



C-ENERGY Technologies AB

Exhaust Gas Recirculation (E.G.R.) system

– NO_x Reduction Solution

Introduction

- founded 2020 in Gothenburg
- engineering experts focusing on the maritime energy transition
- environment and climate require sustainable solutions for marine exhaust emissions
- usual solutions (LNG conversions or SCR retrofits) are coming with high CAPEX and OPEX
- C-ENERGY Technologies provides an E.G.R. system for any possible marine or stationary application
- C-ENERGY Exhaust **G**as **R**ecirculation E.G.R. system is a proven design
- Providing EEXI and CII compliance for existing diesel engines
- robust and reliable NO_x reduction solution
- verified functionality, performance and durability

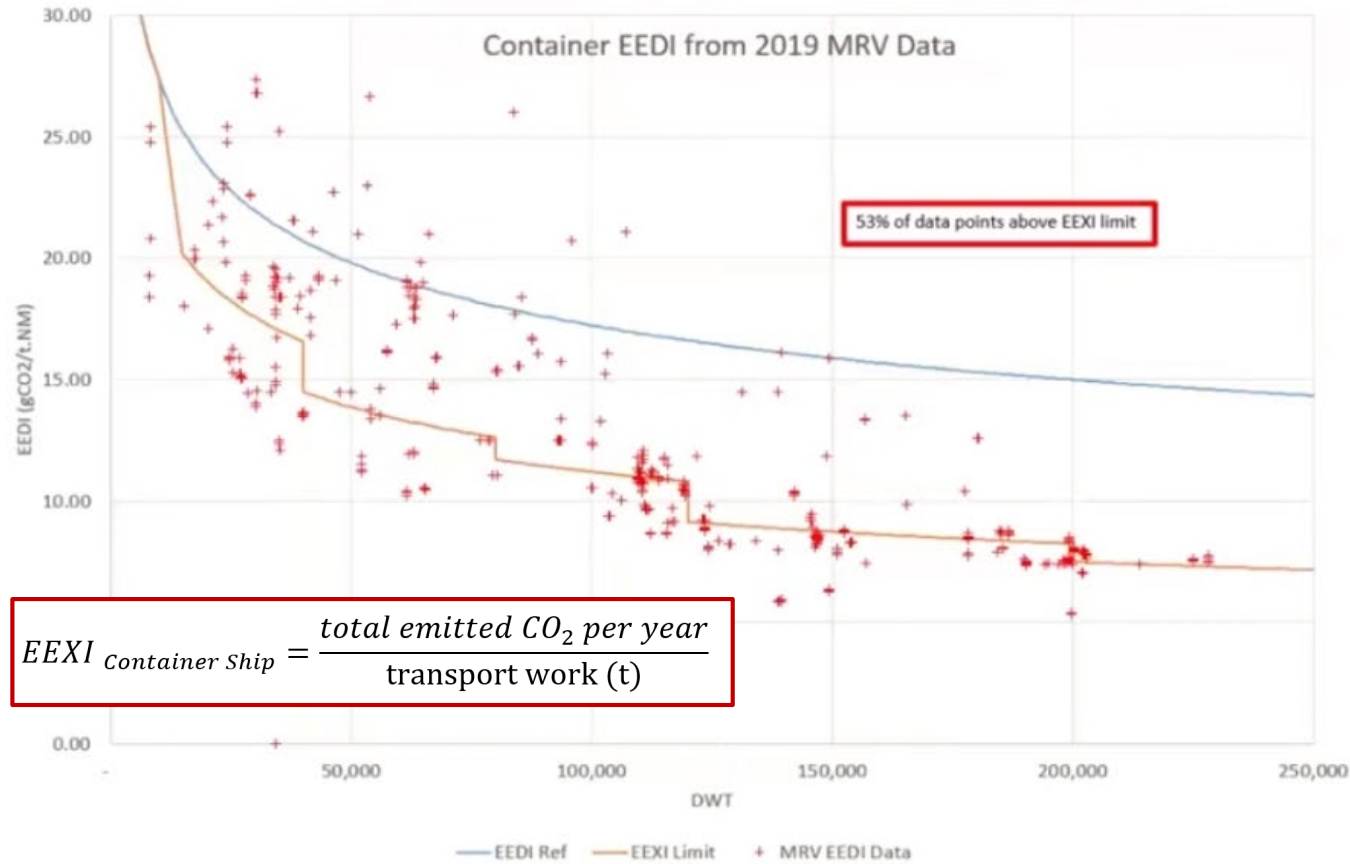
Background

- IMO's mandatory measures approved by MEPC to cut the carbon footprint of all ships
- two new measures are: Energy Efficiency Existing Ship Index (EEXI) & Carbon Intensity Indicator (CII)
- the new amendments are expected to be adopted by 2023

About the **Energy Efficiency Existing Ships Index (EEXI)**

- for the majority of ship types, the requirements follow the EEDI phase relevant for new ships in 2023
- EEXI compliance to be documented by all ships
- EEDI compliant vessels most likely have to add further documentation
- pre-EEDI certified vessels may obtain further documentation if EEXI cannot be fulfilled

