sets that drive two electric Rolls-Royce Azipull thrusters. In case of failure of the gen sets the central diesel-driven shaft is fitted with a shaft generator that can be tied in to the Azipulls. This is necessary since the vessel has no rudders.

Hampshire	Kotug-Smit	Netherlands	hybrid	2014	newbuild
Experience	Damen	Netherlands	hybrid	2015	newbuild

* *Adventure is the former Med Regulus (MSC Shipping), ex Hampshire (Damen Shipyards), ex Hampshire (Kotug-Smit) ex Adventure (Damen Shipyards), ex Bernardus (Iskes). VB Ivy ex Med Polaris (MedTug) ex Experience ex Multratug 28, ex Experience.* Both tugs had their hybrid additions removed prior to transfer to MedTug (MSC Shipping).

Fairplay IX	Fairplay	Germany	hybrid (boost)	2015	newbuild
Fairplay XI	Fairplay	Germany	hybrid (boost)	2015	newbuild

* Built 2015 Astilleros Armon, Spain. Schottel tractor tug. Dimensions 29,67 (oa) x 13,50 (oa) m. Draught 6,60 max m. Main engines 3x MTU 16V-4000m 63L/23F total output 6.000 kw / 8.160 bhp. Two Volvo gen sets 220 kW and 440 kw respectively. Schottel hybrid propulsion system including two Schottel azimuthing thrusters SRP 4000 with hybrid gearboxes, two electric motors (600 kW each) and an integrated steering control system. Bollard pull ahead 90 tonnes.

Svitzer Euro	Svitzer	Australia	hybrid	2015	newbuild
Svitzer Perentie	Svitzer	Australia	hybrid	2015	newbuild
Svitzer Boodie	Svitzer	Australia	hybrid	2015	newbuild
Svitzer Dugong	Svitzer	Australia	hybrid	2015	newbuild

* Built by ASL, Singapore. 33,3 x 13,0 x 3,5 m. 650 GT. 80,0 tbp. Diesel-electric with battery banks.

Isa	Tugboat Isa	Netherlands	hybrid (stacked)	2015	newbuild

* **This tug was described in full in TugeZine 18**. Ex Sil-Jeske B, Bouwman Marine Services (Wout Bouwman). The tug is fitted with PM motors on the main drive shafts aft of the clutch and can sail in diesel-only mode, diesel-electric mode or stacked / boost diesel-electric mode. The operating profile of the tug did not justify installation of a battery pack.

SD Power	Kotug	Bahamas	hybrid gearbox	2015	newbuild

* In-field support tug operating off Guyana. Ex *BB Power*, Bukser og Berging. Dimensions are 42,50 (oa) x 15,00 (mld) x 8,20 m. Draught is 6,30 m. The tug is fitted with four main engines: 2x ABC 8-DZC of 1.900 kW / 2.584 bhp each and 2x ABC 6-DZC of 1.400 kW / 1.900 bhp each. There are also two 690-kW shaft generators, two 400-kW auxiliary engines and one 200 kW auxiliary engine. Propulsion is by two Schottel azimuthing thrusters fitted with c/p props in nozzles. Two bow thrusters in addition to two stern thrusters allow DP operations. Power is transmitted via the Kumera hybrid gearbox.

Hai Yang Shi You 525	CNOOC	China	LNG-only	2015	newbuild
Hai Yang Shi You 526	CNOOC	China	LNG-only	2015	newbuild

* Fitted with Rolls-Royce Bergen C26:33L9PG gas engines. Rolls-Royce gas fuelled Bergen engines meet IMO Tier II and Tier III regulations as well as US EPA rules on NOx, with a 25 percent reduction in CO2 emissions, a 80-90 percent reduction in NOx emissions and a virtual elimination of SOx emissions and particulates. Built by Zhenjiang.

Telstar	Svitzer	Netherlands	hybrid (boost)	2016	newbuild

* Eddy-type tug. The main difference compared to *Eddy-1* – apart from size and power – is that the thrusters – Veth in this case – have the electric motor omitted but instead the tug is fitted with a PM motor / generator on the main drive shafts. Purchased by Svitzer with the acquisition of the Amsterdam Port Towage share belonging to Iskes Towage.

Noordzee	Navy	Netherlands	hybrid	2016	newbuild
Waddenzee	Navy	Netherlands	hybrid	2016	newbuild
Zuiderzee	Navy	Netherlands	hybrid	2016	newbuild

* These Damen ASD 2810-hybrids also have battery-packs and shore-power connection. The Dutch Royal Navy has an advantage over private users in that the electric power at the Den Helder Naval Base comes cheaper than for individual private owners.

Seaways 24	Kotug	Singapore	hybrid	2016	newbuild

* In-field Support Vessel. Designed by Robert Allan Ltd. RAmpage 5500-ZH type. Built by Keppel-Singmarine. Dimensions are 55,00 (oa) x 15,00 (mld) x 7,33 m. Draught max 6,05 m. 125 tbp ahead, 107 tbp astern. Speed ahead hybrid mode 15 knots, ahead electric mode 7 knots. Seaways has since been purchased by Kotug.

Harvey Stone	Harvey Gulf	U.S.A.	hybrid	2016	newbuild

* In-field Support Vessel with towing capability. The propulsion machinery comprises a pair of GE 12V250 MDC main engines with EPA Tier 4 emission certification; each rated 3.495 kW at 1.000 rpm and driving a Schottel SRP 3030CP azimuth thruster with a 3,400 mm CP propellers via a Reintjes LAF 3414 single input / dual output gearbox. This set-up achieves at least 13 knots and 106 tbp.

Name	operator	flag	type	built	retro-fit
Svitzer Kadala	Svitzer	Australia	eco-diesel-electric	2016	newbuild
Svitzer Dugite	Svitzer	Australia	eco-diesel-electric	2016	newbuild
Svitzer Mulga	Svitzer	Australia	eco-diesel-electric	2016	newbuild
Svitzer Gwardar	Svitzer	Australia	eco-diesel-electric	2016	newbuild
Elemarateyah	Drydocks World	Dubai	LNG-dual-fuel	2017	newbuild

* At the time it was announced that an option for 6 tugs had been taken but this apparently was been dropped. Construction of the tug was treated by Dry Docks World Dubai as a shipyard training object. Consequently the construction delayed depending on the yards' other workload. The main engines and thrusters had been ordered by the end of 2015 .

Dux	Østensjø	Norway	LNG-dual-fuel	2017	newbuild
Pax	Østensjø	Norway	LNG-dual-fuel	2017	newbuild
Audax	Østensjø	Norway	LNG-dual-fuel	2017	newbuild

* Built by Astilleros Gondan. Dimensions are 40,20 x 16,00 x 6,10 m. Draught max is 7,00 m. GT 1.056 t. LNG tank capacity: 33,0 m³. Ahead bollard pull 107,5 tonnes, astern bollard pull 103 tonnes, escort force indirect steering rated at 167 tonnes, braking force at 10 knots rated 200 tonnes and a free running speed ahead in excess of 15 knots. The gas fuel installation consists of a Wärtsilä LNG Pac IMO-Type C vacuum-insulated LNG tank with Tank Connection Space (TCS) located in the LNG tank hold, and two Wärtsilä 6L-34-DF dual fuel main engines. Operating at Statoil's Melkøya LNG Gas terminal at Hammerfest.

Yuribey	FSUE Atomflot	Russia	Eco diesel-electric	2017	newbuild

* Built by Craneship. Four Caterpillar gen sets run via a PEMS to two electrical ABB Azipods. A full report on this tug was published in Lekko International 228.

KST Liberty	Keppel-Smit	Singapore	LNG-dual fuel	2018	newbuild
Maju Loyalty	Maju Tugs	Singapore	LNG-dual-fuel	2018	newbuild

* Built by Keppel Singmarine. Fitted with portable deck-mounted gas tanks. In 2022 Keppel-Smit and Maju were purchased by Rimorchiatori Mediterranei,

Delivered	Ningbo Port	China	LNG-dual-fuel	2018	newbuild

* RAstar 3800-DF design. Niigata engines.

Fregate	De Boer Dredge	Fr. Guyana	hybrid	2018	newbuild

* Combination shiphandling tug / water-injection dredger. Main engines are two Caterpillar 3512-C total output 2.850 kW. The main power generators each deliver 1.058 kW / 680 V AC / 50 Hz. The E-motors for the thrusters each deliver 400 kW / 690 V AC / 60 Hz.

Bogacay XXXVIII	Sanmar	Turkey	hybrid gearbox	2019	newbuild

* Fitted with Caterpillar AVD-system with hydraulic planetary gears. The Caterpillar AVD (Advanced Variable Drive) is a hydro-mechanical propulsion system. The planetary gear set allowing seamless clutch engagement of main engines, auxiliary engines, or both to provide a scalable power installation. This allows propeller speed independent of engine speed so optimal engine efficiency can be achieved, leading to fuel savings of 15 – 20%. The Caterpillar AVD system is integrated with the Caterpillar 3512 main engines, a C32 auxiliary engine, Caterpillar MTA 627 fixed pitch azimuthing thrusters, and bridge controls. The tug has Fifi 1 designation with 70 tonnes bollard pull. The AVD system also includes a fully integrated control system with customizable operating modes and display panels on the bridge. Compared to a conventional tug with equivalent bollard pull, the Return-on-Investment is estimated at three years or less based on projected fuel and operating cost savings.

Vilja	Port of Lulea	Sweden.	hybrid	2019	newbuild

* Icebreaking shiphandling tug. TundRA-3600 design. Yard: Astilleros Gondan. Dimensions are 36,0 m (oa) x 13,0 m (mld) x 6,7 m with a draught of 7,0 m. Diesel / mechanical output 2x 2.720 kW (total 7.308 bhp). Hybrid / boost output equivalent to 8.432 bhp. Bollard pull 90 tonnes, max 100 tonnes. Finnish-Swedish Ice Class 1A Super FS,'Icebreaker'.

Gisas Power	Gisas	Turkey	all-electric	2019	newbuild
Gisas Power II	Gisas	Turkey	all-electric	2020	newbuild
Gisas Power IV	Gisas	Turkey	all-electric	2023	newbuild

* NavTek ZEEtug 30 design. First boat delivered May, 2019. E-output 2x 925 kW. Dimensions 18,70 (oa) x 6,70 (mld) x 4,30 m. Draught 3,15 m (design).

Ishin	Nihon Tugboat	Japan	LNG-dual fuel	2019	newbuild

* Built by Kanagawa Zosen. Nihon Tugboat is a Mitsui OSK subsidiary. The *Ishin* is powered by two Yanmar 6EY26DF dual-fuel engines total output 3.000 kW. *Ishin* was delivered 27-2-2019 and operational in April 2019. According to Yanmar the engines emit 80% less NOx, 99% less sulphur and particulate matter and 25% less CO_2 compared to conventional diesel engines.

Delivered	Rim. Riuniti	Italy	hybrid	2019	newbuild

* Wärtsilä HY hybrid power module with engines, energy storage system and power electronics delivering 80 tbp.

PSA Aspen	PSA Marine	Singapore	LNG dual-fuel	2019	newbuild

* Harbour / coastal shiphandling tug. Built byPaxOcean Shipyard. RAmparts 2800-DF design. 447 GT. Dimensions: 28,2 (oa) x 11,5 (mld) x 5,5 m. Maximum navigational draught 4,6 m. 56 tbp. Main engines Niigata 6L-28AHX dual-fuel, each 1.618 kW at 750 rpm (4.400 bhp total). Fitted with Niigata ZP-31 Z-Peller azimuthing thrusters with 220 cm diameter fixed-pitch propellers and zero-to-idle slipping clutches. LNG storage tank and gas fuel system supplied by Gloryholder Liquefied Gas Machinery. Gas is stored in the 25 m3 vacuum insulated IMO Type C LNG storage tank. Theis is the third LNG-fuelled tug in Singapore after the Keppel-Smit / Maju duo. In addition to eliminating SOx and particulate matter emissions while achieving 80% NOx emissions reduction, the operation of the harbour tugs in LNG mode has also achieved about 20% reduction of CO2 and 15% lower noise levels.

The RAstar 3800-DF design LNG dual-fuel tug YONG GANG

FREGATE - seen here on 9-05-2018 running trials - is a comb and a water injection dredging 'plough' hanging from the s

PSA ASPEN seen here 26-08-2019 shortly after arrival from the hull

XIAO TUO 60 was delivered to Ningbo Port, China
photo: courtesy Robert Allan Ltd

ination of shiphandling tug with the towing winch forward
stern photo: R.& F. van der Hoek

the builders. The tug has the LNG storage tank fitted inside
photo: PSA Marine

Name	operator	flag	type	built	retro-fit
PSA Oak	PSA Marine	Singapore	LNG dual-fuel	2020	newbuild

* Built by PaxOcean Shipyard. 481 GT.Dimensions 28,80 (oa) x 13,00(mld) x 5,80 m. Draught 5,10 m (navigational). Main engines 2x Wärtsilä W9L-20DF at 1.200 rpm. Total output 3.330 kW (4.528 bhp). Fitted with Wärtsilä WST-16-FP azimuthing thrusters. LNG tank capacity 25,4 m^3.

