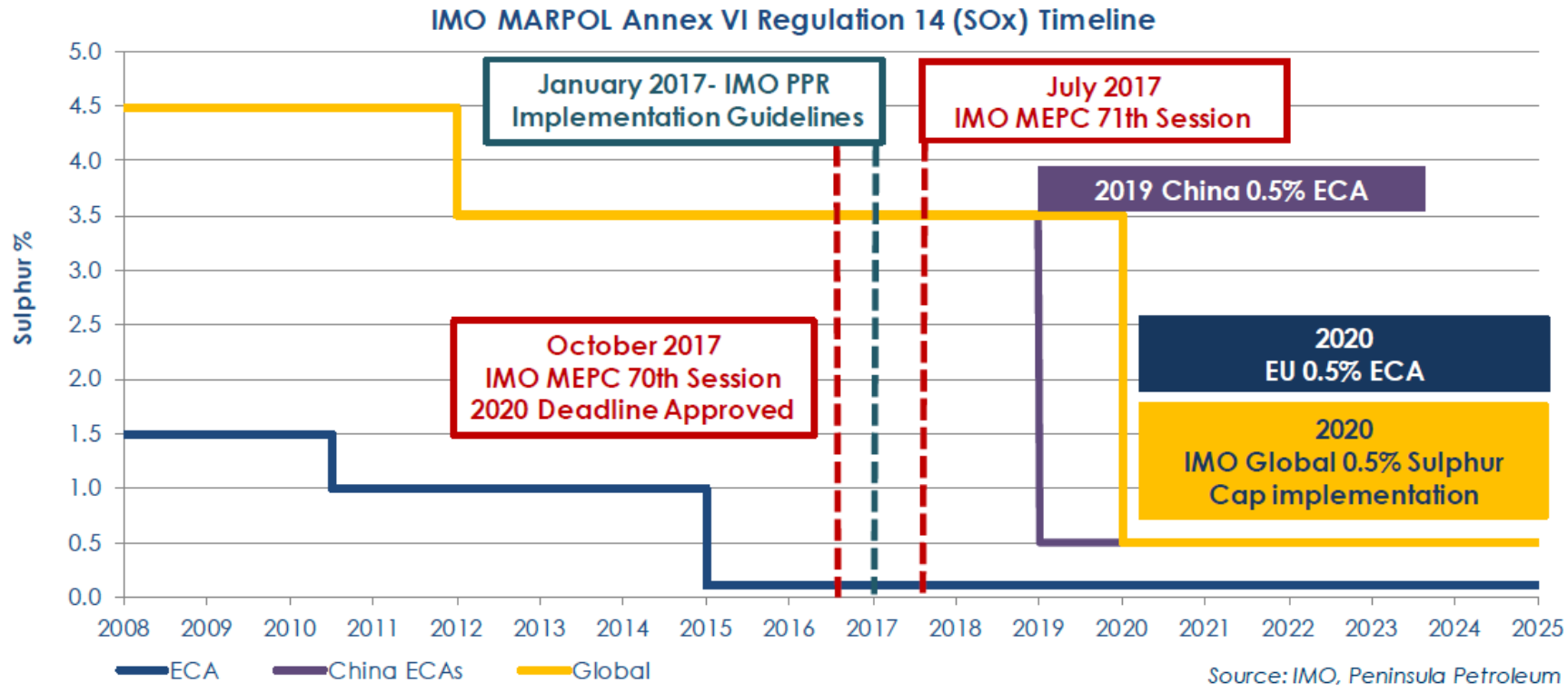
SULPHUR CAP

COMPLIANCE OPTIONS- SOLUTIONS & CHALLENGES

IMO MARPOL & Regional SOx Regulations



Compliant Options Available

1. **RUN THE VESSELS WITH MGO (distillate)**
2. **RUN THE VESSELS with LSHFO 0.5%**
3. **RUN THE VESSELS WITH HSFO and EGCS**
4. **RUN THE VESSELS WITH LNG**
5. **RUN THE VESSELS WITH ALTERNATE MARINE PETROLEUM FUELS (LPG, Methanol, LPG, BioFuels and DME)**

Assessment of Fuel Oil Availability (MEPC 70/05/03)

Fuel demand projections in the base case, high case and low case in 2020

Sulphur (% m/m)	Petroleum Derived fuels			LNG
	<0.10%	0.10-0.50%	>0.50%	
	Million tones per year			
Base case	39	233	36	12
High case	48	290	14	12
Low case	33	198	38	13

Assessment of Fuel Oil Availability (MEPC 70/05/03)