Indicative impact on the global container ship fleet



Lloyd's Register

EEXI Compliance Retrofit Solution:

C-ENERGY E.G.R.

plus

Fuel Saving Option (FSO)

Source: Lloyd's Register Webinar March 2021

About the **Carbon Intensity Indicator (CII)**

- CII defined as CO₂ emissions per transport task (e.g. CO₂/dwt x nautical mile)
- from January 1st 2023, all ships above 5,000 gt have to calculate and report their CII annually
- based on the CII, ships will be rated from A to E (where A is best) according to the following scale :

A – Major Superior

B – Minor Superior

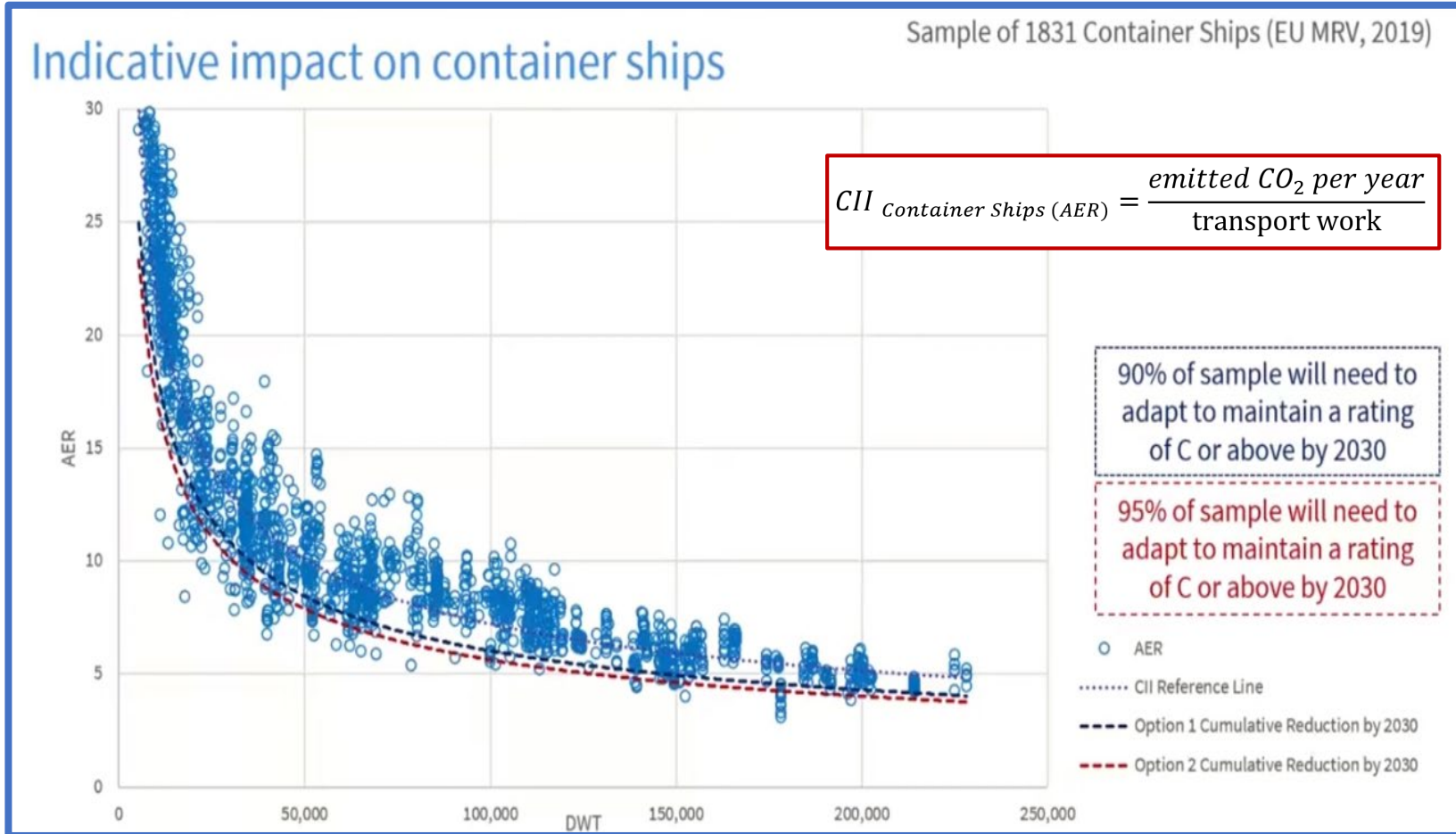
C – Moderate



D – Minor inferior

E – Inferior performance level

- **for D & E: action plan required to improve rating to C or higher**



Source: Lloyd's Register Webinar March 2021

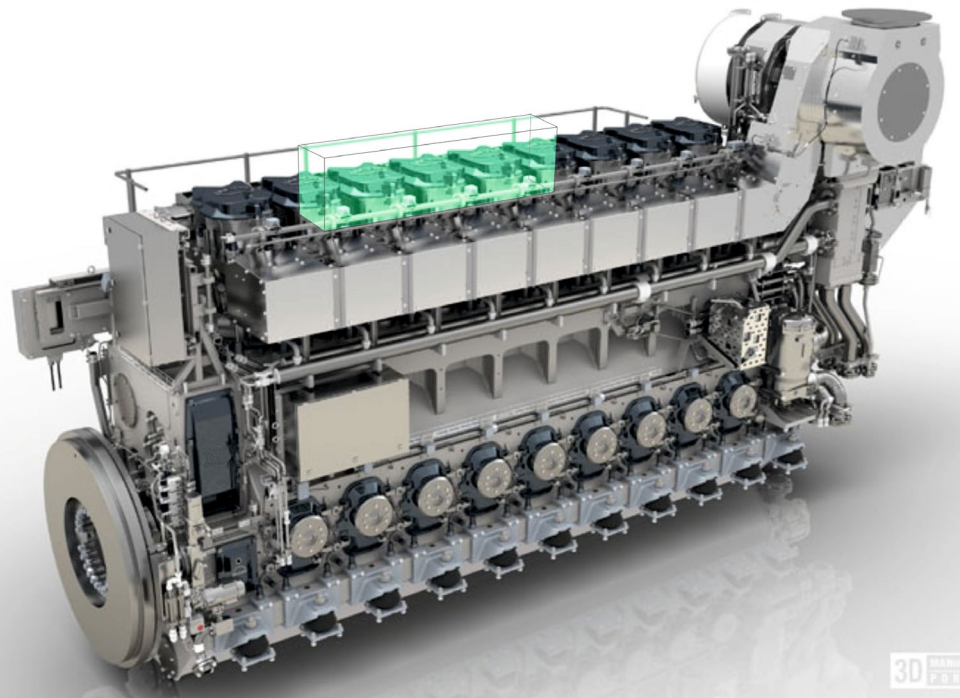
CII Compliance Retrofit Solution:

C-ENERGY E.G.R.

plus

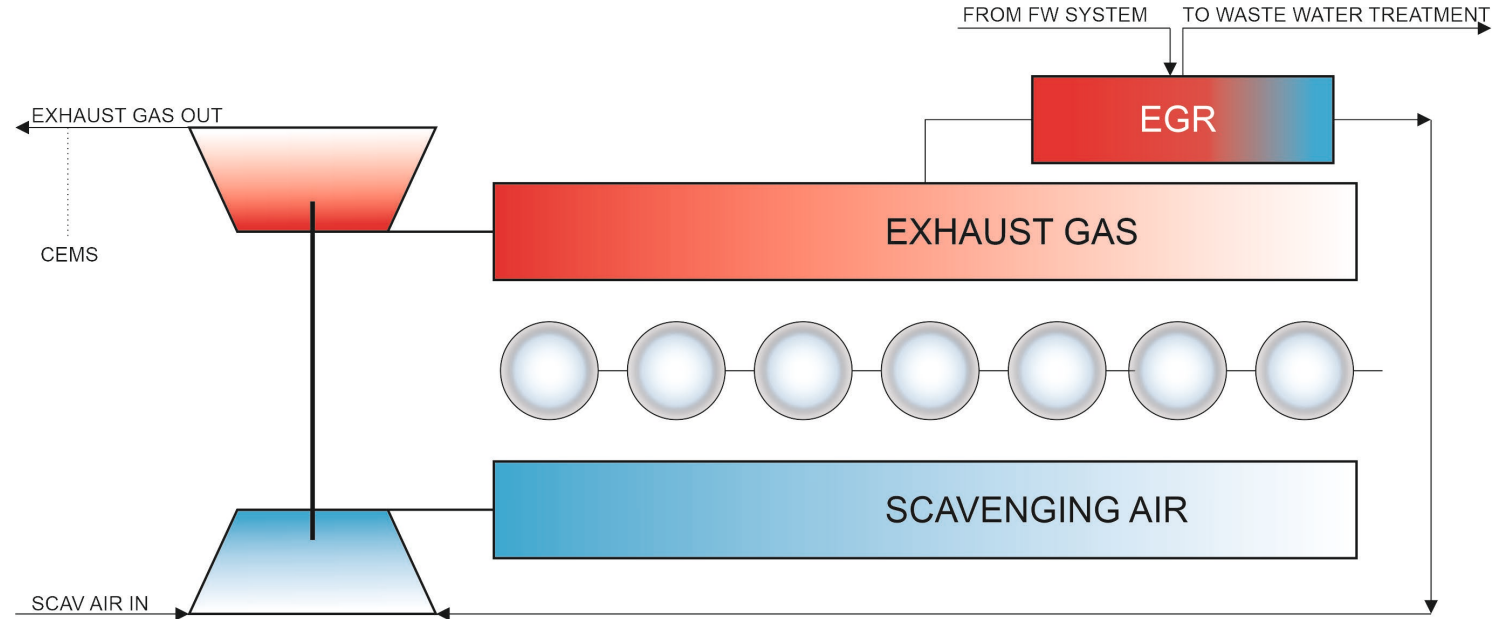
Fuel Saving Option (FSO)

