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INSTALLING A HYBRID ENERGY BALANCE SYSTEM ON A PORT-CONTAINER SHIP

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Maritime transportation developed environmental pollution issues nowadays. For this reason "International Maritime Organization (IMO)" gived different amendments in order to reduce the polluting emissions produced by ships.There is a natural and continuous concern to reduce marine pollution and to implement the requirements stipulated by Annex VI of the International Convention for the Prevention of Pollution of the Marine Environment - MARPOL; The emission of carbon dioxide CO_2, in the gases resulting from naval propulsion engines, has alarming values, considering that CO_2 is the main negative factor in producing the greenhouse effect and implicitly global warming. Shipbuilders are aware that ship engines emit harmful exhaust gases and certain chemical compounds that are dangerous to human health and to the environment. One way for reducing pollution is by using unconventional energies captured from the marine environment, outside the ship, like solar or wind, which lead to the saving of a part of the fossil fuels and lubricants consumed on board the ships. Indirectly in this way earth's fossil fuel reserves can also be preserved. In this paper, we have studied a hybrid system formed from non-conventional electricity generating systems (a Flettner Balloon and four large vertical wind turbines) and a conventional one which uses fossil fuel. The non-conventional electricity generating system captures and uses the wind energy. The existence of two systems on board, the reactive, classical and the active, coming from wind energy, gives the possibility that in the event of failure of one of them, the other can be used. Also, the existence of the two independent electricity generating systems makes it possible to carry out overhauls and repairs without the ship being stationary or adrift during them; The article main points are: the elements of the hybrid energy system, placing the Flettner helium Balloon on a container ship as an alternative power source of energy, placing four large vertical wind turbines on a container ship as an alternative source of energy, energy balance of electricity generating systems, from non-conventional sources, connecting conventional and non-conventional power sources to the ship's main power bar, electrical load of the ship's consumers, conclusions.
Keywords: Flettner Balloon, environment, hybrid system, green energy

УСТАНОВКА ГИБРИДНОЙ СУДОВОЙ СИСТЕМЫ ЭНЕРГОБАЛАНСА НА КОНТЕЙНЕРОВОЗЕ

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Перед морской транспортной отраслью в настоящее время остро стоит проблемами загрязнения окружающей среды. По этой причине «Международная морская организация (ИМО)» внесла различные поправки, чтобы уменьшить выбросы загрязняющих веществ, производимые судами. Существует естественная и постоянная забота о сокращении загрязнения морской среды и выполнении требований, предусмотренных Приложением VI к Международной конвенции по охране окружающей среды. Предотвращение загрязнения морской среды - МАРПОЛ; Эмиссия двуокиси углерода CO2 в газах, образующихся в результате работы судовых двигателей, имеет тревожные значения, учитывая, что CO2 является основным негативным фактором возникновения парникового эффекта и косвенного глобального потепления. Судостроители знают, что судовые двигатели выделяют вредные выхлопные газы и некоторые химические соединения, опасные для здоровья человека и окружающей среды. Одним из способов уменьшения загрязнения является использование нетрадиционных источников энергии, получаемых из морской среды за пределами судна, таких как солнечная энергия или ветер, что приводит к экономии части ископаемого топлива и смазочных материалов, потребляемых на борту судов. Косвенно таким образом можно также сохранить запасы ископаемого топлива на Земле. В этой статье мы изучили гибридную систему, состоящую из нетрадиционных систем производства электроэнергии (воздушный шар Флеттнера и четыре больших вертикальных ветряных турбины) и традиционной системы, использующей ископаемое топливо. Нетрадиционная система производства электроэнергии улавливает и использует энергию ветра. Наличие на борту двух систем, реактивной, классической и активной, поступающей от энергии ветра, дает возможность в случае выхода из строя одной из них использовать другую. Также наличие двух независимых систем выработки электроэнергии позволяет проводить капитальные и ремонтные работы без остановки или дрейфа судна во время них. Основные положения статьи: элементы гибридной энергетической системы, размещение гелиевого шара Флеттнера на контейнеровозе в качестве альтернативного источника энергии, размещение четырех больших вертикальных ветряков на контейнеровозе в качестве альтернативного источника энергии, энергетический баланс систем выработки электроэнергии, от нетрадиционных источников, подключение традиционных и нетрадиционных источников электроэнергии к судовой главной электросети, электрическая нагрузка судовых потребителей, выводы.
Ключевые слова: воздушный шар Флеттнера, окружающая среда, гибридная система, зеленая энергия.

1. Introduction

Technical characteristics of the port-container ship where we are installing the hybrid system:

$L = 168{,}56\ m$
$l = 29{,}4\ m$
$Capacity = 1638\ TEU$
$GT = 19795\ t$
$D = 39449\ t$
4 Diesel generators
$P = 2000\ kW$ each

Where:
L=Ship length;
l=Ship width;
D=Displacement

2. The elements of the hybrid energy system, which uses non-conventional energy

I will install on the port-container with the above features, the following devices:

- A Flettner rotor with helium;
- 4 large vertical wind turbines on the main deck of the ship;

2.1 Placing the Flettner helium Balloon on a container ship as an alternative power source of energy

2.1.1 Flettner Balloon

The Flettner Balloon has an aerodynamic profile, with two stabilizers, with the role of maintaining its position in the air. It is positioned in an air current at a certain altitude, at which the wind direction and speed are approximately constant. The balloon remains in a fixed position relative to the ship to which it is attached, regardless of the different angles from which the wind blows and the direction of movement of the ship. During all this time it will generate electric current. The stronger the wind, the faster the balloon will spin and generate more electricity.

The Flettner helium Balloon, positioned at about 300 m above the container ship, will generate approximately 1000 kWh.[1]

To calculate the volume, mass and lift of the Flettner helium Balloon, we likened it to an airship.

2.1.2 Constructive characteristics of the balloon

$L_B = 245\ m$
$V_b = 200\,000\ m^3$
$m_b = 5000\ kg = 5\ t$
$\rho_A = 1{,}29\ kg/m^3$
$g = 9{,}8\ m/s^2$
$P = 1000\ kW$
$U = 690\ V = 0{,}69\ kV$

$$F_a = \rho_A V_b g = 1{,}29 \times 200000 \times 9{,}8 = 2528400 N = 2528{,}4\ kN \quad (1)$$

Where:
L_B = Balloon length;
V_b = Balloon volume;
m_b = Balloon mass;
ρ_A = Air density;
g = Gravitational acceleration;
P = Power generated by the rotor;
U = Voltage of the electric current generated;
F_a = Ascent force of the balloon.

2.1.3 Calculation of the intensity of the electric current through the power cable:

$$P = \sqrt{3}\, UI \cos\varphi \quad (2)$$

Where:
$\cos\varphi \cong 1$ =>

$$I = \frac{P}{\sqrt{3}U} = \frac{1000kW}{\sqrt{3}x0{,}69\ kW} = 837{,}7A \cong 838A \quad (3)$$

=> From the tables of the electric cable manufacturers, it follows that for an intensity current of 838 A, we need two three-phase cable systems, with a minimum section of 300 mm^2. For safety I will consider 6 single-phase cables of type CYY(-F) with an upper section of 1 x 400 mm^2.[2] This type of cable has an outer diameter of 38 mm, a copper mass of 4000 kg/km and a total mass of 4030 kg/km.

