

Green Propulsion

A total solution with Mega-Guard Green Propulsion products:

- GreenPod steerable electric thruster
- GreenMotor electric motor for propulsor
- GreenGen electric generators for combustion engines
- GreenBattery electric energy storage system
- GreenInverter high power inverter (motor/generator/battery)
- GreenEMS energy management system
- GreenPCS propulsion and steering control system
- DC Bus
- Full hybrid
- Serial and parallel hybrid
- World wide service network
- Class type approved

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Who we are



Our passion for shipping and technology is the engine of our company. The high-quality knowledge and experience of our employees is the driving force that pushes us forward to reach new achievments. The sum of these results in controlled processes, plus a complete range of reliable and well-considered, market-oriented innovations.



Praxis Netherlands head office, Leiderdorp

Praxis Automation Technology, founded in 1965, in the Netherlands, began with manufacturing and supplying alarm and monitoring systems for sea going vessels. During the years, our experience combined with extensive research, enabled the company to other complete solutions in the ship automation and navigation equipment field. Today we design and produce the third generation of the complete "Mega-Guard" Green Propulsion, navigation and automation for ships entirely in-house. Recently we extended the "Mega-Guard" product range with electric and hybrid propulsion systems in order to show our commitment to environmental friendly propulsion. We provide a total in-house developed and manufactured electric and hybrid propulsion solution for shipowners and shipyards who care about the environment. We supply our products to international shipyards, ship owners and installation companies and serve them via our selected global network of service and maintenance points.

Mega-Guard Green Propulsion

Introduction

Praxis Automation Technology BV has extended the Mega-Guard product range with a new concept for Green Propulsion in order to show our commitment to environmental friendly propulsion of ships. We provide a total in-house developed and manufactured electric and hybrid propulsion solution for shipowners and shipyards who care about the environment and on-board safety.

The following applications are covered by Mega-Guard Green Propulsion:

- Battery power and electric motor Full electric
- Diesel electric Generator power and electric motor Serial hybrid Battery plus generator power
- > Parallel hybrid Battery plus generator power. Shaft driven by electric motor and/or combustion engine

and electric motor

The backbone of Mega-Guard Green Propulsion is the energy distribution with an highly efficient DC Bus and communication between the different Green Propulsion products with redundant Ethernet.

As for all Mega-Guard products, Mega-Guard Green Propulsion is supported by a worldwide service network and comes with a guaranteed availability of spare parts and support of 20 years as a minimum. All Mega-Guard products are designed to the highest standards of safety and are class approved by all major classification societies.

Mega-Guard Green Propulsion can be further extended with other Mega-Guard products such as Heading Control, Dynamic Positioning and Control, Alarm and Monitoring systems.



Green Propulsion product summary

The Mega-Guard Green Propulsion product line is built-up with the following main products:

GreenPod

GreenPod is a highly efficient steerable thruster covering propulsion applications from 100kW to 2.2MW. Two versions are available: an electric motor mounted 'under water' in line with propeller shaft and a version with a so called L drive with electric motor mounted inside hull on top of the thruster. GreenPod contains a permanent magnet high efficiency electric motor to support a green environment. Up to two electric steering motors provide 360 degrees steering functionality of GreenPod.



GreenMotor and GreenGen

GreenMotor electric motor and GreenGen electric generator are highly efficient permanent magnet electrical machines for propulsion and electric power generation. In fact, a GreenMotor can also be used as a GreenGen and vice versa. Low speed versions of GreenMotor are available for direct mounting to a propeller shaft without gearboxes. Medium and high speed versions are available for connecting to third party thrusters and , in case of generator application, to variable speed combustion engines in order to realize a highly efficient generator set to support a green environment.



GreenBattery

GreenBattery is a safe, highly efficient and modular energy storage system with relatively low weight and small volume. Each GreenBattery has a capacity of 80kWh and a nominal DC Bus voltage of 832VDC. Multiple GreenBatteries can be mounted in parallel to realize energy storage systems ranging from 80kWh to 4MWh. Each GreenBattery includes a Master BMS and DC Bus contactor. Various safety devices are built into GreenBattery. In the unlikely event of a battery cell explosion, it does not propagate to other cells (no thermal runaway) and it is contained inside the battery housing in order to guarantee a safe energy storage system without pollution to the surrounding environment of GreenBattery.