E.G.R. – WORKING PRINCIPLE & TECHNICAL SETUP



- small dimensions of E.G.R. box
- easy to install
- access for engine services

- Constant Emission Monitoring System (CEMS)



ARGUMENTS FOR C-ENERGY E.G.R. (1/2)



C-Energy's E.G.R. solution follows a **Two-Step approach**:

1. NOx reduction of more than 80% enables maritime IMO Tier III level.

2. Set back fuel injection timing reduces up to 10% fuel consumption and consequently CO2 emissions.

→ fulfillment of new emissions regulations combined with


→ short Return of Investment due to fuel savings and lower OPEX (versus SCR and Dual-Fuel LNG conversions)

- installation requires a few days only
- even during sailing at multi engine propulsions

- C-ENERGY guarantees the defined emission levels at the funnel/chimney
- prove via constant emission monitoring systems

ARGUMENTS FOR C-ENERGY E.G.R. (2/2)





CET Marine AB
Repslagaregatan 3a
413 18 Gothenburg
Sweden

DNV GL SE Ship Classification
Machinery & Piping Systems
Brooktorkei 18
20457 Hamburg
Germany

Date:	Our reference:	Your reference:	Job ID:
2021-12-08	M-SA-MP/SVENED/ 10701727-J-8		10701727-1

Exhaust Gas Recirculation System

Reference is made to your e-mails dated 2021-10-21, 2021-12-02 and 2021-12-03. The following submitted documents are stamped and given the status as shown below.

Document No	Rev	DNV No	Title	Code	Status
001	1.0	2	EGR-Schematic-View		Approved
002	1.0	3	Logic-Signals		Approved
003	1.0	4	System-Communication		For Inf.
004	1.0	5	Cabinet-Design		For Inf.
005	1.0	6	Abbreviations		For Inf.
		8	c-energy_egr_technical-specification_to_DNV_2021-12-02		For Inf.
		2021- 14	FMEA_for_C-		For Inf.
		12-02	ENERGY_EGR_system		
		17	c-energy_egr_product-presentation		For Inf.

General Comments	Type
<p>1</p> <p>Scope of Approval</p> <p>The design of the Exhaust Gas Recirculation System is in compliance with the requirements of DNV rules for R.I.C. engines (RU-SHIP Pt.4 Ch.3 Sec.1). The sludge system is not part of this approval.</p> <p>Document No. 001/1.0, "EGR-Schematic-View", Document No. 002/1.0, "Logic-Signals", Document No. 003/1.0, "System-Communication", Document No. 004/1.0, "Cabinet-Design", Document No. 005/1.0, "Abbreviations", Document No. (empty), "c-energy_egr_technical-specification_to_DNV_2021-12-02", and Document No. (empty)/2021-12-02, "FMEA_for_C-ENERGY_EGR_system" have all been reviewed in accordance with DNVGL Pt.4 Ch.3</p>	<p>Important Note</p>

DNV Headquarters, Veritasveien 1, P.O.Box 300, 1322 Høvik, Norway. Tel: +47 67 57 99 00. www.dnv.com

DM9db736.docx

- DNV has issued a “Class Approval” in principle for our E.G.R. system on Diesel engines
- the design of the Exhaust Gas Recirculation (E.G.R.) system is in compliance with the requirements of DNV rules for R.I.C. engines (RU-SHIP Pt.4 Ch.3 Sec.1)
- our customers will always be supported in case of any Class questions



REFERENCE



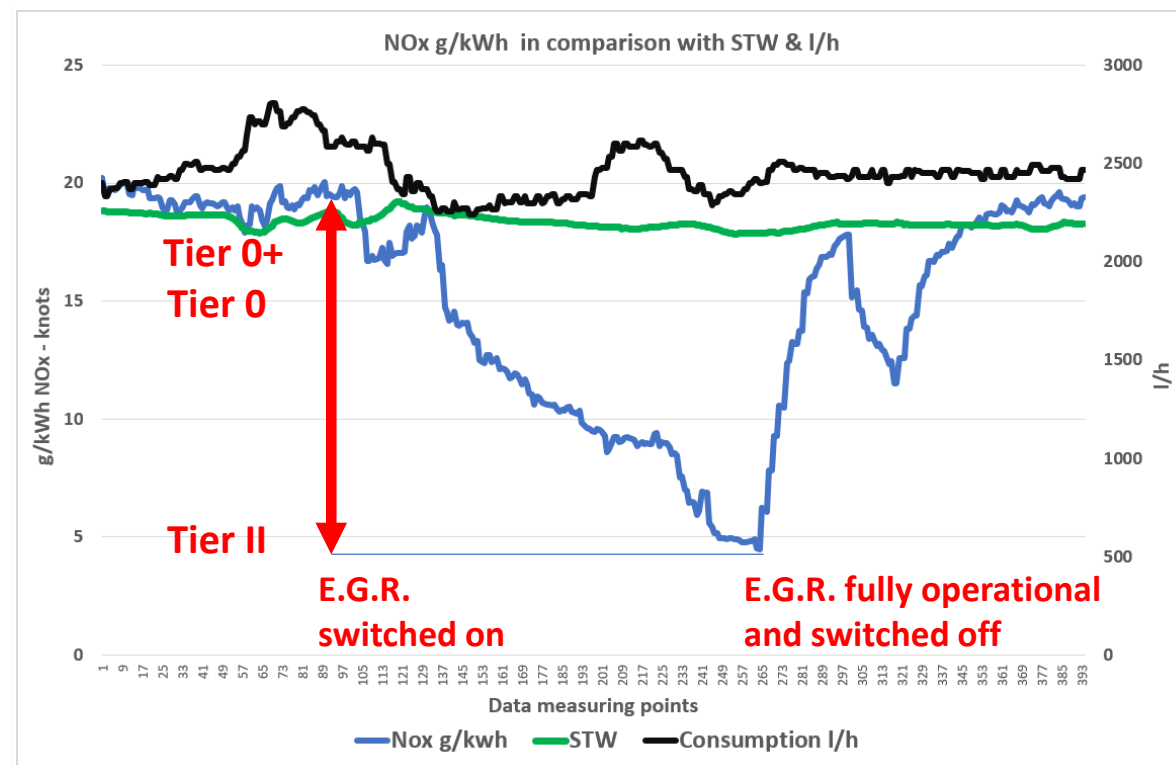
Roll-On/Roll-Off ferry with 4x Sulzer 8L ZA40S main engines, each 5.7 MW
(510 rpm, Diesel-Mechanic application)