=> for a cable length of 300 m = 0.3 km, the total mass of a cable m_c is:

$$m_c = 4030 \times 0{,}3 = 1209\ kg = 1{,}209\ t \quad (4)$$

The total mass of electrical cables m_{ct} that the Flettner helium Balloon must support is:

$$m_{ct} = 6 \times m_c = 6 \times 1{,}209\ t = 7{,}254\ t \quad (5)$$

2.1.4 Anchoring the Flettner Balloon with helium

To anchor the balloon I will use 4 anchor lines, made of polypropylene and polyester fiber.

From the data provided by the manufacturer we can see:

$d = 80\ mm$
$m_p = 0{,}31\ m/kg$
$F_R = 1225\ kN = 1225000\ N$

Where:
d= Diameter of line;
m_p= Weight of the line
F_R= Resistance force of the line

2.1.4.1 Advantages of spinning polypropylene and polyester fiber ropes:

- They do not absorb water;

- High heat resistance;
- Great flexibility in time;
- Easy to handle.

2.1.4.2 Calculation of the mass of a 300 m line (m_{p300}):

$$m_{p300} = 300\,m\,x\,m_p = 300\,m\,x\,0{,}31\,m/kg = 93\,kg \quad (6)$$

2.1.4.3 Calculation of the mass of the 4 lines (m_{pt}):

$$m_{pt} = m_{p300} x\,4 = 93\,kg\,x\,4 = 372\,kg = 0{,}372\,t \quad (7)$$

2.1.4.4 Calculation of the resistance forces of the 4 lines (F_{RT}):

$$F_{RT} = 4\,x\,F_R = 4\,x\,1225\,kN = 4900\,kN \quad (8)$$

2.1.4.5 Comparison of the ascent force F_a with the total drag force of the lines F_{RT}

$$F_a = 2528{,}4\,kN$$
$$F_{RT} = 4900\,kN$$

It can be seen that $F_{RT} > F_a$ meaning that the lines resist in the process of anchoring the balloon.

From the previous calculations we can see that the Flettner helium rotor must support a mass of 12.626 t.

$$m = m_{ct} + m_{pt} + m_b = 7{,}254 + 0{,}372 + 5 = 12{,}626\,t \quad (9)$$

2.1.5 Calculation of the minimum lift force $F_a^{'}$ required for the balloon to stay suspended in the air

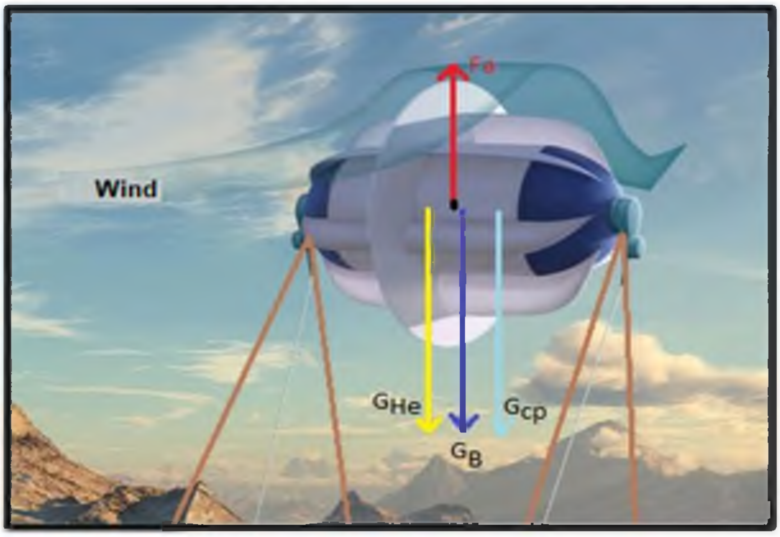

Figure 1: Forces that occur and influence rotor lift

$$\sum F_y = F_a^{'} - G_{He} - G_B - G_{cp} \quad (10)$$

Where:

G_{He} = helium weight;
G_B = balloon weight;
G_{cp}= weight of cables and lines.

If:

$$\sum F_y = 0 \quad (11)$$

$$0 = F_a^{'} - G_{He} - G_B - G_{cp} \quad (12)$$

$$F_a^{'} = G_{He} + G_B + G_{cp} = m_{He} g + m_b g + m_{cp} \quad (13)$$

$$m_{He} = \rho_{He} V_B = 0{,}179 x 200000 = 35800\,kg \quad (14)$$

$F_a^{'} = 35800 x 9{,}8 + 5000 x 9{,}8 + 7626 x 9{,}8 = 474574{,}8\,N = 474{,}5748\,kN$

From the above calculations we can see that the minimum required ascent force

$F_a^{'} = 474{,}5748\,kN$, is much lower than the ascent force

$F_a = 2528{,}4\,kN$ that the balloon can lift.

2.1.6 Calculation of the minimum volume of the Flettner Balloon - if it is filled with helium

$F_a^{'} = 35800\text{x}9{,}8 + 5000\text{x}9{,}8 + 7626\text{x}9{,}8 = 474574{,}8\text{N} = 474{,}5748\text{kN}$

$$F_a = \rho_A V_B g \quad (15)$$

$$F_a^{'} = \rho_A V_{BHe} g \quad (16)$$

$$474574{,}8 = 1{,}29 x V_{BHe} x 9{,}8 \quad (17)$$

$$V_{BHe} = \frac{474574{,}8}{9{,}8 x 1{,}29} = \frac{474574{,}8}{12{,}642} = 37539{,}5349\,m^3 \cong 37540\,m^3$$

The minimum volume of the balloon filled with helium is de 37540 m^3 for the Flettner Balloon to be buoyant.

2.1.7 Calculation of the minimum ascent force $F_a^{''}$ necessary for the balloon to stay in the air, when it is full of hydrogen

$$\sum F_y = F_a^{''} - G_H - G_B - G_{cp} \quad (18)$$

Where:

G_H = hydrogen weight;

G_B = balloon weight;

G_{cp} = weight of cables and lines.

