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FUTURE WORKS

“Retrofitting existing propulsion installations fitted with a synchronous generator into a variable speed generator”

Adrián Sarasquete

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EMENASA Group – VIGO

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PERFORMANCE ON PROPULSION AND GENERATION SYSTEM

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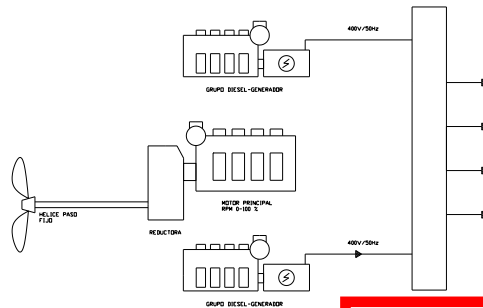
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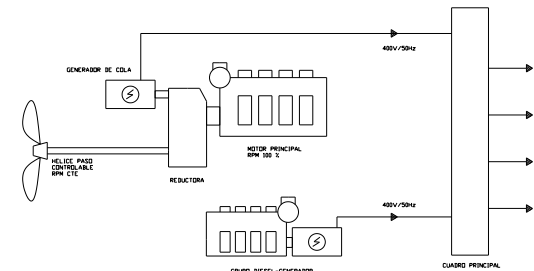
CONCLUSSIONS

FUTURE WORKS

FP drive train + Gensets



CPP drive train + Shaft Generator



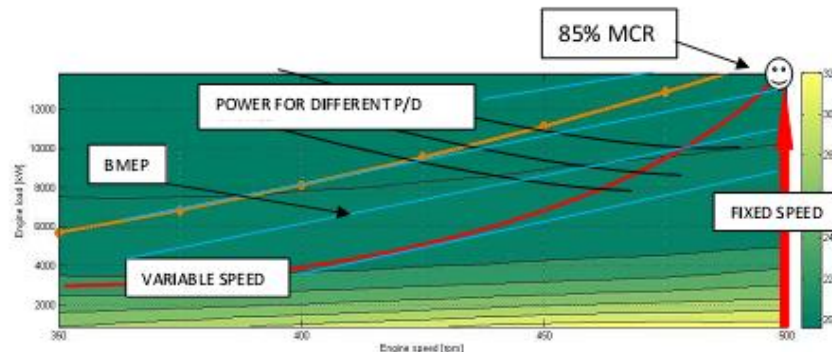
LOW EFFICIENCY

✗ Diesel engines (Gensets) operating at constant speed with variable load

✗ Diesel engines (Main engine) operating at constant speed with variable load

✗ Better BSFC on Main Engine

✗ Low propeller efficiency at low speed



WORKING PRINCIPLES

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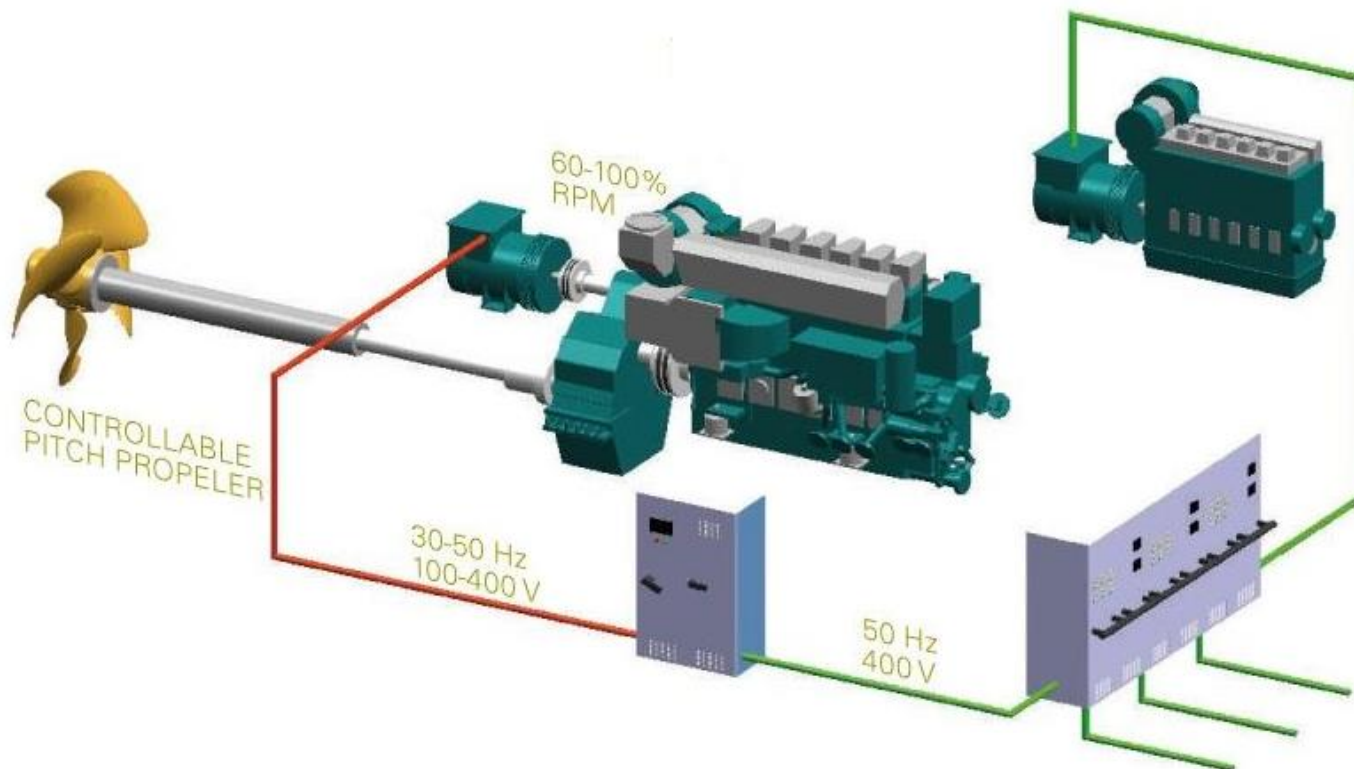
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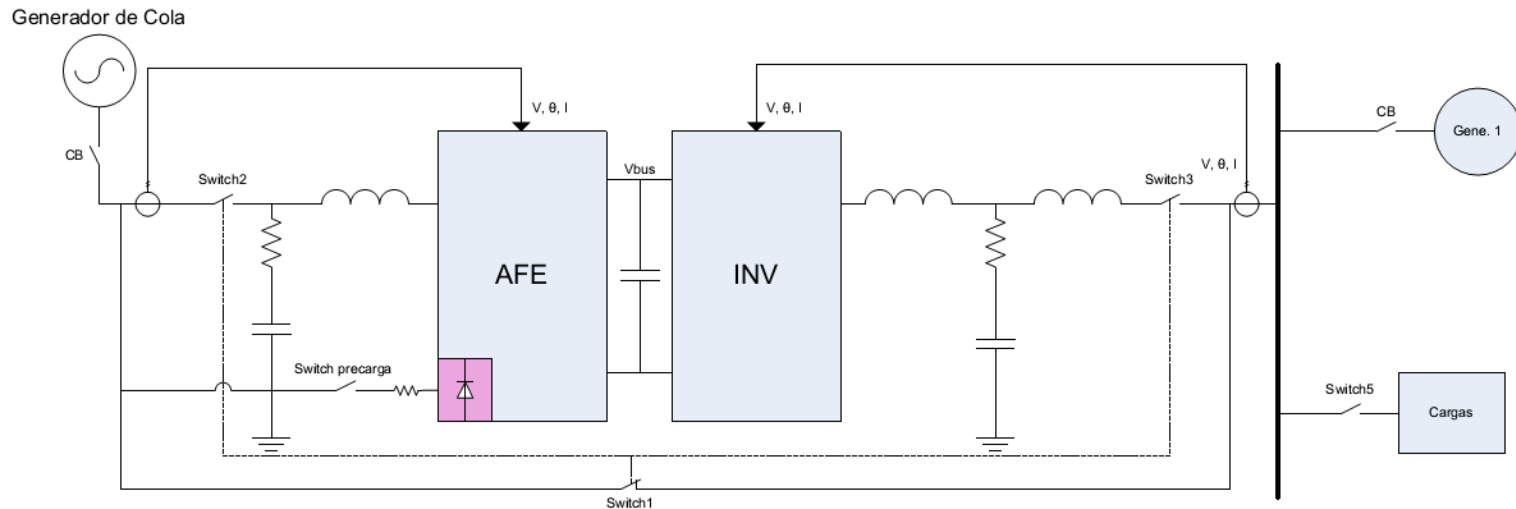
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FUTURE WORKS

