Ingeteam ELECTRIFYING A SUSTAINABLE FUTURE

Decarbonization through electrification of maritime industry

Descarbonización de la industria naval a través de la electrificación

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64 Congreso Ingeniería Naval – 64CIN, 26 al 28 de marzo de 2025

Andoni Torre, Business Unit Director, Drives & Automation, Marine, Metals & Mining

WHO WE ARE

Ingeteam is an international technology company specialized in the conversion of electrical energy, with advanced technology in rotating electric machines, power electronics, automation and control.

We strive to meet the needs of our customers, to offer the best and most competitive products, systems and services.

Our staff is the key to our success.

We apply continuous improvement in operations, processes and organization, to remain agile and competitive.

Our aspiration is to be a benchmark in the generation and conversion of electrical energy in the target business sectors.

Ingeteam, main magnitudes

Present in

15 countries

and new markets.

5.5%

of the turnover, invested in R&D +500 engineers in R&D

+3,500 employees

In the world.

+80 years

in the electrical sector.

Ingeteam, technological core

GENERATORS AND MOTORS, SUBMERSIBLE PUMPS

POWER ELECTRONICS

AUTOMATION, CONTROL & PROTECTION

Ingeteam, business sectors

Wind Generation

Solar PV Generation

Battery Energy Storage Systems (BESS)

Green Hydrogen

Hydro Generation

Water Sector

Railway Traction

Marine Sector

Ingeteam, business sectors

Metals Sector

Mining Sector

Test Bench

Oil & Gas

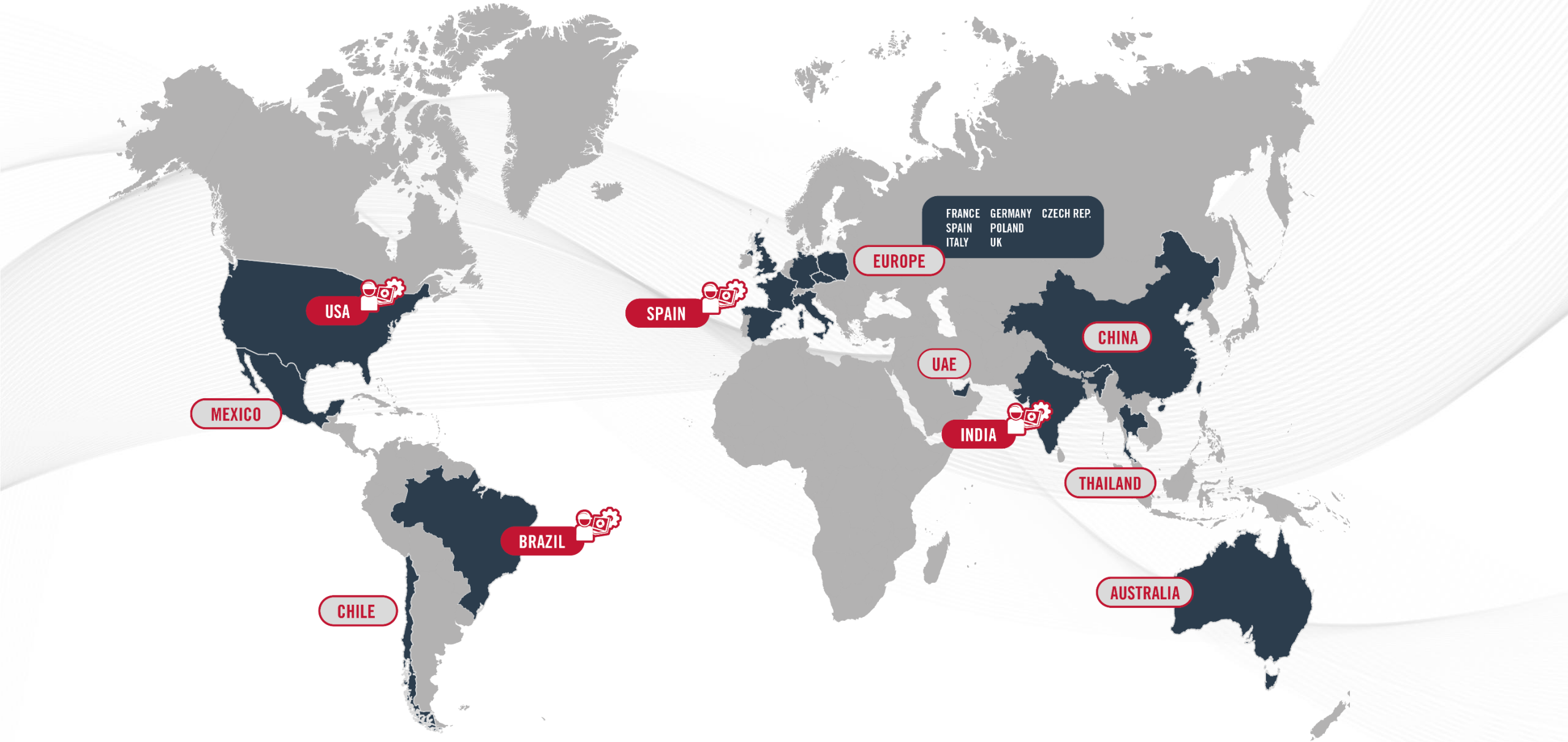
Smart Grids

EV Chargers

Flexible Power Generation

Reverse pumping stations

Ingeteam, in the world



Ingeteam, main production facilities

FREQUENCY CONVERTERS, INVERTERS, EV CHARGERS AND CONTROL SYSTEMS

Spain (16,800 m²)

- Sesma (Navarra)
- Ortuella (Bizkaia)

ROTATING ELECTRIC MACHINES (GENERATORS, MOTORS AND PUMPS)

Spain (53,500 m²)

- Beasain (Gipuzkoa)
- Segorbe (Castellón)

ELECTRONIC EQUIPMENT FOR AUTOMATION, CONTROL AND PROTECTION SYSTEMS

Spain (3,200 m²)

- Zamudio (Bizkaia)

Ingeteam, main production facilities

FREQUENCY CONVERTERS, INVERTERS AND CONTROL SYSTEMS

Brazil (5,250 m²)

- Campinas (Sao Paulo)

FREQUENCY CONVERTERS

India (5,100 m²)

- Chenai (Tamilnadu)

ROTATING ELECTRIC MACHINES (GENERATORS, MOTORS AND PUMPS), FREQUENCY CONVERTERS AND EV CHARGERS

USA (12,500 m2)

- Milwaukee (Wisconsin)

Ingeteam, laboratories

High power laboratories up to 40 MW and 30 kV

POWER ELECTRONICS LABORATORY

Zamudio (Bizkaia)

ROTATING ELECTRIC MACHINES LAB

Beasain (Gipuzkoa)

RAILWAY TRACTION LABORATORY

Zamudio (Bizkaia)

HYDRAULIC MACHINES LABORATORY

Beasain (Gipuzkoa)

CYBERSECURITY, COMM. & IEC61850 SYS.

Zamudio (Bizkaia)

LAB FOR RENEWABLE ENERGIES

Sarriguren (Navarra)

4.0 LABORATORY FOR VIRTUAL SIMULATIONS

Zamudio (Bizkaia)

Marine&Ports, experience

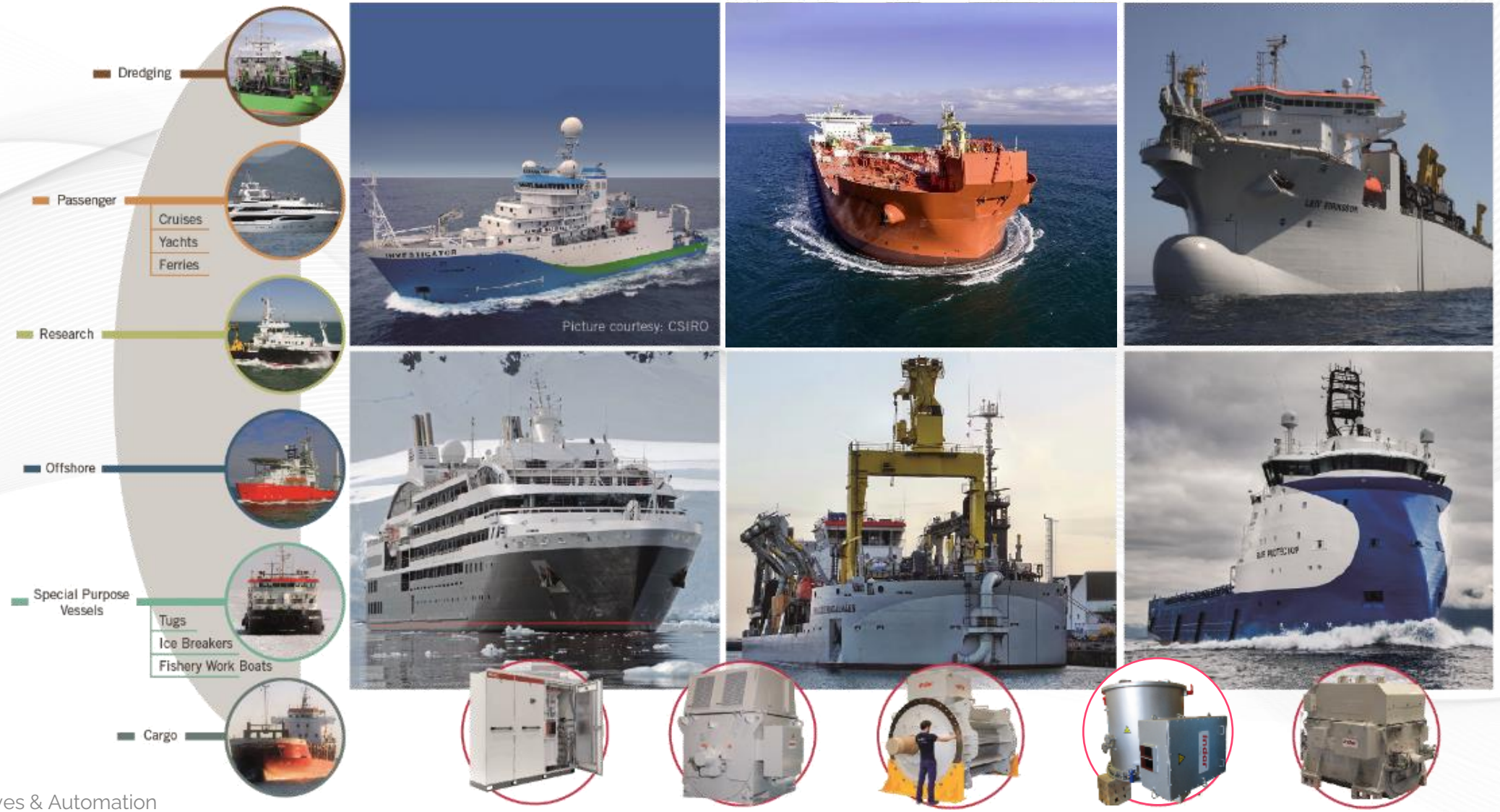
More than **960 vessels** propelled with our technology

More than **1500** low and medium voltage converters in operation **(+2 GW).**

More than **1,700** low and medium voltage motors & generators in operation.

Source: Drives & Automation

Marine&Ports, experience



Source: Drives & Automation

INGETEAM INDAR™ Electric Rotating Machines
Induction, Synchronous and PM Technology

Our machines are designed, manufactured and tested according to the criteria and standards of the International Electrotechnical Comission.

Indar's motors adapt to the requirements by the various classifying bodies for marine application.

Aplication	General Use Motors	Direct Propulsion Motors	Low Noise Propulsion Motors	Submersible Motors	Generators	PTO/PTI/PTH
Output	600 – 15,000 kW	600 - 25,000 kW	600 - 10,000 kW	400 - 6,500 kW	1,250 - 40,000 kVA	Up to 10 MW
Voltage	Up to 15 kV	Up to 6.6 kV	Up to 3.3 kV	Up to 3.3 kV	Up to 15 kV	Up to 6,6 kV
Speed	Up to 2,000 rpm	Up to 350 rpm	Up to 350 rpm	Up to 400 rpm	Up to 1,200 rpm	Low and medium/High speed
Variable speed	Yes	Yes	Yes	Yes	Yes	Yes
Insulation Class	H	H	H	H	H	H
Starting / Operation	PWM / Sinusoidal	PWM	PWM	PWM / Sinusoidal	PWM / Sinusoidal	PWM / Sinusoidal

Source: Drives & Automation

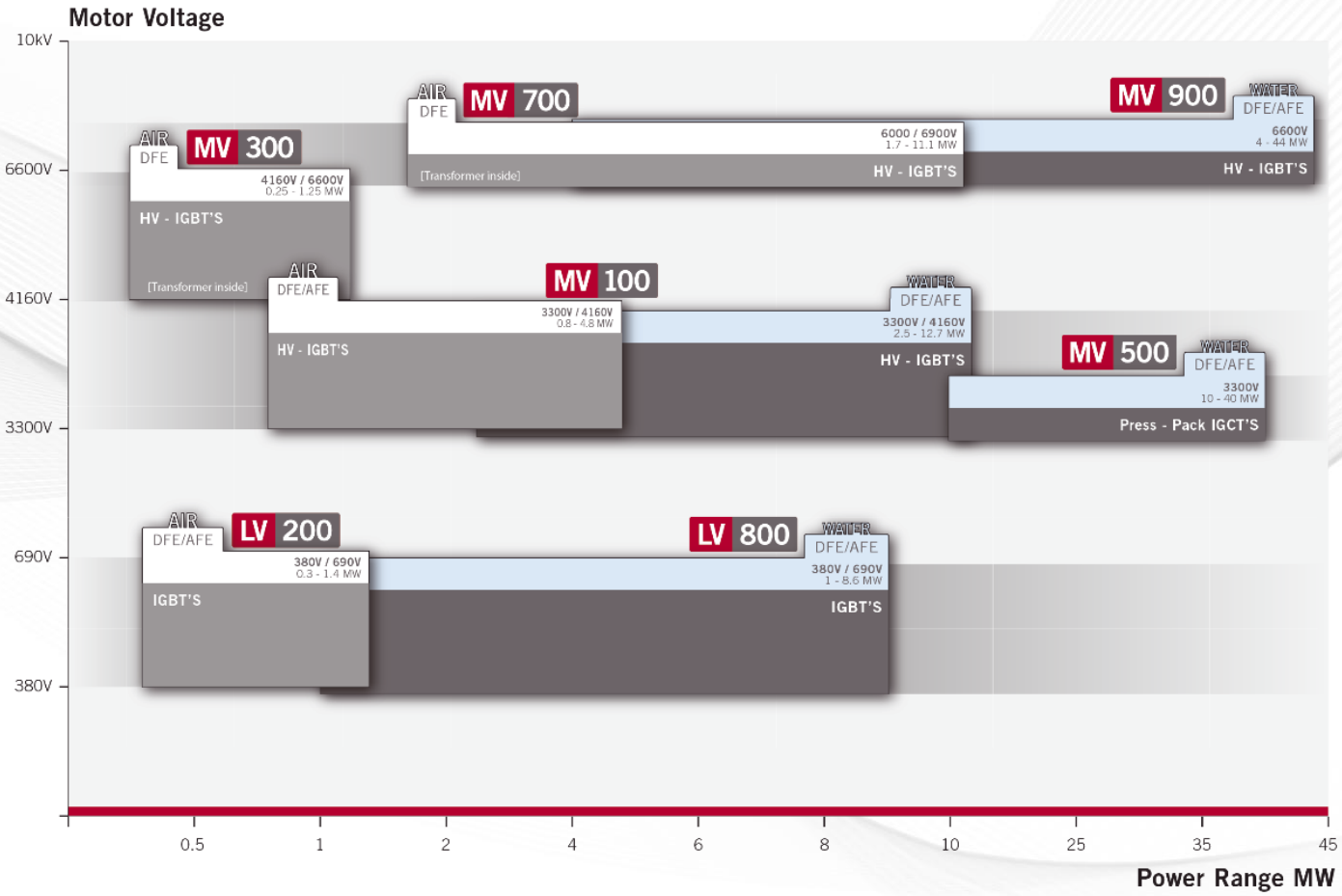
INGEDRIVE™ Variable Speed Drive
Low and Medium voltage, up to 44 MVA