If:

$$\sum F_y = 0 \tag{19}$$

$$0 = F_a'' - G_H - G_B - G_{cp} \tag{20}$$

$$F_a'' = G_H + G_B + G_{cp} = m_H g + m_b g + m_{cp} g \tag{21}$$

$$F_a'' = m_H g + m_b g + m_{cp} g \tag{22}$$

$$m_H = \rho_H V_B = 0{,}0899x200000 = 17980\ kg \tag{23}$$

$$F_a'' = 17980\ x\ 9.8 + 5000\ x\ 9.8\ +\ 7626\ x\ 9.8 = 299938.8\ N = 299{,}9388\ kN$$

From the above calculations we can see that the minimum required ascent force of the balloon filled with hydrogen F_a'' is 299,9388 kN which is much lower than the ascent force $F_a = 2528{,}4\ kN$, which the balloon can lift.[3]

2.1.8 Calculation of the minimum volume of the Flettner Balloon – if it is filled with hydrogen

$$F_a'' = 299{,}9388\ kN = 299938{,}8\ N$$

$$F_a = \rho_A V_B g \tag{24}$$

$$F_a'' = \rho_A V_{BH} g \tag{25}$$

$$299938.8 = 1.29\ \text{x}\ V_{BH}\ \text{x}9{,}8 \tag{26}$$

$$V_{BH} = \frac{299938{,}8}{1{,}29x9{,}8} = \frac{299938{,}8}{12{,}642} = 23725{,}5814\ m^3 \cong 23726\ m^3$$

The minimum volume of the balloon filled with hydrogen is 23726 m^3 for the Flettner Balloon to be buoyant.

2.1.9 Calculation of the dimensions of the Flettner Balloon if it is filled with helium or hydrogen compared to the initial volume:

$$V_B = 200000\ m^3$$

$$V_{bHe} = 37540\ m^3$$

$$V_{bH} = 23726\ m^3$$

$$\frac{V_B}{V_{BHe}} = \frac{200000}{37540} = 5{,}327 \cong 5$$

$$\frac{V_B}{V_{BH}} = \frac{200000}{23726} = 8{,}429 \cong 8$$

$$L_B = 245\ m$$

$$A_B = \frac{\pi D^2}{4} = \frac{3{,}14x25^2}{4} = 490{,}625\ m^2 \tag{27}$$

$$L_{BH} = \frac{245}{5} = 49\ m$$

$$V_{BHe} = 37540 \cong 40000\ m^3$$

$$A_{BHe} = \frac{490{,}625}{5} = 98{,}125\ m^2$$

$$D_{BHe} = \sqrt{\frac{4A_{BHe}}{\pi}} = \sqrt{\frac{4x98{,}125}{3{,}14}} = 11{,}18\ m \tag{28}$$

$$L_{BH} = \frac{245}{8} = 30{,}625 \cong 31\ m$$

$$V_{BH} = 23726 \cong 25000\ m^3$$

$$A_{BH} = \frac{490{,}625}{8} = 61{,}328\ m^2$$

$$D_{BH} = \sqrt{\frac{4A_{BH}}{\pi}} = \sqrt{\frac{4x61{,}328}{3{,}14}} = 8{,}83\ m \tag{29}$$

2.2 Placing four large vertical wind turbines on a container ship as an alternative source of energy

2.2.1 Vertical wind turbines

For positioning the 4 large vertical wind turbines on a port-container ship, we will have to sacrifice two bays, more precisely, two turbines will be located in the first bay in the bow, port/starboard, and two other turbines at the stern of the ship port/starboard. [4]

The foundation of each turbine has a diameter of 4 m. Bearing in mind that around the foundation there will have to be an access road and a space for connection and subsequent maintenance, we will consider that the area required to place a foundation is 25 m^2.

$S_R = 25\ m^2$

Where:

S_R= area required for the foundation of a turbine.

We will build a 10 m high metal foundation to benefit from stronger winds with an area of 25 m^2 on which the 24 m high wind turbine will be positioned.

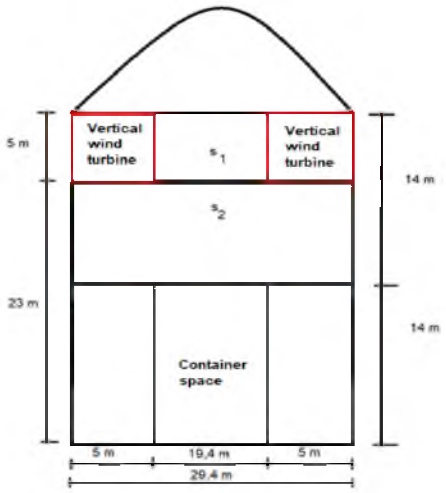

Figure 2: Positioning scheme of 2 of the 4 large vertical wind turbines installed in the bow of the port-container ship

From the above diagram we can see that the 2 turbines located in the bow of the ship, they will occupy the spaces of 2 containers each. A 45-foot container with the dimensions L= 13.76; l= 2.5 m; H=2.58 m. The space between the 2 turbines located

at the bow of the ship, along its width, will be left free, for good wind circulation.
$S_1 = 19{,}4x5 = 97\ m^2$

The space behind the rotors towards the stern of the ship will also be left free.
$S_2 = (14 - 5)x29{,}4 = 9x29{,}4 = 264{,}6\ m^2$

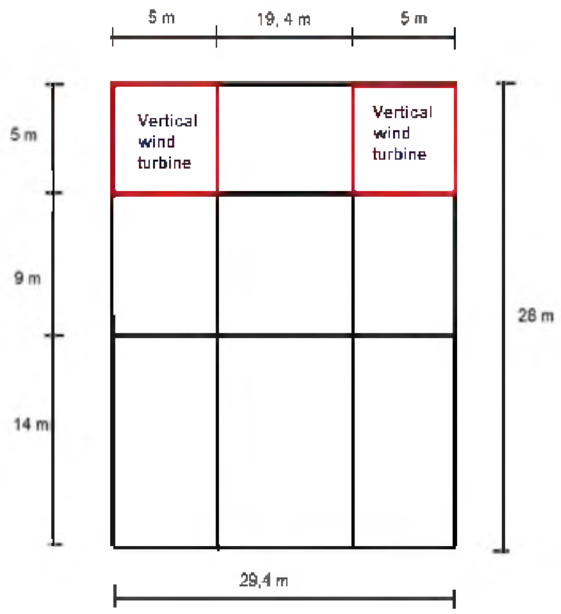

Figure 3: Positioning scheme of 2 of the 4 large vertical wind turbines in the stern of the port-container ship

2.2.2 Constructive characteristics of the vertical wind turbines

The turbine is made of glass fiber reinforced plastic/carbon fiber reinforced polymer. This being a light and resistant material.

The weight of a rotor together with the foundation is about 40 t.

Table 1: Data sheet of a large vertical wind turbine adapted for a port- container ship:

Model	24 x 4
Turbine	
Hight x diameter(m)	24 x 4
Material	glass fiber reinforced plastic/ carbon fiber reinforced polymer
Rotor Speed (rpm)	0-225, variable
Structure	
Tower	Cylindrical - made of steel
Foundation height (m)	10
Rotor and foundation weight (t)	40
Components	
Electric motor	90kW, 50/60 Hz IE4,IP55
Ambient conditions	
Operating Temperature	+50- -30 C
Wind speed required for operation	0-25 m/s
Resistance to wind force	70 m/s

Table 2: Energy generated by a large vertical wind turbine

Ship Speed : 19 Nd		
True wind power (m/s)	**Direction true wind (◦)**	**Generated energy (*kWh*)**
10	60-130 şi 230-300	500
22	105-135 şi 225-255	2000

From the table above, we can see that at a ship speed of 19 Kn and a wind of 10 m/s, a single large vertical wind turbine can generate 500 kWh, and for a wind of 22 m/s, it can generates 2000 kWh.