Ralph	Harbor Docking	U.S.A.	hybrid	2019	newbuild
Capt. Robb	Harbor Docking	U.S.A.	hybrid	2019	newbuild

* Built by Washburn & Doughty. First U.S. vessels with all-Caterpillar diesel-electric propulsion. Propulsion: 2x Caterpillar 3512 main engines each 2.550 bhp; 2x 600 kW C-18 gen sets, 1x 200 kW C7.1 harbour gen set, 2x 750-hp ABB electric motors. 90 tons bollard pull with main engines and electric boost. Electric power can be added to the main engine power. First full year running was 2020 with fuel costs down by 48% and operation without main engines for 47 percent of the time. Emission reduction: NOx down 20%, Carbon Dioxide down 46%, Hydrocarbon emissions down by 43% and Particulate Matter down by 78%.

Delta Teresa	Baydelta	U.S.A.	hybrid	2019	newbuild

* Built by Nichols Bros. Designed by Jensen Maritime. Propulsion: 2x Caterpillar 3516 main engines, 2x 300 kW Cat C9.3 gen sets and 1x 150 kW C7.1 gen set can supply electricity to two 650 hp Marelli electric motors. Including boost power from the e-motors 90 tons bollard pull.

Michigan	Great Lakes	U.S.A.	hybrid	2019	newbuild
Pennsylvania	Great Lakes	U.S.A.	hybrid	2020	newbuild
Wisconsin	Great Lakes	U.S.A.	hybrid	2020	newbuild
Illinois	Great Lakes	U.S.A.	hybrid	2022	newbuild
Indiana	Great Lakes	U.S.A.	hybrid	2022	newbuild

* Built by Great Lakes Shipyard. Damen Stan Tug 1907-ICE design. Propulsion: main engines 2x 1.000 bhp MTU 8V-4000 Tier III diesel engines, 2x 99 kW John Deere / Marathon diesel gen sets, Logan Flexa Drive system, 2x 75 hp electric motors on Twin-Disc reduction gears. For idling, low speed travelling and light tows the electric propulsion drive train is used.. Additional cost for the hybrid package some USD 750.000. Break-even has been calculated at seven years in service.

Gisas Power III	Gisas	Turkey	all-electric	2020	newbuild

* NavTek ZEEtug 45 design. E-output 2.900 kW. Dimensions 26,20 (oa) x 10,60 (mld) x 4,32 m. Draught 4,55 m.

Sparky	Auckland Ports	New Zealand	all-electric	2022	newbuild

* First all-electric tug built by Damen Shipyards. **See article elsewhere in this issue**.

City Barge 1	Kotug City Barge	Netherlands	all-electric	2021	newbuild
City Barge 2	Kotug City Barge	Netherlands	all-electric	2022	newbuild
City Barge 3	Kotug City Barge	Netherlands	all-electric	2023	newbuild

* Operated by Kotug, manager Circle Line Logistics. See article elsewhere in this issue. Dimensions: 5,7 (oa) x 2,38 m. Draught 0,5 m max. Air draught 0,9 m. Propulsion by two Torqeedo 10 kW electric pods. Power comes from two battery banks each 21 kWh fitted in interchangeable containers. Hull made of Polyethyleen.

Design stage	Petrocity	Brazil	hybrid	20xx	newbuild

* Wärtsilä signed a MOU to develop an environmentally friendly shiphandling tug based on their HYTug concept which incorporates hybrid propulsion and battery bank options.

Elektra	BeHaLa	Germany	hydrogen	2022	newbuild

* Pushboat

Spartan	Seabulk Towing	U.S.A.	hybrid	2022	newbuild
Titan	Seabulk Towing	U.S.A.	hybrid	2022	newbuild

* Built by Master Boatbuilders. Design Robert Allan RApport 3000. 82,3 tons bollard pull. Propulsion: main engines 2x 2.550 bhp Caterpillar 3512; 2x 565 kW Cat C18 gen sets, 1x 200 kW Cat C7.1 gen set' 2x 560 kW ABB electric motors aft of Berg azimuthing thruster. Total installed horsepower, including the electric motors, is over 6,600 bhp. *Spartan* is Seabulk's first hybrid tug. Prepared for future addition of battery banks.

Chicago	Hamburg Port	Germany	hybrid	2022	newbuild

* Workboat / plough dredger. Built by Hitzler Werft, Lauenburg. Dimensions 25,00 (oa) x 8,43 m. Daught max. 2,60 m. Air draught 5,50 m. 15,3 tbp. Main engines 2x Caterpillar C18 total output 1.000 kW (1.360 bhp). Electric drive: 2x Buchele e-motor total 120 kW. The diesels are fuelled with synthetic GTL. After-treatment of exhaust gasses by DPF and SCR.

Haisea Wamis	Haisea Marine	Canada	all-electric	2023	newbuild
Haisea Wee'git	Haisea Marine	Canada	all-electric	2023	newbuild
Haisea Brave	Haisea Marine	Canada	all-electric	2023	newbuild

* Built by Sanmar Tuzla. Robert Allan ElectRA 2800-SX design. 6.000 kWh battery storage. 70 tbp. Dimensions: 28,40 x 13,00 mld x 5,60 m. Operating at Kitimat and recharging via shore connection (hydro-electric power – therefore effectively zero emissions).

Haisea Kermode	Haisea Marine	Canada	LNG dual fuel	2023	newbuild
Haisea Warrior	Haisea Marien	Canada	LNG dual fuel	2023	newbuild

* Built by Sanmar Altinova. Robert Allan RAstar 4000-DF design. 100 tbp.

Name	operator	flag	type	built	retro-fit
Saam Volta	SAAM Towage	Canada	all-electric	2023	newbuild
Chief Dan George	SAAM Towage	Canada	all-electric	2023	newbuild
* Built by Sanmar Shipyards. Robert Allan ElectRA 2300-SX design. 2x Caterpillar C-32 gen sets 840 kW each; 55 minutes charging capacity. 3.800 kWh battery storage total in two separate battery rooms by NCM (Nickel Cobalt Magnesium) battery cells. Battery management systems designed by Corvus Energy. 70 tbp. Dimensions: 23 x 12,00 mld. Fitted with 2x Schottel SRP-460-LE azimuthing drives powered by 2.100 kW PM motors. Operating at the Port of Vancouver.					
E-Pusher 1	Kotug	Netherlands	all-electric	2023	newbuild
* Operated by Kotug on long term charter to Cargill, Zaandam, The Netherlands. **See article elsewhere in this issue.**					
Hydrogen One	Maritime Partners	U.S.A.	hydrogen	2023	newbuild
* inland waters push boat for operation on the Mississippi. Designed by Elliot Bay Design Group. Propulsion power 2.700 hp of which 1.700 hp by fuel cell and 1.000 hp by batteries. The hybrid comes from the use of two types of fuel producing electricity. Methanol fuel is processed on board into hydrogen via e1's reformer methanol-to-hydrogen fuel cell. ABB electrical power distribution system. IMO 2030 compliant and meets all US Coastguard Subchapter M regulations. Expected PM is 0%, CO2 emissions less than 80% compared to conventional electrical power via fossil fuel.					
BB Electra	Bukser Berging	Norway	all-electric	2023	newbuild
* Robert Allan ElectRA design					
under construction	Sanmar	Turkey	all-electric	2023	newbuild
* Robert Allan ElectRA design					
Hydrotug 1	Port of Antwerp	Belgium	hydrogen df	2024	newbuild
* Hydrogen fuelled. 65 tbp tractor tug. Main engines 2x BeHydro 12-DZD-H2, 4.000 kW medium speed dual fuel diesel / hydrogen, total output 5.500 bhp. Fitted with DPM (diesel particulate matter) filer and SCR Selective Catalytic Reduction. Hydrogen storage on deck 54 cylinders pressurised at 350 bar. Total 400 kg hydrogen. Vessel not yet operational, installation work being finalised. Project run by CMB Tech and BeHydro. End user will be Port of Antwerp.					
under construction	Qinhuangdao Port Co.	China	hybrid	202x	newbuild
* Launched 15-6-2023. Output 2x 1.618 kW.					
NH3 Kraken	Amogy Inc.	USA	ammonia	1957	2023
* Field test vessel transformed from conventional fuelled tug to ammonia-powered zero-emission tug. Vessel not intended for commercial towing. Reconstruction: Feeney Shipyard, New York.					
Leon-H	TB Waterwerk	Netherlands	hybrid	2023	newbuild
* Built by Werft, Urk, The Netherlands. Design: Werft Hybrid Cat 2411e. Delivery expected for Q4 2023.					
e-Wolf	Crowley	U.S.A.	all-electric	2023	newbuild
* Built by Master Boatbuilders, Coden, USA. Design: Crowly Engineering Services (Jensen Maritime Consultants). Estimated bollard pull 70 short-tons. Main propulsion battery 6,2 MWh supplying two Schottel azimuthing thrusters SRP-430-LE (2.050 kW motor each) with propeller diameter 2,5 m. For long transits and emergency use 2x 300 kW gen sets were fitted. Battery capacity calculated for two ship assists in the port of San Diego. Estimated greenhouse gas emissions annually NOx 17,8 tons, diesel PM 0,25 tons and CO2 310 tonnes.					
Under construction	Port of Antwerp	Belgium	all-electric	20xx	newbuild
* Damen RSD tug.					
Kotug ordered 1	Kotug	Canada	dual-fuel	202x	newbuild
Kotug ordered 2	Kotug	Canada	dual-fuel	202x	newbuild
* Methanol dual-fuel. Builder Sanmar Shipyards.					
Methatug	Port of Antwerp	Belgium	alt.fuel	20xx	newbuild
* Methanol fuelled					
designed	Damen	Netherlands	C-LNG	2018	shelved
* A project jointly by Damen and Svitzer to develop a compressed-LNG driven shiphandling tug. Design was completed but otherwise shelved.					
design phase	Harland & Wolff	U.K.	hybrid	20xx	newbuild
* Planned are zero-emissions harbour / coastal tugs 25,5 x 12 m and a bollard pull of 50 tonnes. The azimuthing stern drives will be energized by modular battery banks. As back-up power biofuel driven generators will be fitted to cover for periods that shore-power is not available for charging the batteries. Project aims at moving loads along the UK Marine Coastal Highway using barges and tugs. Proven battery and propulsion technology will be used in the designs.					
Damen e-Multicat			all-electric	2023	design
* Design presented at the Southampton Workboat Show in 2023. **See article elsewhere in this issue.**					
design phase	Svitzer	Sweden	methanol DF	2025	newbuild
* Shiphandling tug with methanol-hybrid fuel cell propulsion. To be operated in the port of Gothenburg where methanol is the low-carbon alternative fuel of choice.					
HB Poraque	Hidrovias	Brazil	hybrid	2023	newbuild
HB Enguia	Hidrovias	Brazil	hybrid	2023	newbuild
* Hybrid push boats built by Belov Engenharia Shipyard, Salvador, Brazil. RApide 2000-E design. 20,4 (0a) x 10,00 (mld) m. Operating draught 2,40 m. Schottel SRP-210-L-FP thrusters. 500 kW battery bank.					

GISAS POWER is the first of a series of all-electric tugs desig

The two SAAM-ordered electric tugs are about to be delivere built by Sanmar. Battery power is 3.616 kW delivering 70 to DYNAMO

LEON H is a shallow-draught multi-purpose workboat cu Netherlands

New Green

by TDI Tugboat Publications

gned by Navtek operating at Tuzla
photo: courtesy Corvus Energy

ed to the owners in Canada. The ElectRA 2300SX tugs were nnes of bollard pull. Seen here under the temporary name
photo: courtesy Sanmar Shipyards

urrently under construction at Werft Shipyard, Urk, The
artwork: Werft Shipyard

Fairplay on Hydrogen
It has just been announced that Fairplay and Mabanaft have signed a Memorandum of Understanding (MOU) regarding the use of hydrogen as the fuel for its Hamburg-based tugs.
The MoU between Mabanaft and Fairplay Towage marks the start of a long-term strategic cooperation. The agreement stipulates that Mabanaft will cover Fairplay Towage's hydrogen needs in the port of Hamburg, ensuring quality, reliability and the highest level of safety.

According to previous information, Fairplay plans to put the first of up to six tugs with "dual fuel" engines into service from 2025. The tugs can operate either with conventional fuel, with biodiesel or with hydrogen.

E-pusher for Hidrovias
Belov Engenharia Shipyard, Salvador, Brazil, recently delivered the first Robert Allan Ltd. designed **RApide 2000-E-pushboat.** *HB Poraque* is the first of two innovative battery / diesel electric vessels for Hidrovias do Brasil S.A., a leading South American logistics operator. *HB Poraque* is the world's first battery-electric shallow draft pushboat. The second vessel - *HB Enguia* - was delivered in May 2023. The vessels will provide terminal assistance in the Amazon River system and can perform their core operations purely on battery power.

"Sakigake" changes fuel
This Japanese tug currently runs on LNG but will be converted from LNG to Ammonia. NYK and IHI Power Systems. This is part of the Green Innovation Fund Project. Ammonia combustion does not produce CO2 and by using CO2-free hydrogen as raw material for ammonia will result in zero emissions across the fuel life cycle.

Ulsan Port Authority
(UPA) plans to replace its old tugs with liquefied natural gas- (LNG)- fuelled tugs. The South Korean government has recently unveiled incentives to assist in the development of LNG bunkering, including the construction of LNG-fuelled ships. UPA said that tugs have been highlighted as a major source of air pollution and particulate matter due to high emissions resulting from engine output.

Amogy
has purchased a second-hand tug and is converting it into a test bed for their . ammonia-to-power technology which feeds liquid ammonia through its on-board cracking modules integrated into a hybrid fuel cell system, which powers the electric motors for zero-carbon shipping.