Global Refinery Production (2012 and 2020) - million tonnes per year

	Production in 2012	Production in 2020
Gasoline	963	1,086
Naptha	256	305
Jet/Kero Fuel	324	331
Middle Distillate	1,316	1,521
of which MGO	64	39
Total Marine Heavy Fuel Oil (HFO)	228	269
of which Marine HFO (S ≤ 0.50% m/m)	0	233
of which Marine HFO (S > 0.50% m/m)	228	36
LPG	113	110
Other	784	537
Total	3,984	4,159

Assessment of Fuel Oil Availability (MEPC 70/05/03)

Global marine fuel demand and supply (2020) base case - million tonnes per year

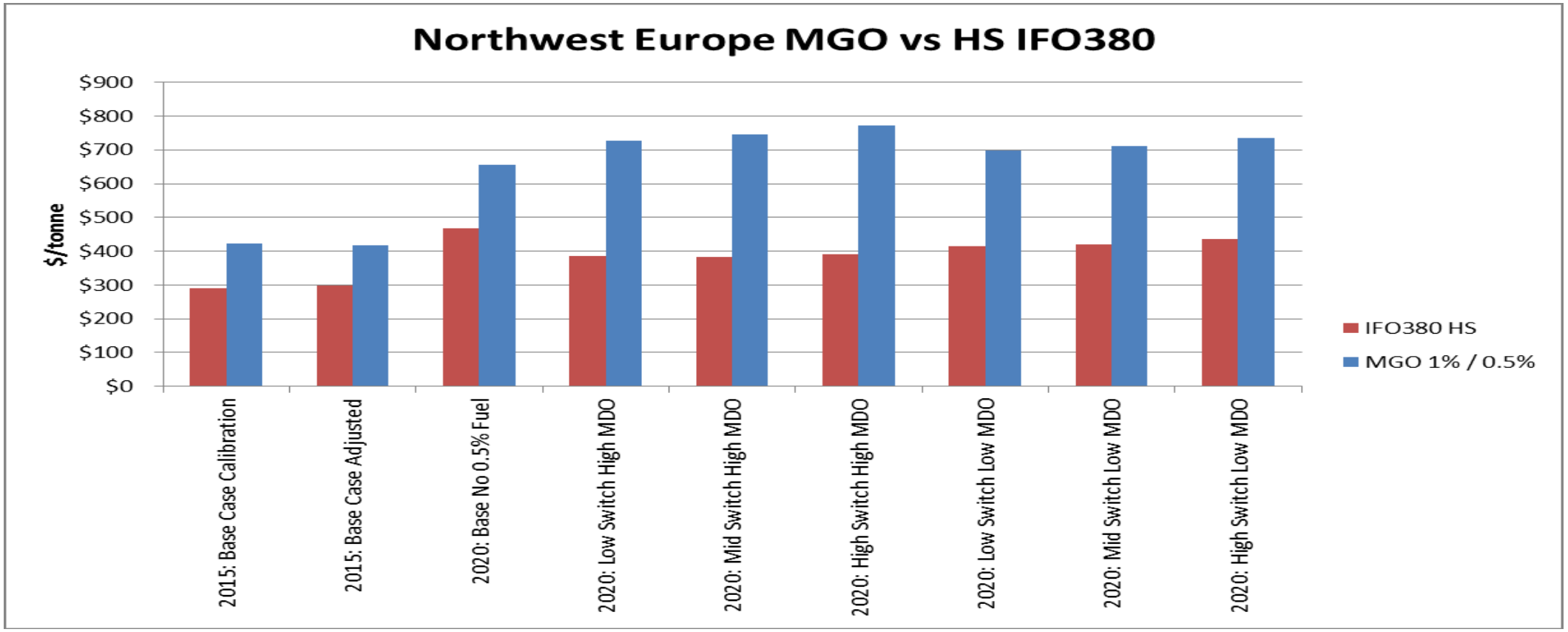
Base case marine fuel demand 2020 (supply)				
Sulphur (% m/m)	**Petroleum-derived fuels**			**LNG**
	<0.10%	**0.10 – 0.50%**	**>0.50%**	
Africa	2 (2)	12 (9)	1 (1)	0.6
Asia	18 (18)	110 (104)	15 (15)	3.1
Europe	9 (9)	54 (55)	8 (8)	1.2
North America	4 (4)	26 (17)	3 (3)	3.4
Latin America	3 (3)	21 (24)	3 (3)	0.1
Middle East	1 (1)	5 (18)	4 (4)	1.8
Russia & CIS	1 (1)	7 (7)	1 (1)	1.8
World	39 (39)	233 (233)	36 (36)	12