Following the installation of the 4 turbines, at a ship speed of 19 Kn and a wind of 10 m/s we will be able to generate approximately 2000 kWh, and for a wind of 22 m/s approximately 8000 kWh.

2.3 Energy balance of electricity generating systems, from non-conventional sources

Table 3: Energy balance of electricity generating systems, from non-conventional sources

Device	**Energy performance E (*kWh*)**	
	Wind at 10 m/s	**Wind at 22 m/s**
Flettner helium Balloon		1000
4 Large vertical wind turbines	2000	8000

The two systems can together generate energy between $E = 2000\ kWh$ and $E^{'} = 8000\ kWh$. During crossings, the ship uses only one generator, of $E = 2000\ kWh$.

From the above calculations, it follows that we can use non-conventional energy systems to cover the minimum energy requirement $E = 2000\ kWh$, thus reducing pollution and lowering the cost of fossil fuels.

Due to international legislation, the ship will use fossil fuel propulsion near and inside the ports.[5]

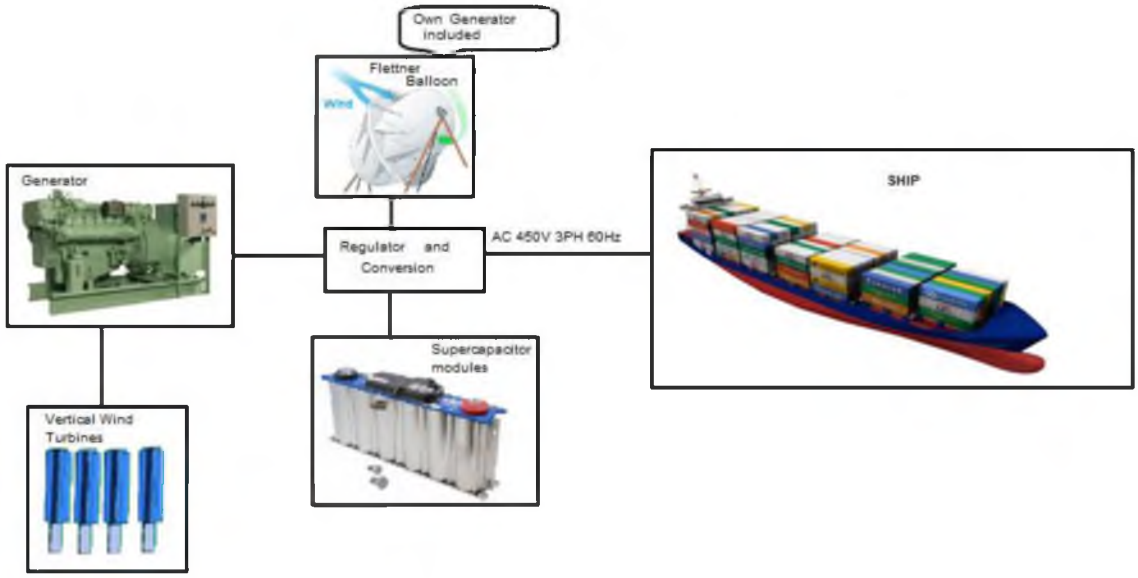

Figure 4: Connection diagram of the hybrid energy system to a port-container ship

Figure 5: Image of the port-container ship with the hybrid energy system installed

2.4 Connecting conventional and non-conventional power sources to the ship's main power bar

The ship will be supplied with energy as follows:

➢ On the port side we will find:

• Generator 1 (G1 – AC450V 3 PH 60 Hz 2000 kVA)

• Generator 2 (G2 – AC450V 3 PH 60 Hz 2612.5 kVA)

• Flettner Balloon (B – AC450V 3 PH 60 Hz 1000 kVA)

• Vertical wind turbine 1 (FR1 – AC450V 3 PH 60 Hz 2000 kVA)

• Vertical wind turbine 2 (FR2 – AC450V 3 PH 60 Hz 2000 kVA)

➢ On the starboard we will find:

• Generator 3 (G3 – AC450V 3 PH 60 Hz 2612.5 kVA)

• Generator 4 (G4 – AC450V 3 PH 60 Hz 2612.5 kVA)

• Vertical wind turbine 3 (FR3 – AC450V 3 PH 60 Hz 2000 kVA)

• Vertical wind turbine 4 (FR4 – AC450V 3 PH 60 Hz 2000 kVA)

Both the four vertical wind turbines installed on the main deck of the ship and the Flettner helium Balloon generate a continuous current. [6] To be able to connect these non-conventional energy sources, to the ship's main power bar, we had to bring the current to 450V AC and 60 Hz.

For this we used 5 current inverters: one 690/450V 1500kVA marked T1 on the electrical diagram for the Flettner Balloon [7] and four 690/450V 2500 kVA marked T2, T3, T4, T5 for each of the four vertical wind turbines FR 1, FR2, FR3, FR4.

The line on which the ACB is located is called the line of force. ACB is a power circuit breaker, with the role of connecting the generator to the main power bar.

ACONIS 2000 PMS stands for Power System Management. It is used for the automatic coupling of energy sources, being located on the command and control line. ACONIS also has the role of supervising currents, protection and load distribution.

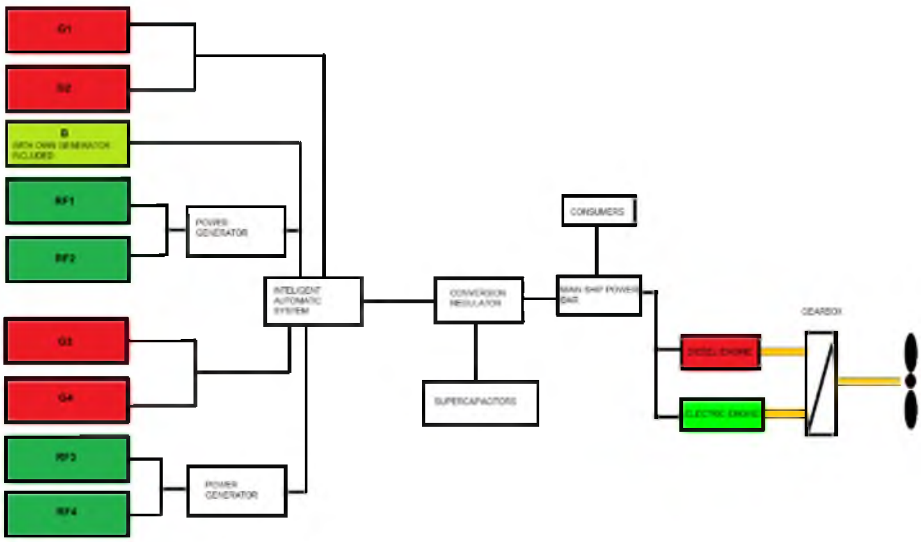

Figure 6 : Hybrid system

There are 3 phases in the ACONIS system.