- ✓ Power Voltage – Frequency Converter
- ✓ Semiconductor technology -> IGBT's
- ✓ Active Front End topology (AFE)



- ✓ LC input filter, LCL output filter
- ✓ Dumper resistance
- ✓ 6 – pulse mode with PWM modulation technique
- ✓ Internal by-pass

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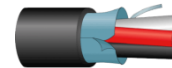
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✓ Grounding Scheme of Network



✓ Current peaks on main consumer starters



✓ Generator Bearings



✓ Generator Cooling



✓ Voltage Drop



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Main features:

Length: 36 m
Beam: 8,2 m
Draft: 3,5 m
Main Engine: 930 bkW
Shaft generator: 144 kWe (180 kVA)
Freq. network: 50 Hz
Voltage level: 380 V

TABLE I. OPERATIONAL SPEED PROFILE

Condition	At Sea	Setting	Trawling	Hauling
Av. Sp.[kn]	11	5	3,3	1,9
Time (%)	18	2	78,8	1,2
Time (hr)	1.305	143	5.649	83



Diameter: 2,5 m
Number of blades: 4
Blade area ratio: 0,498
Design pitch ratio: 1,09
Rotational speed: 181,6 rpm

Stern trawler (Atlantic)



PERFORMANCE CALCULATION

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TABLE II. THEORETICAL CALCULATION RESULTS

Cond.	At Sea	Trawling	Setting	Hauling	
Av. Speed	11,0	3,3	5,0	1,9	kn
%	0,2	0,8	0,0	0,0	
h	1.305,6	5.657,8	143,6	86,2	
N1	181,6	181,6	181,6	181,6	rpm
Av. Power	500,0	450,0	325,0	180,0	kW
Energy	652,8	2.546,0	46,7	15,5	MWh
N2	181,6	163,0	163,0	163,0	rpm
Av. Power	500,0	395,0	301,0	150,0	kW
Energy	652,8	2.234,8	43,2	12,9	MWh
Shaft Speed	0,0%	-10,2%	-10,2%	-10,2%	
Power Reduction	0,0%	-12,2%	-7,4%	-16,7%	
EN Saved (Prop.)	0,0	311,2	3,4	2,6	MWh
BSFC	0,0%	3,0%	3,0%	3,0%	
EN Saved (Total)	0,0	320,5	3,5	2,7	MWh
k\$ Saved	0,0	60.558,8	670,7	503,0	€
Total Saved	61.732,5	€			