Assessment of Fuel Oil Availability (MEPC 70/05/03

Refinery Products and Crude Oil prices (USD/tonnes except for Brent)

Product	2010	2012	2014	2016	2018	2020
MGO 0.10% m/m SUL	672	997	896	452	552	616
Fuel oil 0.50% m/m SUL	-	-	-	-	-	595
Fuel oil 1% m/m SUL	625	918	809	390	497	569
Fuel oil 3% m/m SUL	521	741	616	252	377	466
Brent crude (USD/bbl)	80	112	99	49	63	77

Prices based on EnSYs Energy Study



Concerns for Availability & 2020

- Global Fuel Compliance via 100% Marine Distillate would not be realistic;
- In 2020 the Global refining Industry will lack sufficient Sulphur plant & Hydrogen plant capacity;
- Refinery CO2 emission will increase;
- Incentives for Refineries to offer heavier 0,5% S grades at lower cost than distillate;
- There might be questions for the heavier fuels in regards to effective onboard use;
- A Full-on Switch to the GLOBAL SULPHUR STANDARD Cannot be occurred overnight.

PROS & CONS for the various Options

1. DISTILLATE LOW SULPHUR

- PROS
  - **Low Cost Modifications Are Required**.
  - **Widely used without major Concerns**
- CONS
  - **Expected high difference price compared with HFO**
  - **Modifications in storage tanks, piping**
  - **Low viscosity and Lubricity issues. Additives and systems (Chillers-Coolers)**

PROS & CONS for the various Options

- LSFO 0.5% Sulphur
  - PROS
    - **No modifications are expected for existing vessels**
    - **Price is expected lower than the Distillate**
  - CONS
    - **Concerns of compliance with ISO 8217/12 parameters**
    - **Mixing/Commingling fuels of different viscosities (ranged from 10 to 180 cSt)/densities increase the risk of incompatibility**
    - **The blending components move towards heavier product, with 15% of treated light distillate have a risk to have a flash point lower than 60.**
    - **Blends with 15% treated light distillate increase the flammability and explosivity limits**
    - **Unstable fuels.**

Exhaust Gas Cleaning Systems (EGCSs)

- PROS
  - **Compliant Method for Continuing using Low Cost Fuel**.
- CONS
  - **Economic Analysis is required**
  - **Regulatory Constraints in Operation**
  - **Technical & Operational Feasibility**
  - **Availability of EGCSs**
  - **Other constraints**

Economic Analysis

EGCS investment costs used in this study

EGCS type	Fixed investment costs (million USD)	Variable investment costs (USD per kW of installed engine power)
Open loop, retrofit	2.3-2.6	55
Open loop, newbuild	1.9-2.4	38
Hybrid, retrofit	2.8-3.4	58
Hybrid, newbuild	2.4-2.8	44