Performance of the E.G.R. on one engine:

- change of emission level from IMO Tier 0+ to Tier II level
- NO_x reduced by 78%.

Fuel Saving Option (FSO)

- approx. 11% fuel saving
- 11% less CO₂ and PM emissions



PROJECT SCHEDULE



Following steps are needed for a E.G.R. installation project:

1. Assessment Data Sheet
2. Letter of Intent (LoI)
3. Site inspection
 - approx. 4 to 8 hours during sailing or at berth
4. Contract signing
5. Preparation time on board
6. Installation time for one inline engine
 - E.G.R. Box installation on cold engine approx. a few hours
 - FSO up to 4 days depending on engine maker and type
 - FSO only an option, independent from the E.G.R Box installation
7. Commissioning / Sea Trial
8. Acceptance Test period (optional)
 - approx. 1 - 3 months

CASE STUDY



- standard 1000 TEU container feeder ship
- one main engine, about 9 MW with IMO Tier II to achieve emission reductions IMO Tier III:

Case Study:	Dual-Fuel conversion	SCR catalyst	C-ENERGY Technologies	
			with fuel saving option	without fuel saving option
1000 TEU Container ship	for Natural Gas	installation	E.G.R. installation	
Engine update costs	2.600.000 €	50.000 €	960.000 €	915.000 €
LNG fuel gas & tank 500m ³	2.400.000 €	n.a.	n.a.	n.a.
SCR cat / Mixing Unit / Comp. air	n.a.	350.000 €	n.a.	n.a.
Shipyard complete	4.550.000 €	1.020.000 €	160.000 €	95.000 €
Project Management	30.000 €	15.000 €	5.000 €	5.000 €
Sea Trial cost	75.000 €	40.000 €	20.000 €	10.000 €
Off-hire (10.000€/day)	560.000 €	280.000 €	140.000 €	70.000 €
total	10.215.000 €	1.755.000 €	1.285.000 €	1.095.000 €
Conversion time in Shipyard	6 weeks	2 weeks	1 week	0.25 week
Commissioning (cold / hot)	1 week	1 week	0.5 week	0.25 week
Sea trial	1 weeks	1 week	0.5 week	0.5 week
total	8 weeks	4 weeks	2 weeks	1 week
OPEX	👍	👎👎👎	👍👍👍	👍👍



SSW Super 1000 type with approx. 13.000 dwt

Note: values and time frame are estimated and can variate depending on Shipyard, location and engine availability.

Advantages of our E.G.R. system vs. SCR system

- DNV Class Approved system
- listed supplier for NOx-Reducing Technologies at the Norwegian NOx Fund
- no dry docking or shipyard is needed
- no additional Urea and Compressed Air are needed
- no extension of the funnel is needed, no loss of space e.g. for Cabins
- E.G.R. system is installed on exhaust pipe at top of the engine, no disturbance for engine maintenance
- engine is needed for approximately a few hours to make to connection to the E.G.R. system
- Fuel Saving Option (FSO) is available
- low CAPEX costs, very low OPEX costs

CASE STUDY



C-ENERGY Technologies



**1000 TEU Container Ship, approx. 9 MW, 5000 rh
and IMO Tier II to III Upgrade**

Business Case calculator

Input		
Fuel average consumption per year	[t / year]	6.000
Bunker price Rotterdam for HFO LS 0,1%	[USD / t]	585
Exchange rate USD / €	[Euro]	0,86
Fuel savings *	[%]	8,00
Investment for E.G.R. system with Fuel saving option	[Euro]	1.285.000
Output		
Bunker price	[Euro / t]	503
Fuel costs per year	[Euro / year]	3.018.600
Fuel savings per year	[Euro / year]	241.488
Payback / ROI	[year]	5,32

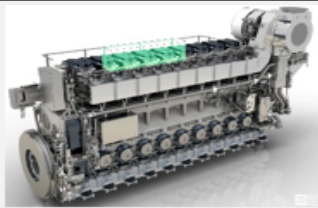
* Depending on engine maker and setup; for more detailed information please fill out our Customer Data Sheet.