Robust + Compact + Reliable

Easy Maintenance

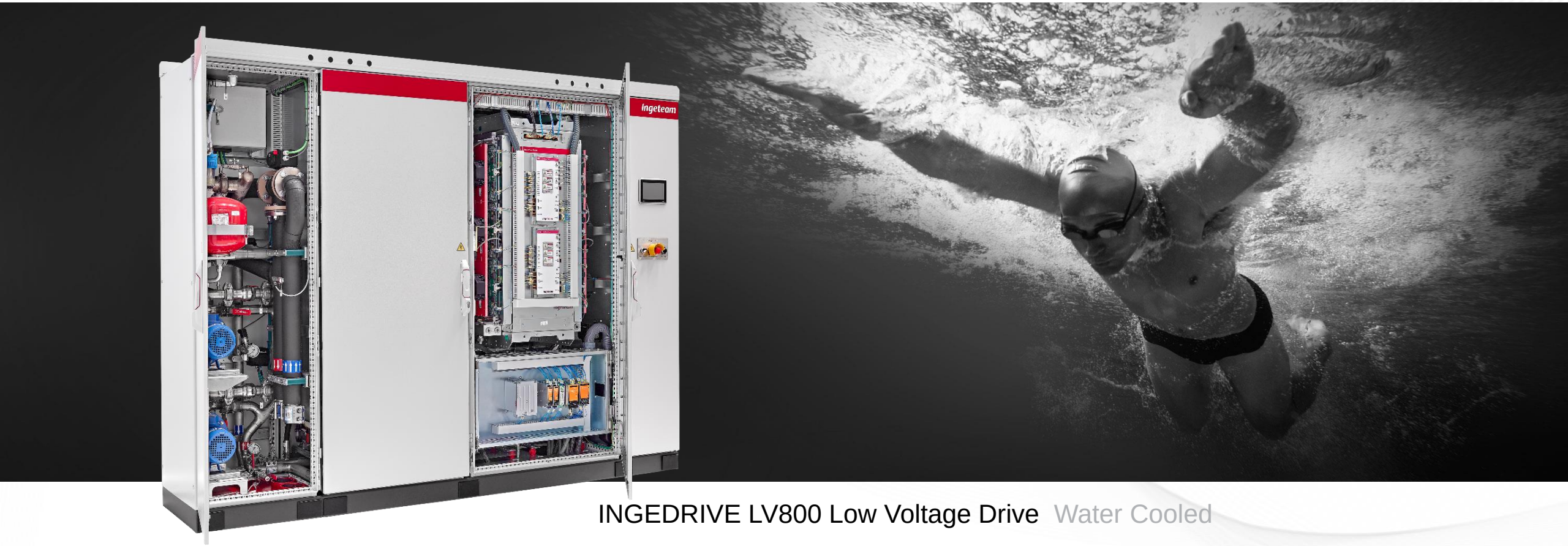
High Modularity

Based on IGBT



Source: Drives & Automation

INGEDRIVE™ LV800



INGEDRIVE LV800 Low Voltage Drive Water Cooled

1 - 9 MW / 400-690 V

INGEDRIVE™ LV800

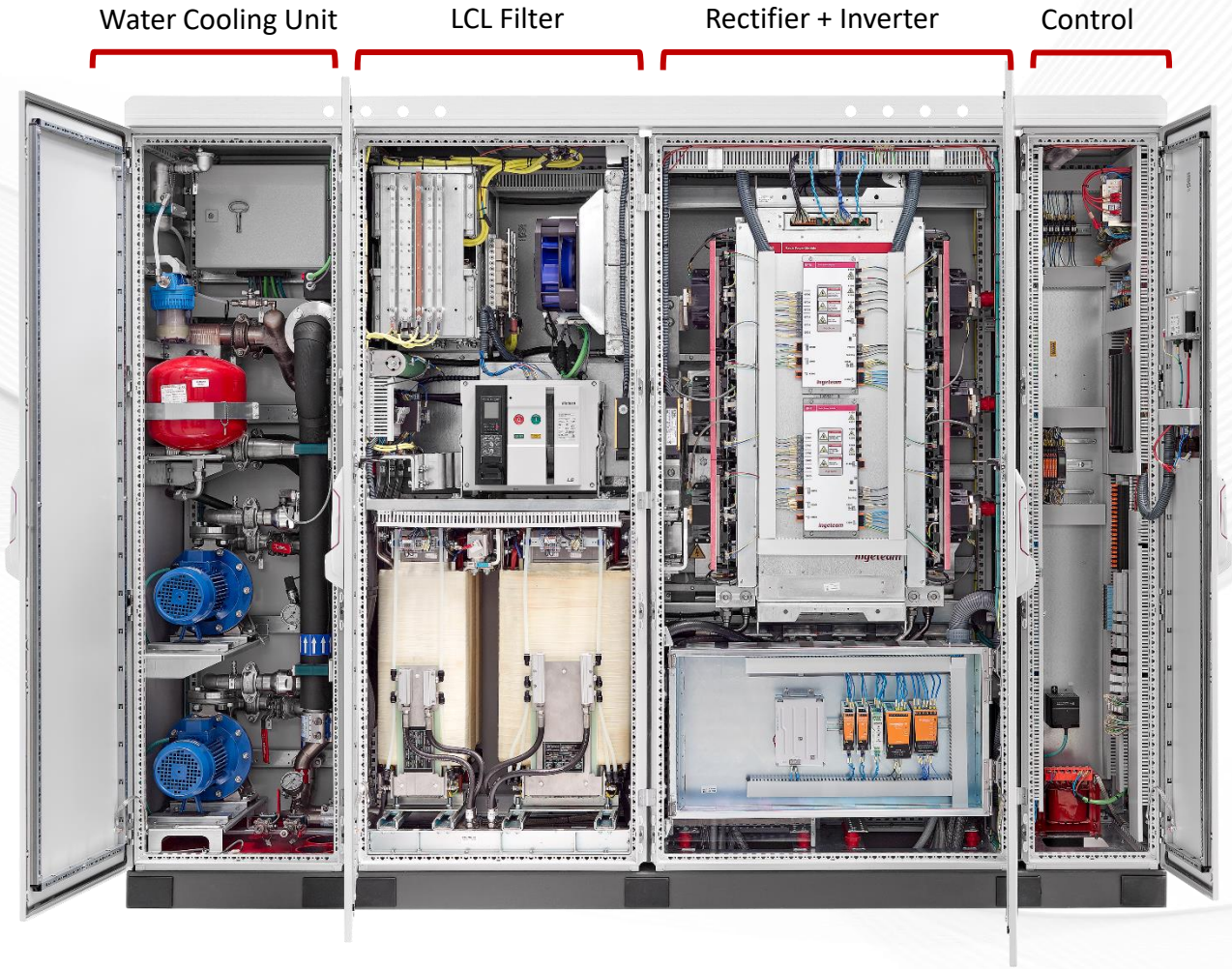
- Output Voltage: 400-690 V
- Power: 1 - 9 MW
- Rectifier: 6,12,18,24 Pulse or AFE (IGBTs)
- Topology: 2-level Voltage Source Inverter
- Water cooled

PS0801/2 – 1500A

- 2 IGBTs in parallel per phase
- "C" Power Stack
- 2 STD Combinations:
  - 1x → 1,790kVA
  - 2x → 3,585kVA

PS0803/4 – 2250A

- 3 IGBTs in parallel per phase
- "E" Power Stack
- 4 STD Combinations:
  - 1x → 2,690 kVA
  - 2x → 5,380 kVA
  - 3x → 8,060 kVA
  - 4x → 10,750 kVA



INGEDRIVE™ MV100

INGEDRIVE MV100 Medium Voltage Water Cooled

2500 to 12700 kW/ 3.3 to 4.16 kV

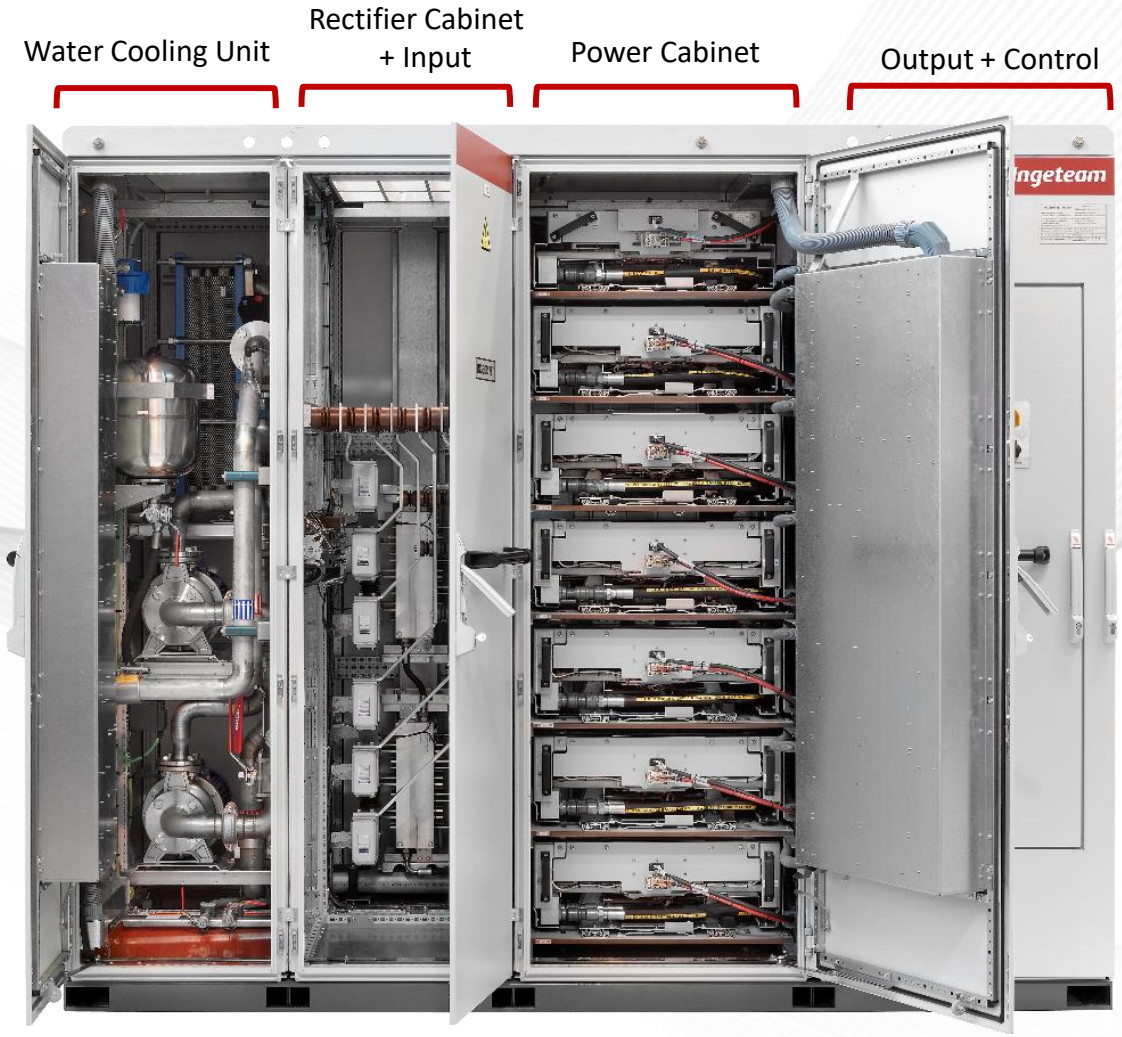
INGEDRIVE™ MV100

- Output Voltage: 3300V and 4160V.
- Power: 2500 to 12700 kW.
- Rectifier: 12,18,24, 36, 48 Pulse or AFE (IGBTs) transformerless.
- Topology: 3-level NPC Inverter.
- Water cooled.

✓ Electric quick connections

✓ Hydraulic quick couplings

withdrawable concept



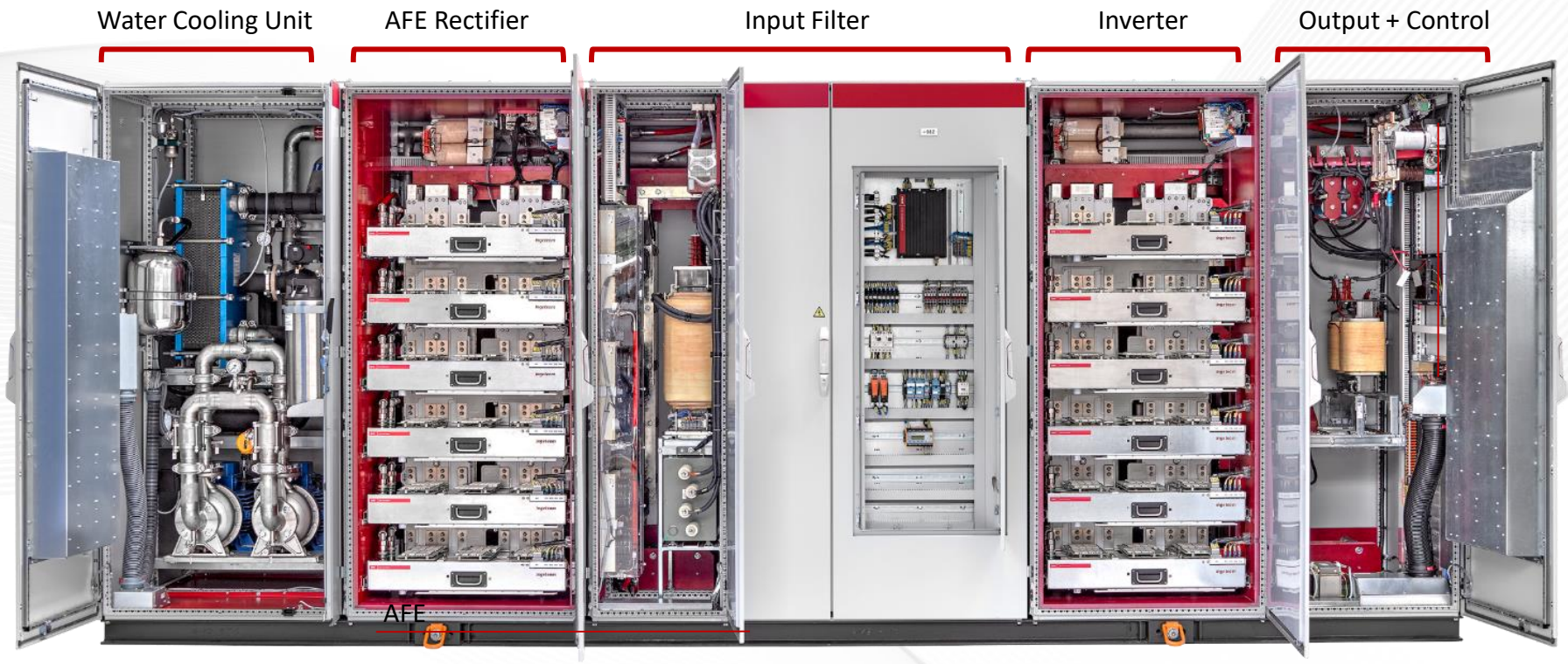
INGEDRIVE™ MV900

INGEDRIVE MV900 Medium Voltage Drive Water Cooled

4-44 MW / 6.6 kV

INGEDRIVE™ MV900

- Output Voltage: 6600 V
- Power: 4-44 MW
- Rectifier: 24 Pulse or AFE (HV-IGBTs)
- Topology: 3-level NPC Inverter
- Water cooled



11 MVA

Power Unit

7 Tn

Weight saving

Up to 7 Tn per unit, depending on configuration.