HB PORAQUE is a recently delivered hybrid push boat designed by Robert Allan Ltd for Hidrovias do Brasil. The boat will work on the Amazone River
photo: Belov Engenharia Shipyard via Robert Allan Ltd

continued from page 198

alternative fuels with less of an ecological footprint than HFO (Heavy Fuel Oil) and MGO (Marine Gas Oil). Identified alternatives are Methanol, Liquified Natural Gas (LNG), Compressed Natural Gas (CNG), Ammonia and even biodiesel.

All alternative fuels do have their own pro's and con's either availability, toxicity, low energy density requiring larger bunkers, etc. **Biodiesel** comes in various forms bu may not be available in required quantities or when production is outrun by demand. However, NOx emission – depending on the mix of biomass – may be such that after-treatment may add to the overall propulsion costs.

Nevertheless, **Svitzer** in 2021 decided that its 10-tug U.K.-based fleet will be adapted for the use of biofuel / -diesel, in this case HVO – Hydrotreated Vegetable Oil. These fuels use waste material and reduce carbon emissions on a well-to-wake basis by 90% compared with marine diesel.

Methanol can be readily produced. A disadvantage is the greater toxicity and flammability compared to diesel. Pressurised tanks are not required but for comparable diesel the storage volume needed is twice larger. SOx is zero, PM is low but NOx is not compliant with IMO Tier III.

Ammonia is currently considered as a promising alternative fuel. There are, however, some problems to overcome. Apart from that it stinks and that a 0,5% saturation of air will kill you it has a very slow flame propagation making sustaining combustion once it gets started more difficult than with other fuels. It therefore will need a pilot fuel like marine gas oil. Blue produced ammonia produces about 85% less CO2. Only green production makes ammonia a zero-carbon fuel. Even then burning ammonia fuel produces NOx and very aggressive Nitrous oxide emissions. **MAN Energy Solutions** along with a string of partners are currently developing a suitable engine.

FAIRPLAY IX seen here on 27-04-2015 is fitted with Schottel azimuthing thrusters with hybrid gearbox *photo: Hans Hoffmann*

Compressed Natural Gas (CNG) is basically LNG pressured to 215 bar which allows it to be stored more easily addressing the problem of the required tank space. Damen Shipyards was pioneering the use, jointly with Svitzer and MTU Friedrichshafen. The project resulted in a complete design for such a tug but was then shelved.

Hydrogen

Offshore Ship Designers have worked with Iskes Towage on the design of a green, hydrogen fuel-cell driven tug. This eventually did not materialise because the fuel-cell technology apparently was not advanced enough. Hydrogen tanks (pressurized to 430 bar) stored the hydrogen. Inthis set-up SOx, NOx and PM was to be reduced to almost zero with CO2 reduced by 70% compared to a conventional diesel-driven tug.

Hydrogen is the basic fuel, but fuel cells also require oxygen. One great appeal of fuel cells is that they generate electricity with very little pollution– much of the hydrogen and oxygen used in generating electricity ultimately combine to form a harmless byproduct, namely water.

LNG

has to be cooled to -162° C and it must be re-gassified prior to feeding an engine. LNG as such is booming and is expected to become an important fuel for ships. LNG-only gas burning engines may have reductions of up to 90% in NOx and up to 20% in CO2 over conventional diesel engines. The main problem is the on-board storage of the LNG taking up a lot of space,

TENDER 4, the first all-electric tug *photo: Will van Dorp*

Tomorrows tugs. Today.

Damen's compact ASD Tug 2111 represents the latest in multi-purpose harbour towage. With 50 tonnes of bollard pull it has the power to confidently handle ships of all sizes, and the combination of Damen's patented twin fin skeg and twin Azimuth thrusters ensures excellent manoeuvrability. The double drum winch is positioned inside the deck house, allowing the single winch to operate over both the bow and stern. And as the latest in tug technology, the ASD Tug 2111 not only comes prepared for full compliance with IMO Tier-III regulations, it will also be available in a full electric version as part of an program for all Damen's compact ASD tugs.

Pictured here:
ASD Tug 2111

Find out more on **Damen.com**

DAMEN
OCEANS OF POSSIBILITIES

The Dutch Royal Navy acquired three Damen ASD-2810 hybrids. The battery packs are charged via the shore-power plant at the Naval Base, Den Helder. WADDENZEE is seen here 30-08-2017 en route Rotterdam *photo: Ruud Zegwaard*

In 2013 Turkish tugboat builder **Sanmar** delivered the world's first two **LNG-powered tugs - *Borgøy* and *Bokn*** - to Norwegian operator Bukser og Berging. In this case, LNG fuel was a tailor-made solution due to the fact that the tugs operate at a LNG terminal. Availability of a LNG bunker station on location thus was not a problem. Emission reductions are 25% CO2, 80-90% NOx, near total elimination of SOx emissions and PM.

Svitzer Europe
has invested in so-called ECO-tugs which basically are diesel-electric vessels. *Svitzer Gaia* and sister *Svitzer Geo* were introduced in 2012. In these tugs fuel consumption is reduced by up to 10% compared to traditional tugs and NOx emissions up to 80%. Built by Baltija Shipyard, the tugs have an overall length of 30,8 m., a beam of 11 m and a 65 tonnes bollard pull. Three 8-cylinder Wärtsilä 8L-20 diesels fitted with Wärtsilä Nitrogen Oxide Reducer installations drive generators to provide the tug with electrical power for propulsion, winches, hotel services, bow thruster, etc.

NYK (Nippon Yusen Kaisha) in 2015 acquired the dual-fuel tug *Sakigake* which uses LNG as the main fuel component.

Inland waters concepts
Various yards and naval architects are now putting out ideas for hybrids & greenies. In The Netherlands, **Kooiman** Shipyard already in 2015 presented a concept design for a LNG-fuelled **pushboat** for use in the liner service on the River Rhine. This project had been underway since 2012 and was also aimed at getting official clearance regarding the use of LNG as fuel on the River Rhine.

The push boat was to have four Wärtsilä main engines running on 1% diesel and 99% LNG. Bunker capacity 160 m3 LNG and 80 m3 diesel fuel. Compared to a direct-diesel vessel CO2 emission would be reduced by nearly 20%, NOx by 60%, SOx by 95% and PM by 80%. A dual-fuel / hybrid solution would reduce NOx to almost zero. Up to now, no such vessel has been built because of regulations although the search for alternatives is ongoing.

Hybride propulsion, however, is seen in increasing numbers on inland waters. The development of swappable containerised battery banks no doubt may bring more inland waters vessels to the hybrid design**. Kotug** meanwhile has developed and built an **all-electric pusher** (see elsewhere in this issue).

Robert Allan Naval Architects have developed a design for a LNG-only tug, typified as the RAngler. The tug was developed more or less around the LNG tank. As an aside, the design could also alter the traditional tugboat-look as they did away with the aft towing deck. An ever increasing number of stern drive tugs are towing over the bow only. The Robert Allan design thus puts the superstructure at one end of the tug maximizing space for the LNG tank and omitting the aft towing deck..

Dutch Royal Navy
In 2016 the Dutch Royal Navy received no less than three of **the Damen ASD 2810-hybrids**. In their case there is a special attraction with shore power, since the Navy operates its own power plant in the base port of Den Helder – where the tugs are stationed. No doubt the tariff for their shore power is extremely competitive!.

"Telstar"
This tug for Iskes Towage, IJmuiden, The Netherlands, was ordered from Holland Shipyard after Iskes had had *Eddy 1* on charter to evaluate the design. Iskes needed a shorter hull as their tugs handle ships through the IJmuiden locks so it was important to have some manoeuvring space. *Telstar* was delivered in 2016.
Two Veth VZ-1800 azimuthing propellers

SPARTAN is one of two hybrid shiphandling tugs delivered to Seabulk Towing
photo: coll. Job van Eijk

with a diameter of 2.600 mm running in nozzles are fitted in-line fore and aft. Main engines are two Mitsubishi S-16R2-T2MPTAW main engines delivering 3.770 kW at 1.500 rpm supplied by Koedood Diesel. Two Scania CV-AB-DI-16090-M gen sets each deliver a total electrical output of 900 kW. The hybrid propulsion control allows for electric only, diesel-direct and diesel-electric operation. The hybrid system was designed and installed by Rotterdam-based **Holland Ship Electric.** Telstar's operational profile fits it's operational are (IJmuiden – Amsterdam range) almost carbon-copy, allowing the tug to operate for most of the jobs on electric alone.

In 2019 ***Svitzer*** *acquired* ***Port Towage Amsterdam****, a 2014-established Iskes – Svitzer Joint-Venture. It also purchased the Iskes tugs that were operating in the JV, including* ***Telstar.***

The Green Gearbox

Another way of reducing the ecological footprint of a tug is by mechanical means. The use of a hybrid gearbox (as opposed to a gearbox integrated in a hybrid propulsion line) can be an alternative. **Kumera**'s KN 2E4D6C-2500 has two separate power intakes which can either run separately or parallel. The gearbox has also three PTO's to serve generator, hydraulic pump and fifi pump. With a width of 3,50 meter and a height of 1,60 meter the unit weighs in at 10 tonnes. In the design several operational modes have been considered.

The Bukser og Berging A/S tug ***BB Power*** was built in 2015. The 130 tbp multi-purpose anchorhandling tug measures 1.155 GT. The tug is fitted with four main engines:, 2 two shaft generators, three auxiliary engines and propulsion is by two Schottel azimuthing thrusters fitted with c/p props in nozzles. Two bow thrusters in addition to two stern thrusters allow DP operations. The main engines are of a father / son configuration. Each set of main engines is coupled to a two-step Kumera hybrid gearbox. With the smaller engines clutched-in and through the two-step gear it is possible to run at 20-25% of engine power at close to optimal burning rate of the engines.

The tug owner estimated the fuel consumption at 30% transit load with the two-step / split gear to be nearly 2 litre / nm less when compared to the same engine set-up with a 1-step gear. Compared to the same type of vessel with just two main engines and a 1-step gear the savings are estimated at nearly 15 litre / nm. Obviously the monetary savings go beyond this due to larger intervals between maintenance of the main engines, a slower degrading of the engine due to cleaner cylinders because of the more optimal running of the main engines.

The tug has since been acquired by ***Kotug*** *and is presently operated as an in-field support tug offshore Guyana, South America renamed as* ***SD Power****.*

LNG for Singapore

BosKalis in 2016 announced the order for two 65 tbp LNG-dual-fuel tugs. These tugs were built by Keppel Singmarine. The tugs were to be operated in Singaporean waters by respectively **Keppel-Smit** and Maju. LNG is carried in type-C ISO-certified container-tanks located on the main deck. Refuelling is done by either shore-to-ship from a road tanker or by swapping the tanks. The Maritime and Port Authority of Singapore (MPA) co-funded up to SGD 2 million per tug. The first tug - *KST Liberty* – was named on 25 April, 2018. This design won the **Outstanding Maritime R&D and Technology Award** at the 2015 Singapore International Maritime Awards.

Caterpillar AVD Drive

The AVD system claims to provide significant improvements in both fuel efficiency and vessel performance through a fully integrated hydro-mechanical propulsion system. The AVD incorporates a planetary gear set allowing seamless clutch engagement of main engines, auxiliary engines, or both to provide a scalable power installation to meet any customer need in terms of maximum vessel speed, power, or bollard pull. This also allows propeller speed independent of engine speed so optimal engine efficiency can be achieved leading to fuel savings of 15 – 20%. Caterpillar states the AVD delivers all the benefits of a variable speed diesel-electric propulsion system at a fraction of the cost and size. The AVD system is also flexible and designed to accommodate multiple configurations. Auxiliary engines can be utilized to accommodate low load or transit operations greatly extending time to overhaul and reducing service costs on main engines. Electric motors can be used instead of hydraulics if required. Diesel engines can be substituted by natural gas engines as the AVD system provides regardless of engine load acceptance. Main engines can also be downsized with supplemental power provided via auxiliary engines or generators if electric motors are used. A prototype tug has been built by Sanmar: ***Bogacay XXXVIII***.

ISA - ex Sil-Jeske B - is a hybrid tug working for dredging and engineering projects

photo: Nico Giltay

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Hybrid for Hamburg

Since 2017 the Hamburg Port Authority has grouped its fleet of workboats under one operator: Flotte Hamburg, with some 50 vessels. A newbuild was added in 2022.

by TDI Tugboat Publications

The idea behind Flotte Hamburg is that by having the fleet under a single operator better use can be made of the quality of the vessels. Also, fleet renewal will bring new multi-purpose vessels to the table and not unimportant – the eco footprint can be reduced.

CHICAGO seen here during hand-over is a multi-purpose hybrid workboat for the Hamburg Port Authority
photo: HPA / Andreas Schmidt-Wiethoff

One of the new acquisitions is a hybrid workboat - *Chicago* – delivered by the Hitzler Werft. The day-to-day task of the vessel is seabed / riverbed levelling, also known as plough dredging. It is the second such vessel in the HPA fleet, the other one is the 17 x 4,58 m levelling vessel *Otto Stockhausen* built more than 60 years ago.

Under the new set-up, however, *Chicago* will also tackle other jobs. This is reflected in the design. Apart from that the vessel is extremely eco-friendly. Designed service life is 25 years. It has a crew of two and will operate coastal, estuary and inland waterways. HPA will also use the vessel for maintenance work, water depth assessment and towage and materials transport on the Elbe North Sea estuary and river and in the port of Hamburg.