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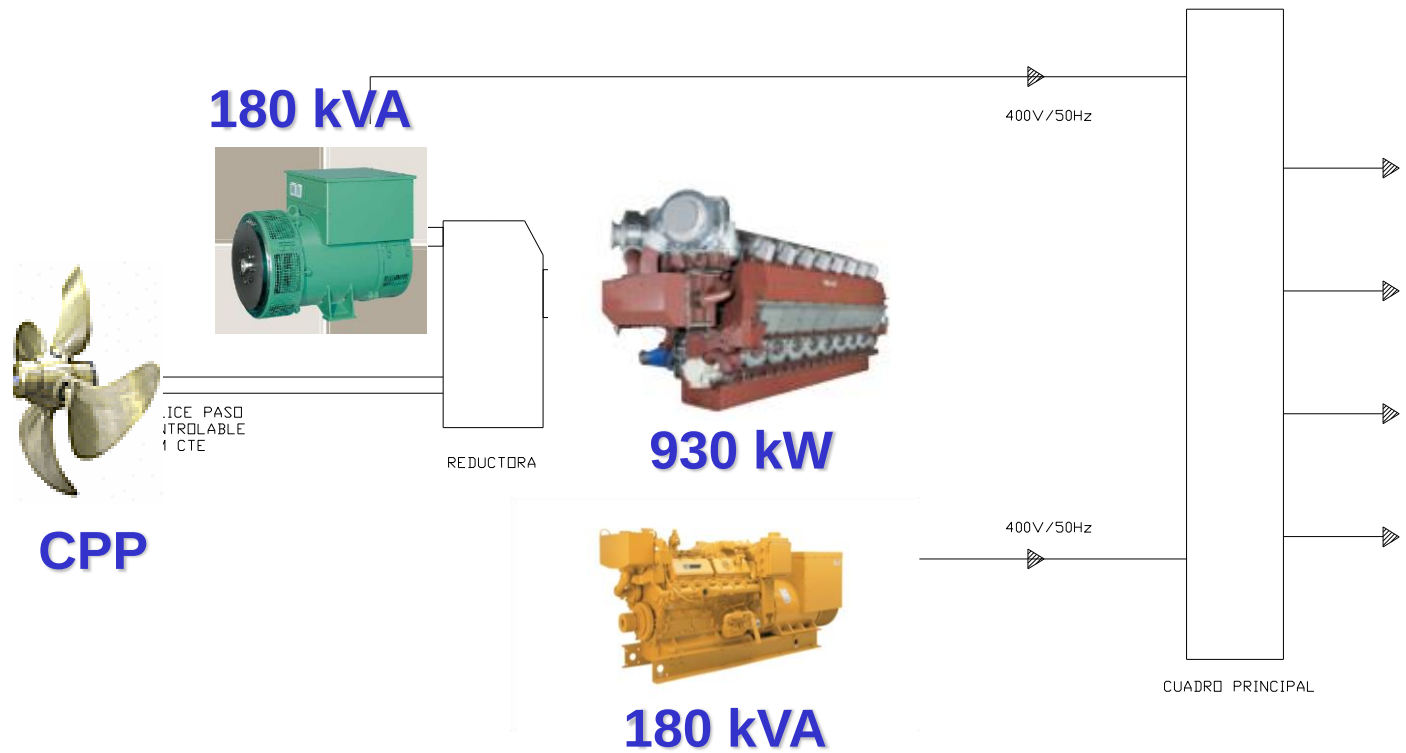
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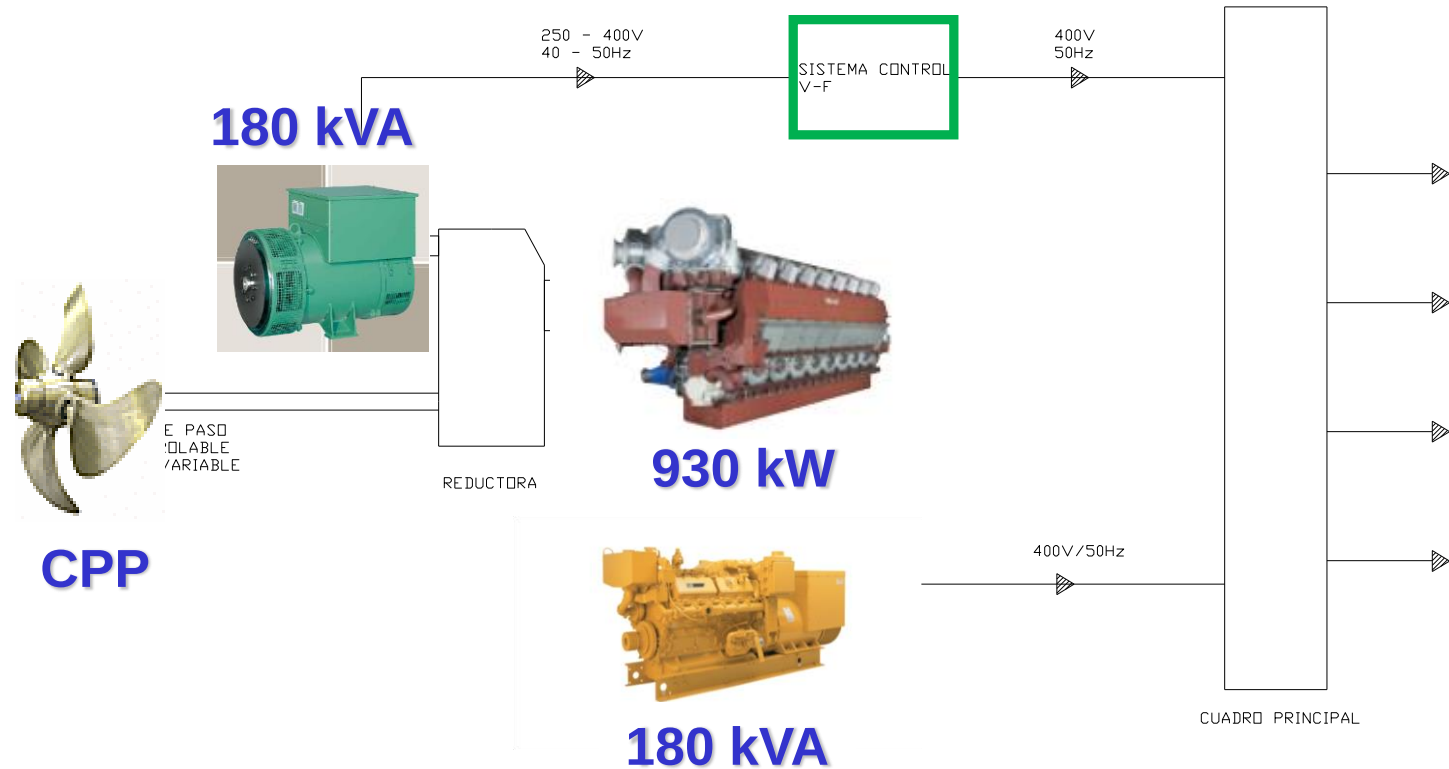
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POWER UNIT CONVERTER WITH V-f CONTROL



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POWER UNIT CONVERTER WITH V-f CONTROL