4.16 MVA/m³

Power Density

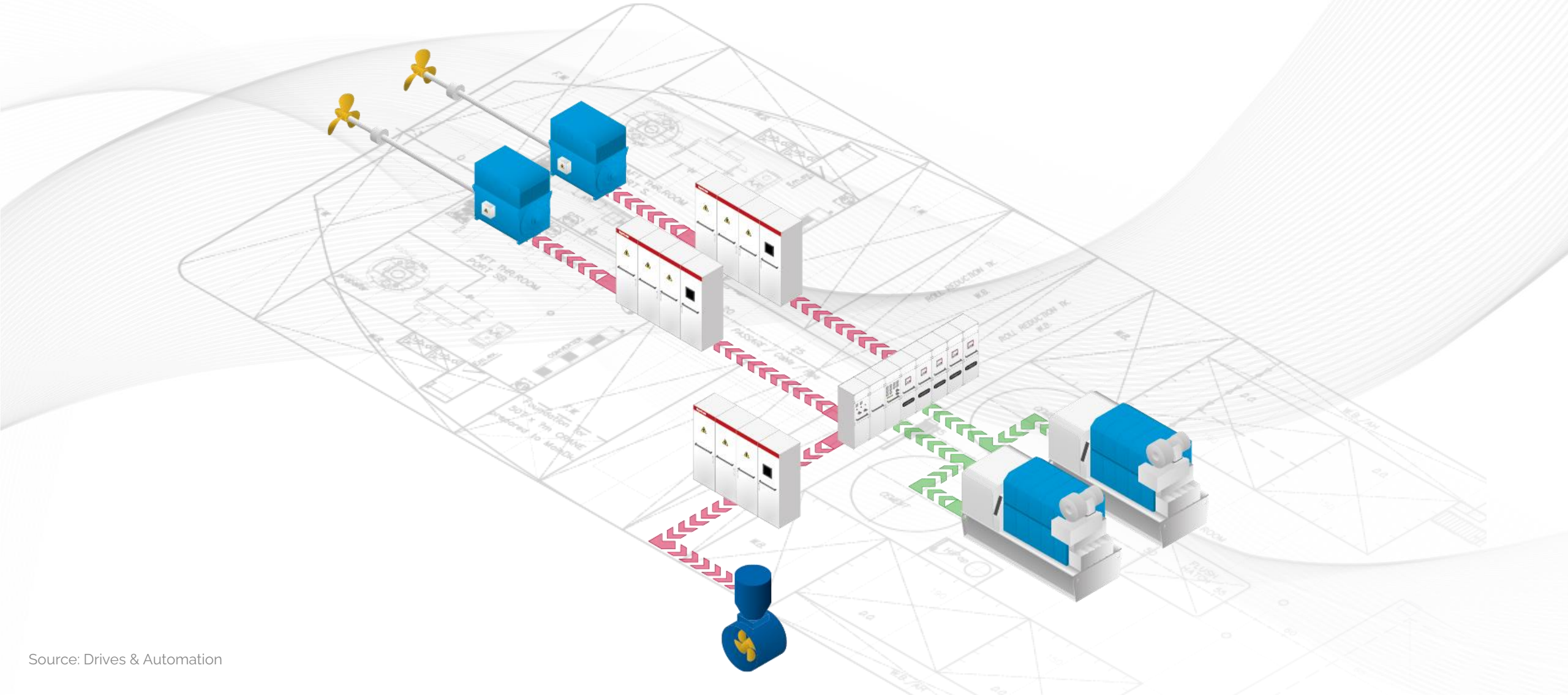
Of the power cabinet.

50 %

Space saving

Up to 50%, depending on configuration.

INGEDRIVE™
TOPOLOGIES - SINGLE DRIVE APPLICATIONS

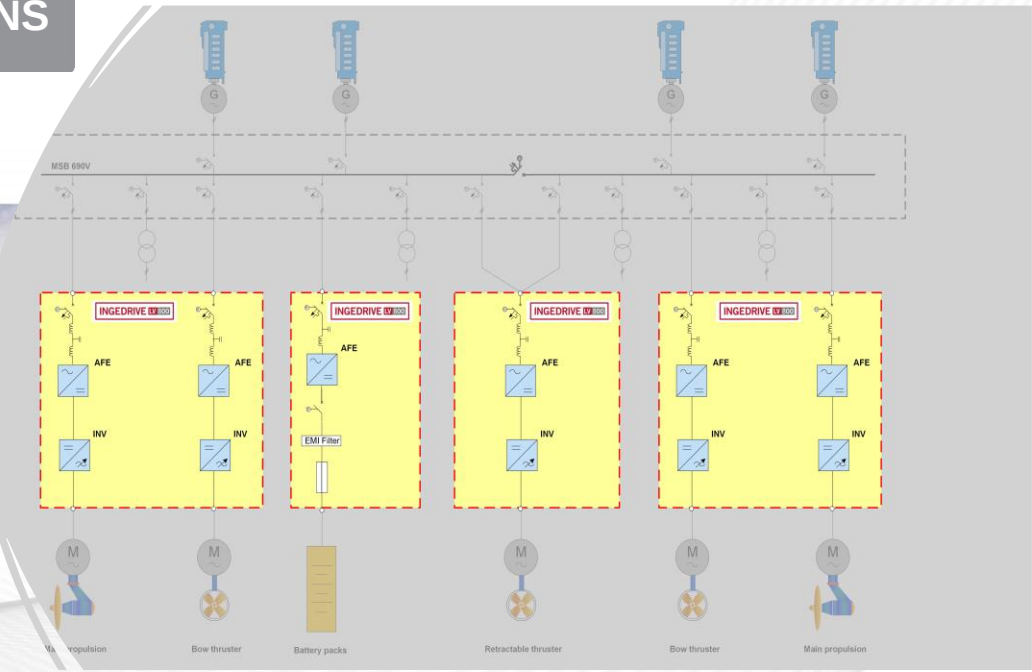


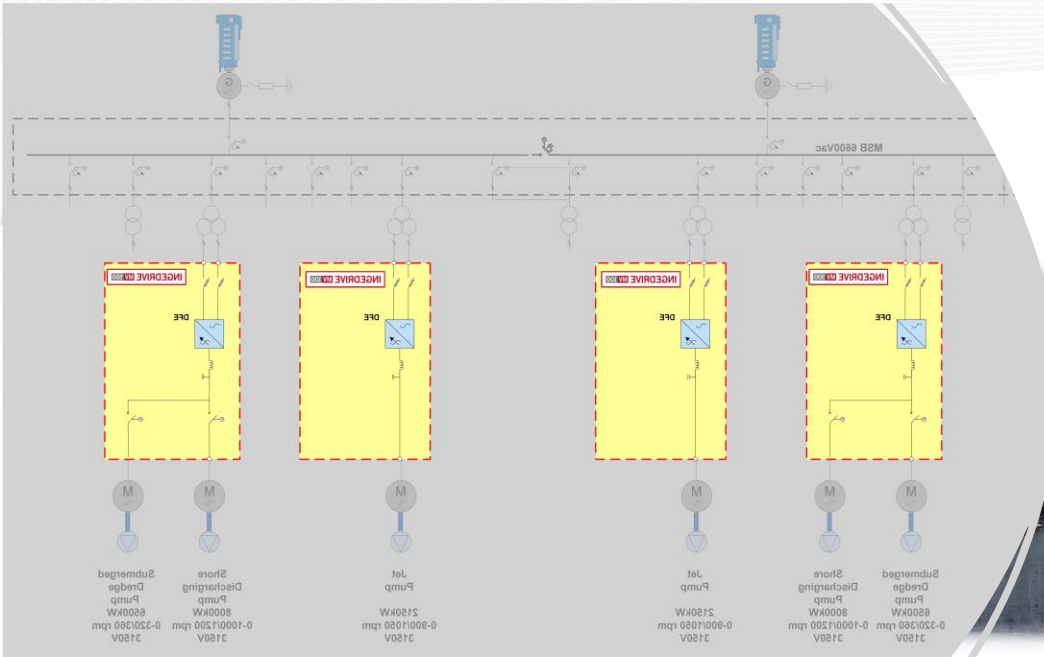
Source: Drives & Automation

CASE STUDY

SINGLE DRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• Two (2) Main Propulsions: AFE-INV: 1,500kW 690V (Induction) • Two (2) Tunnel Thrusters: AFE-INV: 1,500kW 690V (Induction) • One (1) Retractable Thruster: AFE-AFE-INV-SFC: 1,500kW 690V (Induction)
Functionalities:	Dual fed single retractable drive for open bustie DP2 operation
Highlights:	Ingedrive LV800 Grid Converter BESS onboard



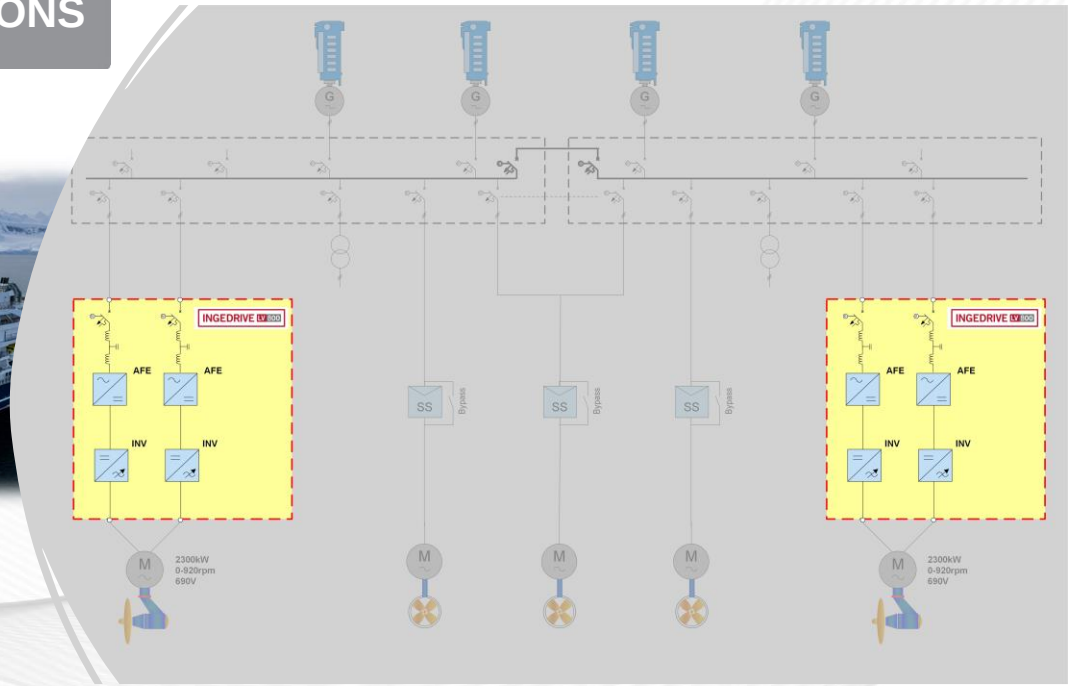


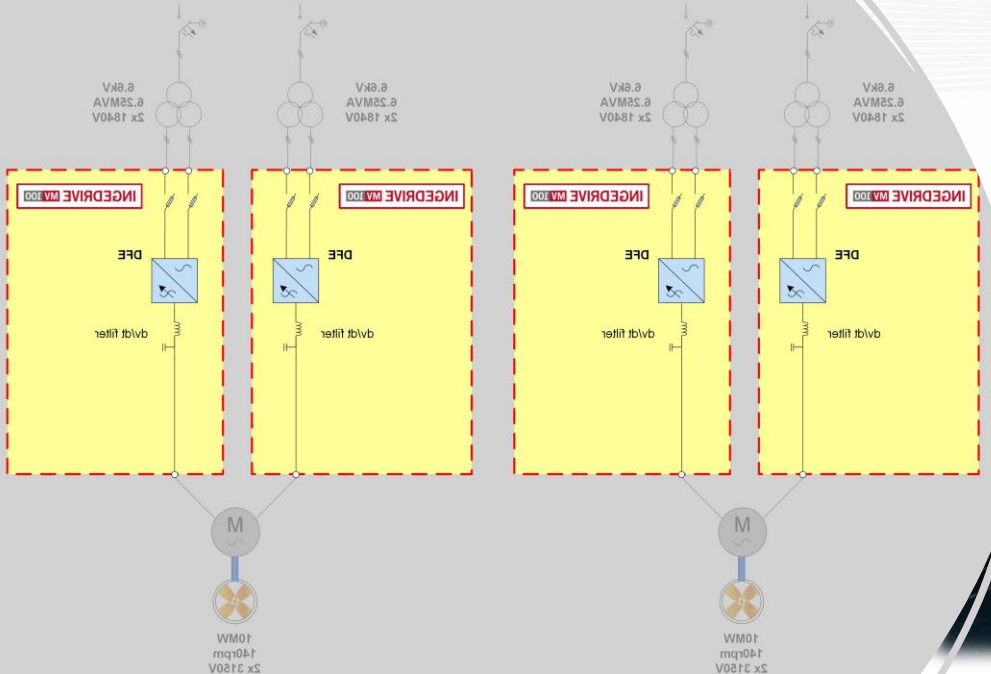
Ingedrive series:	MV500
Features:	• Two (2) Inboard & Submerged Pumps: 12P DFE-INV: 8,000kW 3,150V (Induction) dVdt filter, Dynamic braking chopper, Changeover switch • Two (2) Jet Pumps: 12P DFE-INV: 2,150kW 3,150V (Induction) dVdt filter, Dynamic breaking chopper
Functionalities:	Dual motor changeover system