CHICAGO seen with plough hanging over the stern
photo: HPA / Andreas Schmidt-Wiethoff via Lehmann Marine

Dimensions are 25,00 (oa) x 8,43 (oa)m, with a draught of 2,60 m maximum. Air draught is 5,50 m. The vessel is Bureau Veritas ice class 1D classed. Main engines are two Caterpillar C-18 with an output each of 500 kW (total output 1.360 bhp) at 2.100 rpm. A Lehman Marine 423 kWh battery bank has been fitted. Electric power provided by 2x Buchele e-motors, output 60 kW each (total 120 kW / 163 bhp) at 2.130 rpm which HPA specifies as providing a reach of two hours sailing at 6 knots. One Caterpillar C4.4 ACERT gen set (99 kW / 134 bhp) at 1.500 rpm.

For its main job the vessel is equipped with a 9,7 m wide silt plough weighing 3,7 tonnes. Bollard pull 150 kN (15,2 tonnes). For secondary duties *Chicago* is fitted with a moonpool with a diameter of1,20 m, Teledyne T20 sonar, a 500 l/min fifi monitor and two 300 kg swl swivelling frames. 2x 10-feet or a single 20-feet container can be carried on board. Apart from hybrid sailing other measures reducing emissions are the use of GTL fuel and after-treatment of exhaust gasses by means of DPF and SCR.

The Kotug E-pusher

The Kotug E-pusher is a radical change-of-concept as far as vessel design is concerned. It also addresses the challenges of energy transition in a unique way.

by Job van Eijk

It all began many years ago at the time when Bas van Hoorn and his brother were frequently abusing the small dinghy carried on board their parents' tug *Riny*, a 27-metre 800 hp vessel built in 1959. As an aside: they regularly worked with *Riny* on charter to the then Sleepdienst (Towage Company) Adriaan Kooren. His parents purchased the tug in 1976 from Bas' grandfather. The dinghy referred to was made of PolyEthyleen, a sort of plastic, and indestructible.

Fast forward to 2018. Bas van Hoorn meanwhile sailed as Master on the Kotug tugs in the port of Rotterdam. It was the year in which inland waters shipping in Europe faced long periods drought resulting in low water levels in the European water systems. Fully laden ships were no longer a possibility – half-loads or less became the norm. Bas was convinced the drought had to with climate change caused by, amongst others, the greenhouse gasses produced by today's shipping.

From this evolved thinking about the energy transition for inland shipping and the necessity in general to achieve CO2 reduction. In addition to this Dutch cities increasingly began to put restrictions on fossil-fuel using cars, transport, construction, etc. The result being that the idea was borne for emission-free shallow-draught push boats.

The design parameters that resulted were:
- Light weight for low draft
- 100% recyclable
- Easily scalable
- Zero-emission
- Accommodating variety energy sources

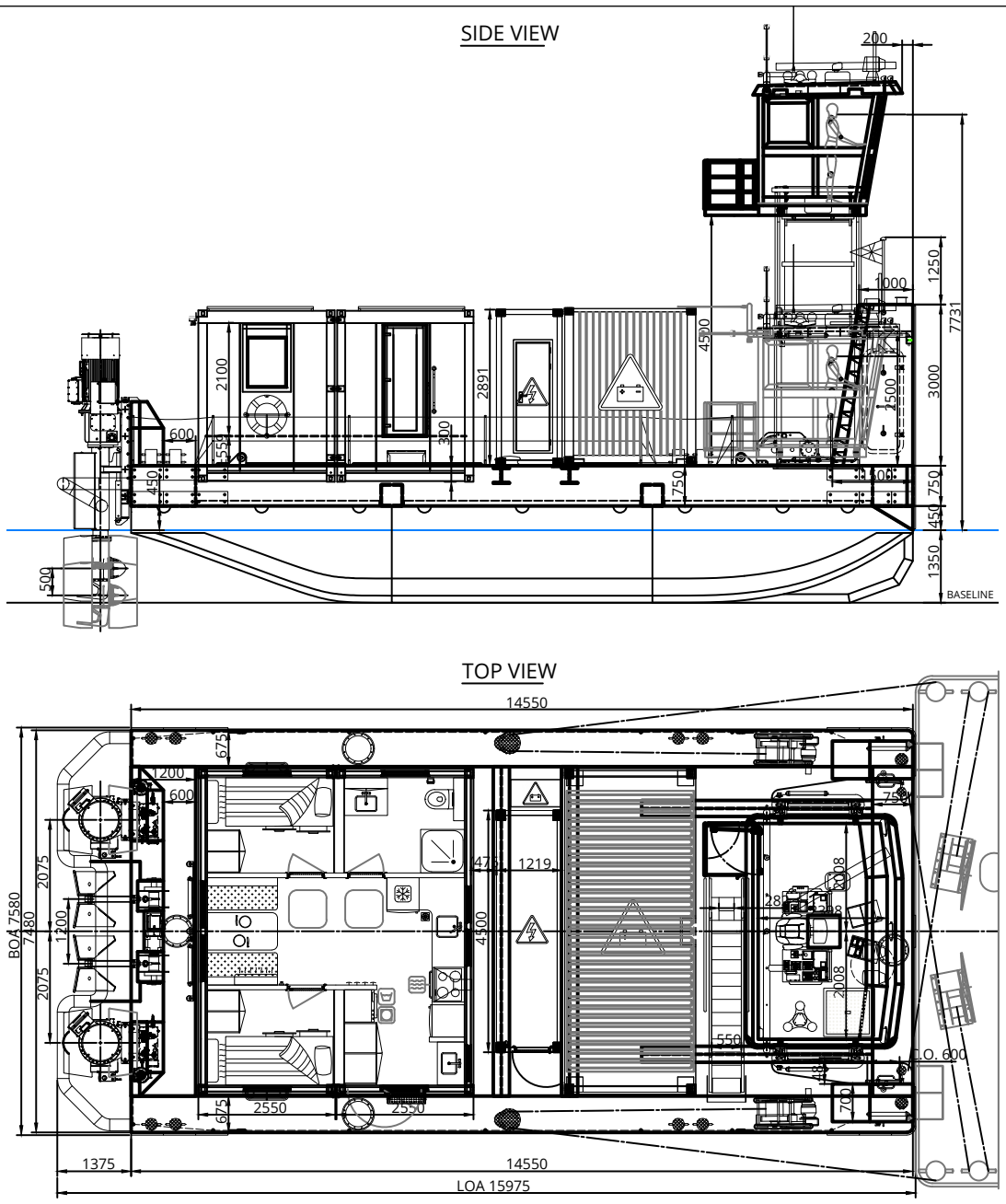
As maximum draught for the push boat 1,35 cm was chosen, this being the minimum water depth ever measured on the River Rhine. Instead of a steel hull the idea was to use PolyEthyleen not as a hull but for a floating device in order to reduce draught. This based om the durability and relatively light weight of the material. All that was otherwise needed for a push boat had to be stacked on top of the floatation device, preferably in a modular format.

In order to make the design attractive to potential users the size of the pusher had to be scalable, likewise emissions had to be reduced as much as possible. Regulations, however, were likely to change – sometimes several times - over the period of energy transition. Electricity seemed a safe bet for now. To further reduce the costs speed of production had to be reduced. This called for standardisation of components.

Bas pitched his idea to Kotug's Ard-Jan Kooren. Kotug has always been innovative and at the fore front of combatting ecological impact – the first ever European hybrid and the first-ever European newbuild hybrids, the re-use of on-board waste heat, the Rotor Tug design, etc. So this idea fitted exactly with their philosophy. Furthermore, it could mean a return to the roots of Kotug, inland waters towage which was where Ard-Jan's great-grandfather started the towing business as captain / owner of a steam tug. As it was Kotug adopted the idea and put the Kotug organisation at work refining the idea.

It all started with the tug RINY's dinghy *photo: coll. Job van Eijk*

Kotug CITY BARGE ONE demonstrating garbage collection advantages with Renewi
photo: coll. Job van Eijk



General Arrangement Kotug E-PUSHER M-type *drawing: Kotug*

Kotug CITY BARGE ONE ashore showing propulsion pods *photo: Kotug / Bas van Hoorn*

(A part of the history of the Kooren's and other Rotterdam-based operators can be found in an earlier article about the development of Rotterdam-based towing in TugeZine 10. A much more in-depth article appeared in Lekko International 224 'Rotterdam Towage through Times' in 2017. A full history of Kooren was published in Tugs, 3000 hp and over – edition 1990 'Son, you haven't got what it takes')

As luck would have it around the same time a start-up company began searching for ways to boost the ability of water transport in confined areas like cities. The basic idea being to remove as much conventional fossil-fuelled heavy traffic from densely populated areas as possible – waste collection being the initial thought. The resulting product was in fact a concept: **Citybarge**. This foresaw low draft emission-free highly manoeuvrable barges – even unmanned and remote controlled or self-navigating – operating along set routes, much like public transport. This would remove many truckloads from the road in addition to – where relevant – protect the often dated inner city quay walls from concentrations of weighty 10 or more tonnes of trucks. That was the idea.

It was at this stage that Bas van Hoorn and Kotug's Manager Fleet Performance & Innovation Koos Smoor got involved. Kotug saw an ideal opportunity to test the principles of the E-Pusher they were developing. So they invested in the design and ultimately – without any subsidies - built the Kotug *Citybarge One*, a 5,70 (overall) x 2,38 m electric push boat consisting of a PE-hull, the all-important deck-frame, interchangeable battery packs and fitted with two azimuthing thrusters – Torqeedo azipods. Draught is 0,50 m.

Kotug CITY BARGE TWO *photo: Kotug / Bas van Hoorn*

Since that first one two further units have followed, Kotug *Citybarge Two* and Kotug *Citybarge Three.* There are slight differences with the first one. While the 'hulls' are PE in every case the first one has a steel frame and the 'hull' is empty. PE is not very dimensionally stable so in no. 2 and 3 the frame is aluminium and the PE foam-filled to provide stiffening and as a bonus making the boat virtually unsinkable.

The **Kotug CityBarge** is marketed by Circle Line Logistics, based at The Hague. The company offers a logistics model consisting of circular routes between transshipments points where cargo is loaded or discharged from / to road or other means of transport for onward delivery. Or liner services in support of industrial processes. For this purpose use is made of the emission-free Kotug CityBarge push boat and wherever required cargo barges adapted for carrying specified goods (construction, parcels, food, retail, etc.).

Kotug and Circle Line Logistics jointly own KotugCityBarge Holding. This JV has nothing to do with the Kotug E-Pusher series described below.

Having proved the concept the E-Pusher was further developed. **Cargill Grain** showed an interest to set up an emission-free water transport to their cocoa factory along the Zaan river, north of Amsterdam. This resulted in a 10-year contract for an E-Pusher and four bulk barges sailing from three loading points in Amsterdam Sea Ports - to Zaandam. Monthly, some 10.000 tonnes of cocoa beans are thus moved emission-free.

The "Kotug E-Pusher 1"
For the construction of an E-Pusher there is no need for a shipyard. All that is needed is a suitable quayside to assemble the various parts.

The 'hull'
itself is assembled – in the case of E-Pusher M-type - from six High-Density Poly-Ethylene (HD-PE) 'cubes' arranged in two rows. The port and starboard cubes are identical and thus interchangeable. The cubes themselves were constructed by **HAAK Services**, Stellendam after lines drawings provided by Padmos Shipyard and **C-Jobs**. They have two longitudinal watertight

Kotug E-PUSHER 1 with barge. Note Kooiman coupler winch position
photo: Kotug / Bas van Hoorn

Airco and connectors of the battery room
photo: Kotug / Bas van Hoorn

Wheelhouse in lowest position
photo: Kotug / Bas van Hoorn

Crew cabin *photo: Kotug / Bas van Hoorn*

bulkheads so in case of an unfortunate breach only one section floods keeping the pusher safe. All cubes are finished with rounded edges along the length of the bottom. The bow cubes are formed with a centre forefoot acting like a 'reversed' skeg and by sort of tunnelling the water underneath the hull – facilitated by the rounded bilges – help to create course stability. The aft cubes are formed so as to release the water flow to the propellers. The cubes are pressure-tested for watertightness prior to delivery. Another pre-delivery test is a vacuum test simulating pressure at 1,50 m draught, which is over the maximum draught of the E-Pusher.

Dimensions of the E-Pusher M-type are 16,00 x 7,4 m with a maximum draught of 1,35 m. Minimum air draught is 4,30 m. The wheelhouse can be raised to provide an eye height of 9,0 m. The beam is a consequence of the standard 20' container plus the minimum walking space required by law plus fixed fenders. The length of the frame was determined by the regulations for a 2-man crew which is up to 86 metres in length. With a 16-metre frame a standard 70-metre barge can be pushed.

The two push knees are the highest point of the vessel at 4,20m. The height was chosen as a protection for the boat and the containers when passing low bridges.

The frame

The most important part of the pusher is a metal frame that holds the cubes - or floaters if you like – together and serves as the basis for the modular units on top. It is engineered in such a way that the frame will re-distribute the down- and horizontal forces as well as the resistance of the water flow while holding the 'floaters' together. All cable trays are attached to the frame but are otherwise unobstructed.