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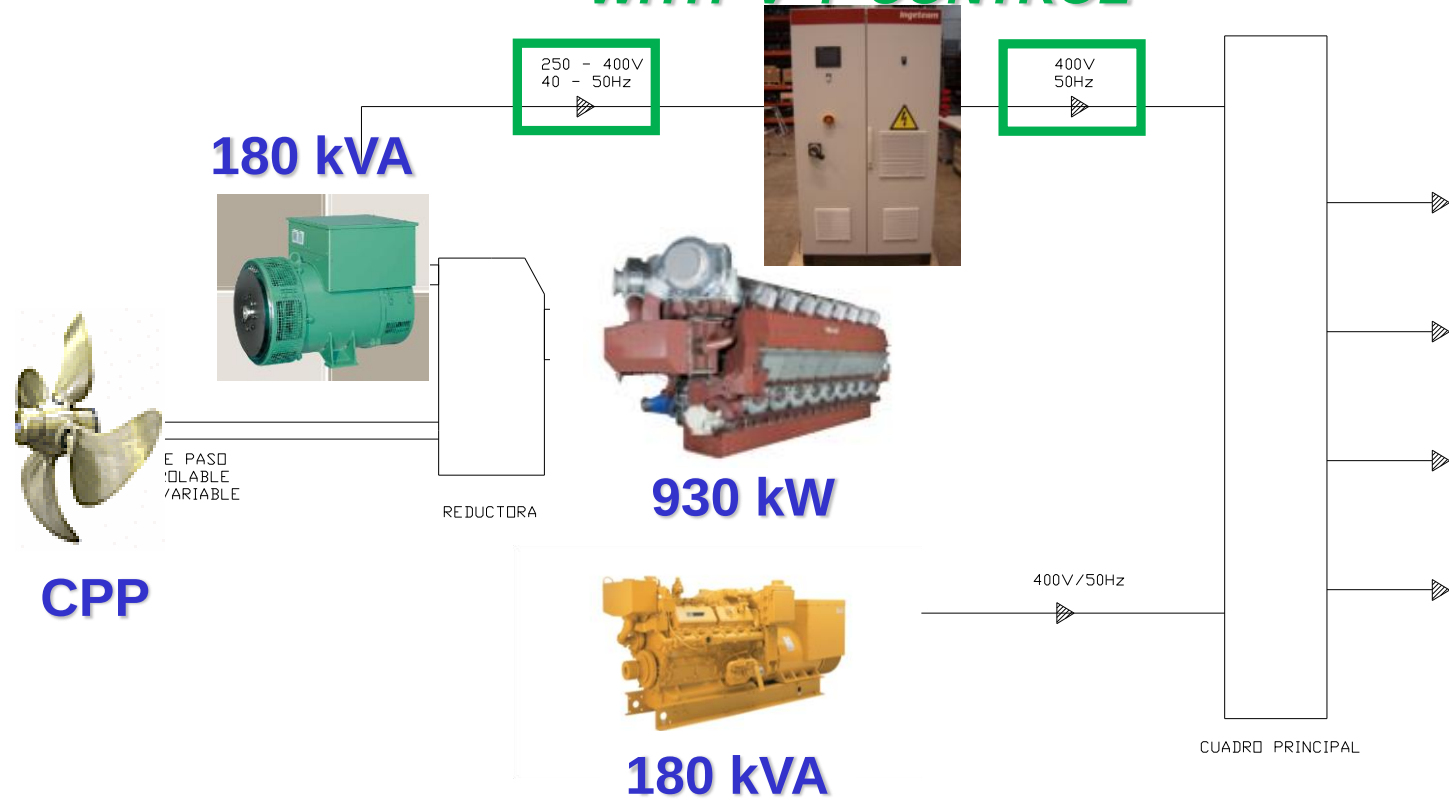
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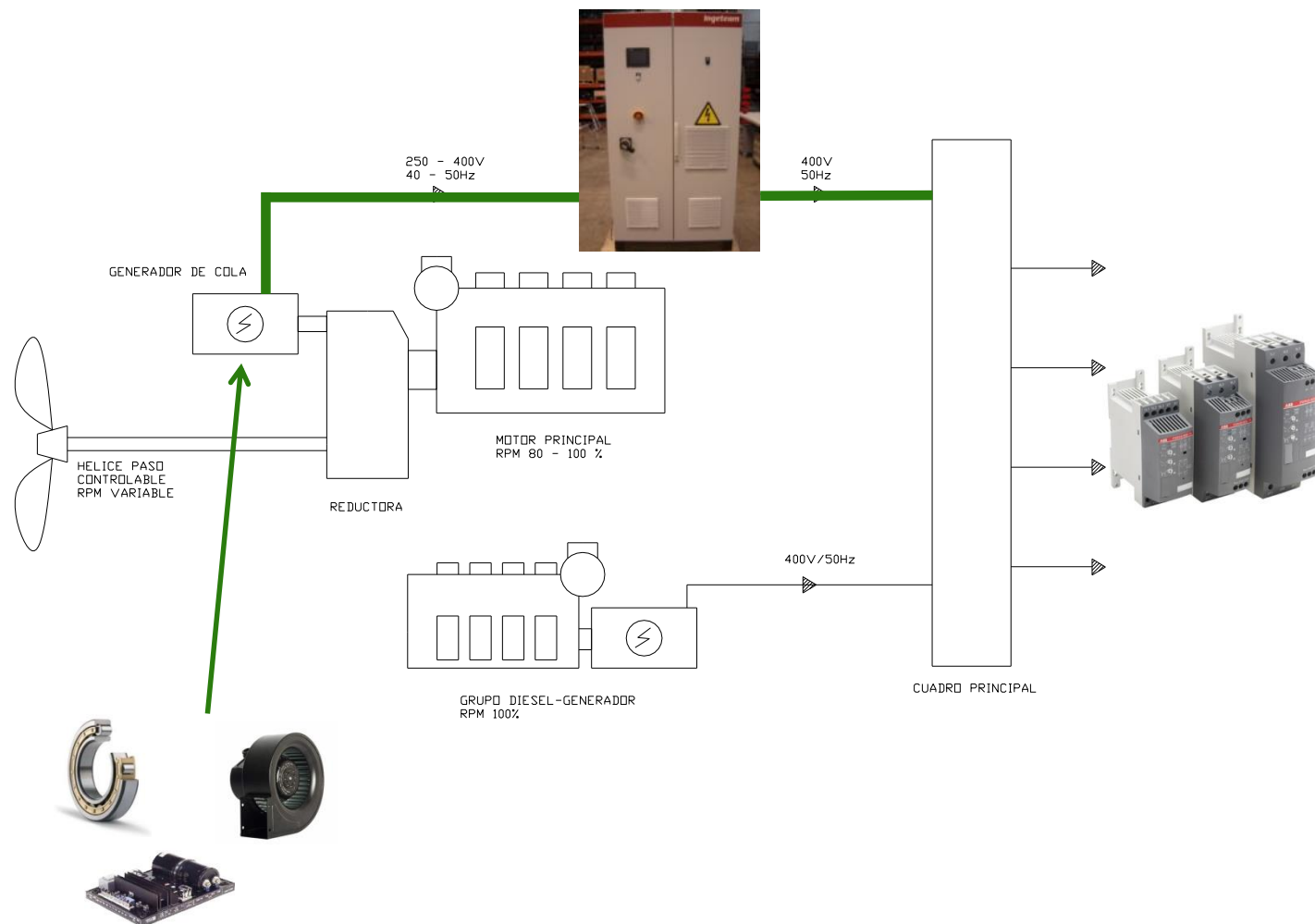
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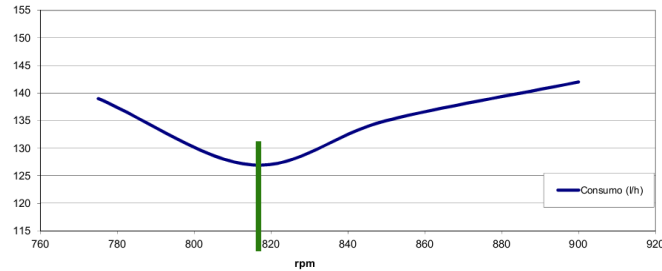
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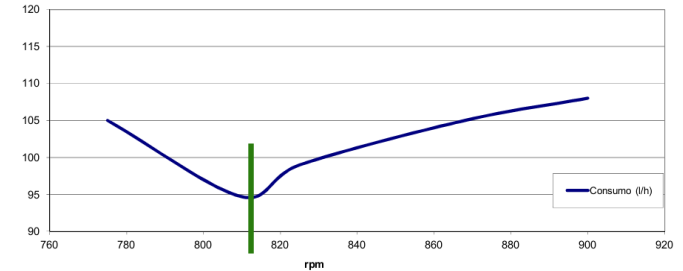
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Arrastre 1



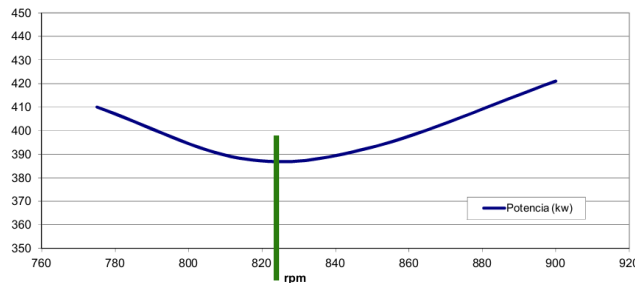
Fuel consumption vs. RPM (Case 1)

Arrastre 2



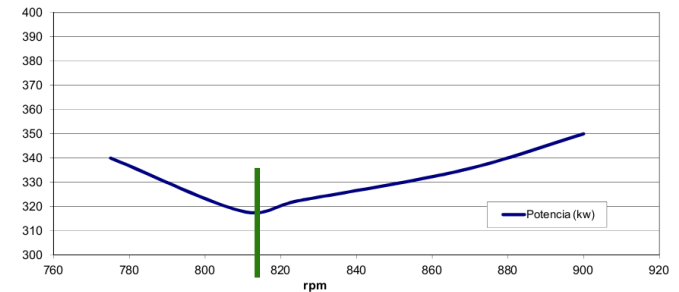
Fuel consumption vs. RPM (Case 2)