Green Propulsion product summary

GreenInverter

GreenInverter covers applications for electric motor and generator drive and includes battery charging with GreenGen generators or with shore power. In addition, a GreenInverter AC is available for AC grid generation to support hotel load. GreenInverter is available in power ranges from 100kW to 2.2MW. GreenInverter is connected to the DC Bus with a nominal voltage of 832VDC. A DC Bus contactor and other safety devices are built into each GreenInverter.





GreenEMS

GreenEMS energy management system allows for automatic energy source selection and control from either the GreenBattery energy banks or GreenGen generator sets. In addition, the energy management system controls the charging of GreenBatteries either by GreenGen generator sets or by shore power.

GreenPCS

GreenPCS propulsion control system fully automates the remote control from bridge of the GreenPod or GreenMotor propulsors. In case of parallel hybrid applications; the combustion propulsion engine is controlled as well and automatic change over from electric propulsion motor (low power) to combustion propulsion engine (high power) is fully supported. The GreenPCS propulsion control system also provides steering functions with the application of GreenPod and third party steerable thrusters.

operator panel

GreenEMS



Applications Green Propulsion

Advantages of electric propulsion

There are two main reasons to change to electric propulsion: zero emissions during electric propulsion and fuel efficiency. Fuel efficiency can be increased with electric propulsion when there is a large difference in operating hours at e.g. cruise speed and maximum speed (or power). The reason for this is that the combustion engine is running only at optimal efficiency when fully loaded; at all other operating points efficiency drops. Electric propulsion when combined with combustion engines realizes that the combustion engine is running at optimal efficiency most of the time, by using the spare power for charging battery packs and/or by switching off one or more combustion engines depending on load requirement. In addition, electric motor propulsion, especially when combined with steerable thrusters, gives a much better maneuverability when compared to combustion propelled vessels as the RPM can be easily controlled from zero to maximum. Some ship applications also require strongly reduced noise emission and this can be realized with the GreenPod steerable thruster as the electric motor is mounted 'under water' for optimum noise reduction.



The Mega-Guard Green Propulsion product line covers various propulsion applications which can be summarized as follows:

Full electric propulsion

The full electric propulsion uses an electric motor to drive the propeller shaft. Electric power is coming from battery banks and charging is done through shore power. Combustion engines are not installed. With large batteries you can have long periods of electric propulsion and the AC grid for hotel load is generated from the battery bank too. The highly efficient GreenPod steerable thruster perfectly fits into full electric applications.



Serial hybrid propulsion

The serial hybrid also uses an electric motor to drive the propeller shaft. Electric power is coming from battery banks or, when battery bank is empty, from a combustion generator set. Charging of the battery bank is done through the combustion generator set or by shore charging. With large batteries you can have long periods of electric propulsion without the need for combustion engines to run as the AC grid for hotel load is generated from the battery bank too. The highly efficient GreenPod steerable thruster perfectly fits into full electric applications.

Applications Green Propulsion

Parallel hybrid propulsion

The parallel hybrid propulsion system uses both a combustion engine and an electric motor to drive the propeller shaft. In fact, the combustion engine and the electric motor are mounted in parallel.

Parallel mounting is generally done in one of two ways:

- The propeller shaft from the combustion engine is split in two parts and the electric motor is mounted in between the two shaft parts. This means that the electric motor is mounted in-line with the propeller shaft. The electric motor has also to carry the usually much higher load from the combustion engine. The highly efficient permanent magnet GreenMotor with hollow shaft fits this purpose.
- The electric motor is mounted on an additional input of the gear box which is mounted in between the combustion engine and the propeller shaft.

Parallel hybrid propulsion allows you to drive the propeller shaft by either the electric motor or the combustion engine or by both (boost mode). In case the vessel is propelled by combustion engine, the electric motor acts like a generator which can be used for charging the battery banks.



In case there is a big difference in between operating hours at cruising speed compared with operating hours at maximum speed/power it makes sense to install a parallel hybrid system. The relatively small electric motor can propel the vessel at cruise speed for longer periods. When maximum speed/power is required, the large combustion engine takes over the propulsion and the electric motor is used as generator for charging the batteries. The parallel hybrid has built-in redundancy as the shaft can be driven by either the electric motor or the combustion engine. The highly efficient GreenMotor perfectly fits into parallel hybrid applications.