Accommodation, energy sources, engine room, wheelhouse – everything is pre-fabricated for quick assembly and wherever possible in standard container units for easy transport. Attaching to the frames is by various means: pins are used for the hull, bolts for the thrusters, winches and the lift system for the wheelhouse. Accommodation containers, switchboard container and energy container are fastened with twist locks.

Kotug E-PUSHER 1 at work transporting cocoa beans emission-free from Amsterdam Port to the Cargill factory in Zaandam *photo: Kotug / Bas van Hoorn*

Strength calculations were prepared by **Padmos Shipyard**, Stellendam, which otherwise had the important job of finding the necessary subcontractors for the various pieces of equipment.

The modules used in the *Kotug E-Pusher 1* are, from forward to aft:
- Wheelhouse
- Energy container – in this case battery banks
- Switchboard container – the only more or less permanent fixture
- Two accommodation containers
- The thrusters

The wheelhouse

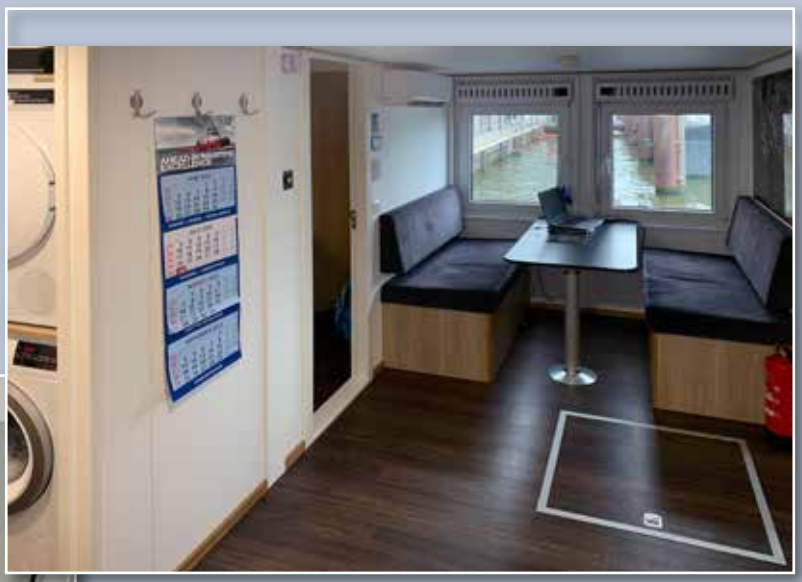
was constructed by **Kampers** Puttershoek of aluminium except for the floor. Panelling by **IJtema**. The view is all round. The wheelhouse can be hydraulically raised using two **Hydronika** Tilburg fork lift hoist mechanisms. Fully extended the helmsman's eyes are at a height of 9 metre.

Nautical equipment was supplied by **Alphatron** installed in custom-made consoles. Gebhard Electro was responsible for the interfacing with the energy container and the domestic power consumption. A wheelhouse control panel shows remaining radius in kilometres and time, battery charge status and the thruster power. This provides the Master to optimise battery status versus thruster power.

The Kotug *E-Barges 1* to *4* are fitted with a **Verhaar Omega** steering

Hull cubes awaiting assembly *photo: Kotug / Bas van Hoorn*

Accommodation: messroom annex recreation, and washing / dryer on the left *photo: Kotug / Bas van Hoorn*



Helmsman's inormation displays: left radar and camera views, right position display, Rate-of-turn indicator, echosounder, wind speed / direction indicator *photo: Kotug / Bas van Hoorn*

Energy control display *photo: Kotug / Bas van Hoorn*

E-Pusher 1 running astern *photo: Ferry van Rijsbergen*

'grid' thruster in the bow to facilitate manoeuvring. The power is supplied from a Shift battery pack. Steering can be controlled from the wheelhouse onboard the E-Pusher.

Controls for the Hydromaster propulsion units can be set for various modes: both units via a single control or each independently controlled. When both thrusters use the single control this may be linked with the River Pilot.

Savings: apart from zero-emissions there is also a significant financial gain. Prior to delivery of the E-Pusher the same work was done by a conventional diesel-driven tug. Comparing the round-trip Amsterdam – Zaandam and based on pricing on the same day the E-Pusher was 2,2:1 cheaper than the diesel tug. By making clever use of night tariff for public shore power the savings can be even greater.

Deck gear
The two barge coupling winches are from **Shipyard Kooijman**. They are of the hydraulic type since hydraulics were already available for the wheelhouse hoists. SK-78 42 mm **Dyneema** is used in these couplers as the connecting line. The winches can be controlled from the wheelhouse.

The hull frame about to be lowered on the hull cubes. Propeller pods already bolted on
photo: Kotug / Bas van Hoorn

Energy container
In this case the energy container has been fitted with battery banks. In total 13 units each consisting of 14 cells were installed in two separate strings for safety reasons and also because the ESTRIN (European Standard Technical Requirements Inland Navigation) regulations stipulates port and starboard propulsion has to be a completely separate drive train. Also installed in this container is the charging infrastructure, the DC/AC conversion and the cooling system (air cooled). Again these systems are doubled creating redundancy.

Hull and frame mated, wheelhouse installed *photo: Kotug / Bas van Hoorn*

The batteries can be charged from every type of shore power location either 32, 63 or 125 Amp. Standard CE plugs are fitted on the power lines. The container - weighing around 26 tonnes – was developed by **EST Floattech**. The Octopus High Energy modules provide 1.820 kWh of energy for the fully electric propulsion system. The customized system installed in the container is marine certified. The two separated DC-outputs feed the propulsion system and two grid converters power the

Part assembled hull alongside at Padmos. Switchboard container already on board
photo: Ruud Zegwaard

onboard AC grid and charges the battery system overnight. Further the container contains HVAC, sensors, and a fire suppression system for safe operation. The container is connected to the Octopus remote monitoring platform which allows us to monitor the battery performance from a distance and perform diagnose and software upgrades when required. The battery cells are Li-Ion NMCs. The safety system in the cell-stacks consists of a solution that prevents cell-to-cell propagation. This means that if one of the cells in the stack overheats, the other cells will not be damaged by the temperature rise. Which also limits the amount of damage in a battery module and outside. Another advantage of the heating being limited to only one cell is that other modules also don't get overheated and thus remain undamaged. Besides that, the entire system has a robust off-gas system, which ensures that in the unlikely case of a thermal runaway the gases are safely routed outside the battery room.

In case of need energy containers can be swapped or a different type of containerised energy put on board. Think of Stage V diesel generators and of energy carriers like LNG / CNG / Bio gas, Hydrogen, Methanol, Ethanol or Ammonia. In all cases what comes out of the energy container is electricity. These energy containers are self-supporting with for instance the diesel gen sets and fuel tank integrated in the container. Other types of fuel carriers require other power generating equipment but in all cases it's a matter of 'plug-and-play'.

The switchboard container
This is the smallest of the containers and the sole more or less permanent part of the pusher. It contains the frequency drives for the propulsion and anchor winch, as well as the hydraulic unit serving the wheelhouse lift and the barge coupling winches. The entire electrical system was designed and built by **Gebhard Electro**.

Accommodation Containers
The two high-cube accommodation containers were widened from 2,44 to 3,00 m. This was a requirement since the accommodation was intended for two persons. High-cube was needed as below the floor of the forward container 2x 1.000-litre water tanks and a single 1.000 litre waste water tank had to be situated. Because of this the container sits in the frame rather than on the frame as the other containers do. The forward container is the 'wet' one with the galley and the sanitary space fitted with shower, toilet and wash basin.

The crew container houses two crew single-berth cabins. The mess / recreation is situated in-between the cabins. Power is obtained by plugging into the 'wet' container. Twelve rooftop solar panels have been fitted making the accommodation self-supporting. The accommodation containers were realised by **Hanse Group** Nieuwerkerk with IJtema taking care of panelling and **WETEC** Stellendam for electric.

Propulsion
is by two electrical **Hydromaster** type 4-TM-300 azimuthing thrusters. The propellers are each driven by a 300 kW 3-phase asynchronous motor. Steering is hydraulic by a HPU each. The thrusters can be moved vertically as required. Stroke is 60 cm. Retracted the propellers

Switchboard container
photo: Kotug / Bas van Hoorn

Energy container
photo: Kotug / Bas van Hoorn

Battery bank *photo: EST Floattech*

Wheelhouse. Nearest camera control desk with port side Hydromaster controls, nav lights, VHF and barge bow thruster control

photo: Kotug / Bas van Hoorn

Galley

photo: Kotug / Bas van Hoorn

rotate above the base line and thus are protected by the hull. Fully extended the props are approximately 50 cm below the baseline rotating in undisturbed water for maximum efficiency. The thrusters are connected to the frame by 14 bolts each.

The rudder propellers allow for maximum manoeuvrability running astern aided by the low weight of the E-pusher itself – approximately 100 tonnes. Even with a barge attached there is no need for flanking rudders or a bow thruster. Depending on the load pushed and the power setting for the thrusters for a distance of 10 km approximately 140 kW is used.

Certification

The difficulty in this case is that no such ground-breaking construction has ever been put forward for inland waters certification. The boat was not constructed in a regular shipyard but assembled on a quay wall, supervised by Kotug. Nevertheless the boat has been constructed with all ESTRIN and Inland Waters Regulations incorporated. **JP Survey**, Barendrecht handled the ultimate certification process supervised by the NBKB – Nederlands Bureau Keuringen Binnenvaart (Dutch Inland Waters Certification Bureau) - resulting in approval 'Communautair (EU, CESNI, ESTRIN) +/- 5.000 m^3'.

The Kotug E-Pusher series

To date, apart from the CityBarge desig, three classes of E-Pusher have been developed: the Kotug E-Pusher S, M and L class. The three classes use the same materials, propulsion type, containerised energy, etc.

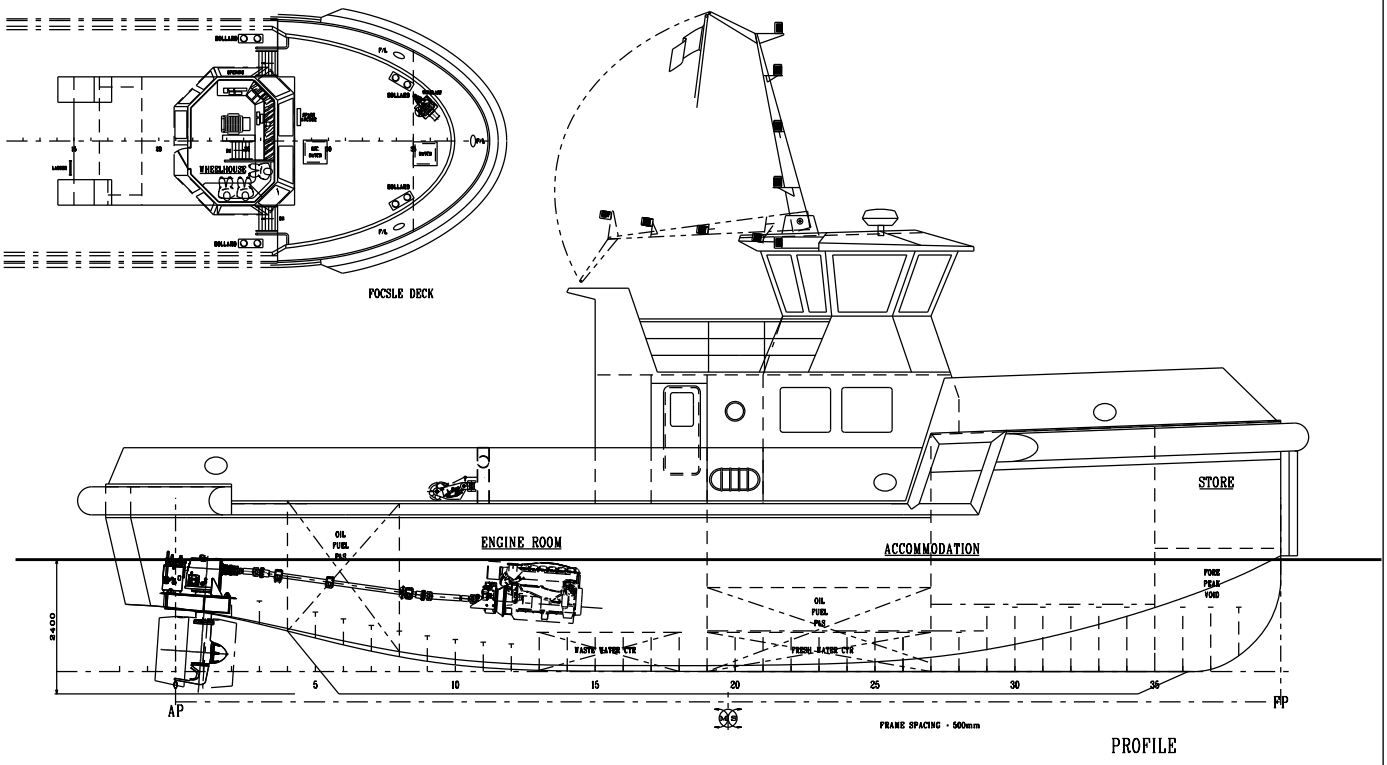
Kotug E-PUSHER 1 with full container load