TAILOR MADE ARRANGEMENTS FOR YOUR ENGINES



IMO Marine NOx emission standards	in force date
Global requirements	
IMO Tier 0+ (trimmed engine)	until 1999
IMO Tier 0	until 1999
IMO Tier I	2000 - 2010
IMO Tier II	2011 - ...

Emission Control Areas (ECAs)	
IMO Tier III: North American and the US Caribbean ECA areas	2016 - ...
IMO Tier III: North Sea and the Baltic Sea areas	2021 - ...
IMO Tier II: Norwegian world heritage fjords (for <u>all</u> ships)	2022 - ...
IMO Tier III: Norwegian world heritage fjords (for <u>all</u> ships)	2025 - ...

	C-ENERGY Technologies				
	Installation options				
	E.G.R. only	E.G.R & Fuel saving option			
What can we do for your engine having:	NO _x upgrade to	NO _x upgrade to	Fuel savings *	Derating *	CO ₂ savings *
IMO Marine NOx emission standards					
IMO Tier 0+ (trimmed engine)	Tier I or II	Tier I or II	up to 12%	approx. 8%	up to 12%
IMO Tier 0	Tier I or II	Tier I or II	-	-	-
IMO Tier I	Tier II	Tier II	up to 8%	nil	up to 8%
IMO Tier II	Tier III	Tier III	up to 8%	nil	up to 8%

* Depending on engine maker and setup; for more detailed information please fill out our Customer Data Sheet.

C-ENERGY SOLUTIONS IN A NUTSHELL



The C-ENERGY Technologies E.G.R. system helps ...

- **NO_x emission reduction**

→ to achieve a better IMO Tier level

- **Reduction of fuel consumption**

→ for a short amortization and fuel cost savings

- **EEXI compliance**

→ for unrestricted/unlimited operation performance

- **CII compliance**

→ for unrestricted/unlimited operation performance

all these officially certified effects

→ contribute to the “zero emission” initiative

C-ENERGYS MISSION STATEMENT



“Preserving the viability of the planet is the task and responsibility of the generation acting responsibly now. Our customers benefit from our advanced E.G.R. system and can provide their individual contribution to the necessary energy transition within the shipping industry.”

“Its time to act!”