CASE STUDY

SINGLE DRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• Two (2) Main Propulsions: AFE-INV: 2 x 1,150kW 690V (Induction) Dynamic braking chopper, Sine filter, Output contactor
Functionalities:	Master – Slave configuration (tandem propulsion)
Highlights:	Redundancy design for half power operation



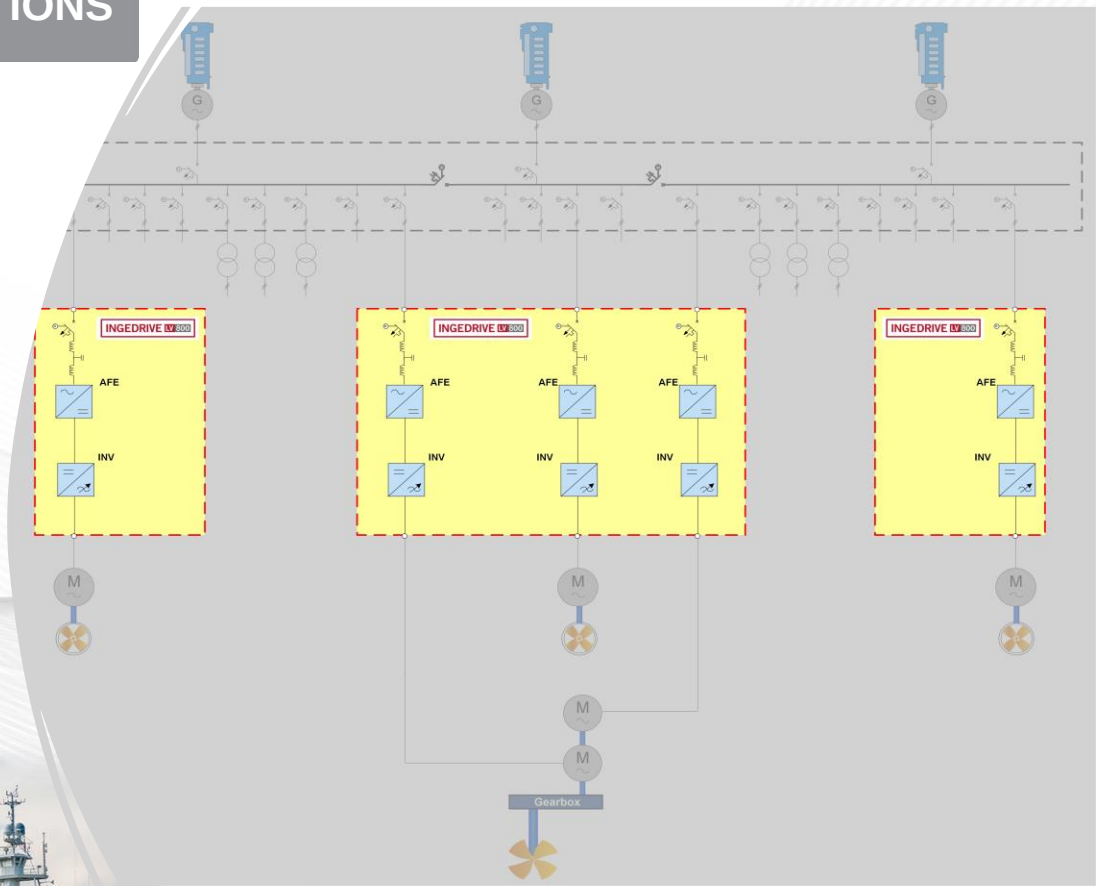


Ingedrive series:	MV100W
Features:	• Two (2) Main Propulsions: 12P DFE-INV: 10,120kW 3,150V (Dual winding induction) Brake chopper, Arc flash detection, Output switch
Functionalities:	Dual winding motor functionality
Highlights:	Redundancy design for half power operation

CASE STUDY

SINGLE DRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• One (1) Main Propulsion: AFE-INV: 2 x 1,500kW 690V (Induction) Sine filter • Two (2) Tunnel Thrusters: AFE-INV: 600 kW 690V (Induction) • One (1) Retractable Thruster: AFE-INV: 800 kW 690V (Induction)
Functionalities:	Master – Slave configuration (tandem propulsion)
Highlights:	ICES 209 Underwater noise standard

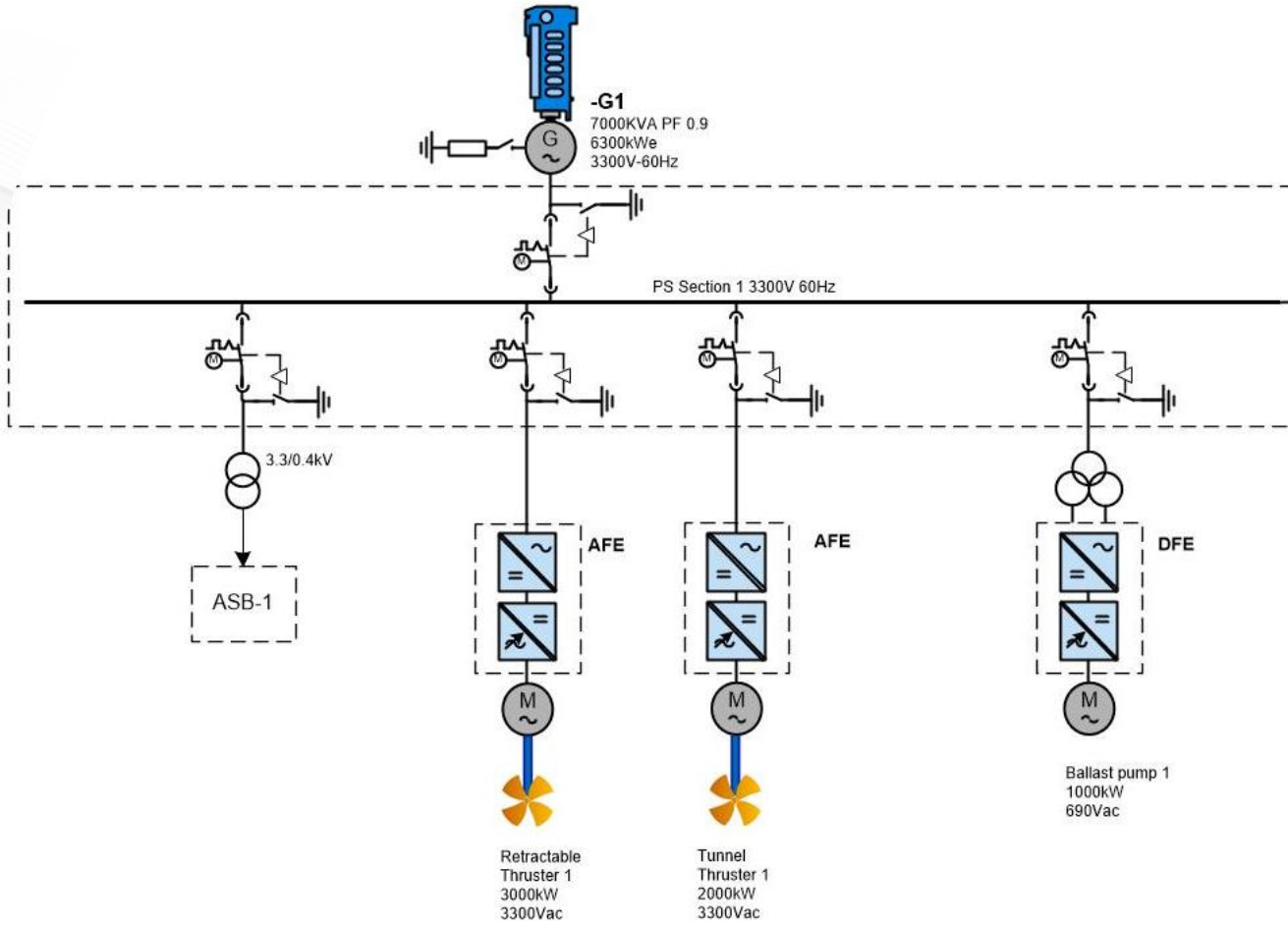


Source: Drives & Automation

CASE STUDY

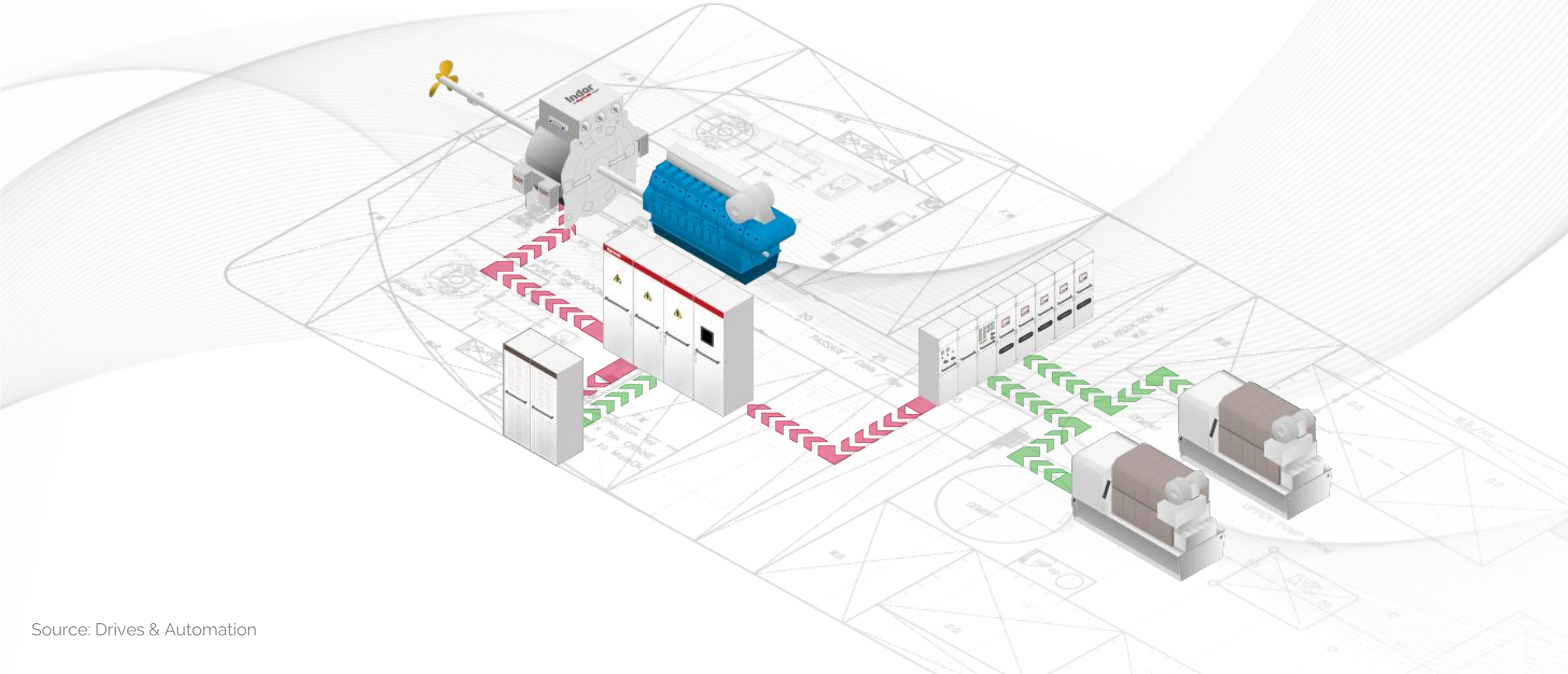
SINGLE DRIVE APPLICATIONS

Ingedrive series:	MV100
Features:	• One (1) Main Propulsion: AFE-INV: 3000kW 3.3kV • One (1) Tunnel Thruster: AFE-INV: 2000 kW 3.3kV • One (1) Ballast pump: DFE-INV: 1000 kW 690V
Highlights:	3.3kV transformerless → increased efficiency, reduced weight and space.