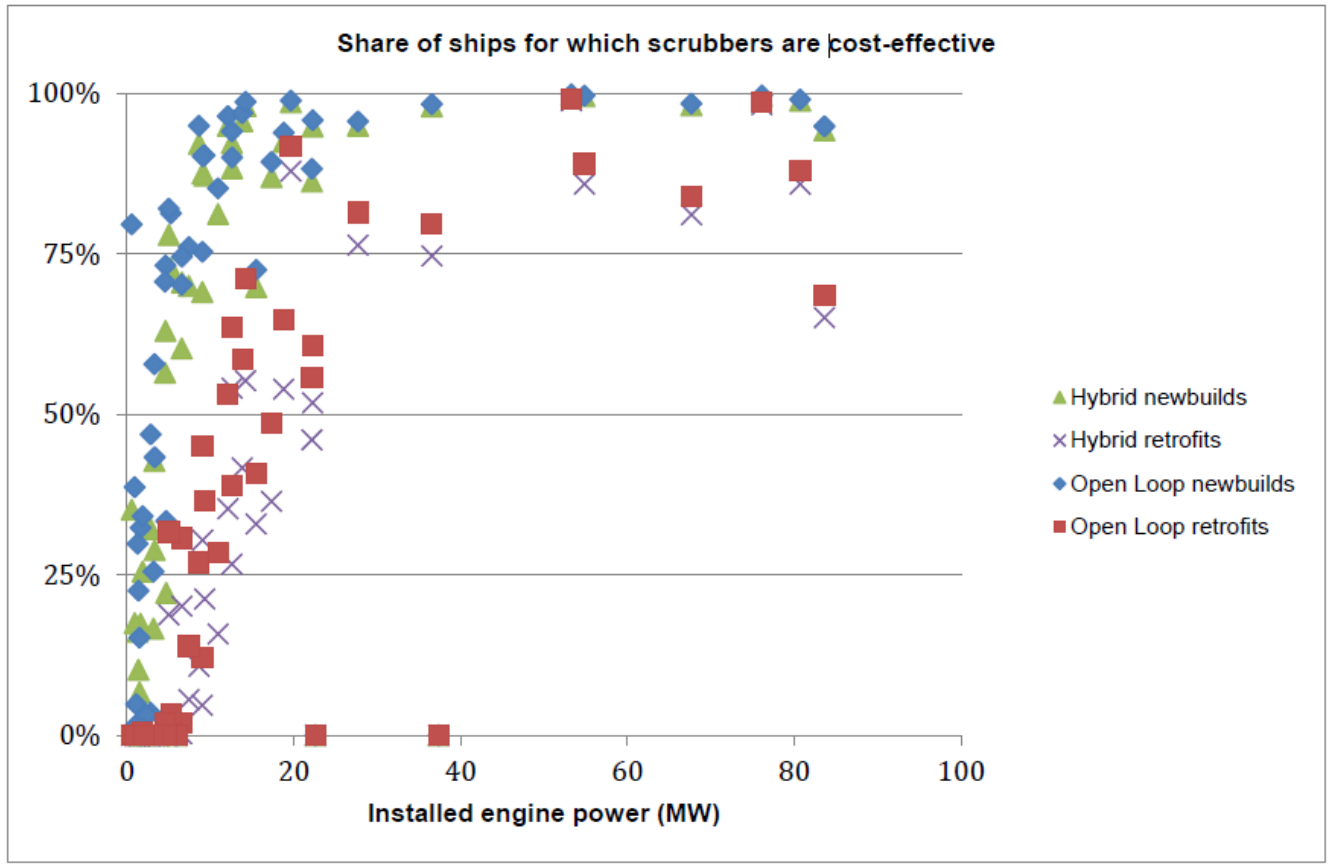
EGCS Operational Costs

EGCS operational costs used in this study EGCS type

EGCS type	Operational costs
Open loop	1% additional fuel + USD 13,000 + 0.4 * $P_{M.E.}$ (kW)
Hybrid	0.50% additional fuel + USD 25,000 + 0.4 * $P_{M.E.}$ (kW)

Technical & Operational Feasibility of EGCS

Cost-effectiveness of EGCSs as a function of engine size



Discounted Pay Back period for a VLGC

Open Loop Discounted Payback Period

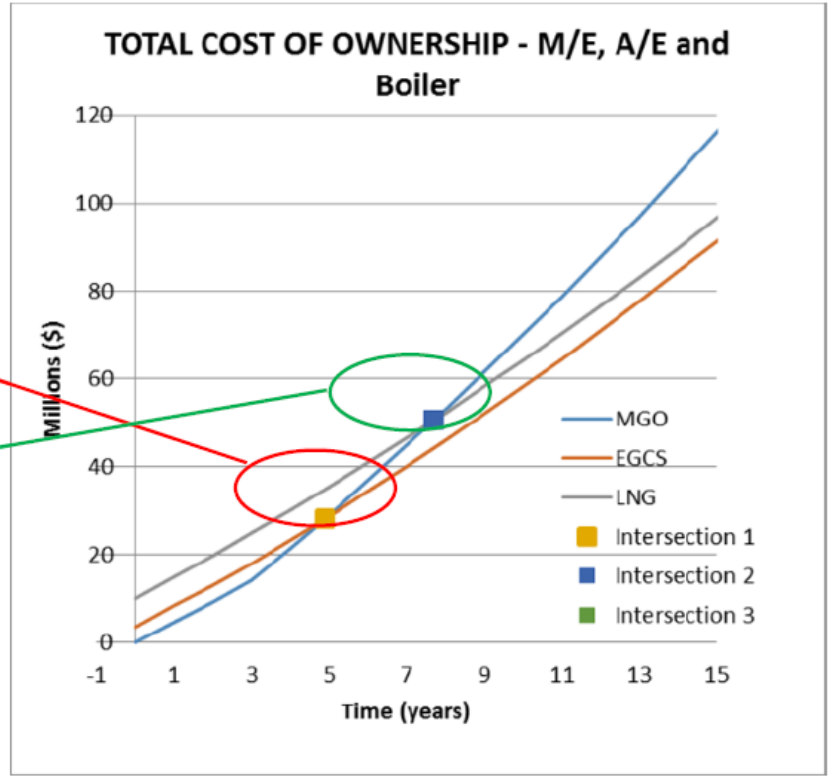
Open Loop EGCS	Discounted Payback Period
M/E	4.9
M/E and A/E	4.7
M/E, A/E and A/B	5.0