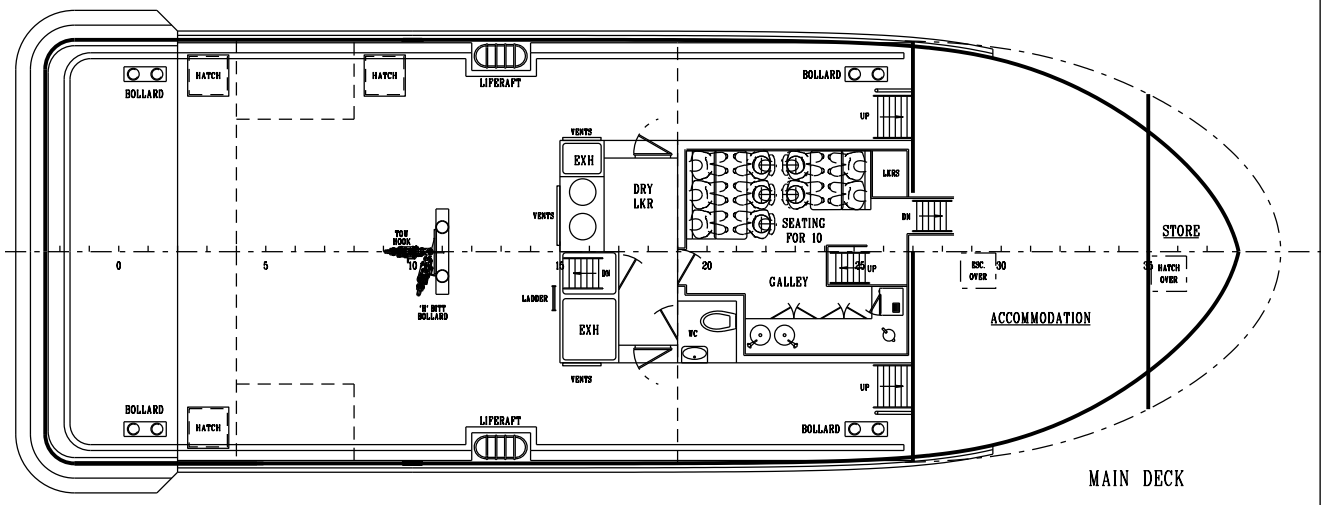
photo: Ferry van Rijsbergen

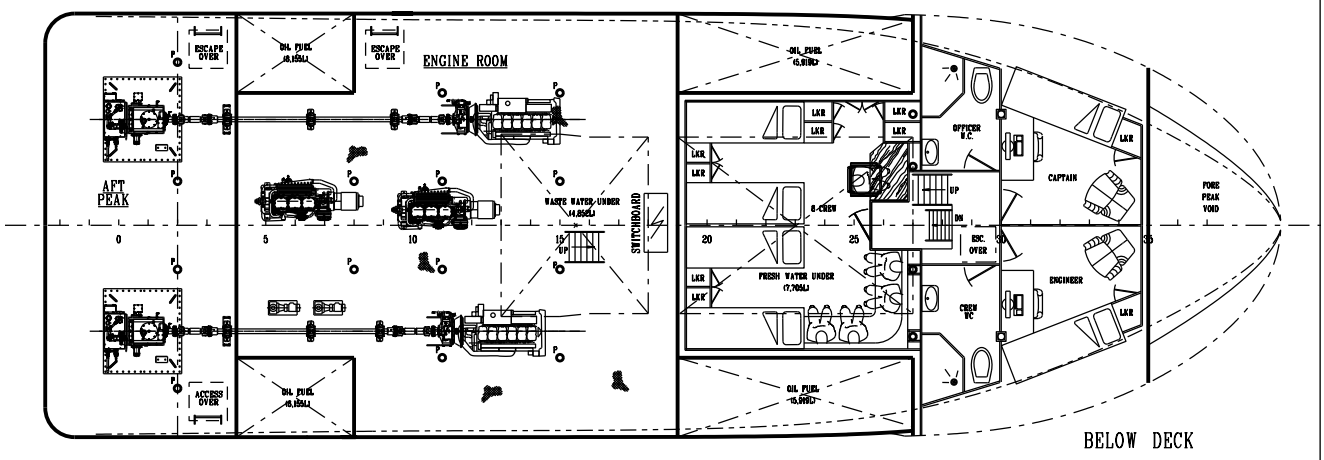
Hydromasters - one in the raised position, the other on in the lowered position, Anchors and anchor winch in between

photo: Kotug / Bas van Hoorn

Dimensions of the three types are as follows:			
	S-type	M-type	L-type
Loa:	9,1 m	16 m	21 m
Beam:	3,0 m	7,4 m	11,2 m
Draft baseline max	0,85 m	1,35 m	1,35 m
Air draft min	1,8 m	4,30 m	4,30 m
Max eye height:	1,7 m approx	9 m	11 m







General Arrangement RIVER PEARL 10 *drawing: Macduff Ship Design*

“River Pearl 10”

A recent delivery marks the entry of Macduff Ship Design in the Indian market. It is the first vessel designed for an Indian owner and built by an Indian shipyard.

by TDI Tugboat Publications

Macduff Ship Design Ltd have been active for over 30 years in the business of naval architecture and marine surveying. Based in Scotland their business over the years has developed globally with deliveries and designs as wide apart as New Zealand and South Africa. Macduff has specialised in fishing vessels, workboats, tugs and pilot vessels. Up till now Macduff has designed more than 200 vessels that are currently in operation, varying in length from 6m to 50m. Macduff’s marine surveying cover vessels in the commercial fishing, aquaculture and general workboat sectors through to the yachting and leisure industry.

River Pearl 10 is a tug / service vessel that was recently delivered to its owners, **Knowledge Marine & Engineering Works Ltd.** The company is relatively young having been started in 2015. Since the start the company evolved from a small ship-repair business to a dredging and ship owning company. Knowledge Marine has several associated / joint-venture companies mostly related to dredging and maritime port infrastructure. Other vessels in the fleet include hopper dredgers, pilot boats, mooring vessels, a backhoe dredger, a survey boat, etc.

The new addition to the fleet was constructed by **Synergy Shipbuilders**, based at Goa, India. Synergy (not to be confused with Synergy Marine Group – a large ship management company) was started in 1988 as Siddarth Engineering & Shipbuilding Pvt. Ltd. The company was established by Mr. Shriram Malik, to build and maintain the own fleet of various Inland vessels. In the year 1996 the company build its first vessel for a domestic client.

“River Pearl 10” is designed as a multirole tug / service vessel with large open working deck aft, forward foc’sle and wheelhouse. Synergy’s yard number 62 has dimensions of 21,00 (oa) / 19,75 (bp) x 7,20 (mld) x 3,00 m. Draught at baseline 2,00 m,, draught maximum 2,40 m.

The hull is dived into 5 watertight compartments. From forward to aft these are: fore peak, forecastle accommodation, crew accommodation, engine room, thruster room / aft peak. The hull is protected by rubber fendering throughout. Forward block fendering has been fitted while in the sides and aft the fendering is tubular. Forward a vertical push-pad protects the bow from below the block fendering to the water line. Frame spacing is 500 mm. The double-chine hull is fitted with a skeg running from frame 4 forward to 36.

On the **main deck** sits the superstructure. At main deck level is the galley and messroom – sitting 10 persons. Aft of the messroom is the entrance from the deck. To port this is combined with a dry locker while to starboard a toilet facility is fitted which can be reached from deck as well as from the messroom. The towing gear

RIVER PEARL 10

photo: courtesy Macduff Ship Design

consists of a H-bitt towing bollard to which is attached the tow hook.

The **forecastle deck is** equipped with an anchor windlass fitted port side.

Below forecastle deck
the **fore peak** tank is void. On top of it sits the store room. The **officer's accommodation** consists of a cabin each for the Master (to port) and the Engineer. Each cabin is fitted with a locker, desk with chair and an easy chair. Aft of these cabins are the sanitary spaces for resp. the officers (to port) and crew (starboard). Each fitted with toilet, wash basin and shower. Further aft is the **crew accommodation** with 8 berths (4x2). Seating is available for 4. The crew accommodation sits on top of the 17.700 litre fresh water tank. The crew accommodation is flanked by two fuel oil tanks each with a capacity of 5.919 litres.

The **engine room** houses the two **Cummins** KTA19-M3 main engines each delivering 500 bhp at 1.800 rpm to the thrusters. The two auxiliaries are sitting in between more or less on the centre line. The switchboard is situated at the forward end of the engine room against the bulkhead. Below the engine room on the centre line sits the 4.852-litre waste-water tank. At the aft end of the engine room , to port and starboard, are a further two fuel oil tanks, capacity each 6.155 litres.

The **thruster room / aft peak** can only be reached from the main deck. The azimuthing thrusters are **Hydromaster** series 4 type WM (well-mounted) with a power of 368 kW / 500 bhp each. Bollard pull generated is 10 tonnes.

The wheelhouse has 360-degree visibility. The helmsman sits to port although near the ship's centre line. A bench to starboard seats three.

The Indian coastline stretches for almost 7.500 kilometres. According to the Ministry of Shipping, around 95% of India's trading by volume and 70% by value is done through maritime transport. It is serviced by 12 major ports and 200 minor and intermediate ports. The total 200 non-major ports are in the following states: Maharashtra (48); Gujarat (42); Tamil Nadu (15); Karnataka (10); Kerala (17); Andhra Pradesh (12); Odisha (13); Goa (5); West Bengal (1); Daman and Diu (2); Lakshadweep (10); Pondicherry (2); and Andaman & Nicobar Islands (23). Keeping port infrastructure in India up to speed thus is a major task keeping the dredging industry busy. They, in turn, require a fleet of support vessels so we may expect more newbuildings from the Indian shipyards over the next years.

Old Green

by TDI Tugboat Publications

All-electric in 1900
Around 1900 electrical power was used to drive tugs on the Aire-Deule Canal, in Germany on the Finow Canal and in Belgium on the Charleroi Canal, between Brussels and Charleroi. In the latter case, the main driver was the transport of coal. The tugs were fitted with a trolley system much like in some cities today on public transport. The tugs could tow two 70-tons barges at a speed of 2 knots. Three-phase electric engines were powered by 600 Volt which was taken from a cable / trolley system along the river bank. The cable was led on board via a movable boom attached to the mast. Free running speed could be as much as 7 knots. The tugs could sail at a distance of up to 60 feet from the shore cable. The system was flexible enough for the tugs to turn around while on the trolley. Designer was a **Mr Leon Gerard.** As an aside, the tugs delivered coal to the generating plant that also fed the power lines for the tugs – a sort of closed loop from source to end-user.

Another type of electric towing happened at several French inland waterways. Here the tug was not a vessel but an electric tractor or a sort of locomotive running on a track along the river bank towing one or more cargo barges. The locomotives thus replaced the earlier one or two hp horse-drawn barges or men-drawn, mostly by the barge master's wife or children, another form of alternative fuel and propulsion.

Several 'green'-tugs-avant-la-lettre sailed in Belgium around 1900. They were electric-only being power-supplied through a trolley system photo taken from a 1976 Lekko-publication

For further reading on the historic electric traction on the French canals we suggest La traction mécanique sur berge en France by Gerard Bianchi, published by the French Musée de la Batellerie

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The E-Multicat

At Seawork Southampton 2023 Damen Shipyards revealed their all-electric E-Multicat design.

by TDI Tugboat Publications

Having previously put several 'greener' tugs in the market, the presentation at the Southampton Seawork show was the first time the Damen Multicat design has undergone a 'green' make-over.

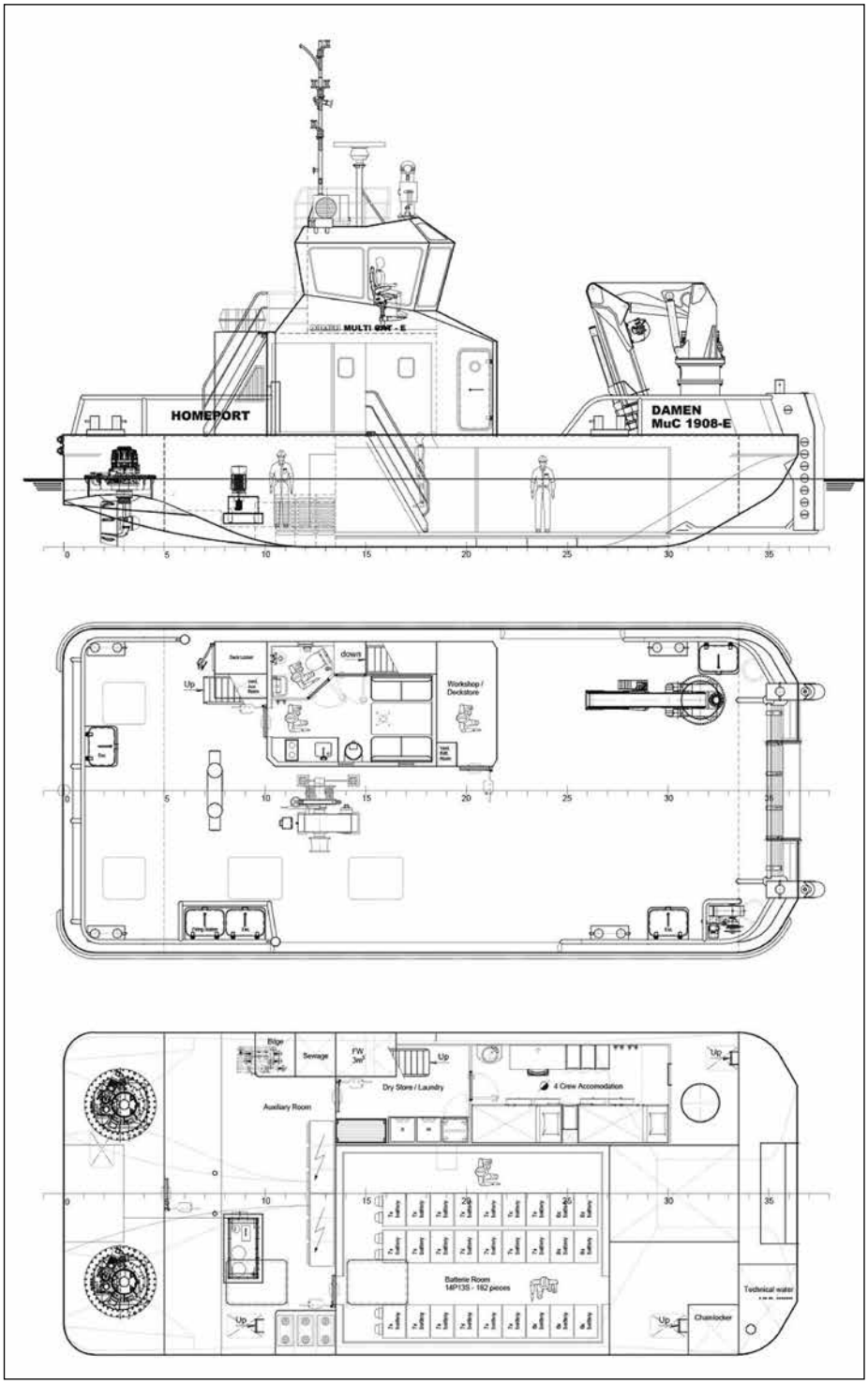
The Multi Cat 1908 Electric builds on the success of 25 years of Multi Cat construction. Combining this experience with the most modern digital and electrical technology the new design clears the way for the zero-emission workboats of the future.