Diesel-electric propulsion

A diesel-electric propulsion system uses generator sets to generate electric power for the electric propulsion motors. The generator sets consist of a combustion engine, which could be gas or diesel, and is connected directly to an electrical generator. The electric propulsion motor is connected directly to the propeller shaft. The diesel electric system usually has multiple generator sets and multiple electric motors connected to a common electrical DC bus. The highly efficient GreenPod steerable thruster and the GreenGen electric generator fits perfectly into diesel-electric applications. Note that there is no electric storage of energy in a diesel-electric propulsion application.

GreenPod steerable electric thruster

GreenPod steerable electric thruster is designed as a highly efficient fit and forget propulsor that additionally saves a lot of engine room space. In fact, due to its low height GreenPod can be mounted in almost any location.

Two versions are available:

- Pod with electric motor mounted 'under water' in line with propeller shaft.
- L drive with electric motor mounted inside hull on top of the L shaped propeller shaft.

GreenPods are available in sizes in between 100kW and 2.2MW. The highly efficient permanent magnet electric motor increases efficiency to support a green environment.





Up to two electric steering motors are mounted on top of GreenPod for reliable and fail safe steering. GreenPod electric propulsion motor is controlled by GreenInverter and the steering motors are controlled by a low power version of GreenInverter. These GreenInverters can be mounted on top of GreenPod for simplified and trouble free installation. GreenInverters are connected directly to DC Bus and to Ethernet communication lines.

Three different propeller configurations can be supplied:

- Pushing standard configuration up to 12.5 knots
 Dual propeller contra rotating propellers for speeds above 12.5 kno
- Nozzle

for speeds above 12.5 knots to increase efficiency at speeds below 5 knots to realize highest bollard pull

GreenPod	GP-100	GP-200	GP-400	GP-800	GP-1200	GP-1600	GP-2200
Rated electric power kW Continuous S1	100	200	400	800	1200	1600	2200
Electric power kW Light Duty S6	130	260	520	1040	-	-	-
Propeller RPM	0-825	0-825	0-420	0-380	0-340	0-300	0-266
Bollard pull kN	17	35	70	140	210	280	350
Propeller Diameter mm	750	750-900	1000-1100	1200-1600	1600-1900	1900-2200	2200-2400
Hub Diameter mm	310	310	490	610	810	990	990
Weight kg	380	490	980	2070	4100	6200	8900

GreenMotor and GreenGen

GreenMotor electric motor and GreenGen electric generator are highly efficient permanent magnet electrical machines for propulsion and electric power generation. In fact, a GreenMotor can also be used as a GreenGen and vice versa.

GreenMotor and GreenGen products are available in RPM ranges in between 266 (low speed direct drive of propeller shaft) and 3600 (high speed generator set). GreenMotor and GreenGen can be either flange or bracket mounted. In addition, customer can choose between hollow shaft or solid shaft on one side or on both sides of the machine. In case of parallel hybrid applications, the low speed GreenMotor can be connected to the propeller shaft on one side and the other side can be connected to the output shaft of gearbox. Versions of GreenGen are available for direct mounting on flywheel housing of several models diesel engines from Cummins, Volvo, Steyr and Hyundai.

Flange mounting connections, vibration damping plates and other specifications can easily be adapted to accommodate other combustion engines. GreenMotor and GreenGen are cooled by water cooling (50% water/50% glycol). Each GreenMotor and GreenGen is controlled by a GreenInverter which is connected to DC Bus of nominal 832VDC.





GreenMotor Direct Drive Parallel hybrid	GM-100	GM-200	GM-400	GM-800	GM-1200	GM-1600	GM-2200
Rated electric power kW Continuous S1	100	200	400	800	1200	1600	2200
Electric power kW Light Duty S6	130	260	520	1040	-	-	-
Motor Diameter mm	395	395	511	678	810	990	990
Motor flange or Mounting bracket	SAE3 2	SAE3 2	SAE12	SAEO 2	tbd 2	tbd 2	tbd 2
Version Low RPM Motor length mm Motor weight kg	0-825 635 170	0-825 714 190	0-420 990 460	0-380 1225 1020	0-340 1650 1940	0-300 1950 2960	0-266 2070 4250
Version Low RPM Motor length mm Motor weight kg	0-3600 290 90	0-3600 310 110	0-1800 440 290	0-1800 620 680	0-1500 870 1150	0-1500 980 1840	0-1500 1075 2670

GreenBattery electric energy storage

GreenBattery is a highly efficient and modular energy storage system with relatively low weight and small volume. Each GreenBattery has a capacity of 80kWh and a nominal DC Bus voltage of 832VDC. Multiple GreenBatteries can be mounted in parallel to realize energy storage systems ranging from 80kWh to 4MWh.