Hybrid Discounted Payback Period

Hybrid EGCS	Discounted Payback Period
M/E	5.8
M/E and A/E	5.6
M/E, A/E and A/B	5.8

Cumulative Annual Cost Balance point

When is Compliant Fuel no longer cost effective?	M/E only			M/E and A/E			M/E, A/E and Boiler		
	C.FUEL vs EGCS	4.58	years	C.FUEL vs EGCS	4.65	years	C.FUEL vs EGCS	4.88	years
	C.FUEL vs LNG	-	years	C.FUEL vs LNG	-	years	C.FUEL vs LNG	7.69	years



Regulatory constraints on EGCS use

- Restriction of Discharge of washwater in:
  - *Several Ports (e.g. Antwerp, Hamburg),*
  - *estuaries (e.g. the Wese) and*
  - *coastal waters (e.g. Alaska, Belgium, Italy).*
- Probable Regulations conflict
  - *with the Water Framework Directive (EC, 2000) and*
  - *the Marine Strategy Framework Directive (EC, 2008).*
  - *The uncertainty resulting from this discussion currently has a negative impact on demand for EGCSs.*

SHIPOWNERS that opt to invest in an EGCS Shall Consider to invest in a HYBRID unit

Technical and operational constraints on EGCS use

- **the space required for EGCSs and the impact on cargo space;**
- **impacts on vessel stability;**
- **impacts on power requirements; and**
- **compatibility of EGCSs with NOx Tier III requirements.**

EGCS availability and Other constraints

- **The production capacity ;**
- **The dry docking capacity ;**
- **Imbalance between cost and benefit for the Owner;**
- **Risk of underperformance**

LNG Option

- PROS
  - Environmentally Friendly Fuel. Meet 0.1% SOx and Nox III and have reduced CO2 emissions;
  - Low OPEX
- CONS
  - High CAPEX;
  - Not yet established LNG Bunkering infrastructure;
  - Large Regional Variations in price
  - High Capacity Volume for Bunker tanks

Discounted Pay Back period for a VLGC

LNG	Discounted Payback Period
M/E, A/E and A/B	7.4

Cumulative Annual Cost Balance point

Cumulative Annual Cost Balance Point	M/E Only	M/E and A/E	M/E, A/E and A/B
Compliant Fuel vs LNG	-	-	7.70 years
Open Loop EGCS vs LNG	Never*	Never*	Never*
Hybrid EGCS vs LNG	11.27 years	13.01 years	11.88 years

** Never means that the balance point is not reached before the end of the study period*

Alternate Marine Petroleum Fuels (LPG, Methanol, LPG, BioFuels and DME)

- PROS
  - Very Clean fuel fully compliance with SOx ;
  - Lower OPEX for LPG;
- CONS
  - Very High Capex;
  - Not Tested Engines and Technology
  - Suitable for specific type of vessels

Concerns & Challenges

- Extreme price differentials caused by shift to 0.5% enhance the economics for EGCS;
- This argument might create a perceived risk that specific refinery investment could become "stranded";
- In turn this will cut the justification for and likehood of investments occurring;
- As a conclusion the FULL compliance by implementing any OPTION needs TIME.
- There is NO EASY AVAILABLE SOLUTION

Challenges to Ensure Consistent Implementation

- Consistent and Effective implementation of the Sox cap is A Must for commercial & Environmental Reasons;
- Uneven implementation Shall Raise UNCERTAINTY for Actual Demand vs Supply chain;
- A Standard form for Reporting FUEL OIL NON AVAILABILITY is required
- Mechanisms to encourage verification of the S% limit stated on BDN;
- Time to ensure that the theoretical blends are suitable for Marine Engines and Crew Risk
- Time line for Developing UNIFORM & EFFECTIVE Implementation

Conclusions

1. Stakeholders to consider transition measures for the effective implementation;
2. Refineries to make the investment that are necessary for supply of compliant fuel;
3. The blending fuels to be in compliance with ISO Standards for safe and effective use onboard;
4. The owners to review carefully the available options and decide based on their real needs;
5. The makers to invest properly in the new technologies offering reliable solutions.

THANK YOU
FOR
YOUR ATTENTION

QUESTIONS?