Arrastre 1



PStotal vs. RPM (Case 1)

Arrastre 2



PStotal vs. RPM (Case 2)

OPTIMAL POINT
812 - 825

RESULTS

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✓ The SHYMGEN system was installed on board Punta Vixia → One year operation

✓ The system was used with 9,4% of maximum speed reduction

✓ 9,1% Savings → 53.150 € / year

✓ 65.000 € aprox. → Payback: 1,2 years

CASE 1: DRY CARGO VESSEL

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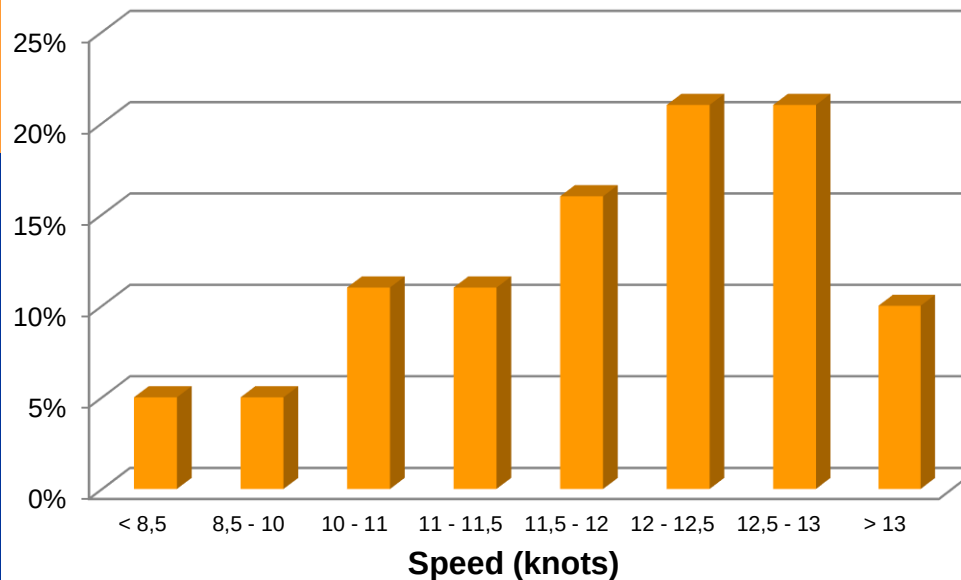
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FUTURE WORKS

Main features:

Length:	120 m
Beam:	15 m
Draft:	7,3 m
Main Engine:	4.200 bkW
Shaft generator:	400 kWe (500 kVA)
Auxiliary plant:	2 x 500 kVA, 50 Hz, 400 V
Propeller:	CPP – constant RPM
Fuel:	HFO380



Design speed: 14,7 knots
Av. speed sailing: 11,8 knots
80 % steaming: 10 – 13 knots!!!

CASE 1: DRY CARGO VESSEL

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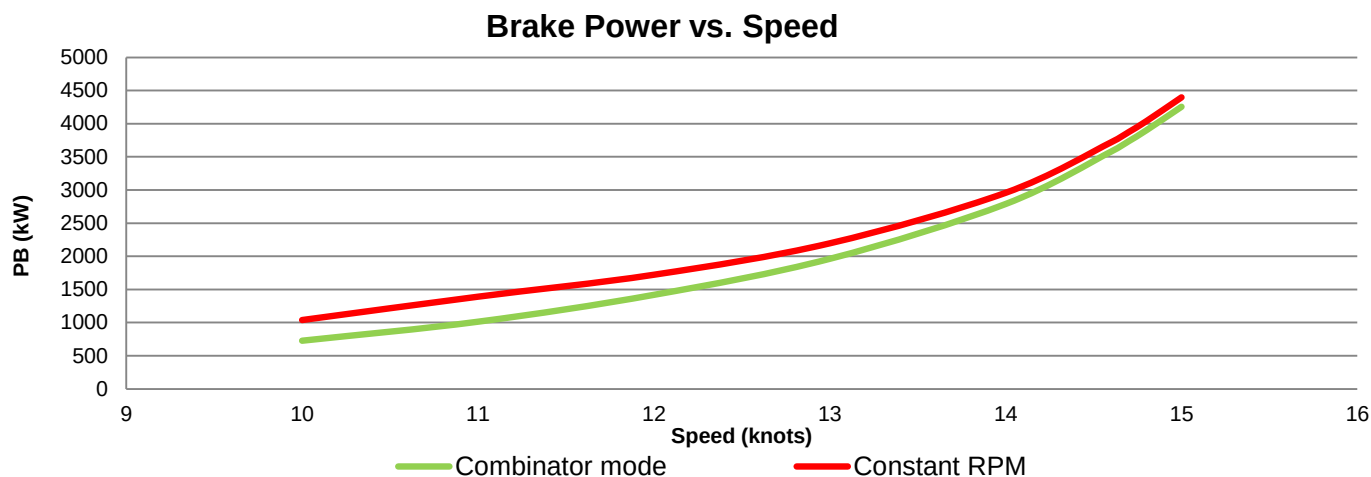
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	Original	Combinator mode	Combinator mode + SHYMGEN**
Fuel* (t)	3.098	2.646	2.603
Reduction Fuel	-	14,6 %	16,0 %
NOx (t)	211	180	178
SOx (t)	174	148	146
CO2 (t)	10.1462	8.662	8.638
Savings (k€)***	-	277,2	303,5

* Specific fuel consumption values from DNV Report "Representative emission factors for use in "Quantification of emissions from ships associated with ship movements between port in the European Community" (ENV.C.1/ETU/2001/0090)