Each GreenBattery is built up with 8 individual batteries and a Master BMS. The Master BMS contains a 5îTFT operator panel with controller and includes a DC Bus contactor and heat exchanger. All external connections are made available on the Master BMS.

Various safety devices are built-in for preventing thermal runaway. In the unlikely event of a battery cell explosion, it is contained inside the battery housing in order to guarantee a safe energy storage system without pollution to the surrounding environment of GreenBattery. Each battery is totally enclosed and GreenBattery includes a pressure based safety release which should be vented to the outside environment.

GreenBattery General specification					
Stored energy	80kWh				
Usable energy 5% to 95%	72kWh				
State of charge measurement	Yes				
Nominal voltage	832VDC				
Minimum voltage at 5 charge %	650VDC				
Maximum voltage at 95% charge	860VDC				
Recommended charge rate	0.5C				
Recommended discharge rate	1C				
Number of cycles	5000				
Number of Batteries	8				
Main BMS	Yes				
Dimensions vertical	H=200, W=40, D=70cm				
Dimensions horizontal	H=100, W=80, D=70cm				
Weight	780kg				
Protection	IP65				
According class	LRS, DNV-GL, ABS and risk based assessment				

GreenBattery vertical 4 x 80kWh

GreenBattery is liquid cooled by seawater or water/glycol and a built-in controller regulates battery temperature in between 20 and 40 degrC. GreenBattery can be placed in any room with the ambient temperature up to 55 degrC. GreenBattery does not heat-up the room.



GreenBattery horizontal 2 x 80kWh

GreenBattery electric energy storage



Battery management

The batteries are built up with Lithium NCA technology battery cells which have considerable lower weight and higher power density when compared to other battery chemistries. In addition the applied Panasonic battery cells have a long track record and are widely used in electric cars. Each battery has 12 temperature measurements and a built-in BMS (Battery Management System) which communicates with the Main BMS. The Main BMS 5îTFT operator panel contains redundant Ethernet ports for communication to GreenInverters for charging/discharging and GreenEMS for energy management. GreenBattery fulfils the latest class requirements and a risk based assessment is made for every project and approved by class. GreenBattery is supplied in two different mechanical lay-outs: a vertical one for space saving and a horizontal one with a lower center of gravity.



GreenBattery Main BMS specification				
Electric connections external	+ and – terminal Quad Ethernet			
Cooling connection external	Seawater or water/glycol Inlet temp max 32degrC Capacity: 5kW			
Safety vent external	½"vent pipe to outside environment			
DC Bus contactor	Yes			
Operator display	5" TFT with controller			
Dimensions	H=19, W=33, D=62cm			
Weight	26kg			



GreenBattery Battery specification				
Stored energy	10kWh			
Nominal voltage	104VDC			
Number of cells	812			
Technology	Lithium NCA			
Enclosure	Totally enclosed Polypropylene UL94-VO			
Electric connections internal	+ and – terminal, BMS connector in and out			
Cooling connections internal	In and out connector			
Internal regulated temperature	In between 20 and 40 degrC.			
Tested on thermal runaway prevention	Yes and does not depend on cooling system			
Dimensions	H=19, W=33, D=62cm			
Weight	79kg			

GreenInverter high power inverter



GreenInverter covers applications for electric motor and generator drive and includes battery charging with GreenGen generators or shore power as well. GreenInverter is built-up in a modular way, supporting applications from 100kW to 2.2MW. GreenInverter is a four quadrant controller with active front end technology. Motor operation changes into generator operation as soon as a motor is driven by propeller (brake energy) or combustion engine (parallel hybrid). The generated energy is used for GreenBattery charging. GreenInverter includes independent safety systems such as Safe Torque Off on AC side and contactor on DC side for connecting and disconnecting the DC Bus from GreenInverter. The contactor also supports pre-charging and discharging in order to safely connect and disconnect GreenInverter from DC Bus. GreenInverter is optimized for DC Bus voltages in between 650VDC and 975VDC and a nominal current up to 450A. This results in a rated power range from 350kW to 500kW. Multiple GreenInverters can be paralleled to increase the power up to 2.2MW. GreenInverter is IP67 protected and can be bulkhead mounted.