Damen's Multi Cat ranges from the small 2 tbp Multi Cat 2004 to the 35 tbp Multicat 3713 with 10 more designs in between. For their introductory model Damen took the Multicat 1908 design which has been around for years.

Dimensions of the MuC 1908 are 19,05 (oa) x 8,40 / 8,00 x 2,75 m with a draught of 2,00 m. For propulsion 2x 265 kW Veth VL-200-si azimuthing thrusters will be installed. The energy required is delivered by an EST Floattech Octopus High Energy 1.820 kWh 700 V dc battery bank. Charging of the batteries comes from shore power. A shore connection for 200 kW 400 V A/C and for 63 Amp 400 V A/C.

Standard deck equipment includes a DMT electric anchor winch and a DMT anchor-handling winch. Also standard is the HS Marine 65 tm crane. An electro-hydraulic powerpack with two 30 kW / 400 V AC/DC pump units is also fitted.

Cut-away rendering showing battery racks
artwork: Damen Shipyards



General Arrangement E-MultiCat 1908 *drawing: Damen Shipyards*

Bollard pull is estimated at 7,0 tonnes, speed 7,5 knots. Endurance at 6,5 knots (12,5 km.hr) is 8 hour. While the vessel is stationary but at work this – depending on power consumption – is expected to be like some 12 hours. The vessel is classed for coastal area work.
As the vessel has limited range it is configured as a day boat. An option, however, is the addition below main deck of a heated and airconditioned 4-berth crew cabin.

Hydromaster for tugs

Hydromaster has delivered many thrusters for a variety of ships. Tugs and workboats of lately have found their way into the delivery lists.

by Job van Eijk

Rhino ferry RHF-3 assisted by Rhino tug RT-3 seen here on 5 June, 1944, approaching the Normandy beaches. This type of propellers were post-war licensed to the U.K. which evolved into Hydromaster *photo: U.S. Coastguard (Wiki Commons Public Domain)*

Steerable thruster have been available since before the Second World War. But it was the war that ultimately gave the boost for the use of them. They could be bolted onto a barge, landing craft, pontoons for river crossings. They could also be used to propel makeshift push boats. Thousands of such units saw war service in the Pacific, during the Normandy landings and throughout Europe. Post war, many were sold off by the Governments and private owners started discovering the advantages.

In the early 1950s a license was issued to the UK, from which Hydromaster was born. The original Hydromaster, valued for its robust fully mechanical design, simplicity, and durability, still works every day on hundreds of ferries, barges and pontoons worldwide. As well as maintaining the original design, Hydromaster continues to invest in innovative solutions and applying the latest insights and technologies.

Hydromaster propulsion units are in operation worldwide, propelling a wide variety of applications such as tugs, ferries, floating cranes, coastal vessels, inland river barges and specialised military craft. The customer base includes governments, armed forces, port, dock and harbour authorities, construction and industrial companies, shipyards and vessel builders. Hydromaster prefers to work closely with customers to work out the best solution for their specific application and environment. Reliability is a big thing since the drives are often working in remote places without nearby back-up or repair shops.

Some interesting deliveries have happened. For instance the delivery of a number of Hydromaster series 3 112 kW / 152 bhp to the British Ministry of Defence where they will be used to drive their Mexefloat barges. The Mexeflote is a landing raft used by the British and Australian Navy to move goods and vehicles between ship and shore. They was first used by British military in the 1960s. They were also used during the Falklands conflict and in humanitarian aid missions. The system

Hydromaster propelled British MOD Mexafloats *photo: courtesy Hydromaster*

is very similar to the 'Rhino Ferry' used in World War 2 which is basically a series of pontoons connected to each other in configurations deemed useful for the situation and location. Incidentally, there were also 'Rhino tugs' – basically one or two floats coupled with the drives bolted at the end towing the large Rhino's.

Another interesting delivery is the 26 x 8,5-metre buoy handling vessel BH 101, built by AMECC, Yangon, for the Myanmar Directorate of Water Resources. Yangon. Two Hydromaster series 4 deck-mounted units were fitted, These particular units use Yanmar diesels as the prime mover, outout 367 kW at 1.950 rpm. The propellers have a diameter of 0,9 m.

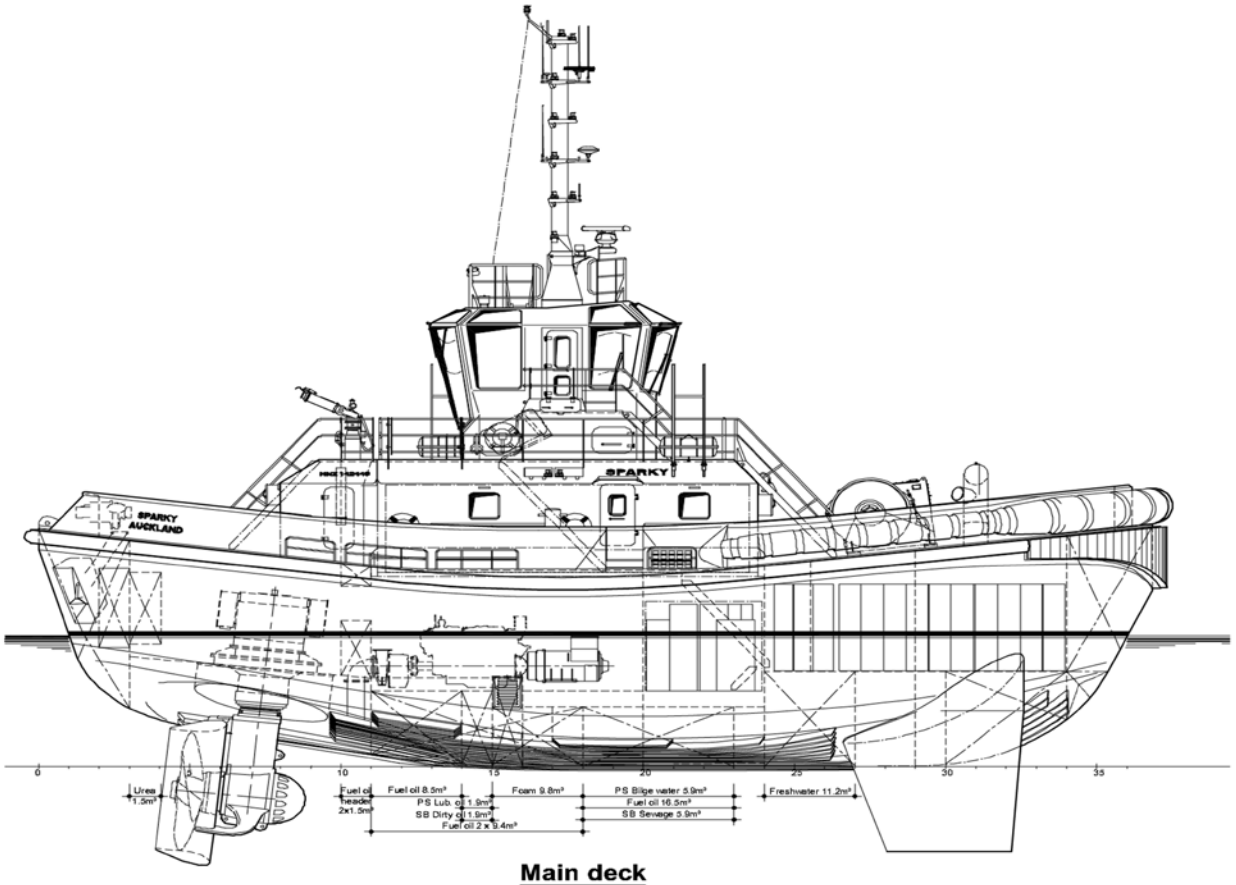
Recently, Hydromasters were delivered to **Kotug** for its all-electric *E-Pusher 1* and to **Synergy Shipbuilders** for installation in *River Pearl*, an Indian workboat with towing capability. **See the respective articles in this issue.**

Hydromaster has its origins in the U.K. but is based in The Netherlands. The U.K. office, Sykes Marine (Hydromaster) Ltd is located at Southend -on-Sea. Hydromaster Far East Pte Ltd is based at Singapore.

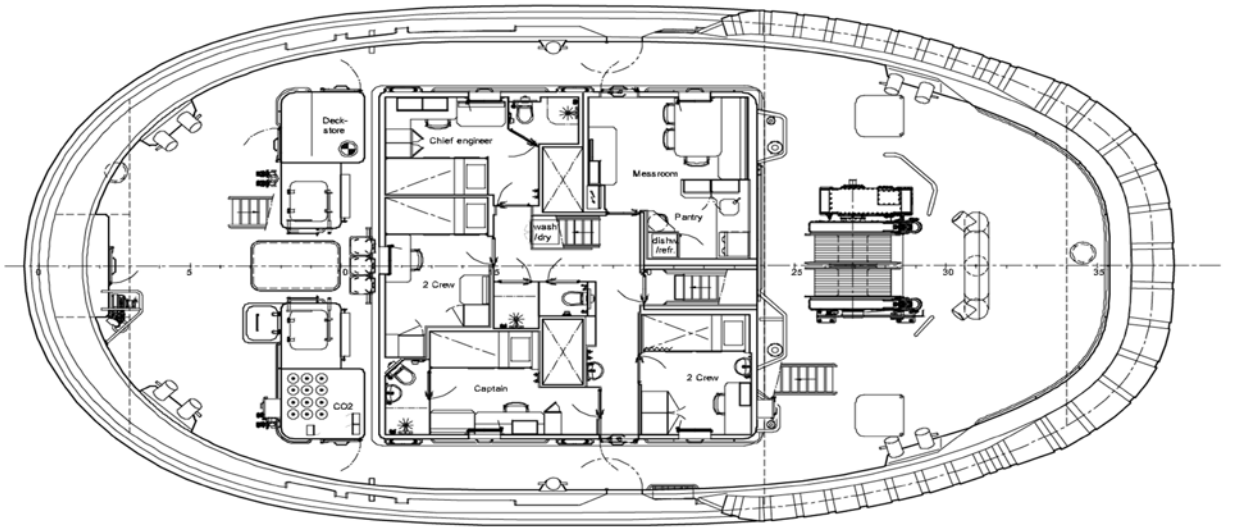
RIVER PEARL, a recent Hydromaster-propelled workboat / tug delivered to India
photo: courtesy Hydromaster

BH 101 buoy-handler with deck-mounted Hydromaster propulsion photo: courtesy Hydromaster

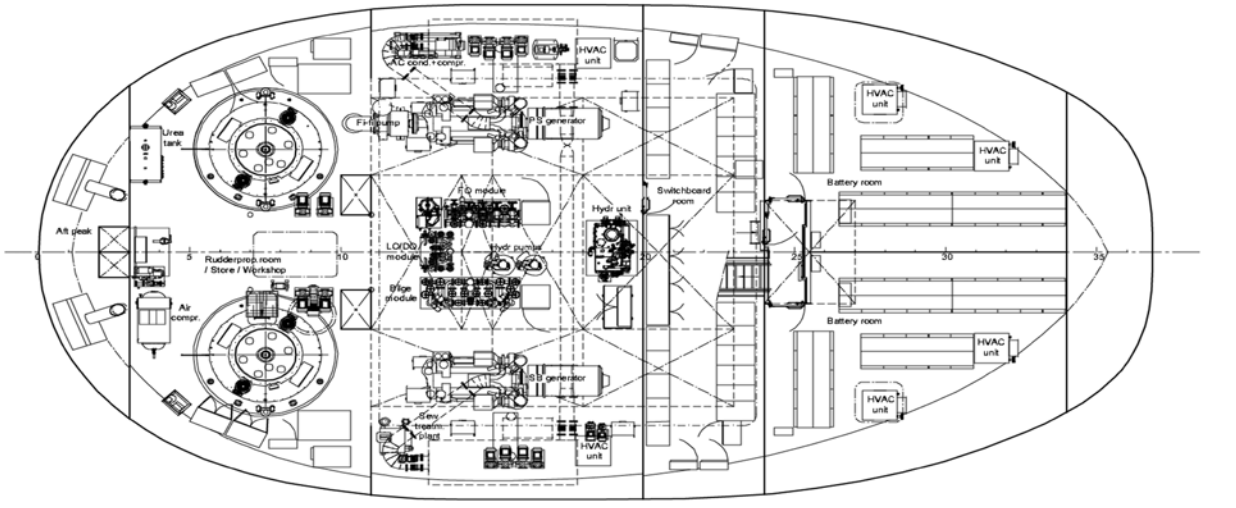
The Kotug E-PUSHER ONE - a ground-breaking all-electric modular push boat - is propelled by Hydromasters and one of the most recent deliveries
photo: Martens Multimedia courtesy Hydromaster



Main deck



Below Main deck



General Arrangement SPARKY *drawing: Damen Shipyards*

Auckland's Green 'Spark(y)'

An award-winning eco-friendly Damen design for a powerful shiphandling tug has been operating at Auckland, New Zealand, since June, 2022.

by TDI Tugboat Publications

The contract between Damen Shipyards and the Ports of Auckland was signed on 29 July, 2019. The newbuild RSD-2513-E design tug arrived on its own keel in Auckland on 7 June, 2022, at the end of the delivery voyage from the builders in Vietnam. She was officially blessed on 8 August, 2022.