ACONIS reads the voltage and frequency entering the system and compares it with the already existing voltage and frequency found in the line leaving it. The role of these comparisons is to make a ABC safe.

PT1A is a transformer with the role of sending the voltage information to the voltmeter V which measures the voltage. It sends the voltage information and the operating frequency to the synchronization panel and the HM counter, which calculates the operating time.

CT1 and CT2 represent some current transformers that send the information to ammeter A and to ACONIS.

AS1 represents an ammeter switch and VS1 represents a voltmeter switch.

The WTD is a junction box, with the role of sending the load information to the local ammeter A and to the wattmeter W in the synchronization panel.

SY is a synchronization module, which takes information from the power bar and the information from each individual source of each electrical current generator G1, G2, G3, G4 and from the non-conventional energy generators FR1, FR2, FR3, FR4, B, for safe coupling in manual mode in parallel to the main power bar.

The W1 ⟶ W line, represents the line to the sync panel.

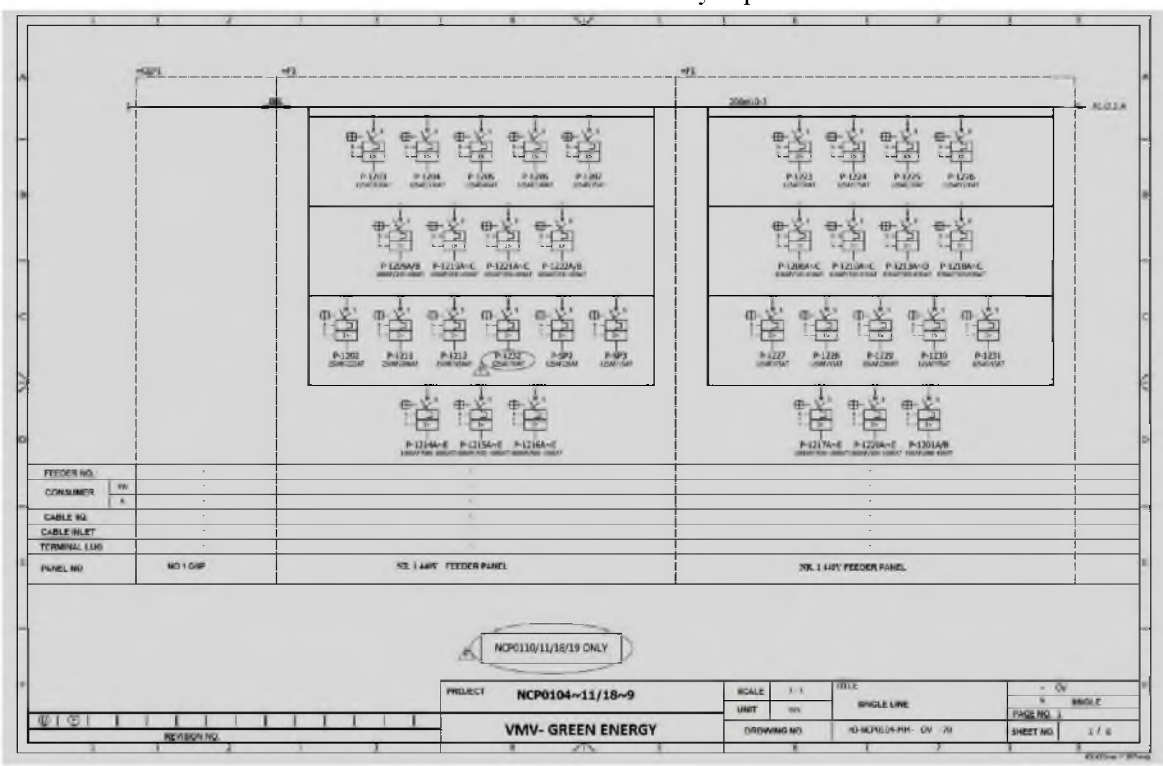

Figure 7: Connecting electrical scheme 1/6 of conventional and unconventional energy sources to the ship main power switchboard

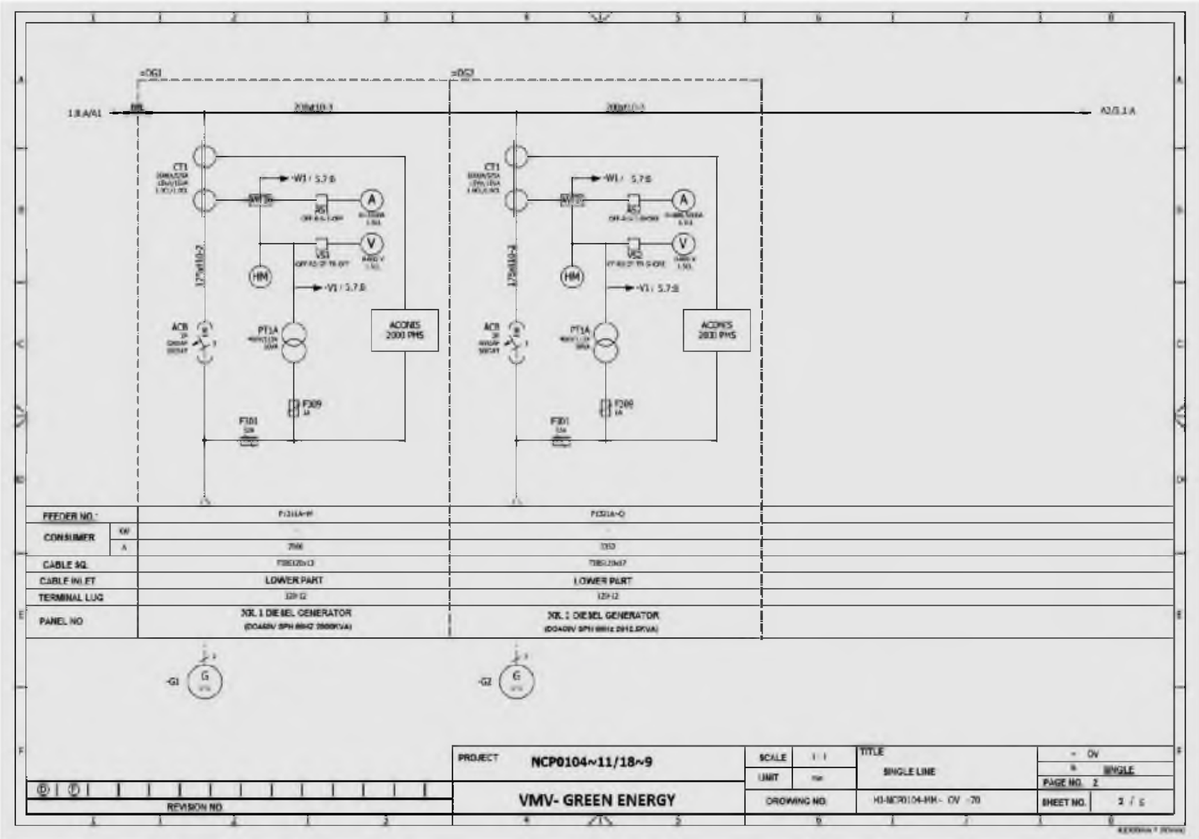

Figure 8: Connecting electrical scheme 2/6 of conventional and unconventional energy sources to the ship main power switchboard