GreenInverter is designed to be installed close to the device to be controlled for distributed DC Bus applications. However, centralized installation of GreenInverter is supported as well. GreenInverter is built-up with two controllers: a dedicated Digital Signal Processor for four quadrant motor and generator control functions and a Control Processor with four Ethernet ports for programming PLC functions in accordance with IEC61131 standard. Input and output signals (including J1939/NMEA2000) of e.g. GreenPod and combustion engines with GreenGen can be directly connected and controlled by GreenInverter.

GreenInverter is also available for following:

- DC/DC conversion: GreenInverter DC/DC
- AC grid generation: GreenInverter AC

These GreenInverters are based upon the standard GreenInverter and extended with magnetics. In addition, a low power GreenInverter LP is available for e.g. steering motor and bow thruster.

GreenInverter General specification

350kW, 480VAC, 420A 650VDC= minimum Greenbattery voltage
500kW, 690VAC, 420A Requires GreenInverter DC/DC
Maximum 5
Yes, Safe Turn Off
Yes, Safe Turn Off
Yes; to connect and disconnect DC Bus
Yes
DC up to 240mm2 AC up to 185mm2
98%
Water/glycol
W=215, L=499, H=99mm
22kg
IP67
LRS, DNV-GL, ABS and risk based assessment

GreenEMS and GreenPCS

Energy Management

GreenEMS energy management system allows for automatic energy source selection from either the GreenBattery energy banks or GreenGen generator sets. In addition, the energy management system controls the charging of GreenBatteries either by GreenGen or by shore power.



GreenEMS operator panel

GreenEMS includes a 5î TFT operator panel on which all data regarding consumers (GreenPod's, GreenBattery charging and hotel load) and producers (GreenGens and GreenBatteries discharging) are available. Mode selection pushbuttons are available as well on GreenEMS 5îTFT operator panel.

GreenEMS contains a project specific control strategy in order to control the consumers and producers. GreenEMS communicates to GreenInverter, GreenBattery and GreenPCS through redundant Ethernet communication ports to monitor and command these devices. As all Green products are built-up from the same technology, a transparent and trouble free control strategy can be implemented in standard IEC61131 language.

Propulsion Control System

GreenPCS propulsion control system fully automates remote control from the bridge of GreenPod or GreenMotor propulsors. In case of parallel hybrid applications, the combustion propulsion engine is controlled as well and automatic change over from electric propulsion motor (low power) to combustion propulsion engine (high power) is fully supported. The GreenPCS propulsion control system provides steering functions with the application of GreenPod and third party steerable thrusters. The GreenPod azimuth lever includes two 2.5îTFT display panels and operator pushbuttons for mode selection. They can be supplied including electrical shaft for synchronous operation. GreenPCS can also be applied for thrusters without steering function. In this case, typically a GreenPod dual lever with two 2.5îTFT displays and two rows of operator pushbuttons is supplied to independently operate the port and starboard side GreenMotor.



GreenPCS operator modes are adapted for every application. An example functionality is given below with two GreenPod steerable thrusters:

- Individual mode
- Combined mode
- Autopilot mode with Mega-Guard HCS
- > DP auto mode with Mega-Guard DP

Praxis commitments

- > Adding value to customeris ships by providing Praxisis range of quality products
- > Quality control and quality assurance system according ISO-9001
- ▶ Environmental management system and social responsibility in accordance with ISO-14001-26000
- Green Propulsion, navigation and automation products in accordance with Class rules IMO Regulations and Wheelmark
- > Spare parts and products support are available for a minimum period of 20 years post delivery
- Praxis offers transparency and continuously provides extensive information about its equipment to the customers
- > Praxis is committed to sustainable shipping

Reference

50 years of experience and stability in the shipbuilding industry. Praxis delivers more than 200 Mega-Guard ship systems every year. The result can be found in our reference list with over 3500 succesfully installed systems on a wide range of vessels all over the world. Our customers and business partners benefit from a co-operation that is oriented on commonly sustained benefits for all parties involved.



Mega-Guard system approvals





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