The basic design of the tug is that of a standard Damen RSD Tug 2513 – on the market since 2018 - but otherwise laid out for all-electric zero-emissions sailing. Dimensions are 24,73 (oa) x 13,13 (oa) x 4,95 m. Draught aft is 6,50 m. Displacement is 615 tonnes. The hull is protected by rubber D-fenders in the sides and aft, while the bow is protected by a combination of cylindrical fenders with block fenders under. The twin-fin skeg concept ensures good course stability.

The propulsion system consists of two **Ramme** TW-1400r_L electric main engines with a total output of 3.700 kW at 500 rpm each driving the **Kongsberg** US-255-P30-FP azimuthing thrusters with a propeller diameter of 3.000 mm. Two Caterpillar C-32-TA IMO Tier III compliant gen sets serve as back-up in case of emergencies. These can also be used to charge the batteries, even in combination with shore power loading. Output is 1.175 kVA, 690 V, 60 Hz. The drive trains deliver 70 tbp ahead, 65 tbp astern. Indirect steering force 75 tonnes, maximum indirect braking forces 100 tonnes. Speed is 12 knots. If need be the tug can run as a hybrid in combination with the batteries.

The battery banks- a total of 2.240 batteries - sit in the **battery room** which is situated between the forward collision bulkhead and the watertight switchboard room bulkhead. Four identical and independent battery packs, each in its own insulated, temperature-controlled battery chamber are directly connected to the propulsion system. The battery packs are designed to have a life equal to or longer that of the tug itself; 30 years / 30,000 cycles.

Battery charging is by a dedicated shore installation. Re-charging from shore takes just 1,5 to 2 hours. CO_2 savings annually are around 465 tons. The battery banks are dimensioned for two assists on a single charge of batteries including 30 minutes of full power (70 tbp).

The **superstructure** – resiliently mounted on the hull to reduce noise and

SPARKY arriving at Auckland at the end of the delivery trip from Vietnam *photo: Auckland Ports*

SPARKY during harbour assist *photo: courtesy Damen Shipyards*

Shore charging station developed by Damen for charging electric tugs *photo: Damen Shipyards*

vibration - at main deck level houses the crew. The Master and Chief Engineer are housed in single berth cabins with private sanitary space – toilet – wash basin – shower. For the crew two cabins are available, each housing two. *Sparky*, however, is laid out for a two-men crew. A shower and a toilet for general use are fitted central in the superstructure. The superstructure also houses the combined messroom / pantry.

Costs

The CAPEX is about twice that of a regular, diesel-driven RSD-2513, but this is offset by using electricity instead of diesel fuel. And maintenance costs are much lower as there are no running hours on main engines. OPEX is therefore much lower. It has been estimated that over the life span of the tug the total cost of ownership is about the same as that of the diesel-driven sister. New Zealand as a country generates a large amount of its primary energy from renewable sources. Electricity for a large part comes from hydro power and geothermal power.

Sparky has been named in TIME's Best Inventions list and has won the Tug of the Year award at the 2022 International Tug and Salvage Conference.

SPARKY assisting at the stern - note DMT towing winch and towing staple
photo: Damen Shipyards

Switchboard room on board SPARKY *photo: Damen Shipyards*

SPARKY accommodation: mess / dayroom with pantry behind
photo: courtesy Damen Shipyards

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Kotug Heat Recycling System
A tugboat produces heat during operation and it requires energy during stand-by periods. Kotug has developed a way to re-cycle the cooling-water heat from the main engines and store the heat in a smart latent heat buffer. When the tug is idle energy is required for climate control and to keep the engines warm. Although the use of shore power reduces emission it comes at a cost. The Heat Recycling System results in a higher energy efficiency and thus 'greener' operation of the tug. The first Kotug Zero Emission Heat Recycling System was installed on Kotug Smit Towage's *ZP Bison* initially for evaluation purposes. The system proved to be an eco-friendly and cost-effective solution. It reduces shore power consumption with 50%, thus cutting CO2 emissions by half. This amounts to approximately 50.000 kWh less on the meter every year. The savings are a major achievement with regard to the reduction of the operational cost and the emission reduction. The Kotug HRS system won the **Maritime Innovation Award** at the Dutch annual Maritime Award Gala.

Tug / dredger
On 9 May, 2018, the Damen WID 2915 hybrid tug / dredger commenced technical trails and bollard pull tests. *Fregate* (IMO 9828467) was built at the Damen Safe Co Ltd Sp z oo, Poland yard and outfitted at the Damen Hardinxveld yard in the Netherlands (yard number 571766). The unique tug / dredger was built for the De Boer (Dutch Dredging) / Iskes Towage joint-venture operation in French Guyana.

The icebreaking shiphandling VILJA operating at the Port of Lulea is a hybrid variety of Robert Allan's TundRA-3600 design *photo: Astilleros Gondan*

Main engines are two Caterpillar 3512-C total output 2.850 kW. The main power generators each deliver 1.058 kW / 680 V AC / 50 Hz. The E-motors for the thrusters each deliver 400 kW / 690 V AC / 60 Hz. An electric DMT double-drum towing winch is fitted forward. The drums can store 200 m x 80 mm and 800 m x 48 mm towlines. The winch aft is a split drum type used for lowering the WID arm.

"Harvey Stone"
is a Multi-Purpose Field Support Vessel (MPFSV) that will serve as a dedicated field support vessel for the Shell *Stones FPSO* offshore terminal. Her primary duties will be to operate as the dedicated pull-back tug, in support of,

HAISEA WAMIS - one of three all-electric tugs for operations at the port of Kitimat *photo: Robert Allan Ltd*

and assisting the berthing, loading and unberthing of offtake tankers of up to 46,287 dwt. The vessel is expected to escort the above FPSO in the event of disconnection from the submerged buoy mooring for hurricane avoidance purposes and is also equipped to tow the FPSO in case of mechanical breakdown at any time during the transit way from or back to the field. Notable features include a hybrid propulsion system and a double-hull.

The Melkøya trio
The first of three dual-fuel RAstar 4000-DF escort tugs, ***Dux***, was delivered to ***Østensjø*** Rederi AS by Spanish shipbuilder Astilleros Gondán S.A. in 2017. Sisters are ***Pax*** and **Audax**. The 40,20 m tugs were built to the order of ***Østensjø*** designed for severe weather operations at Statoil's Melkøya LNG Gas terminal at Hammerfest in the extreme north of Norway. The tugs were awarded the **Tug of the Year 2017** title by Tug Technology & Business magazine.

Japanese companies
teamed up to operate the first Japanese LNG-fuelled tug. Mitsui OSK Lines ordered a dual-fuel tug from Kanagawa Dockyard Co in Q4 2017. *Ishin* was delivered in 2019, operated by Mitsui subsidiary Nihon Tug-Boat Co in Osaka Bay. LNG fuel is supplied by Osaka Gas, which set up a bunkering service in the Sakai-Senboku Port. Dimensions of the tug are 43,6 x 9,3 m with a draught of 3,15 m. Main engines are two Yanmar 6EY-26DF dual fuel engines. Speed is 16,4 knots.

Harland & Wolff / Macduff design for zero-emissions coastal tugs artwork: Macduff Ship design

Baydelta
ordered a **hybrid tug** with Rolls-Royce systems from Nichols Brothers Boat Builders. Designed by **Jensen Maritime** the Delta-class shiphandling tug *Delta Teresa* was delivered to the owners in early 2019. Two Caterpillar C-3516-C Tier 3 diesels totalling 3.990 kW / 5.426 bhp were installed as well as two 424 kW electric motors that can deliver boost power or drive the propellers direct.

"PSA Oak"
is an LNG tug designed by Wärtsilä and built by PaxOcean Shipyard. The order with Wärtsilä, booked in March 2018 was for a tug with a length of 28 meters and a bollard pull of 50 tons to operate with two Wärtsilä 20DF dual-fuel engines running primarily on LNG fuel. Wärtsilä also supplied its LNGPac fuel storage and supply system as well as steerable thrusters and the Wärtsilä ProTouch control system.

The ZEE tug
The ZEE or Zero Emissions Electric tug was designed by Navtek Naval Technologies to the order of Gisas Shipbuilding Industry, Istanbul. Gisas currently employs a fleet of five tugs in the Sea of Marmara and in the Tuzla industrial shipyard zone. The tug basically is a day boat thus allowing charging of the batteries by night through a shore connection. It's operating profile is such that one charge per day will be enough. The power banks can be loaded at high speed with an estimated one-hour cycle only. Bollard pull 31 tonnes. Power comes from a Corvus Orca energy storage system featuring two battery packs with a total storage capacity of 1.484 kWh. Two 968 kW each Siemens motors drive the fixed-pitch propellers. Charge is DC straight to the tug, which ensures 10 years of good battery life, according to NavTek. The drive systems are supplied by ABB.

eWOLF - the all-electric tug under construction for Crowley artwork: Crowley

Schottel SYdrive-M
Presented to the market in 2019 the system is suitable for both retrofit and newbuilds. It is not a hybrid in the accepted sense but is a mechanical-link connecting port and starboard mounted azimuthing thrusters. Thus driving two propellers with a single main engine.

According to Schottel, the system does not require any additional electronic components or gearbox. The system also omits the need for medium or heavy duty slipping clutches, CP propellers or dedicated engines to supply power to a FiFi-pump.

The retrofitting is expected to convert the direct-driven vessel into a greener and more cost-efficient vessel.

Like most things in shipping, everything has been done before. In the dim past galleys were hybrid-powered by oarsmen and sail; early steamers used sail-assist and not to forget the early seagoing tugs that went cruising for towing jobs and used sails for station keeping and saving coal. An early hybrid by today's terminology was Norfolk, Va, based Rebel Marine's NORFOLK REBEL, delivered from the builders in 1980. Keel laid on 1 April, 1978. The 'tugantine' as it was dubbed, used wind power for mob / demob and as tow-assist during suitable wind situations. It reportedly reached fuel savings up to 50% though on average it was 30% overall. NORFOLK REBEL measured 17 x 4,6 m with a draft of 1,7 m. The gaff schooner rig had a sail area of 750 sq.ft. while the main engine had an output of 320 bhp. She was purposely designed by Merritt N. Walter to the order of Rebel Marine's owner, the late Capt. Lane Briggs.

Capt. Briggs had previously experimented with sails in his tug STEEL REBEL – initially as a bit of fun but as a serious subject when he noticed the savings that could be made on his fuel bill. As an aside, the Briggs family also operated a marina. The 'Rebel' suffix in the tug's name was actually the name of Lane Briggs' dog, as the story goes. This vessel made 4,5 knots on sails alone when in favourable winds. Towing speed win wind assist increased the speed with 1 to 2 knots. Wind-assist, however, very much depends on a variable which may or may not be available when needed. In Rebel Marine's operating area they could use the sail assist in approximately 60% of the time. This resulted in a 25-35% savings in fuel as well as time.

NORFOLK REBEL was built by Howdy Bailey Yacht Services. The boat was introduced to the towage industry in in March, 1979, by one of Lane's s sons, Capt. J. Briggs, at the International Tug Convention in Hamburg. The Tugantine featured a 320 bhp main engine and has accommodation for five, although sail handling can be done by just two crew. Speed under sail was 7 to 8 knots, under power 10 knots. Advantage of the NORFOLK REBEL over the STEEL REBEL was that the 'Norfolk' was capable of sailing into the wind.The Tugantine was equipped for diving and salvage work but additionally carried an insulated fish hold to allow the boat to go out commercially fishing as well. NORFOLK REBEL is still around run by Capt. Steve Briggs and in 2022 participated in the Great Cheaspeake Bay Schooner Race, an annual event founded by Capt. Lane Briggs in 1990 photo: coll. Job van Eijk