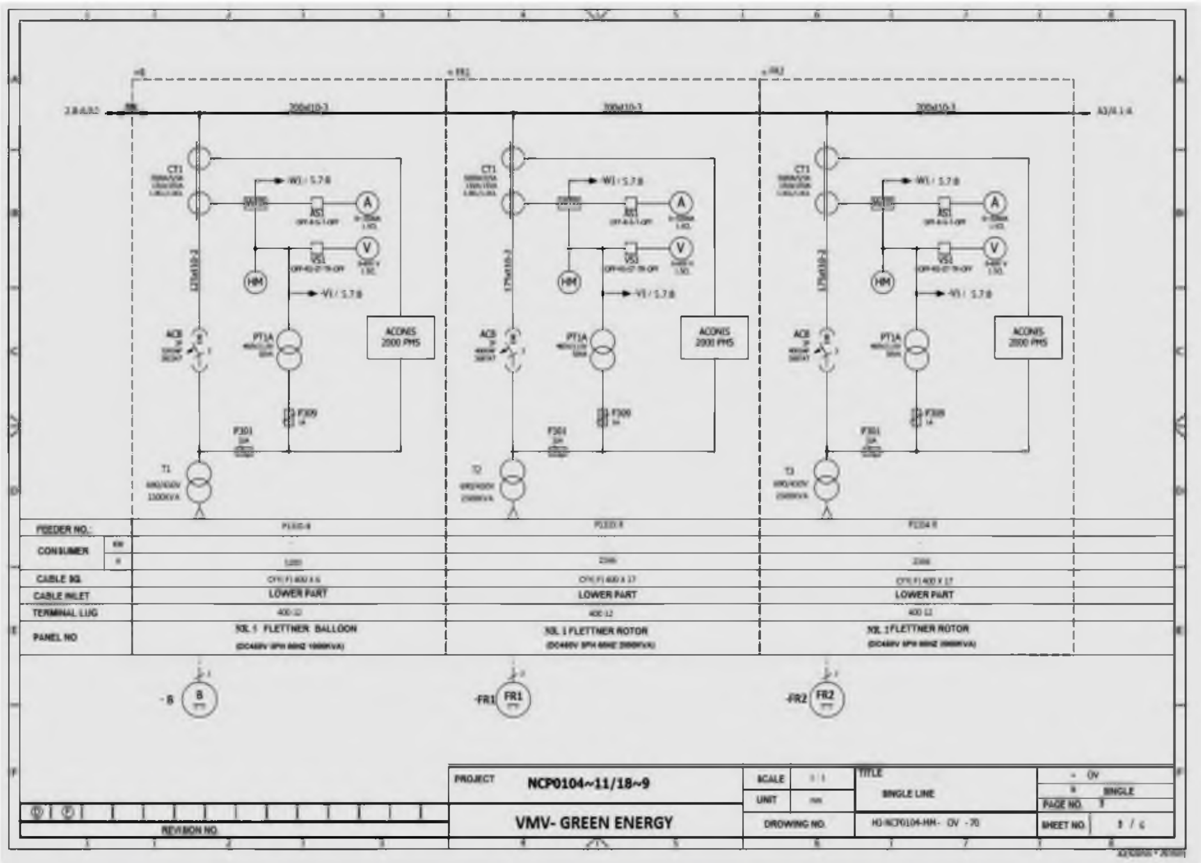

Figure 9: Connecting electrical scheme 3/6 of conventional and unconventional energy sources to the ship main power switchboard

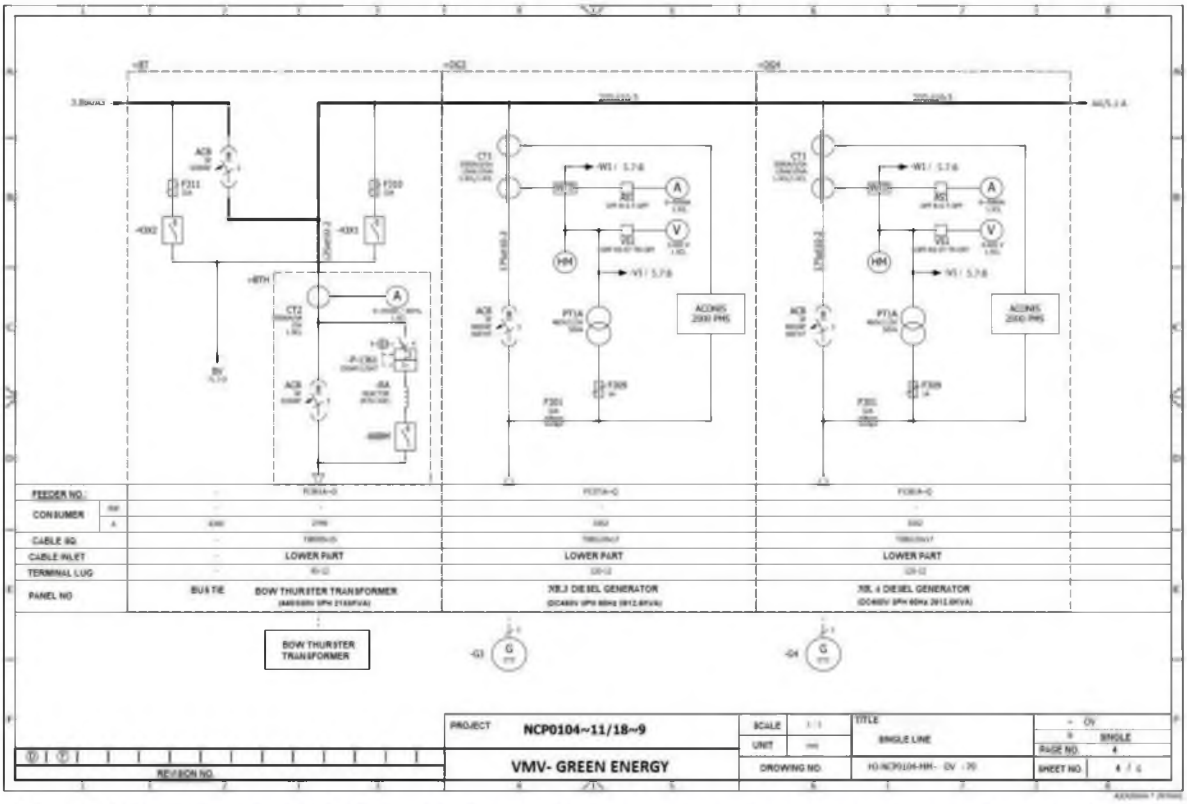

Figure 10: Connecting electrical scheme 4/6 of conventional and unconventional energy sources to the ship main power switchboard