BACKUP

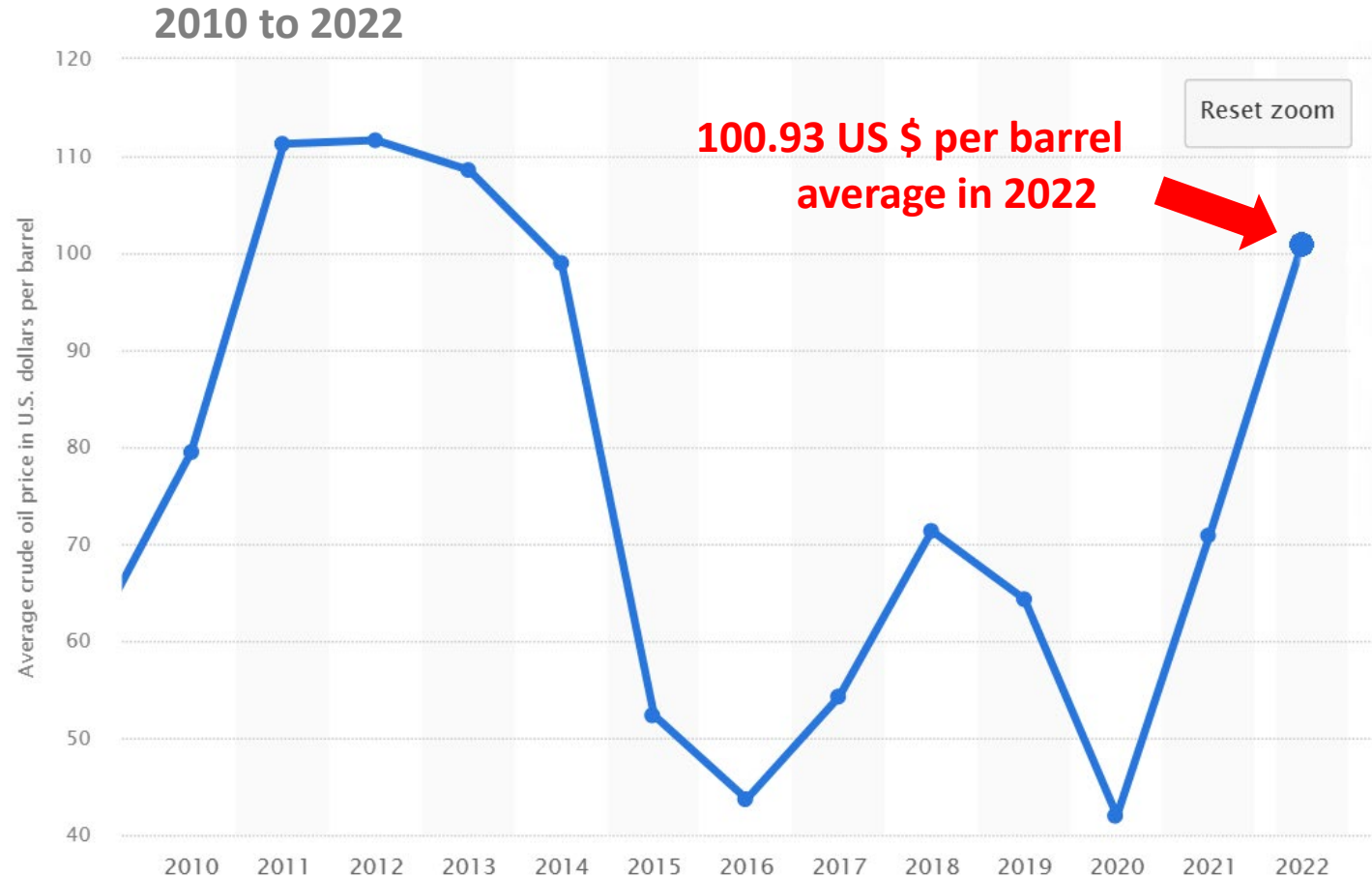
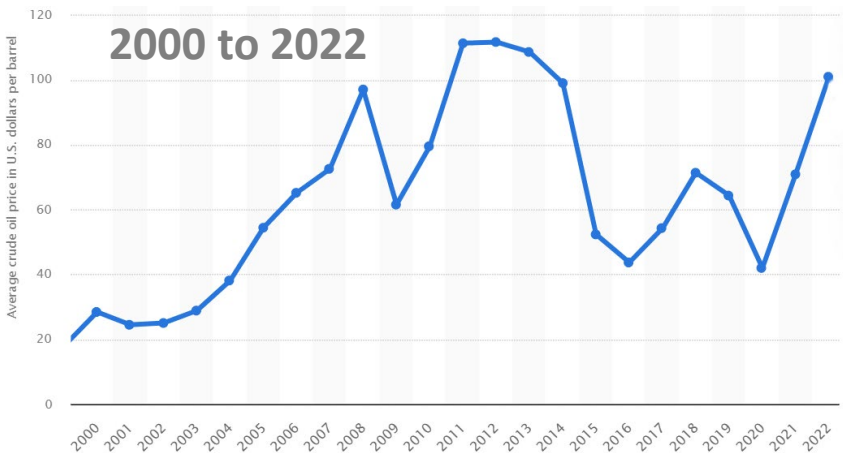
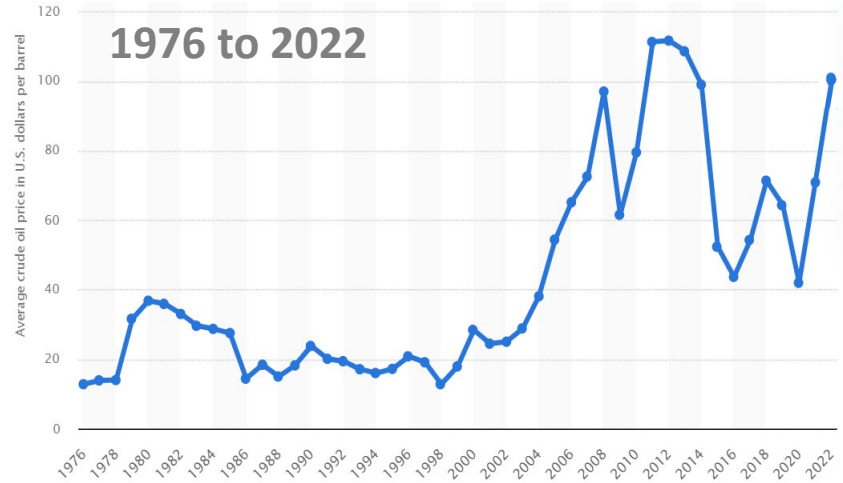
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Average annual Brent crude oil price

© Statista 2023

(in U.S. dollars per barrel)