Source: Drives & Automation

INGEDRIVE™
TOPOLOGIES - POWER TAKE IN / POWER TAKE OFF

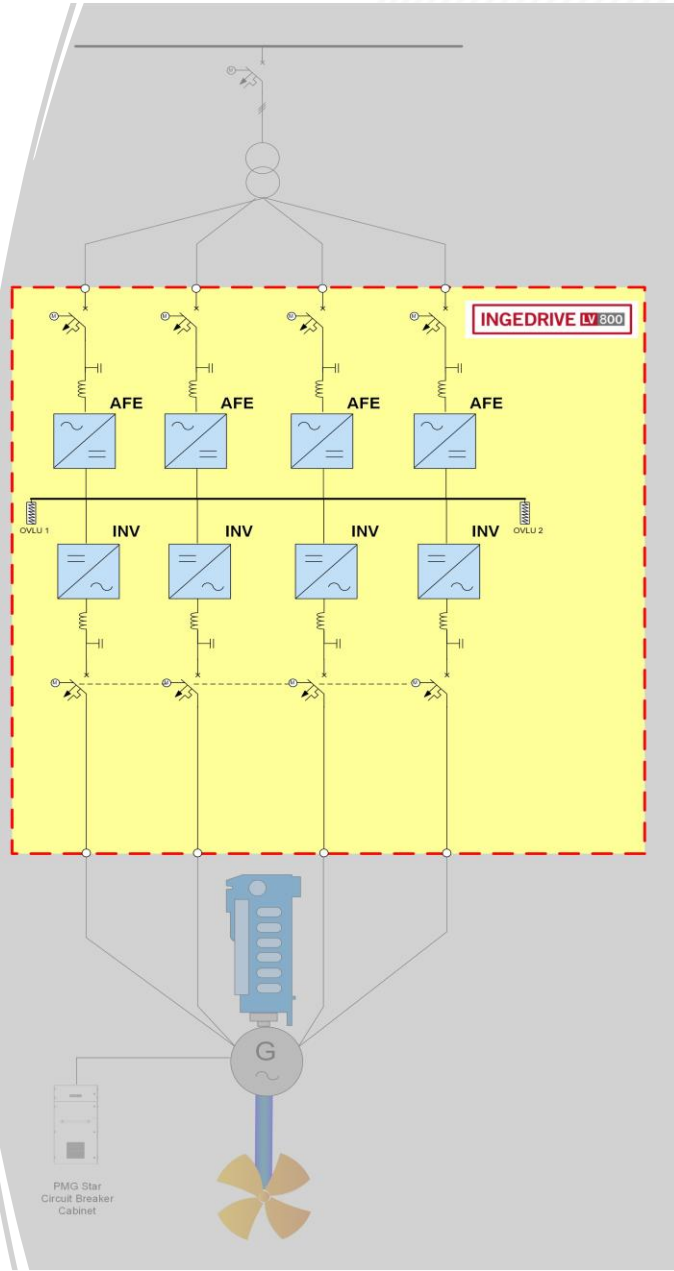


Source: Drives & Automation

CASE STUDY

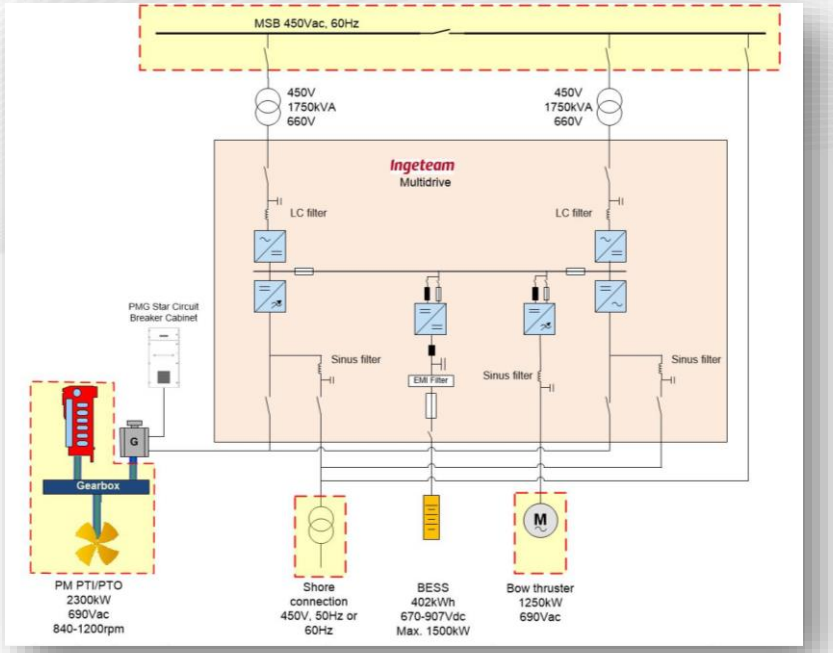
Hybrid PTO / PTI / PTH

Ingedrive series:	LV800
Features:	• PTO Converter: 4,950 kW 690V (SC current 8,800A @2sec) Output dVdt Filter Output switch and Overvoltage limiter unit for dual winding Permanent Magnet Shaft Generator
Functionalities:	PTO and PTI Boost operation modes
Ingedrive series:	LV800

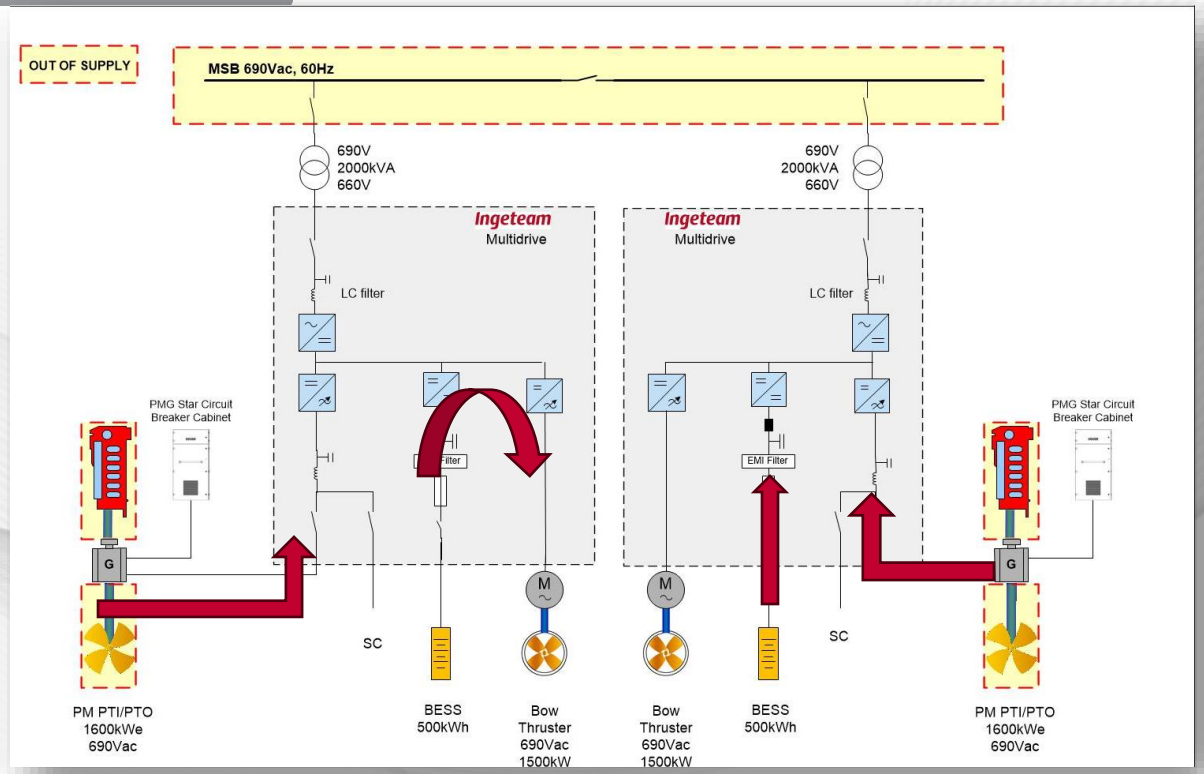


CASE STUDY

Hybrid PTO / PTI / PTH



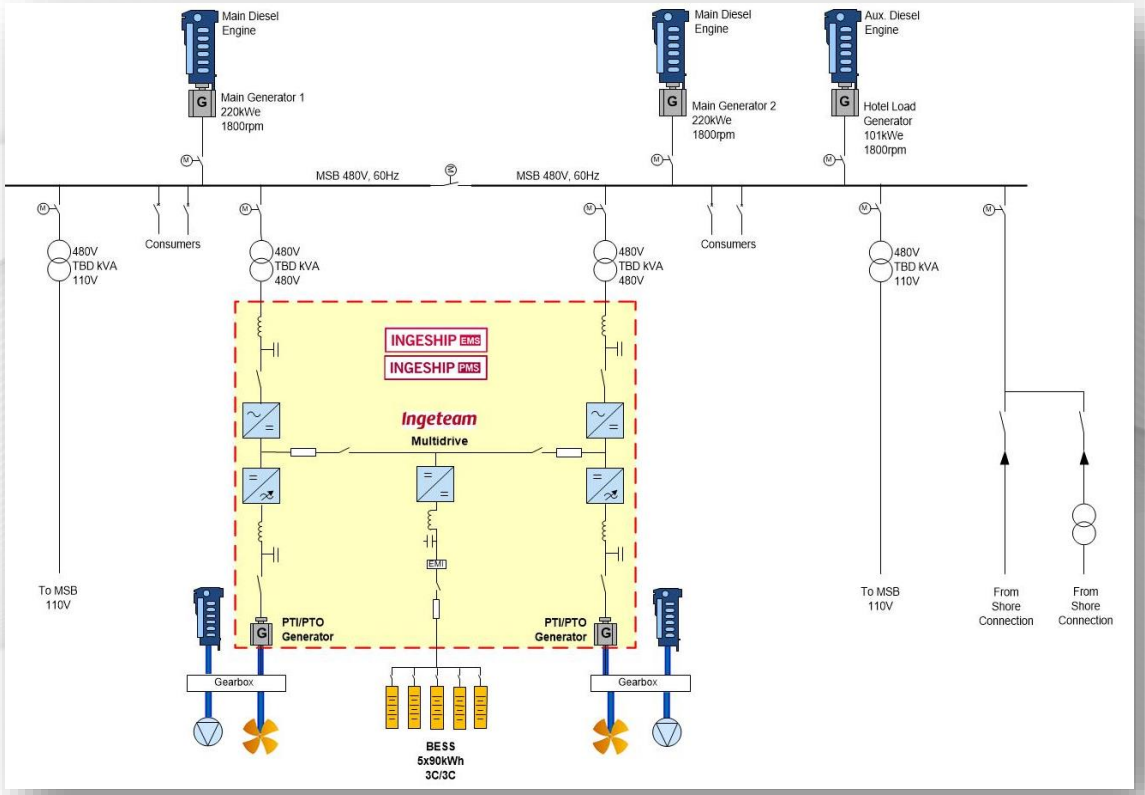
Source: Drives & Automation



Ingedrive series:	LV800
Features:	• PTO Multidrive: Redundant inverter and rectifier PTO: 2,300kW 690V (Short Circuit 4,400A @2sec) INV: 1,250kW 690V (Output Sinus Filter) DCC: 1,600A (DC/DC with EMI Filter and battery precharge) Shore connection Excitation and Overvoltage limiter unit Synchronous Shaft Generator
Functionalities:	Peak shaving and Spinning Reserve (black-out recovery)

CASE STUDY

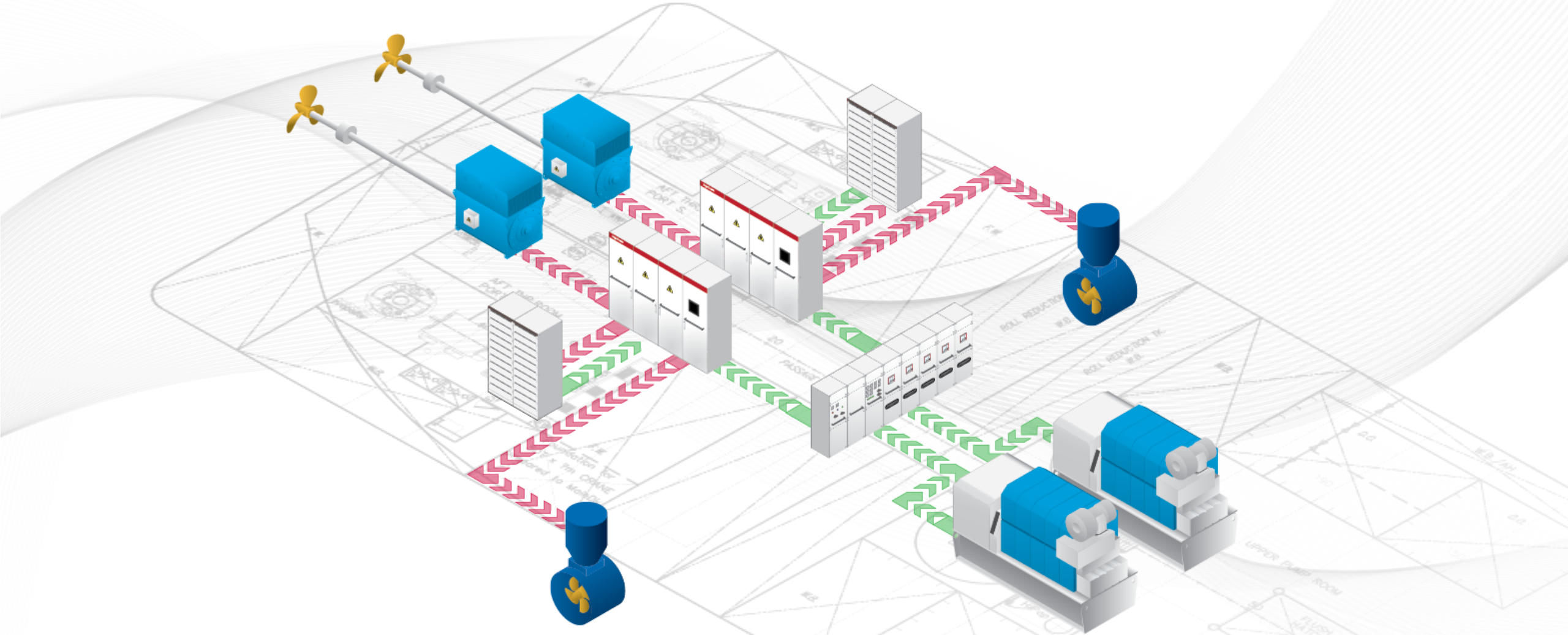
Hybrid PTO / PTI / PTH



Ingedrive series:	LV800
Features:	PTO/PTI Multidrive: Redundant inverter and rectifier DCC: 1,600A (DC/DC with EMI Filter and battery precharge)
Functionalities:	Peak shaving and Spinning Reserve (black-out recovery). Full Electric operation during transits. PTI booster during pulling.

Source: Drives & Automation

INGEDRIVE™
TOPOLOGIES - MULTIDRIVE



Source: Drives & Automation

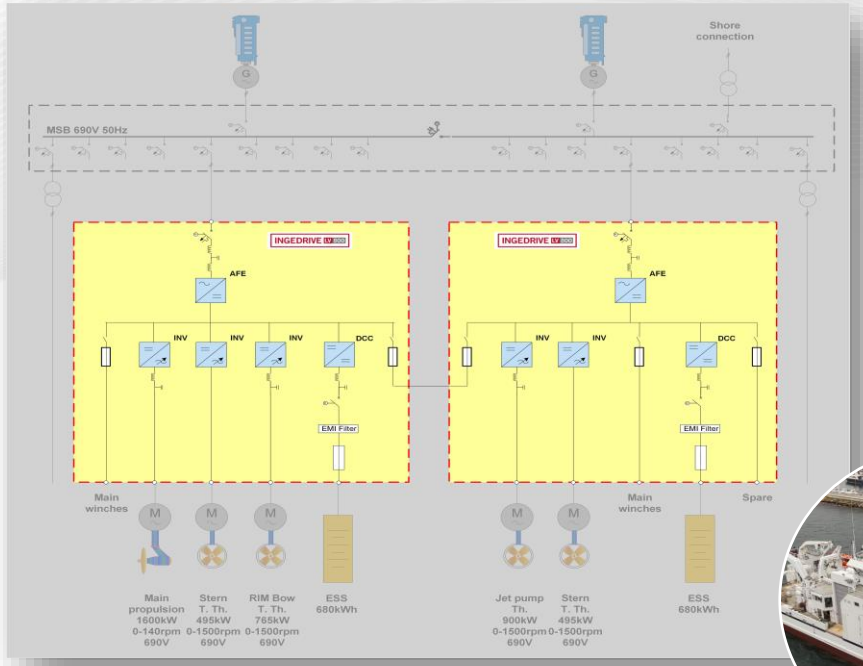
CASE STUDY

MULTIDRIVE APPLICATIONS

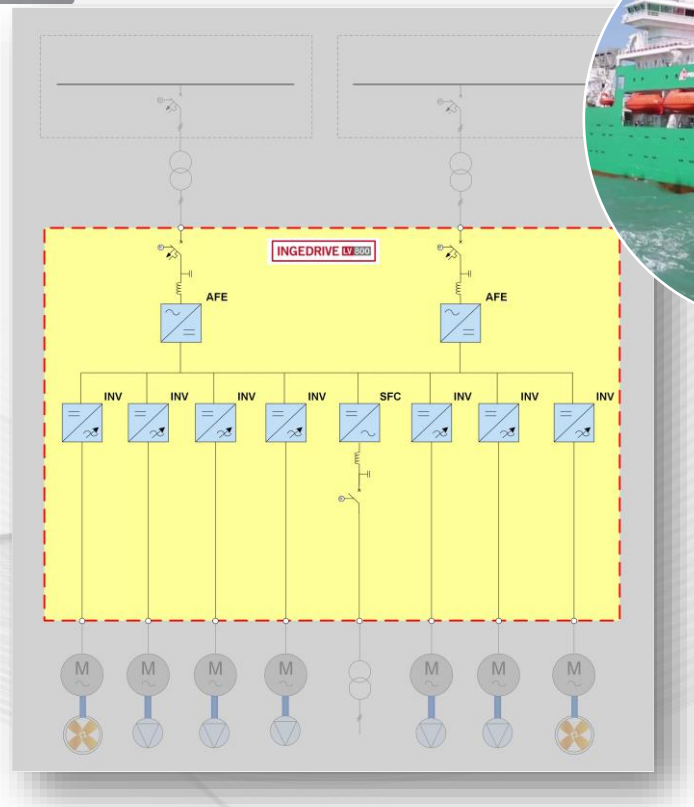
Ingedrive series: LV800

Features:

- Two (2) Multidrive:
AFE 2,250A 690V (LCL Filter)
DCC: 2,500A 800-1050V (DC Filter)
INV (Main propulsion): 1600kW 690V Sine filter (Induction)
INV (Stern tunnel thruster): 500kW 690V (Induction)
INV (Bow tunnel thruster): 765kW 690V dVdt filter (Induction)



Source: Drives & Automation



Ingedrive series: LV800

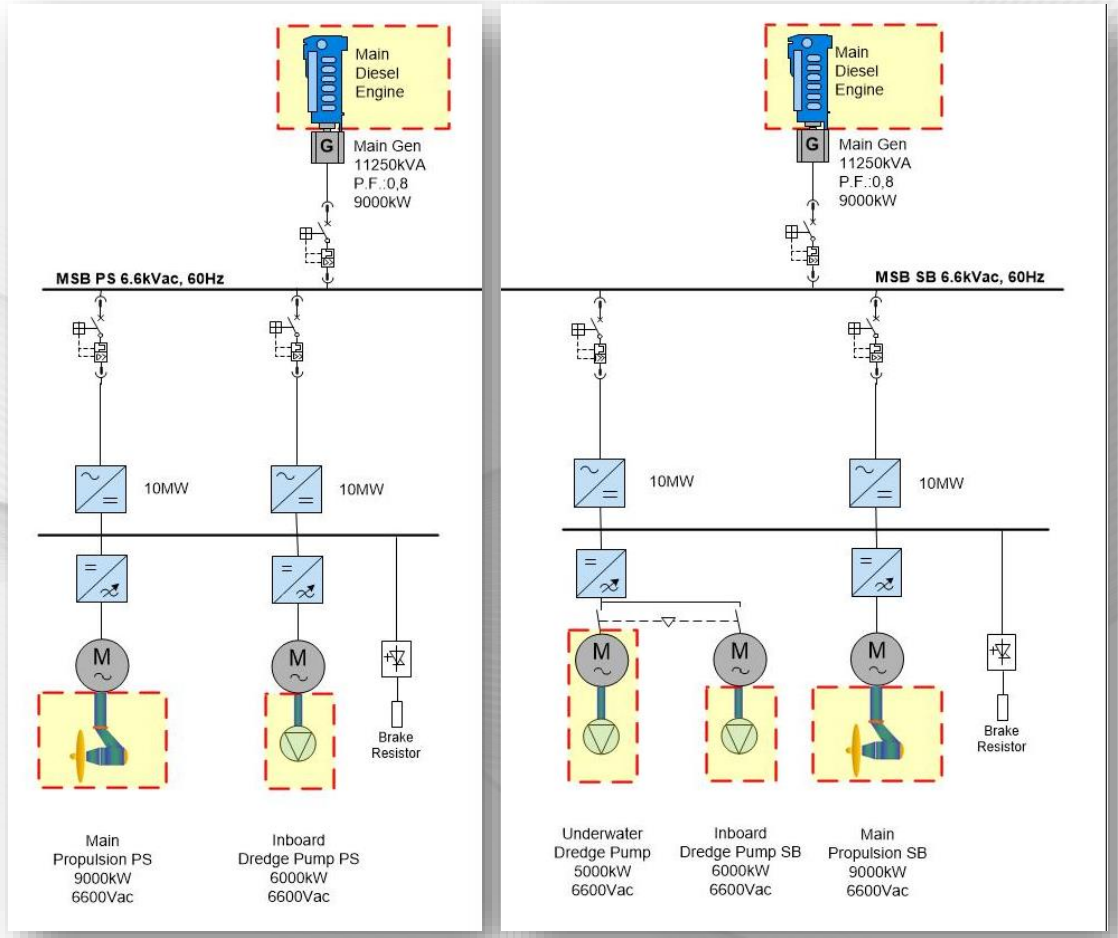
Features:

- One (1) Multidrive:
Two (2) AFE 2,500kW 690V
LCL Sine filter
- Two (2) Thrusters 600kW 690V (Induction)
- One (1) Static Frequency Converter 1,020kVA 660V
Sine filter, Output contactor
- Two (2) Jet pumps 1,100kW 690V (Induction)
- Three (3) Hydraulic pumps 225kW 690V (Induction)

CASE STUDY

MULTIDRIVE APPLICATIONS

Ingedrive series:	MV900
Features:	• Two (2) Multidrive: 6,6kV 2xAFE 10MW, 1xINV 9MW for Main Propulsion, 2x6MW Dredge Pump • Two (2) Multidrive: 6,6kV 2xAFE 10MW, 1xINV 9MW for Main Propulsion, 2x6MW Dredge Pump & change-over for Under Water Pump



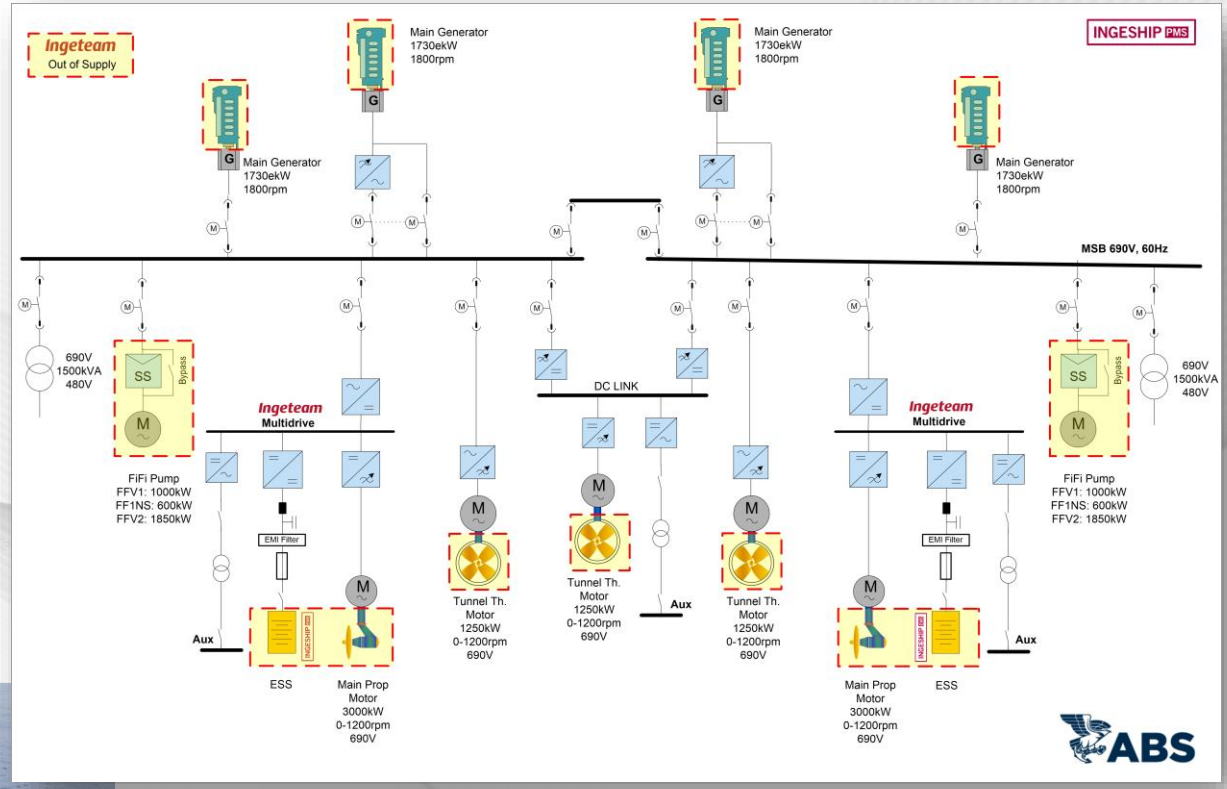
INGEDRIVE MV900 6.6 kV Medium Voltage Drive

Source: Drives & Automation

CASE STUDY

MULTIDRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• Two (2) Main Propulsions AFE-INV-DCC-SFC:3000kW • One (1) dual feed AFE-INV for Retractable Thruster: 1,200kW 690V (Induction) • Two (2) 1,250kW Tunnel Thrusters
Functionalities:	Spinning Reserve, Peak Shaving, Engine Smoothening
Highlights:	4x Thrusters available on WCFDI

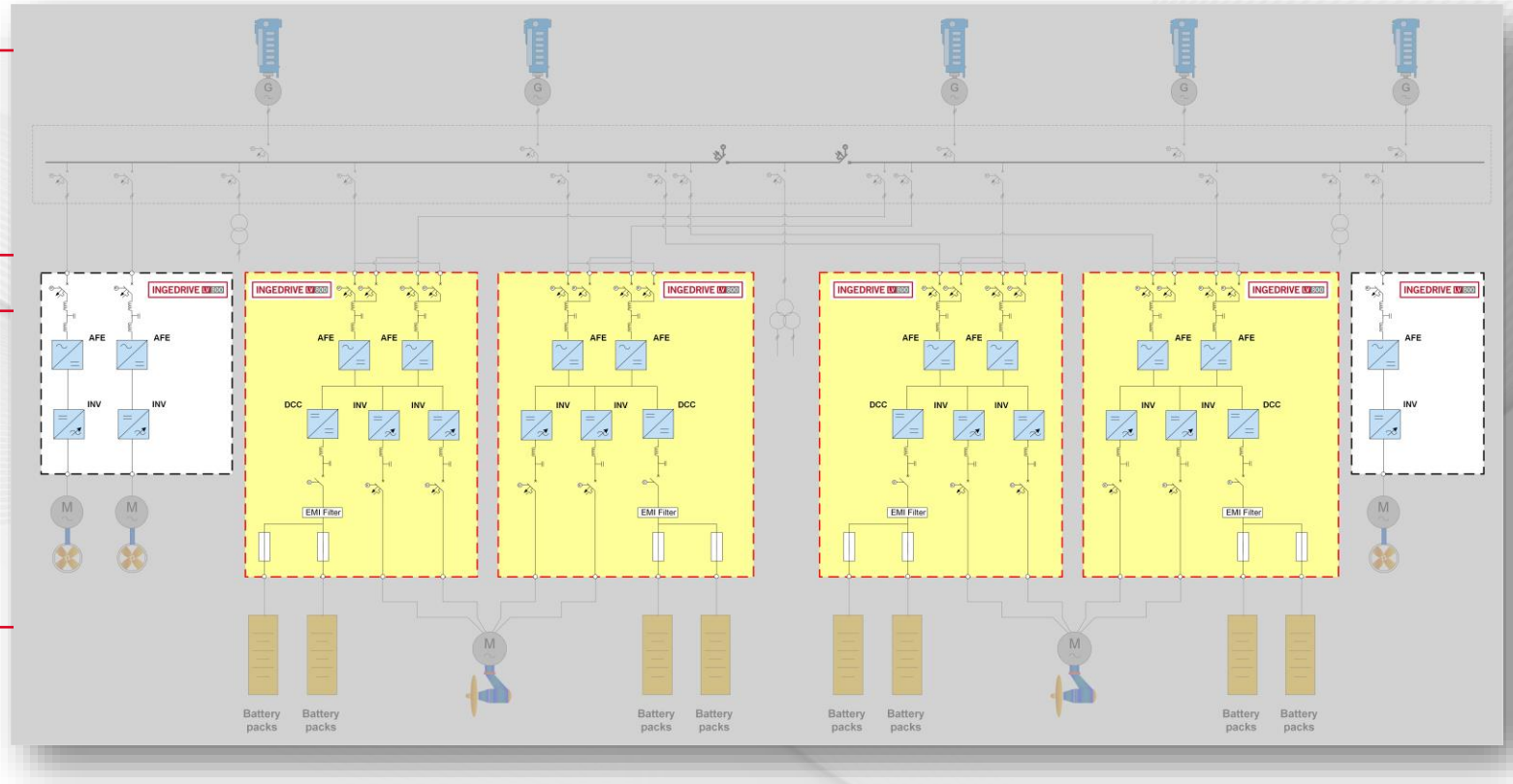


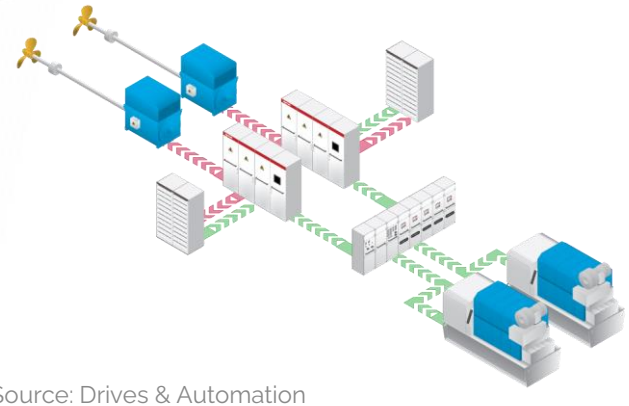
CASE STUDY

MULTIDRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• Two (2) Main Propulsions: AFE-INV-DCC: 5,500kW 690V (Permanent Magnet) Sine filter, Overvoltage limiter unit, Output switch • Three (3) Tunnel Thrusters: AFE-INV: 1,500kW 690V (Induction)
Functionalities:	Hybrid Electric Propulsion System (HEPS)

Highlights:	POD propeller
	6 Levels redundancy
	- MSB sections
	- Converter 1&2
	  - AFE rectifier
	  - AFE inverter
	- Dual winding motor
	- BESS