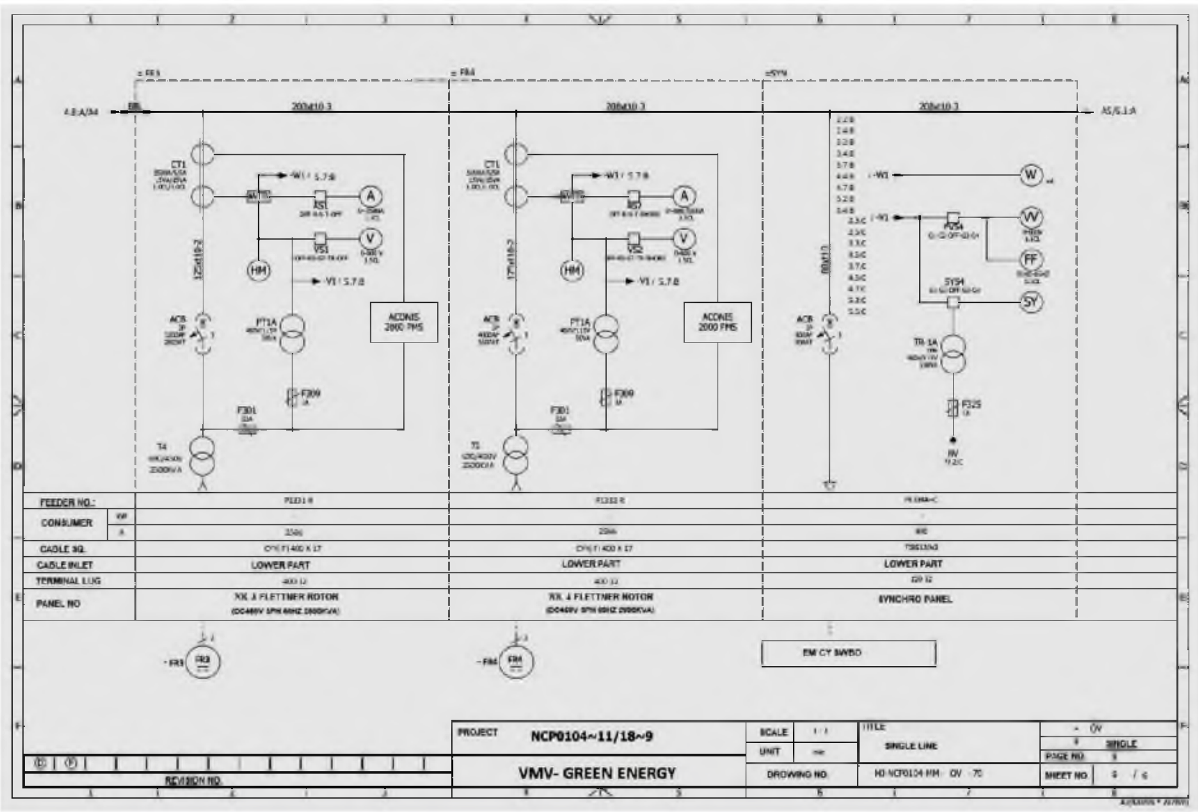

Figure 11: Connecting electrical scheme 5/6 of conventional and unconventional energy sources to the ship main power switchboard

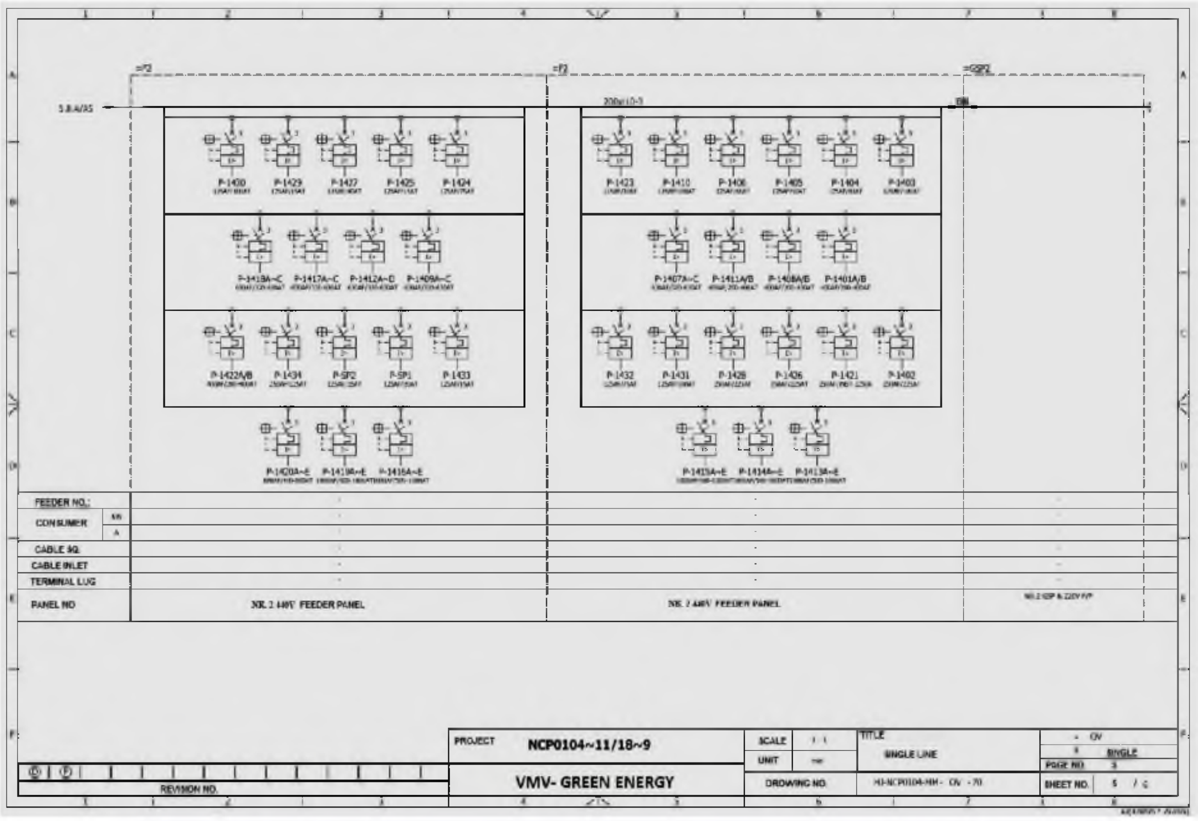

Figure 12: Connecting electrical scheme 6/6 of conventional and unconventional energy sources to the ship main power switchboard

2.5 Electrical load of the ship's consumers

The components of the electrical hybrid installation for the production of electric current [8]:

➢ Conventional energy sources:

• Main Generator (LG- large generator): 3 pieces on AC 450 V / 2,090 kW;