** Electric Demand of Auxiliary plant 250 kW

*** Price of Rotterdam 28/02/2013

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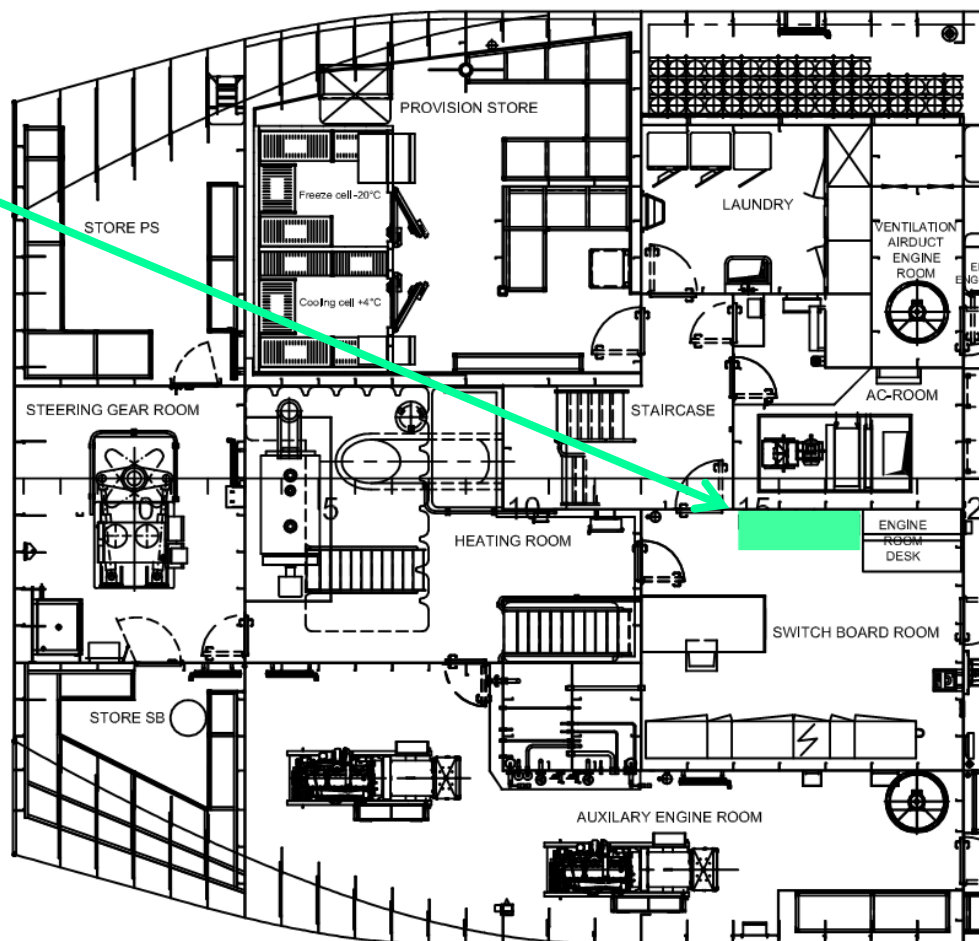


SHYMGEN 360E:

Nominal Power: 360 kVA

Reduction Speed Range: 30 %

Dimmensions: 2000 x 1960 x 600 mm



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SHIPOWER CONCERNS	COMMENTS	ASSOCIATED COSTS
Available Space	Deck / Bulkhead Opening NOT required!!!	-
	Reduced Foot Print (including maintenance area) 3,3 m2	-
Main Switchboard modifications	Only new 3-pole shielded cable layed	8.000 €
Shaft Generator modifications	Isolated bearings, Force ventilation cooling	5.000 €
Class Society requirements	Certified equipment / Trials on board	6.000 – 9.000 €
Propeller	Combinator mode adjustment (service engineer from propeller manufacturing)	
Maintenance	SHYMGEN board	1.000 € / year
Equipment cost		64.000 €
Installation cost		8.000 €

SHIPOWER CONCERNS	ASSOCIATED SAVINGS
Operation savings	26.300 €
Maintenance savings (Auxiliary Plant)	2 x 15.000 €

1,6 years PAYBACK

CASE 2: RORO VESSEL

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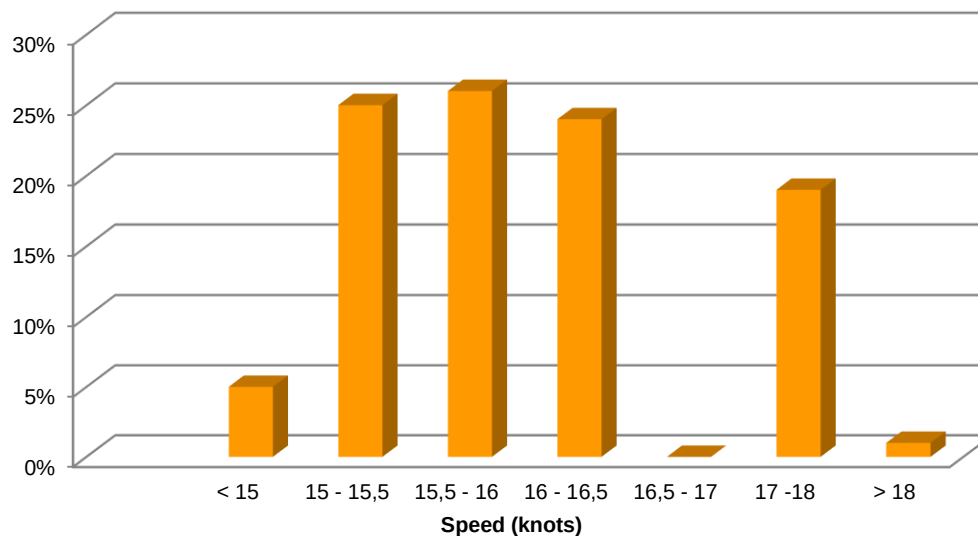
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FUTURE WORKS

Main features:

Length:	130,3 m
Beam:	22,6 m
Draft:	6,7 m
Main Engine:	14.500 bkW
Shaft generator:	1.432 kWe (1.790 kVA)
Auxiliary plant:	2 x 750 kVA, 50 Hz, 380 V
Propeller:	CPP – constant RPM
Fuel:	HFO380



Design speed: 20,4 knots

Av. speed sailing: 16,02 knots

94% steaming: 15 – 18 knots!!!

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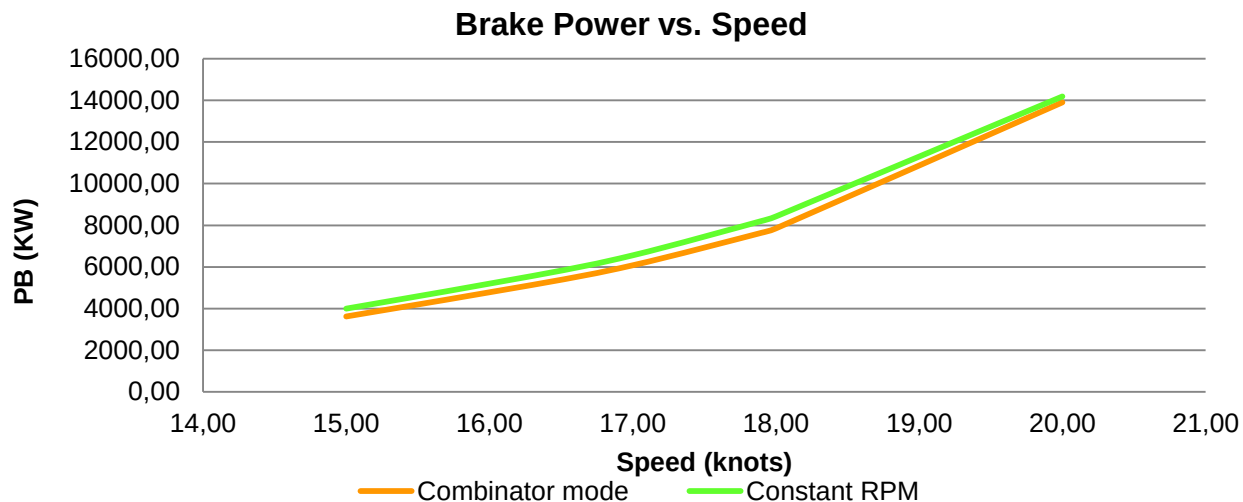
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	Original	Combinator mode	Combinator mode + SHYMGEN**
Fuel* (t)	6.785	6.403	6.349
Reduction Fuel	-	5,6 %	6,4 %
NOx (t)	464	437	435
SOx (t)	381	360	358
CO2 (t)	22.370	21.101	21.070
Savings (k€)***	-	234,5	267,4