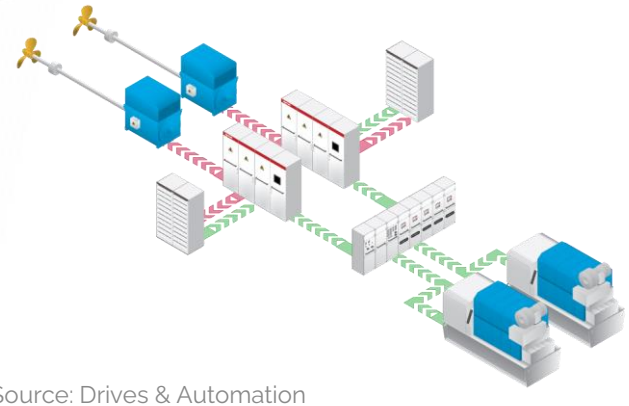


Source: Drives & Automation

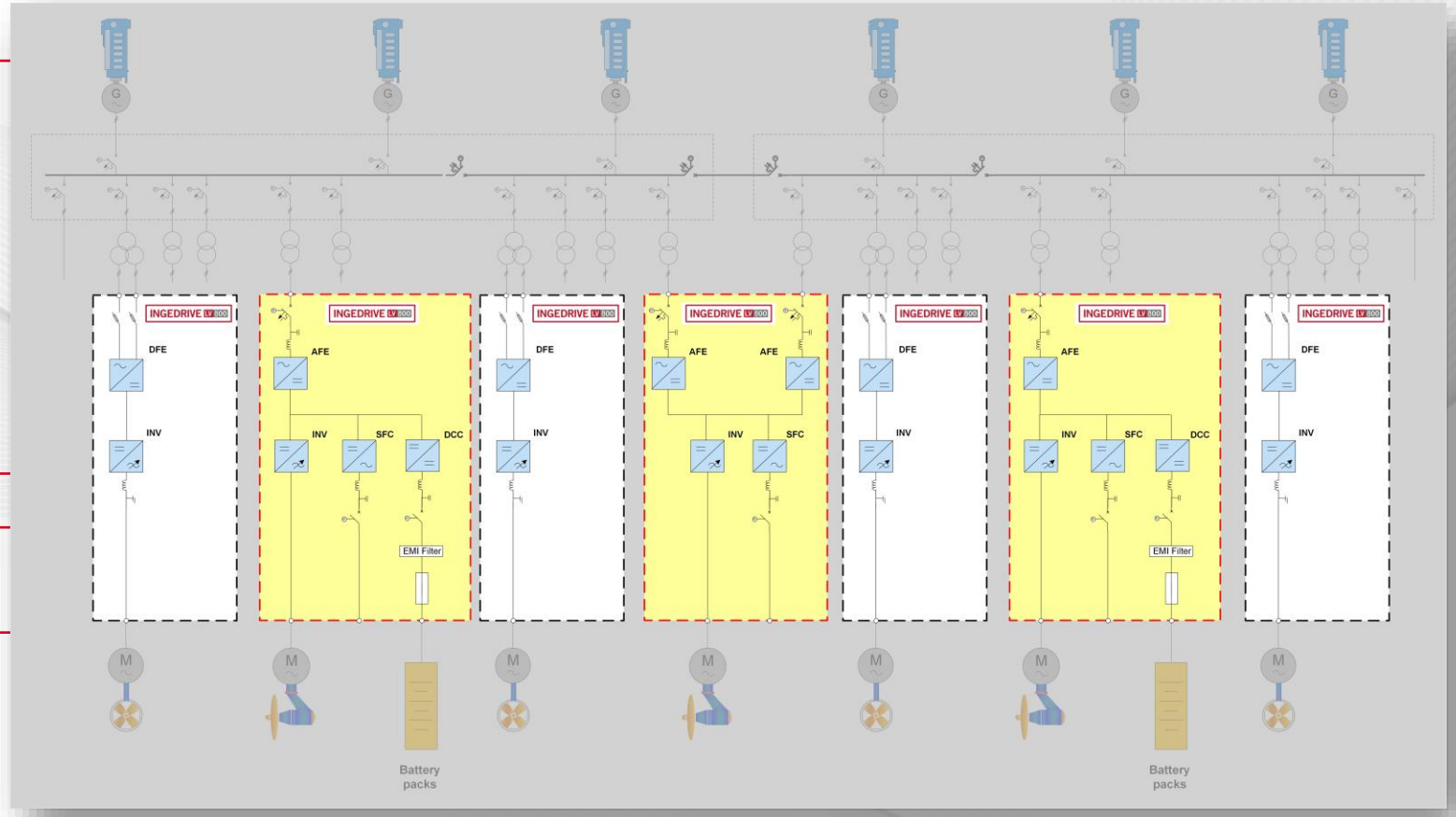
CASE STUDY

MULTIDRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• One (1) Main Propulsion: AFE-AFE-INV-SFC: 3,200kW 690V (Permanent Magnet) Sine filter, Overvoltage limiter unit, Output switch • Two (2) Retractable Thrusters: AFE-INV-DCC: 2,400kW 690V (Induction) • Two (2) Main Propulsions: 12P DFE-INV: 3,200kW 690V (Permanent Magnet) Sine filter, Overvoltage limit uniter, Output switch • Two (2) Tunnel Thrusters: 12P DFE-INV: 2,500kW 690V (Induction)
Functionalities:	Hybrid Electric Propulsion System (HEPS)
Highlights:	POD propeller WCFDI: loss of 1 thruster



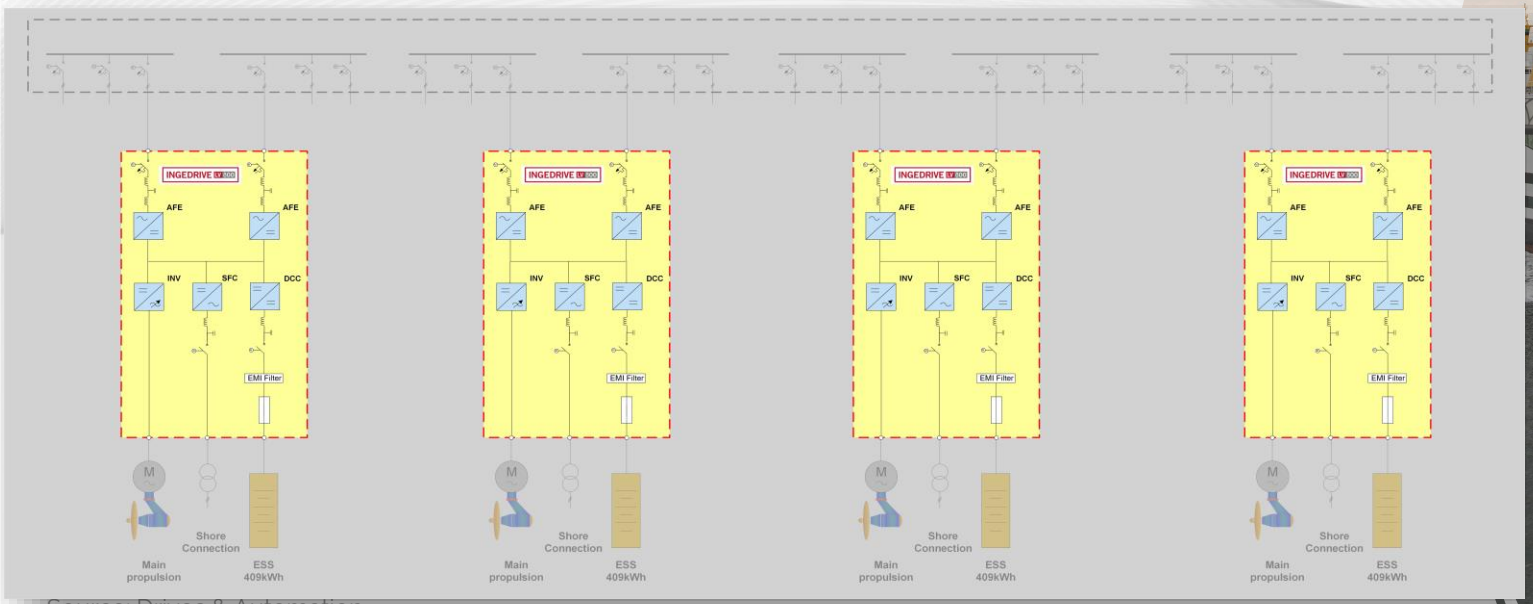
Source: Drives & Automation



CASE STUDY

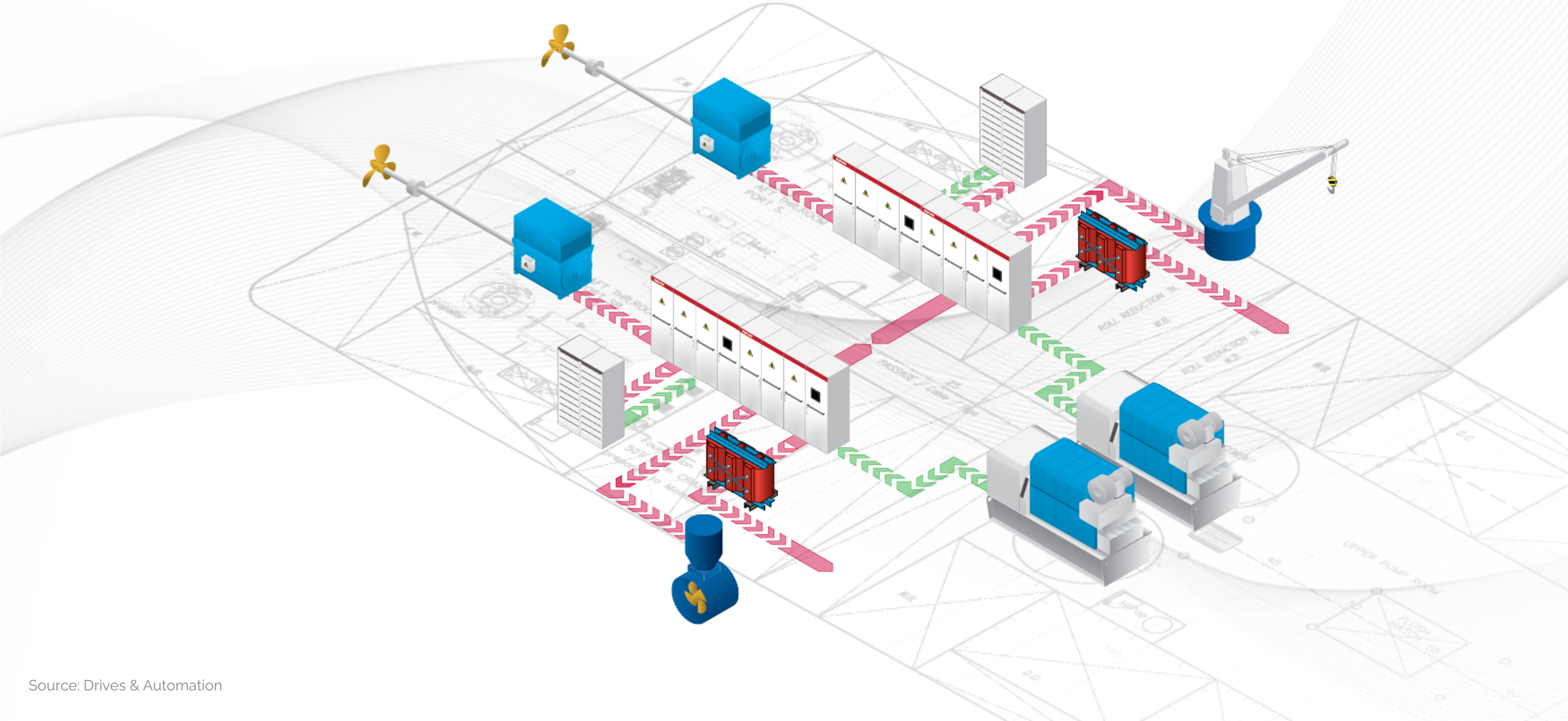
MULTIDRIVE APPLICATIONS

Ingedrive series:	LV800
Features:	• Four (4) Main Propulsions: AFE-INV-DCC-SFC: 1,800kW 690V (Induction) Shore connection, Sine filter
Functionalities:	Hybrid Electric Propulsion System (HEPS) with Shore Connection at port
Highlights:	4 x 409kW/h Batteries In operation since year 2016



Source: Drives & Automation

INGEDRIVE™
TOPOLOGIES - DC GRID



Source: Drives & Automation

INGEDRIVE™ DC GRID
Technology

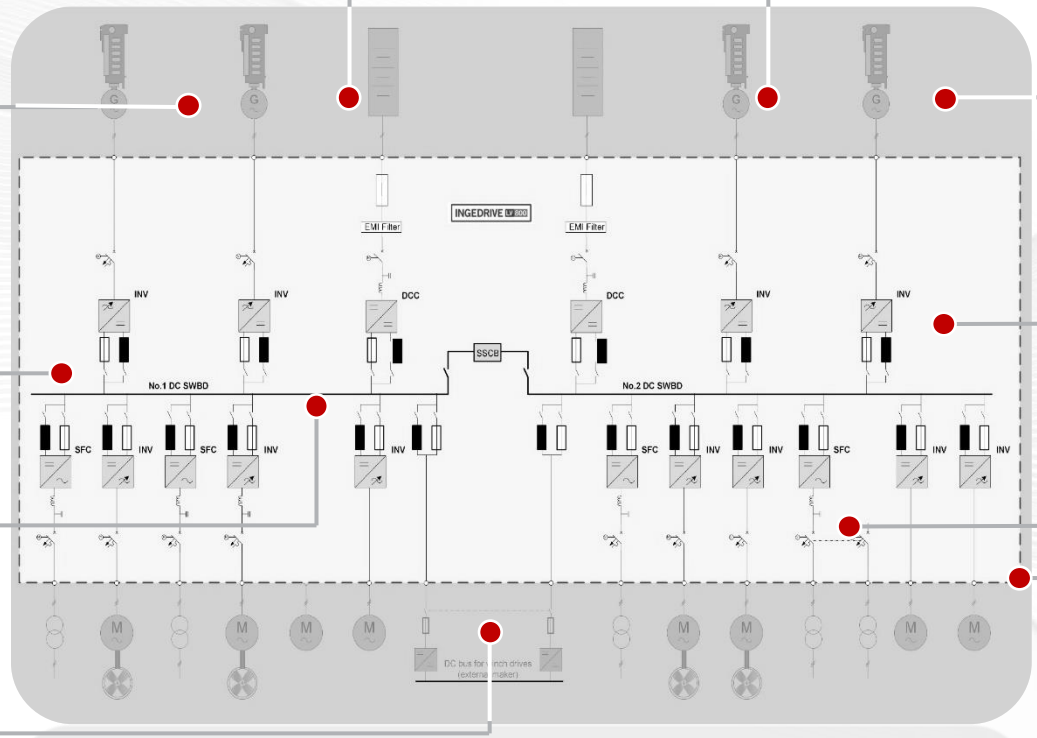
Energy storage
- Batteries and fuel cells