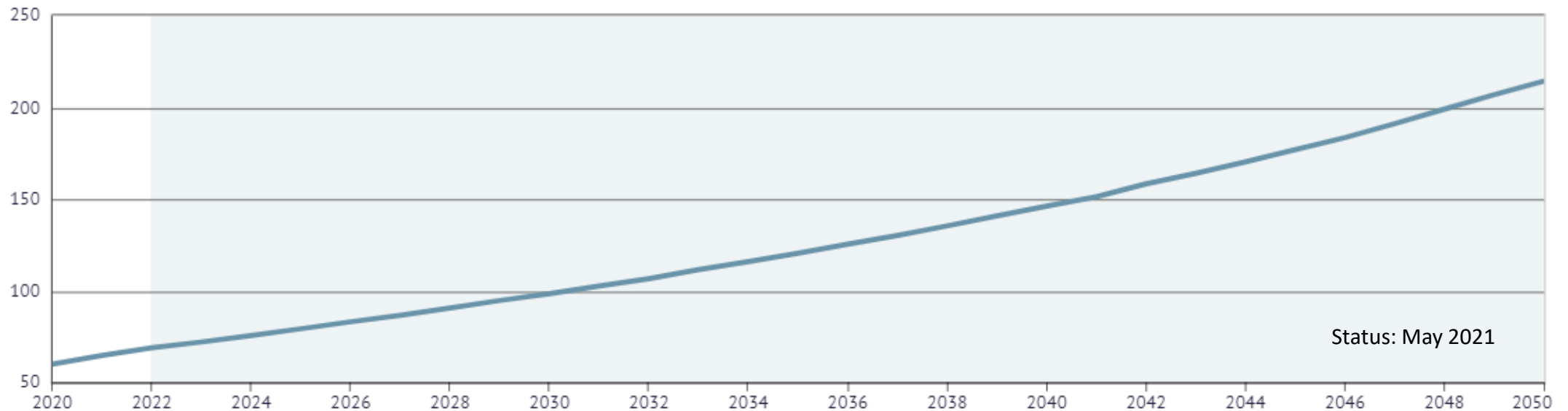


What is the future price of Brent crude oil?

The current EIA forecast that Brent crude oil prices will average **74.95 US \$ / barrel** in 2022. Oil prices are rising due to an increase in demand and a decrease in supply.

EIA: Long-Term Brent Crude Oil Price Projection

US\$ per barrel



Status: May 2021

What is the price of MGO in Rotterdam?



Rotterdam MGO

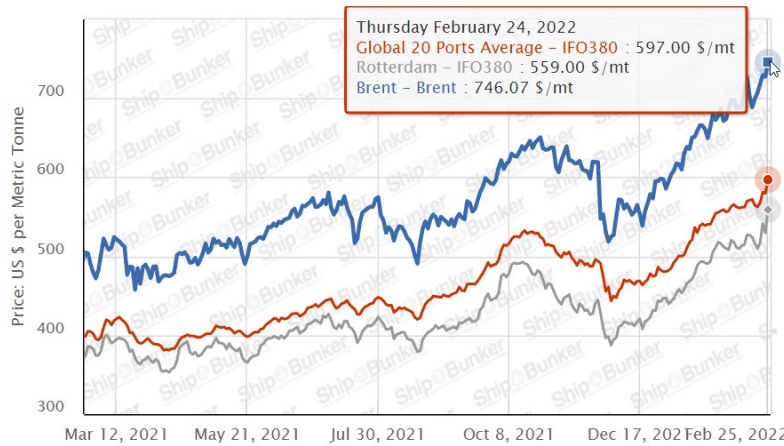
October 2021: 690 \$/t 610 €/t
November 2021: 700 \$/t 603 €/t
December 2021: 620 \$/t 540 €/t

January 2022: 770 \$/t 680 €/t

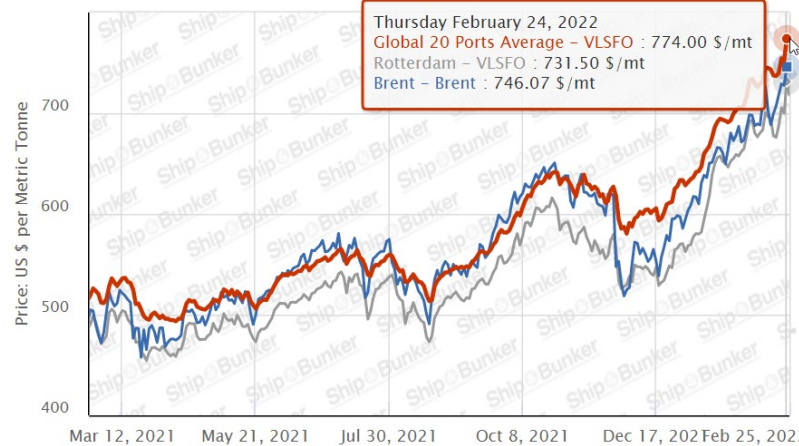
January 2023: 890 \$/t 817 €/t

What is the average fuel price over the last year in Rotterdam?

HFO 380 (max. 3.5% S)



VLSFO (max. 0,5% S)



MDO (max. 0,1% S)



	High	Low	Average
Global 20 Ports	\$597.00	\$381.00	\$458.50
Rotterdam	\$559.00	\$353.00	\$423.50
Brent	\$746.07	\$457.75	\$567.50

	High	Low	Average
Global 20 Ports	\$774.00	\$493.50	\$578.50
Rotterdam	\$731.50	\$454.50	\$542.50
Brent	\$746.07	\$457.75	\$567.50

	High	Low	Average
Global 20 Ports	\$904.50	\$556.00	\$670.00
Rotterdam	\$866.00	\$490.00	\$622.50
Brent	\$746.07	\$457.75	\$567.50

Source: <https://shipandbunker.com/>

Manufacturer

C-ENERGY Technologies AB

Claes Jakobsson
Gothenburg, Sweden



Promotion, Sales and Tendering

Alternative Energy Solutions

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