* Specific fuel consumption values from DNV Report "Representative emission factors for use in "Quantification of emissions from ships associated with ship movements between port in the European Community" (ENV.C.1/ETU/2001/0090)

** Electric Demand of Auxiliary plant 400 kW

*** Price of Rotterdam 28/02/2013

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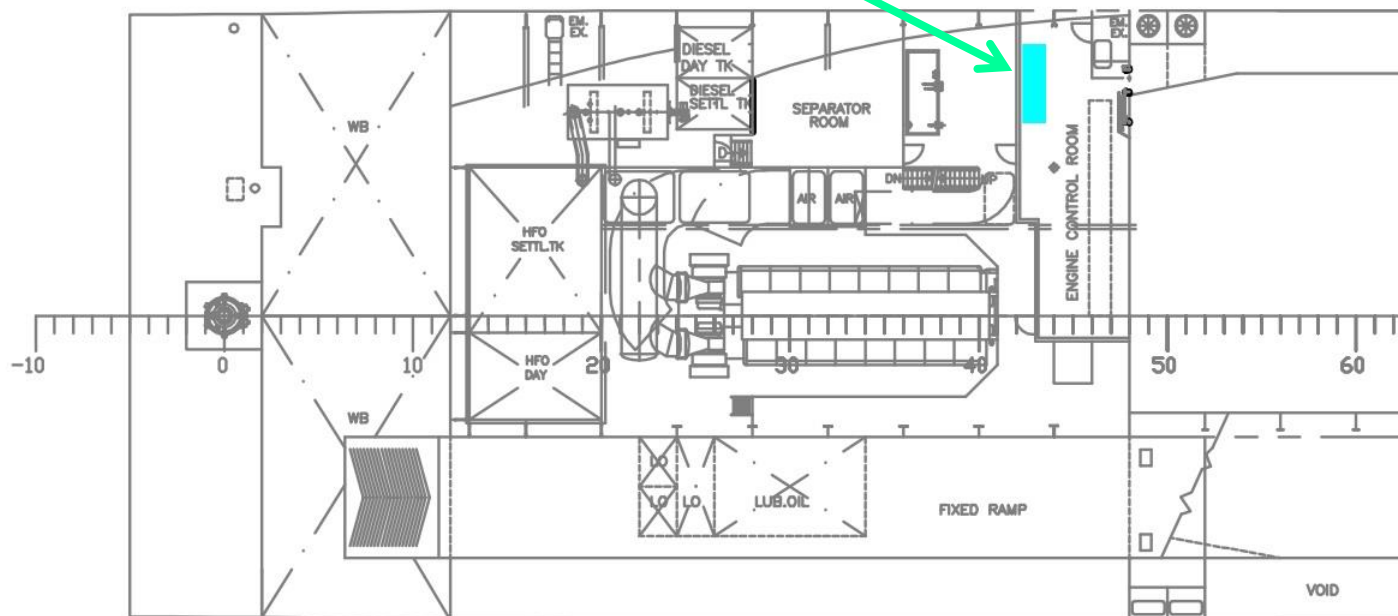


SHYMGEN 500E:

Nominal Power: 500 kVA

Reduction Speed Range: 10 %

Dimmensions: 3200 x 1960 x 600 mm



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SHIPOWER CONCERNS	COMMENTS	ASSOCIATED COSTS
Available Space	Deck / Bulkhead Opening NOT required!!!	-
	Reduced Foot Print (including maintenance area) 4,6 m2	-
Main Switchboard modifications	Only new 3-pole shielded cable layed	12.000 €
Shaft Generator modifications	Isolated bearings, Force ventilation cooling	8.000 €
Class Society requirements	Certified equipment / Trials on board	6.000 – 9.000 €
Propeller	Combinator mode adjustment (service engineer from propeller manufacturing)	
Maintenance	SHYMGEN board	1.000 € / year
Equipment cost		98.000 €
Installation cost		10.000 €

SHIPOWER CONCERNS	ASSOCIATED SAVINGS
Operation savings	32.900 €
Maintenance savings (Auxiliary Plant)	3 x 21.000 €

1,4 years PAYBACK

CASE 3: MULTIROLE OFFSHORE VESSEL

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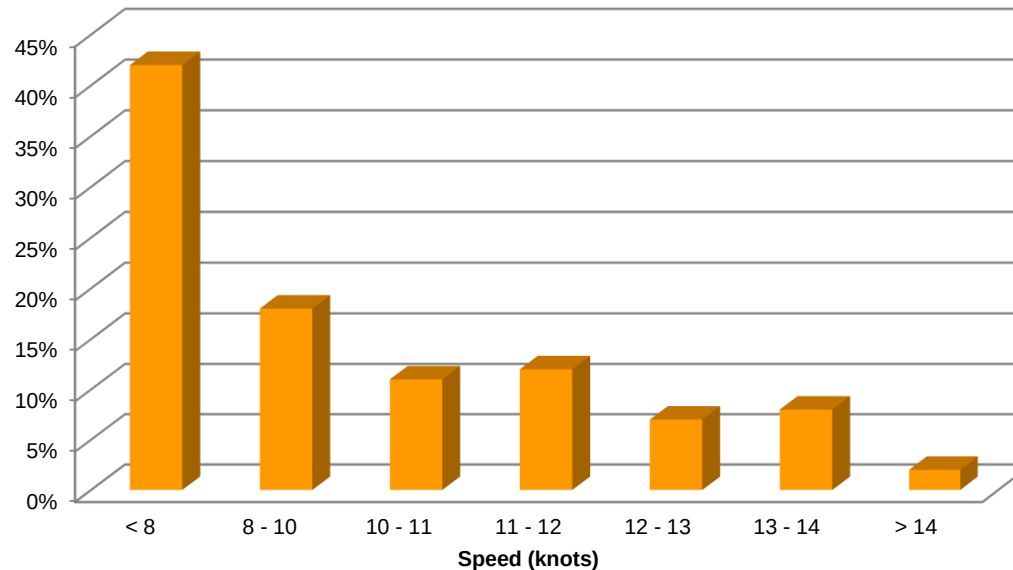
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Main features:

Length:	80 m
Beam:	17 m
Draft:	5,7 m
Main Engine:	2 x 4.000 bkW
Shaft generator:	2 x 1.250 kWe (1.562 kVA)
Auxiliary plant:	2 x 750 kVA, 50 Hz, 400 V
Propeller:	CPP – constant RPM
Fuel:	HFO380