No synchronizing
- Generators and bus tie

Future new energy sources
- Easy expandable system

Shore DC charging
- Fast power for batteries

Dual fed redundancy
- Motors and supplies



Variable Speed Generators
- Fuel saving

Smaller footprint
- High power density

High efficiency
- Less power conversion

50/60 Hz Shore connection
- No synchronizing

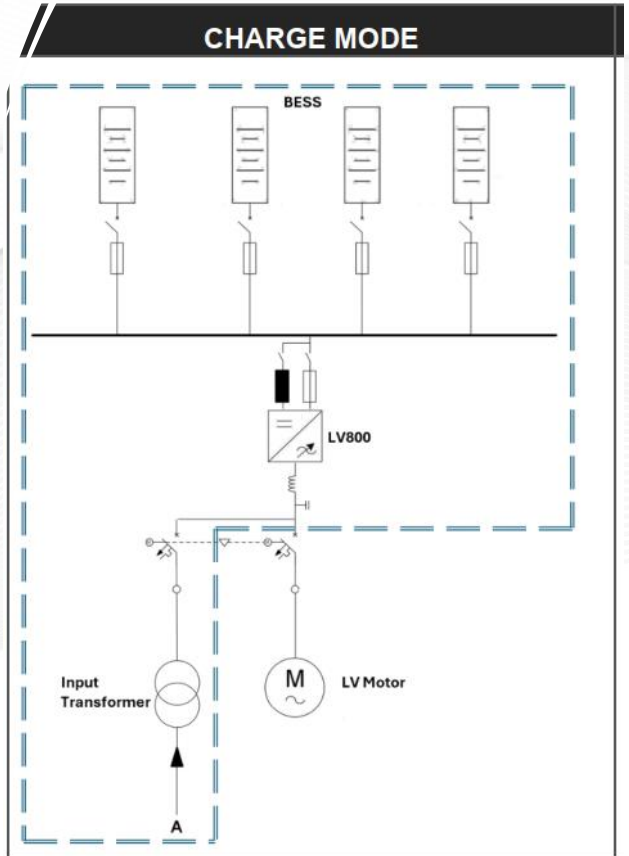
Unique distribution capability
- All systems in one

INGEDRIVE™ MEDIUM VOLTAGE - DC GRID
Fast Chage of High Powers

Requirements:

- ***Speed: 35 – 40 knot***
- ***Energy: 35 – 40 MWh***
- ***Power: 55 – 60 MW***
- ***Charging time: 30 min***
- ***Lightship***
- ***Highest Efficiency***

INGEDRIVE™ MEDIUM VOLTAGE - DC GRID
Fast Chage of High Powers



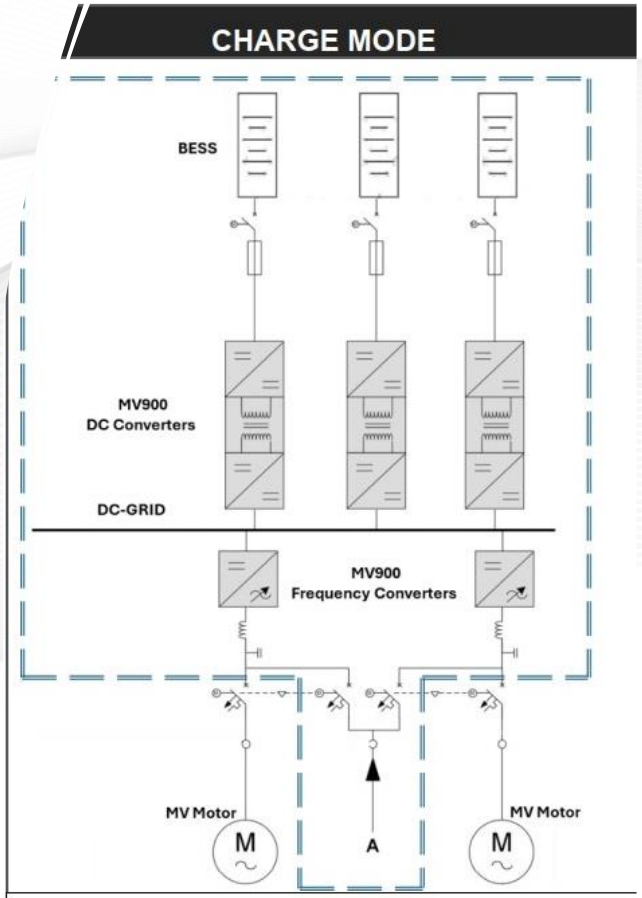
In this mode of operation, the elements involved in the energy transfer are:
- Port network, connections and switchboards, A (*)
- Input Transformer
- LV800 - AC/DC mode
- BESS (*)

- On AC topology, the connection from the ship to the port is made at max 15kVac/50Hz and by means of transformers the voltage is reduced to 660Vac. From this low voltage, Ingedrive LV800 units working as AC/DC converters charge the battery strings.
- For navigation, Ingedrive LV800 units working as DC/AC converters supply the propulsion low voltage motors from the batteries.
- Current levels above 6000A, 1 transformer per motor.

PARAMETER	Units	Value
Rated Power	kVA	7000
Rated Voltage (primary/secondary)	V	15000/660
Efficiency (full load)	%	99.18
Weight	kg	12500
Dimensions L/H/W	mm	3500/3300/1600

Table 8: : Main characteristics of input transformer

INGEDRIVE™ MEDIUM VOLTAGE - DC GRID
Fast Chage of High Powers



In this mode of operation, the elements involved in the energy transfer are:

- Port network, connections and switchboards, A (*)
- MV900 Frequency converter – AC/DC mode
- MV900 DC converter - DC/DC

- On MV-DC topology, the connection from the ship to the port is made at 7.2kVac/50Hz. This AC current is rectified by AFE converter to obtain a DC grid of 10 kV. From this DC voltage, MV900 DC/DC step-down converters, with isolation based on high frequency transformers, charge the battery strings.

- During navigation, DC/DC converters feed the DC-Grid from the batteries, and then frequency converters, working as DC/AC converters, transform the direct current into AC current with the necessary quality and characteristics to operate the medium voltage 6.6kV propulsion motors.

INGEDRIVE™ MEDIUM VOLTAGE - DC GRID
Fast Chage of High Powers

INGEDRIVE MV SOLUTION		INGEDRIVE LV SOLUTION	
ON BOARD ELEMENTS	Efficiency	ON BOARD ELEMENTS	Efficiency
MV900 - AFE - Frequency Converter	98.86%	INPUT TRANSFORMER	99.18%
MV900 - DC - DC Converter	98.02%	LV800 - AFE - Frequency Converter	98.46%
TOTAL:	**96.9%**	TOTAL:	**97.7%**

Table 11: Comparison of efficiencies in charging mode

INGEDRIVE MV SOLUTION		INGEDRIVE LV SOLUTION	
ON BOARD ELEMENTS	Efficiency	ON BOARD ELEMENTS	Efficiency
MV900 - DC - DC Converter	98.02%	LV800 - INV - Frequency Converter	97.89%
MV900 - INV - Frequency Converter	99.02%	LV Motor	96.98%
MV Motor	97.61%		
TOTAL:	**94.7%**	TOTAL:	**94.9%**

Table 12: Comparison of efficiencies in navigation mode 100%

- MV-DC Grid topology has a slightly lower intrinsic efficiency than the low-voltage solution. This is due to the need to include more elements in the conversion line.
  In the dimensioning of the system for the battery charging process this will slightly affect the sizing of the port system and/or the charging time. It does not affect the dimensioning of the batteries.

- However, to make a real comparison, it is necessary to include in the analysis the difference in total weight and its real impact on power or sailing losses.

INGEDRIVE™ MEDIUM VOLTAGE - DC GRID
Fast Chage of High Powers

INGEDRIVE MV SOLUTION				INGEDRIVE LV SOLUTION			
ON BOARD ELEMENTS	Qty.	Weight [kg]	Total Weight [kg]	ON BOARD ELEMENTS	Qty.	Weight [kg]	Total Weight [kg]
MV900 - DC - DC Converter	4	22000	88000	INPUT TRANSFORMER	8	12500	100000
MV900 - INV - Frequency Converter				LV800 (1) - INV - Frequency Converter	6	8200	49200
LV800	2	3000	6000	LV800 (2) - INV - Frequency Converter	2	11000	22000
MV Motor	8	11400	91200	LV Motor	8	11000	88000
		TOTAL:	185200			TOTAL:	259200

Table 14: Weight comparison

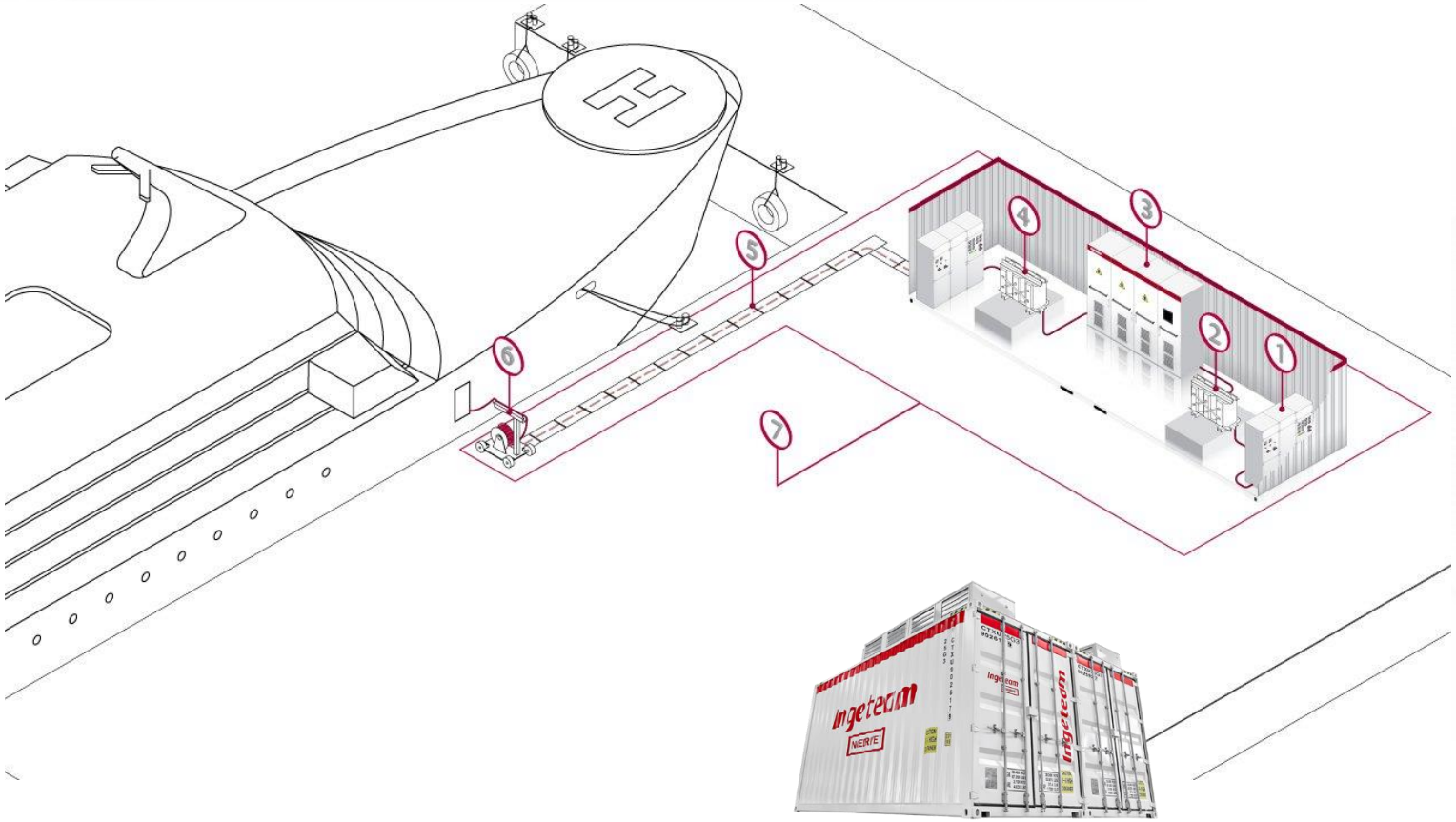
INGEDRIVE MV SOLUTION				INGEDRIVE LV SOLUTION			
ON BOARD ELEMENTS	Qty.	Surface [m²]	Total Surface [m²]	ON BOARD ELEMENTS	Qty.	Surface [m²]	Total Surface [m²]
INGEDRIVE MV900	4	17	69	INPUT TRANSFORMER	8	6	45
INGEDRIVE LV800	2	4	8	INGEDRIVE LV800 (1)	6	8	49
				INGEDRIVE LV800 (2)	2	10	20
		TOTAL:	77			TOTAL:	114

Table 15: Surface comparison

- MV-DC Grid topology is largely a much lighter topology saving around 73Tn and 114m3, critically for fast speed aluminum ferries.
- Additionally, savings are obtained on power cables weight and busbars.
- The additional weight on LV topology would imply more battery installed for achieving the same navigation profile.

INGEGRID™
OPS – On Shore Power Supply

On-shore power supply installations allow ships to charge their electric systems while docked in ports, through the use of converters



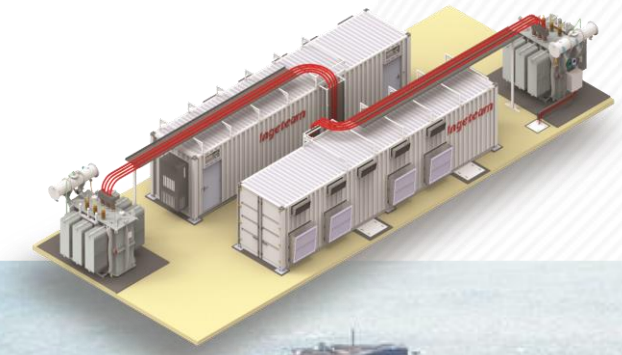
1. Grid side switchgear
2. Port side transformer
3. Converter
4. Ship side transformer
5. Ship side switchgear
6. Cabling system

Source: Drives & Automation

CASE STUDY

On-shore Power Supply (OPS)

- *PORT OF KIEL (GERMANY)*
- *NOGA (BAHRAIN)*
- *PORT OF HAMBURG (GERMANY)*
- *PORT OF CADIZ (SPAIN)*
- *KHALIFA PORT – AD PORTS (UAE – ABU DHABI)*
- *PORT OF ASYAPORT (TURKEY)*
- *PORT OF ROTTERDAM DAMEN SHIPREPAIR (NL)*
- *PORT OF BARCELONA (SPAIN)*
- *ONE-DYAS (NETHERLANDS)*
- *HAROPA - PORT LE HAVRE (France)*
- *GIOIA TAURO (ITALY)*



Source: Drives & Automation

Conclusions
Why leading companies like yours, are partnering with us?

PRODUCT RANGE:
We offer a comprehensive range of proven and reliable electrical equipment for marine appications.

R&D:
We are committed to innovation and development of full in-house technology.

R&D expenditure accounts for 6% of net sales.

FLEXIBILITY:
Our engineering teams can provide you with flexible solutions tailored to meet your project needs.

WORLDWIDE:
We have manufacturing facilities and service centers strategically located in Europe, Asia, North and South America to deliver the most efficient support and service to you.

EXPERIENCE:
We have 20+ GW of installed power capacity worldwide and 20+ years of experience in the Industry. More than 600 vessels.

PARTNERSHIP:
We are partners, providing you active support for each specific project throughout the entire product life cycle.

Source: Drives & Automation

Ingeteam

ELECTRIFYING A SUSTAINABLE FUTURE