• Main Generator (SG- small generator): 1 piece on AC 450 V / 1600 kW;

• Emergency generator: 1 piece of AC 450 V / 150 kW;

➢ Non-conventional energy sources:

• Flettner Balloon (B): 1 piece on AC 450 V / 1000 kW;

• Vertical wind turbines (RF): 4 pieces on AC 450 V / 2000 kW;

Table 4: Number of generators required for each operation:

Time		**Conventional energy sources**	**Non-conventional energy sources**
During Ocean Crossing	No refrigerated containers	SG x 1	RF x 1
	With refrigerated containers	SG x 1, LG x 2	B x 1, RF x 3
During the maneuver	No refrigerated containers and no bow thruster	SG x 1	-
	With refrigerated containers and without bow thruster	SG x 1, LG x 2	-
	Without refrigerated containers and with a bow thruster	SG x 1, LG x 1	-
During cargo operations	With refrigerated containers and bow thruster	SG x1, LG x 3	-
	No refrigerated containers	SG x 1	-
	With refrigerated containers	SG x 1, LG x 2	-
In Emergency	-	EG x 1	-

Tabel 5 : Alternative sources and conventional electrical generators

CONDITIONS			Alternative sources of energy	Conventional sources of energy						
			Sea passage	Sea passage	Maneuver		During cargo operations	In port	In Em`cy	In fire
					Without thurster	With thurster				
Without reefer containers	Generator capacity (kW)		2000	1600	1600	3690	1600	1600	150	150
			RF X 1	SG X 1	SG X 1	SG X 1 + LG X 1	SG X 1	SG X 1	EG X 1	EG X 1
	Total Load (kW)	Before PC	**1032.8**	**1032.8**	**1344.4**	**3011.1**	**1132.2**	**893.3**	**108**	**97.6**
		After PC 1	812.8	812.8	1034	2700.7	860.2	614.1	-	
		After PC 1&2	812.8	812.8	1034	2700.7	860.2	614.1		
		After PC 0&1&2	812.8	812.8	1034	1034	860.2	614.1		
	Generator Load (%)	Before PC	**64.55**	**64.55**	**84.03**	**81.6**	**70.76**	**55.83**	**71.98**	**65.06**
With reefer containers (6 kW x 650 bucati= 3900kW)	Generator capacity (kW)		7000	5780	5780	7870	570	5780	-	-
			B x 1 + RF X 3	SG X 1 + LG X 2	SG X 1 + LG X 2	SG X 1 +LG X 3	SG X 1+ LG X 2	SG X 1 + LG X 2		
	Total Load (kW)	Before PC	**4993.4**	**4993.4**	**5305.1**	**6971.7**	**5092.9**	**4853.9**		
		After PC 1	4712.8	4712.8	4934	6600.7	4760.2	4521.3		
		After PC 1&2	812.8	812.8	1034	2700.7	860.2	621.3		
		After PC 0&1&2	812.8	812.8	1034	1034	860.2	621.3		
	Generator Load (%)	Before PC	**86.39**	**86.39**	**91.78**	**88.59**	**88.11**	**83.98**		

2.6 Definitions

During the crossing:

➢ Navigation at a speed corresponding to 90% SMCR of the main engine.

During the maneuver:

➢ When the ship leaves or enters the port. [9]

During cargo operations:

➢ When the cargo is loaded or unloaded.

In Port:

➢ When the ship is in port.

The electrical load for each moment is influenced by the climatic conditions.

Large consumer group:

• Refrigerated containers: 3900 kW (6 kW x 650 pieces);

• Bow thruster: 1600kW.

If the generators putted in parallel fail to start, all PC (particular cases - PC1, PC2) with consumers including the bow thruster (PC0) will start, without delay.

Load factor:

➢ The ratio between the required average power and the maximum power;

Diversity factor:

➢ Based on statistical and experimental data;

Task required:

➢ Input x load factor x diversity factor (kW);

PC (particular case):

➢ Non-essential load in case of generator overload or if parallel loading gives errors.

2.7 Conclusions

The hybrid system described in this article is part of the Green Ship concept, where alternative methods of naval propulsion are analyzed.

Continuous efforts are being made to reduce costs, noise and pollution, thereby creating a dynamic market for non-conventional, green, environmentally friendly alternative sources of electricity supply, thus making for a cleaner, greener environment.

By using the hybrid system, we increase safety in operation through the existence of two relatively independent electricity generating systems, one in relation to the other.

Transport modes need to become more sustainable, smarter and more resilient.

Although maritime transport has improved its environmental footprint in past years, it still faces big challenges when it comes to decarbonising and reducing pollution.

One method of reducing pollution generated from naval industry is using the hybrid system describied in this article. World should continue developing new technics, new methods, new devices which use non-conventional sources of energy in order to reduce pollution and to save the envinronment.

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ASPECTS OF VENTILATION PRINCIPLES IN SHIPS MACHINERY ROOMS

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To maintain the air parameters in the rooms within the permissible or comfortable limits, the ventilation systems are designed to circulate the air in the rooms on board, usually without heat treatment or humidity. Ventilation systems consist of machines that provide the energy for air circulation (fans), main ducts connected to the suction and exhaust of the fans, branches and distribution components. For machinery spaces related to ships, ventilation systems are vital for the proper functioning of thermal engines used as propulsion systems. Gas turbines are heat engines used as propulsion systems usually for special ships.
Keywords: ventilation, flow, machinery, fan.

НЕКОТОРЫЕ АСПЕКТЫ ПРИНЦИПОВ ВЕНТИЛЯЦИИ СУДОВЫХ МАШИННЫХ ОТДЕЛЕНИЙ

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Для поддержания параметров воздуха в помещениях в допустимых или комфортных пределах системы вентиляции предназначены для циркуляции воздуха в помещениях на борту, как правило, без термической обработки или увлажнения. Вентиляционные системы состоят из машин, обеспечивающих циркуляцию воздуха (вентиляторы), основных воздуховодов, соединенных с всасывающими и вытяжными вентиляторами, ответвлений и распределительных элементов. Для помещений машинного отделения, связанных с судами, системы вентиляции жизненно важны для правильного функционирования тепловых двигателей, используемых в качестве двигательных установок. Газовые турбины — это тепловые двигатели, используемые в качестве двигательных установок, как правило, для специальных судов.
Ключевые слова: вентиляция, поток, машины, вентилятор.

1. Introduction

Natural ventilation is based on the idea of free movement of air masses, the displacement being dictated either by the kinetic energy of the flowing air or by the difference in air density at different temperatures. Ventilated compartments have ventilation ducts that exit at the top (outlet to the atmosphere), are movable in the direction of the atmospheric air flow, and either introduce or remove air from the ventilated compartment. The kinetic energy of the air mass is transformed in the ventilation pipes into the static pressure difference, which is the basis of the air exchange in the rooms. Fans are used to move air in and out of the compartment when artificial ventilation is used. Regardless of the weather, these fans will provide ventilation when needed. The ventilation system ensures the transport of air used as replacement air or