Design speed: 17 knots
Av. speed sailing: 9,8 knots

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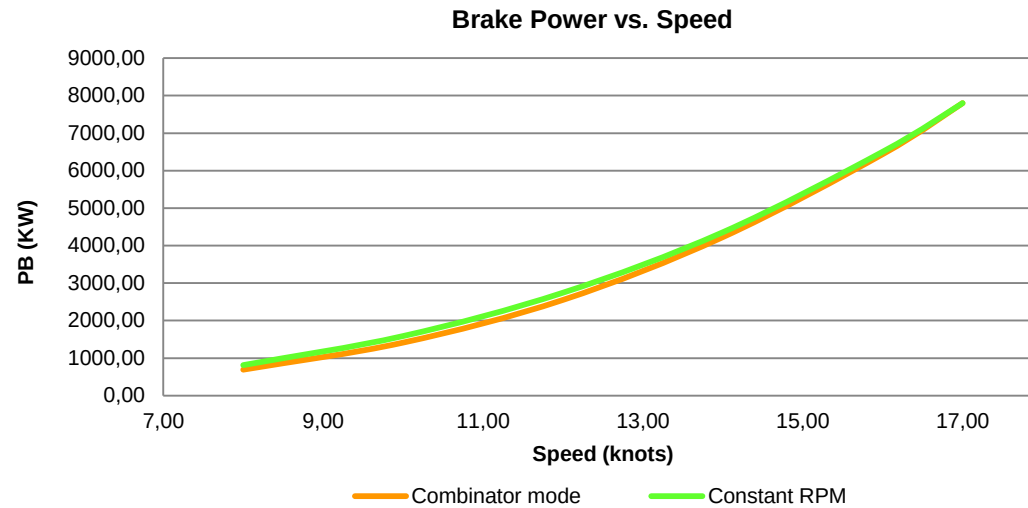
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	Original	Combinator mode	Combinator mode + SHYMGEN**
Fuel* (t)	2.517	2.472	2.405
Reduction Fuel	-	6,7 %	9,2 %
NOx (t)	179	159	157
SOx (t)	148	138	136
CO2 (t)	8.609	8.020	7.982
Savings (k€)***	-	108,9	150,2

* Specific fuel consumption values from DNV Report "Representative emission factors for use in "Quantification of emissions from ships associated with ship movements between port in the European Community" (ENV.C.1/ETU/2001/0090)

** Electric Demand of Auxiliary plant 500 kW

*** Price of Rotterdam 28/02/2013

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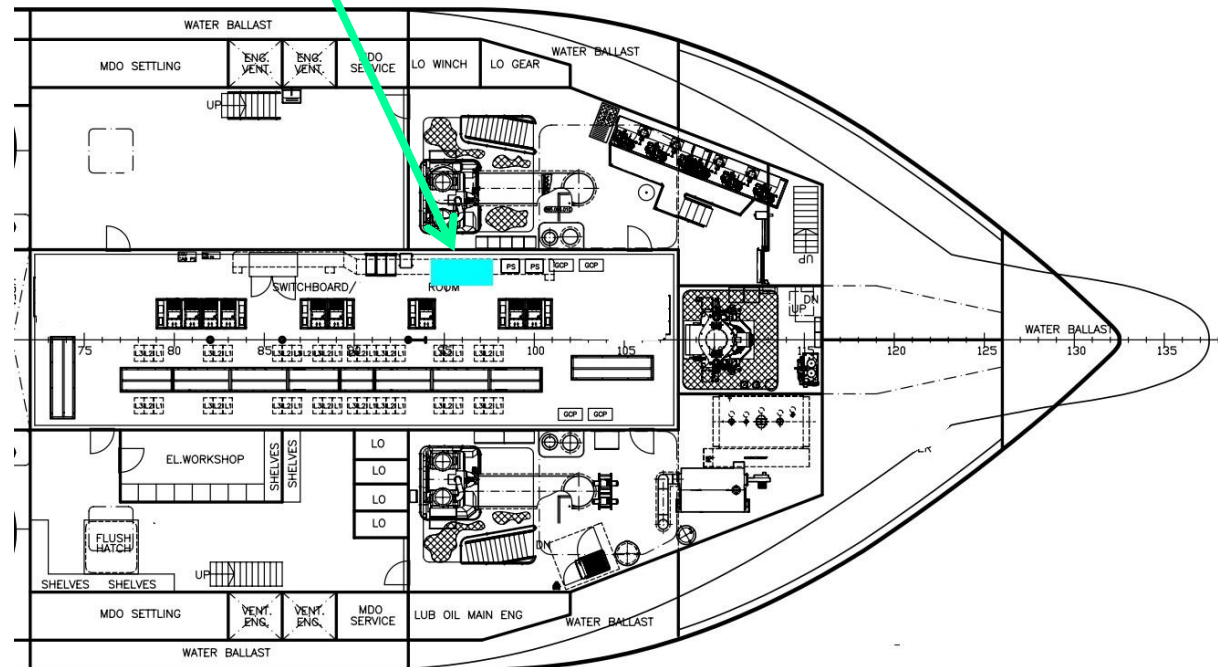


SHYMGEN 600E:

Nominal Power: 620 kVA

Reduction Speed Range: 25 %

Dimmensions: 4000 x 1960 x 600 mm



CASE 3: MULTIROLE OFFSHORE VESSEL

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SHIPOWER CONCERNS	COMMENTS	ASSOCIATED COSTS
Available Space	Deck / Bulkhead Opening NOT required!!!	-
	Reduced Foot Print (including maintenance area) 5,5 m2	-
Main Switchboard modifications	Only new 3-pole shielded cable layed	12.000 €
Shaft Generator modifications	Isolated bearings, Force ventilation cooling	8.000 €
Class Society requirements	Certified equipment / Trials on board	6.000 – 9.000 €
Propeller	Combinator mode adjustment (service engineer from propeller manufacturing)	
Maintenance	SHYMGEN board	1.000 € / year
Equipment cost		108.000 €
Installation cost		10.000 €

SHIPOWER CONCERNS	ASSOCIATED SAVINGS
Operation savings	41.300 €
Maintenance savings (Auxiliary Plant)	2 x 12.000 €

2,2 years PAYBACK

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- ✓ The use of variable speed power generation system can lead to significant fuel savings
- ✓ Solutions for new ships & retrofitting vessels
- ✓ Affordable Investments
- ✓ Cavitation, vibrations and noise were reduced
- ✓ Slow Steaming is being more & more used →

SHYMGEN opportunity!!!

FUTURE WORKS

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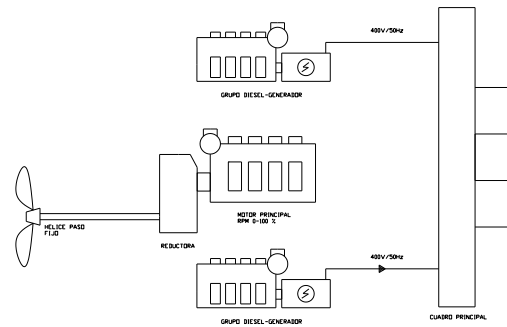
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Implementation of SHYMGEN system on FP configuration vessel



Increase the range of speed reduction controlling overloads at low frequency

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